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RAPID REORGANIZATION OF PLANT COMMUNITIES IN GEOLOGICAL TIME: CONTEXT FOR ANTHROPOCENE VEGETATION CHANGE

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Abstract: This study investigates the dynamics of vegetation change under the combined influence of climate variability and anthropogenic pressures, adopting a multi-scale and interdisciplinary perspective. By integrating ecological, climatic, and historical approaches, the research examines patterns of vegetation redistribution, structural transformation, and biodiversity shifts across different spatial and temporal frameworks. The findings highlight climate change as a dominant driver of vegetation dynamics, manifested through elevational and latitudinal range shifts, altered species composition, and the emergence of novel ecosystems. Simultaneously, human activities are identified as critical co-drivers, amplifying and accelerating ecological transformations. Beyond these established insights, the study advances a systems-oriented understanding of vegetation change by emphasizing cross-scale interactions, legacy effects, and cumulative environmental impacts. It underscores the presence of ecological thresholds and non-linear responses, revealing that vegetation systems may undergo rapid and potentially irreversible transitions once critical limits are exceeded. Additionally, the research conceptualizes vegetation as both a sensitive indicator of environmental change and an active regulator of ecosystem processes, influencing biogeochemical cycles and overall system stability. Methodologically, the study highlights the importance of integrating diverse analytical tools, including ecological modeling, remote sensing, and paleoecological reconstruction, to capture the complexity of vegetation dynamics. The results demonstrate that traditional linear and static approaches are insufficient for understanding and managing contemporary ecosystems. The study concludes that effective environmental management requires adaptive, flexible strategies that account for uncertainty, resilience, and transformation. By providing a comprehensive and integrative framework, this research contributes to a deeper understanding of vegetation dynamics in the context of global change and supports the development of informed, forward-looking conservation and sustainability policies.

Keywords: neophytes, Quaternary, paleoecology, vegetation turnover, biodiversity, ecosystem dynamics, global change.

INTRODUCTION

Climate change and anthropic activity is altering the composition, structure, and spatial distribution of plant and animal communities across the globe (Seidl & Turner 2022; Prabowo *et al*., 2023; Sudjana *et al*., 2024; Taofiqurohman *et al*., 2024). Recent studies show that vegetation assemblages in both terrestrial and marine ecosystems are reorganizing as species track shifting temperature and moisture regimes, often leading to novel communities and changing ecosystem functions (Rubenstein *et al*., 2023; Lenoir & Svenning, 2015; Zhu *et al*., 2024; Pinsky *et al*., 2020; Martin *et al*., 2019; Van Der Putten, 2012). These changes can be rapid in some systems, but strongly lagged or heterogeneous in others (Rubenstein *et al*., 2023; Lenoir & Svenning, 2015; Zhu *et al*., 2024; Zu *et al*., 2021; Cannone & Pignatti, 2014; Lenoir *et al*., 2008; Alexander *et al*., 2018).

In terrestrial ecosystems, plant assemblages increasingly reflect warmer climatic conditions (Odagiu *et al*., 2021; Petrescu-Mag & Bănățean-Dunea 2022; Papuc & Petrescu-Mag, 2023; Haziri 2024). Across France, plant communities have shifted toward species with higher thermal preferences within less than a decade, indicating a rapid increase in warm-adapted species relative to cold-adapted ones across multiple habitats (Martin *et al*., 2019). Elevational gradients show pronounced restructuring: in western Europe, the optimum elevation of forest plants has moved upslope by about 29 m per decade, affecting the core of species' ranges and not only their margins (Lenoir *et al*., 2008). Similar upward shifts and range contractions are reported for subtropical and Himalayan mountain floras, where most species extend their upper limits and community composition at high elevations becomes richer but more transient, suggesting assemblages in flux under warming (Zu *et al*., 2021; Telwala *et al*., 2013). Grassland communities dominated by short-lived species can track climate particularly quickly, with community composition shifting toward species associated with warmer, drier niches at rates comparable to recent warming and drying trends (Zhu *et al*., 2024). At the same time, many alpine and montane communities exhibit lags, internal "range filling," and complex turnover, with persistence of some dominant species and delayed

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local extinctions leading to non-equilibrium assemblages (Cannone & Pignatti, 2014; Bates *et al*., 2014; Alexander *et al*., 2018).

In marine systems, climate warming drives rapid redistribution of species and reorganization of vegetation-related assemblages (Adrias *et al*., 2025; Afriana, 2025; Wagey *et al*., 2025; Febrianti *et al*., 2025; Parmisana *et al*., 2025; Syamsuddin *et al*., 2025). Many marine taxa, including foundation species that structure plant-like habitats, shift poleward, deeper, or along complex directions as they follow changing thermal and oxygen environments, reshuffling food webs and community structure (Lenoir & Svenning, 2015; Pinsky *et al*., 2020; Sorte *et al*., 2010; Bates *et al*., 2014; Yulianda *et al*., 2025). Deep-water coral communities, which provide three-dimensional habitat analogous to forests, are projected to move from mid-slope to deeper bathyal depths, causing substantial losses of taxonomic and functional richness at current depths and gains deeper down, effectively redistributing ecosystem functions along depth gradients (Sipahutar & Rifardi, 2023; Mulya *et al*., 2023; Rakka *et al*., 2025). Coastal benthic communities associated with sediments and macrophytes show multidecadal shifts in species composition and functional traits; ecosystem functioning can change positively or non-linearly with warming even when standard diversity indices remain relatively stable, indicating subtle but important reorganization of assemblages (Armitage *et al*., 2024). Seagrass communities, key primary producers and habitat-forming plants in shallow seas, are expected to undergo widespread range reductions and strong changes in both local (α) and spatial (β) diversity, leading to differentiation or homogenization of regional floras depending on location (Daru & Rock, 2023). On some temperate coasts, warming, ocean currents, and increased herbivory promote shifts from macroalgal-dominated to coral-dominated communities, altering competitive hierarchies and the structure of plant-associated assemblages over large spatial scales (Kumagai *et al*., 2018).

Current vegetation change, driven by land use, climate warming and non-native species, is of a magnitude and speed comparable only to a few major episodes in the late Quaternary and deep time. Fossil pollen and plant macrofossil records allow direct comparison between present day turnover and past climatically or catastrophically forced reorganizations of plant communities.

PURPOSE OF THE MINI-REVIEW

The aim of this mini-review is to evaluate the extent to which contemporary plant community reorganization differs from past vegetation dynamics by integrating evidence from modern ecological studies, Quaternary paleoecological records, and deep-time geological events. Specifically, it seeks to (i) compare the rates, drivers, and patterns of vegetation change across different temporal scales, (ii) assess whether current Anthropocene dynamics represent a continuation of natural processes or a fundamentally novel phenomenon, and (iii) highlight the role of anthropogenic factors - particularly climate change, land-use transformation, and the spread of non-native species - in shaping present-day vegetation trajectories.

QUATERNARY GLACIAL–INTERGLACIAL TRANSITIONS AND ABRUPT EVENTS

Global syntheses of >1100–1180 pollen records show that the last deglaciation (since ~18 ka BP) produced very large, rapid shifts from steppe–tundra to boreal and then temperate forests, with multiple major rearrangements around 18.8, 16, 14.6 and 11.6 ka BP in central Europe and similar synchronous afforestation pulses elsewhere (Rey *et al*., 2020; Ammann *et al*., 2013; Bjune *et al*., 2022). In northwest Europe, vegetation changes at the onset of the Younger Dryas cooling were effectively instantaneous at decadal resolution, with shrub–tundra re expansion as forests retreated (Engels *et al*., 2022; Engels *et al*., 2024). High resolution records from central Europe indicate decadal to century scale lags between climatic shifts and full community reorganization, but still extremely rapid on geological timescales (Ammann *et al*., 2013; Engels *et al*., 2024). Regional records from the Polar Urals and Texas likewise document swift shifts between mesic woodland and more open, drier communities across the Bølling–Allerød/Younger Dryas/Holocene sequence (Bjune *et al*., 2022; Seersholm *et al*., 2020) (Table 1, Figure 1).

Table 1.

Timescales and drivers of Quaternary vegetation shifts

Episode / driver	Typical response time of vegetation	Main forcing context	References
Last deglaciation (global warming)	Decades–centuries per major phase	Orbital-scale climate, ice retreat	(Rey *et al*., 2020; Ammann *et al*., 2013; Bjune *et al*., 2022; Mottl *et al*., 2021)
Younger Dryas abrupt cooling/warming	Years–decades for onset; ≤ centuries for full reorganization	Rapid climate instability, circulation changes	(Engels *et al*., 2022; Engels *et al*., 2024; Bjune *et al*., 2022; Seersholm *et al*., 2020)
Late Holocene human land use & fire	Centuries–millennia cumulative	Agriculture, burning, deforestation	(Rey *et al*., 2020; Zapolska *et al*., 2023; Nogué *et al*., 2021; Adeleye *et al*., 2021)
Last ~200–2000 years (Anthropocene)	Decades–centuries; globally widespread	Land conversion, invasions, anthropogenic warming	(Stegner & Spanbauer, 2023; Mottl *et al*., 2021; Nogué *et al*., 2021; Walentowitz *et al*., 2023; Rey *et al*., 2020; Zapolska *et al*., 2023).

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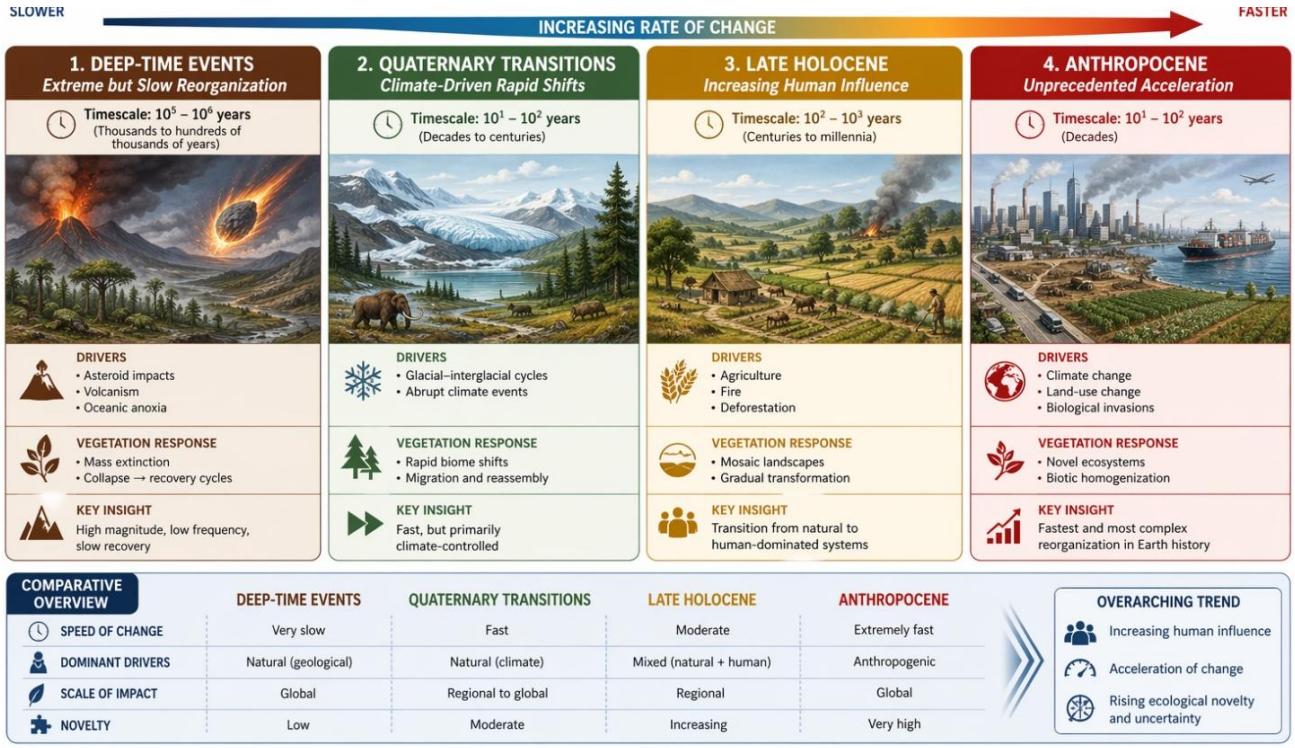


Fig. 1. Comparative dynamics of vegetation change across time scales (from deep-time events to the Antropocene) (original plate, designed by the author and edited using OpenAI, 2026).

LATE HOLOCENE AND ANTHROPOCENE ACCELERATION, INCLUDING NEOPHYTES

On continents, a globally unprecedented acceleration of vegetation compositional change begins ~4.6–2.9 ka BP and equals or exceeds deglacial rates; this reflects growing human pressures superimposed on natural variability (Mottl *et al*., 2021; Sugden, 2021). In Europe, humans gradually replace climate as the dominant driver of vegetation structure in the last 5–7 ka, with agriculture, fire, and species introductions creating mosaics of novel communities and increasing open habitat diversity (Rey *et al*., 2020; Zapolska *et al*., 2023). Quantitative comparisons of potential natural vegetation with pollen-based reconstructions indicate that by 6 ka BP European land cover had already diverged strongly (~70% human pressure index), rising to ~87% today (Zapolska *et al*., 2023). North American pollen records show two peak intervals of elevated abrupt change: the Pleistocene–Holocene transition and the last ~200 years, with recent increases in first and last appearances and abrupt shifts linked to land conversion, anthropogenic climate change and non-native introductions (Stegner & Spanbauer, 2023). On islands, human arrival over the last 5000 years increases vegetation turnover rates by a median factor of 11, and non-native pollen proportions rise sharply in the last 1000 years, documenting long, dynamic trajectories of invasion and novel assemblages (Nogué *et al*., 2021; Walentowitz *et al*., 2023).

DEEP TIME CATASTROPHES AND RAPID VEGETATION OVERTURN

Across the Cretaceous–Paleogene (K–Pg) impact event (~66 Ma), diverse latest Cretaceous floras suffered large taxonomic losses; regional studies in Montana estimate disappearance of ~63% of plant taxa and a 23–33% richness drop, followed by recovery of richness within <1 Myr but strong community restructuring and dominance shifts between conifers and angiosperms (Deibel *et al*., 2024; Vajda & Bercovici, 2014). Global palynological syntheses show a characteristic sequence of diversity collapse, opportunistic "crisis" taxa and pioneer communities (e.g. fern spikes), and slower recovery of more complex forests, a pattern shared with the end Permian and end Triassic mass extinctions despite different causal mechanisms (large igneous province volcanism, severe climate and anoxia vs. asteroid impact) (Vajda & Bercovici, 2014). During the Early Jurassic Toarcian Oceanic Anoxic Event (~183 Ma), rapid volcanogenic warming (~6.5 °C) drove a pronounced drop in floral richness and a shift from mixed, moisture adapted vegetation to low diversity assemblages of drought tolerant taxa; although richness rebounded relatively quickly, community composition remained fundamentally altered (Slater *et al*., 2019). These deep time episodes document rapid collapse and reassembly of plant communities under extreme climatic or catastrophic forcing, but typically over 10^3–10^5 year scales.

COMPARING PRESENT DAY CHANGE WITH GEOLOGICAL ANALOGUES

Global pollen syntheses show that Late Holocene and especially recent centuries' rates of vegetation turnover match or surpass those of the last deglaciation, implying that cumulative human effects now rival or exceed major natural reorganizations in magnitude and spatial extent (Mottl *et al*., 2021; Stegner & Spanbauer, 2023; Rey *et al*., 2020; Zapolska *et al*., 2023). In some regions, modern vegetation resembles glacial assemblages in overall stress imprint,

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but with distinctive homogenization and loss of connectivity driven by land use change and non-native species, representing a novel, anthropogenically dominated state rather than a simple recurrence of past configurations (Caballero-Rodriguez *et al*., 2017; Stegner & Spanbauer, 2023; Goodenough & Webb, 2022; Walentowitz *et al*., 2023).

INTEGRATIVE PERSPECTIVES ON VEGETATION DYNAMICS: TOWARD A PREDICTIVE AND SYSTEMS-ORIENTED FRAMEWORK

Positioned at the interface between empirical synthesis and forward-looking interpretation, this chapter advances a conceptual consolidation of vegetation dynamics by moving beyond descriptive and case-specific analyses. Rather than reiterating previously discussed mechanisms or historical trajectories, it proposes an integrative, systems-oriented framework aimed at enhancing the predictive capacity and applied relevance of vegetation science in the context of accelerating global change.

From descriptive ecology to predictive ecology

A central limitation of traditional vegetation studies lies in their predominantly retrospective character. While reconstructing past dynamics—ranging from deep-time biotic turnovers to recent anthropogenic transformations—has provided indispensable insights, the current pace of environmental change necessitates a transition toward predictive ecology. This shift involves not only extrapolating existing trends but also incorporating non-linear dynamics, threshold effects, and emergent properties of ecological systems.

Predictive models must therefore integrate multi-scalar drivers, including climatic variability, biotic interactions, and anthropogenic pressures. Crucially, these models should be probabilistic rather than deterministic, reflecting inherent uncertainties and enabling scenario-based planning. The integration of paleoecological analogues with contemporary monitoring data represents a promising avenue for improving model robustness.

Cross-scale interactions and system complexity

Vegetation systems are inherently hierarchical, with processes operating across spatial and temporal scales. Localized interactions—such as plant-soil feedbacks or species competition—intersect with regional climatic gradients and global biogeochemical cycles. Understanding vegetation change thus requires a cross-scale analytical approach that captures both bottom-up and top-down dynamics.

Complexity theory offers a useful lens in this regard, emphasizing feedback loops, tipping points, and adaptive responses. For instance, small perturbations at the microhabitat level may cascade into large-scale biome shifts under certain conditions. Conversely, large-scale drivers such as climate change may manifest heterogeneously due to local buffering capacities or ecological resilience.

Functional traits and ecosystem resilience

Moving beyond taxonomic composition, the functional trait paradigm provides a more mechanistic understanding of vegetation responses. Traits related to resource acquisition, stress tolerance, and reproductive strategies determine not only species survival but also ecosystem-level processes such as productivity and nutrient cycling.

In this context, resilience can be redefined as the capacity of a vegetation system to maintain functional integrity despite structural changes. This perspective allows for the possibility that ecosystems may undergo compositional turnover while preserving key functions, thereby challenging traditional conservation paradigms that prioritize species constancy.

Anthropogenic influence as a structural driver

Human activity has transitioned from being an external disturbance factor to a primary structural driver of vegetation dynamics. Land-use change, biological invasions, and climate forcing interact in complex ways, often producing novel ecosystems that lack historical analogues.

This necessitates a reframing of ecological baselines. Rather than attempting to restore pre-disturbance conditions—which may no longer be attainable—management strategies should focus on adaptive trajectories that optimize ecosystem services under current and projected conditions. This approach aligns with the concept of "managed resilience," wherein human intervention is not minimized but strategically directed.

Methodological innovation and data integration

Advances in remote sensing, machine learning, and ecological informatics are transforming the study of vegetation dynamics. High-resolution spatial data, coupled with long-term temporal datasets, enable the detection of subtle patterns and early warning signals of ecosystem change.

However, methodological innovation must be accompanied by rigorous validation and theoretical grounding. The integration of heterogeneous data sources—ranging from satellite imagery to paleoecological proxies—poses challenges related to scale compatibility and uncertainty propagation. Addressing these challenges requires standardized protocols and interdisciplinary collaboration.

Toward a unified conceptual model

Synthesizing the elements discussed above, a unified conceptual model of vegetation dynamics should incorporate: multi-scalar drivers and interactions, functional trait variability and ecosystem processes, non-linear dynamics and threshold behavior, anthropogenic influences as integral components, and predictive and scenario-based methodologies.

Such a model would not only enhance scientific understanding but also support decision-making in conservation, land management, and climate adaptation.

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Implications for future research

Future research should prioritize the development of integrative models that are both empirically grounded and computationally sophisticated. Particular attention should be given to: identifying early warning indicators of regime shifts, quantifying the role of biotic interactions under changing climates, assessing the long-term stability of novel ecosystems, bridging the gap between ecological theory and policy implementation.

This chapter underscores the necessity of moving toward a predictive, systems-oriented paradigm in vegetation science. By integrating multiple lines of evidence and embracing complexity, researchers can better anticipate and manage the profound transformations shaping the Earth's vegetation in the Anthropocene.

CONCLUSIONS

This study has systematically examined the dynamics of vegetation change across multiple temporal and spatial scales, emphasizing the complex interplay between climatic variability, ecological processes, and anthropogenic pressures. The findings confirm that vegetation systems are inherently dynamic, shaped by both gradual environmental shifts and abrupt disturbances, with patterns that are increasingly influenced by human activity in the Anthropocene.

The core conclusions of the research remain robust: climate change acts as a primary driver of vegetation redistribution, structural transformation, and biodiversity reconfiguration. Elevational and latitudinal shifts, alterations in species composition, and the emergence of novel ecosystems are not isolated phenomena but interconnected responses within a broader adaptive landscape. Additionally, the study reaffirms that human activities—ranging from land-use change to resource exploitation—function not merely as external stressors but as integral components of contemporary ecological systems.

Building upon these established findings, the integration of the newly introduced analytical chapter adds a critical layer of interpretation by situating vegetation dynamics within a more comprehensive, systems-oriented framework. Specifically, it underscores the importance of cross-scale interactions, where processes operating at geological, historical, and contemporary timescales converge to shape present-day ecological outcomes. This perspective highlights that current vegetation patterns cannot be fully understood without acknowledging legacy effects and cumulative impacts.

Furthermore, the extended discussion brings into focus the concept of ecological thresholds and non-linear responses. Vegetation systems may exhibit resilience up to a point, beyond which rapid and potentially irreversible transformations occur. This insight reinforces the necessity of moving beyond linear predictive models toward more nuanced approaches that incorporate feedback mechanisms, tipping points, and adaptive capacity.

Another significant contribution integrated into these conclusions is the recognition of vegetation as both an indicator and a regulator of environmental change. Vegetation not only responds to climatic and anthropogenic drivers but also actively influences biogeochemical cycles, microclimates, and ecosystem stability. This dual role positions vegetation at the center of sustainability discourse and environmental management strategies.

Importantly, the study also highlights the growing relevance of interdisciplinary methodologies. The convergence of ecological modeling, remote sensing, paleoecological reconstruction, and socio-environmental analysis provides a more holistic understanding of vegetation dynamics. Such integrative approaches are essential for addressing the complexity of current and future environmental challenges.

In practical terms, the findings suggest that effective environmental management and conservation strategies must be adaptive, forward-looking, and grounded in an understanding of system complexity. Static conservation models are increasingly inadequate in the face of rapid environmental change. Instead, flexible frameworks that accommodate uncertainty, promote resilience, and anticipate transformation are required.

As a final remark, this research not only consolidates existing knowledge on vegetation change but also advances the discourse by embedding it within a broader conceptual and analytical context. By integrating multi-scale dynamics, non-linear processes, and interdisciplinary perspectives, the study provides a more comprehensive foundation for both scientific inquiry and policy development. Future research should continue to refine these approaches, with particular emphasis on predictive accuracy, scenario modeling, and the translation of scientific insights into actionable strategies for sustainable ecosystem management.

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AUTHORS CONTRIBUTIONS

Ioan Valentin Petrescu-Mag contributed to all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

REFERENCES

Adeleye M, Mariani M, Connor S, Haberle S., Herbert A, Hopf F, Stevenson J, Long-term drivers of

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vegetation turnover in Southern Hemisphere temperate ecosystems. *Global Ecology and Biogeography*, 30, 557-571, 2021.

Adrias KJA, Amparado OA, Adamat LA, Tabugo SRM, Uncovering biodiversity: intertidal marine macroalgae in Sacol Island, Zamboanga City, Philippines. *Aquaculture, Aquarium, Conservation & Legislation*, 18(3), 1370-1380, 2025.

Afriana W, Economic impact of climate change on pelagic fish migration: a systematic review of the literature. *Aquaculture, Aquarium, Conservation & Legislation*, 18(5), 2114-2122, 2025.

Alexander J, Chalmandrier L, Lenoir J, Burgess T, Essl F, Haider S, Kueffer C, McDougall K, Milbau A, Nuñez M, Pauchard A, Rabitsch W, Rew L, Sanders N, Pellissier L, Lags in the response of mountain plant communities to climate change. *Global Change Biology*, 24, 563-579, 2018.

Ammann B, Leeuwen J, Knaap W, Lischke H, Heiri O, Tinner W, Vegetation responses to rapid warming and to minor climatic fluctuations during the Late-Glacial Interstadial (GI-1) at Gerzensee (Switzerland). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 391, 40-59, 2013.

Armitage P, Burrows M, Rimmer J, Blight A, Paterson D, Multidecadal changes in coastal benthic species composition and ecosystem functioning occur independently of temperature-driven community shifts. *Global Change Biology*, 30, e17482, 2024.

Bates A, Pecl G, Frusher S, Hobday A, Wernberg T, Smale D, Sunday J, Hill N, Dulvy N, Colwell R, Holbrook N, Fulton E, Slawinski D, Feng M, Edgar G, Radford B, Thompson P, Watson R, Defining and observing stages of climate-mediated range shifts in marine systems. *Global Environmental Change-Human and Policy Dimensions*, 26, 27-38, 2014.

Bjune A, Alsos I, Brendryen J, Edwards M, Haflidason H, Johansen M, Mangerud J, Paus A, Regnéll C, Svendsen J, Clarke C, Rapid climate changes during the Lateglacial and the early Holocene as seen from plant community dynamics in the Polar Urals, Russia. *Journal of Quaternary Science*, 37, 805-817, 2022.

Caballero-Rodriguez D, Lozano-García S, Correa-Metrio A, Vegetation assemblages of central Mexico through the late Quaternary: modern analogs and compositional turnover. *Journal of Vegetation Science*, 28: 504–514, 2017.

Cannone N, Pignatti S, Ecological responses of plant species and communities to climate warming: upward shift or range filling processes? *Climatic Change*, 123, 201-214, 2014.

Daru B, Rock B, Reorganization of seagrass communities in a changing climate. *Nature Plants*, 9, 1034-1043, 2023.

Deibel P, Mantilla G, Strömberg C, Plant taxonomic turnover and diversity across the Cretaceous/Paleogene boundary in northeastern Montana. *Paleobiology*, 50, 608-626, 2024.

Engels S, Lane C, Haliuc A, Hoek W, Muschitiello F, Baneschi I, Bouwman A, Ramsey B, Collins J, De Bruijn R, Heiri O, Hubay K, Jones G, Laug A, Merkt J, Müller M, Peters T, Peterse F, Staff R, Ter Schure A, Turner F, Van Den Bos V, Wagner-Cremer F, Synchronous vegetation response to the last glacial-interglacial transition in northwest Europe. *Communications Earth & Environment*, 3, 130, 2022.

Engels S, Lane C, Hoek W, Baneschi I, Bouwman A, Brogan E, Ramsey B, Collins J, De Bruijn R, Haliuc A, Heiri O, Hubay K, Jones G, Jones V, Laug A, Merkt J, Muschitiello F, Müller M, Peters T, Peterse F, Pueschel A, Staff R, Ter Schure A, Turner F, Van Den Bos V, Wagner-Cremer F, Biodiversity responses to Lateglacial climate change in the subdecadally-resolved record of Lake Hämelsee (Germany). *Quaternary Science Reviews*, 331, 108634, 2024.

Febrianti AS, Halide H, Andika, Rajalau AN, The effect of global ocean factors on the crown-of-thorns starfish (Acanthaster planci, Linnaeus, 1758) population in the Great Barrier Reef, Australia. *Aquaculture, Aquarium, Conservation & Legislation*, 18(1), 210-216, 2025.

Haziri A, Invasive alien plant species (IAPS), identified in the Polog region–Republic of North Macedonia. *Analele Universităţii din Oradea*, *Fascicula Biologie*, 31(1), 40-43, 2024.

Goodenough A, Webb J, Understanding spatiotemporal variation in richness and rate of within-site turnover for vegetation communities in Western Eurasia over the Last 4000 Years. *Diversity*, 14(12), 1096, 2022.

Kumagai N, Molinos G, Yamano H, Takao S, Fujii M, Yamanaka Y, Ocean currents and herbivory drive macroalgae-to-coral community shift under climate warming. *Proceedings of the National Academy of Sciences*, 115: 8990-8995, 2018.

Lenoir J, Gégout J, Marquet P, Marquet P, Ruffray P, Brisse H, A significant upward shift in plant species optimum elevation during the 20th century. *Science*, 320, 1768-1771, 2008.

Lenoir J, Svenning J, Climate-related range shifts – a global multidimensional synthesis and new research directions. *Ecography*, 38, 15-28, 2015.

Martin G, Devictor V, Motard E, Machon N, Porcher E, Short-term climate-induced change in French plant communities. *Biology Letters*, 15(7), 20190280, 2019.

Mottl O, Flantua S, Bhatta K, Felde V, Giesecke T, Goring S, Grimm E, Haberle S, Hooghiemstra H, Ivory S, Kuneš P, Wolters S, Seddon A, Williams J, Global acceleration in rates of vegetation change over the past 18,000 years. *Science*, 372(6544), 860-864, 2021.

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Mulya MB., Aldyza N, Afkar A, The prevalence of coral health issues in the conservation area of Benteng, Weh Island, Sabang, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 16(2), 1166-1176, 2023.

Nogué S, Santos A, Birks H, Björck S, Castilla-Beltrán Á, Connor S, De Boer E, De Nascimento L, Felde V, Fernández-Palacios J, Froyd C, Haberle S, Hooghiemstra H, Ljung K, Norder S, Peñuelas J, Prebble M, Stevenson J, Whittaker R, Willis K, Wilmshurst J, Steinbauer M, The human dimension of biodiversity changes on islands. *Science*, 372, 488-491, 2021.

Odagiu A, Petrescu-Mag IV, Proorocu M, The fig tree (*Ficus carica*) growing area extends to northern Romania. *Advances in Agriculture & Botanics*, 13(3), 63-65, 2021.

Păpuc T, Petrescu-Mag RM, Ten of the most notorious invasive plant species around the world. *Advances in Agriculture & Botanics*, 15(1), 55-64, 2023.

Parmisana JRL, Natividad MB, Leopardas VE, Gerasmio IP, Tatil WT, Community structure of the seagrass meadows of Malamawi Island, Basilan Province, Philippines. *Aquaculture, Aquarium, Conservation & Legislation*, 18(3), 1290-1300, 2025.

Petrescu-Mag IV, Bănățean-Dunea I, Measurements of the diameter of the fig stem (*Ficus carica*) in Romania for six years show the transition from a small shrub to a tree-like plant. *Research Journal of Agricultural Science*, 54(2), 131-135, 2022.

Pinsky M, Selden R, Kitchel Z, Climate-driven shifts in marine species ranges: scaling from organisms to communities. *Annual Review of Marine Science*, 12, 153-179, 2020.

Prabowo B, Fahlevy K, Subhan B, Santoso P, Hadi TA, Atmaja HE, Hudha F, Elfahmi, Syafrizayanti, Andriani Y, Arafat D, Bashari MH, Variation in species diversity and abundance of sponge communities near the human settlement and their bioprospect in Pramuka Island, Jakarta, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 16(3), 1186-1198, 2023.

Rakka M, Metaxas A, Nizinski M, Climate change drives bathymetric shifts in taxonomic and trait diversity of deep-sea benthic communities. *Global Change Biology*, 31(8), e70407, 2025.

Rey F, Gobet E, Schwörer C, Hafner A, Szidat S, Tinner W, Climate impacts on vegetation and fire dynamics since the last deglaciation at Moossee (Switzerland). *Climate of the Past*, 16(4), 1347–1367, 2020.

Rubenstein M, Weiskopf S, Bertrand R, Carter S, Comte L, Eaton M, Johnson C, Lenoir J, Lynch A, Miller B, Morelli T, Rodriguez M, Terando A, Thompson L, Climate change and the global redistribution of biodiversity: substantial variation in empirical support for expected range shifts. *Environmental Evidence*, 12(1), 7, 2023.

Seersholm F, Werndly D, Grealy A, Johnson T, Early E, Lundelius E, Winsborough B, Farr G, Toomey R, Hansen A, Shapiro B, Waters M, McDonald G, Linderholm A, Stafford T, Bunce M, Rapid range shifts and megafaunal extinctions associated with late Pleistocene climate change. *Nature Communications*, 11, 2770, 2020.

Seidl R, Turner MG, Post-disturbance reorganization of forest ecosystems in a changing world. *Proceedings of the National Academy of Sciences*, 119(28), e2202190119, 2022.

Sipahutar AN, Rifardi, Effect of sediment accumulation rate on coral cover in the waters of Setan Island, West Sumatra, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 16(4), 2264-2275, 2023.

Slater S, Twitchett R, Danise S, Vajda V, Substantial vegetation response to Early Jurassic global warming with impacts on oceanic anoxia. *Nature Geoscience*, 12, 462-467, 2019.

Sorte C, Williams S, Carlton J, Marine range shifts and species introductions: comparative spread rates and community impacts. *Global Ecology and Biogeography*, 19, 303-316, 2010.

Stegner M, Spanbauer T, North American pollen records provide evidence for macroscale ecological changes in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America*, 120(43), e2306815120, 2023.

Sudjana L, Sodikin, Astarika R, Spatial analysis of mangrove cover change and land suitability for its rehabilitation in Tanjungpinang City, Riau Islands Province, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation,* 17(6), 2905-2921, 2024.

Sugden A, The pace of Holocene vegetation change. *Science*, 372, 803-805, 2021.

Syamsuddin ML, Haq HD, Ismail MR, Syamsudin F, Sunarto, Abdurrahman U, Variability in sea surface temperature and sea surface height in connection with global warming in the Java Sea. *Aquaculture, Aquarium, Conservation & Legislation*, 18(2), 555-565, 2025.

Taofiqurohman A, Ismail MR, Zallesa S, Integrated analysis of human activities and environmental pressures along the coast of Ciletuh-Palabuhanratu UNESCO Global Geoparks, Indonesia: An ODEMM linkage framework and TOPSIS approach. *Aquaculture, Aquarium, Conservation & Legislation* 17(1), 98-115, 2024.

Telwala Y, Brook B, Manish K, Pandit M, Climate-induced elevational range shifts and increase in plant species richness in a Himalayan biodiversity epicentre. *PLoS ONE*, 8(2), e57103, 2013.

Vajda V., Bercovici A, The global vegetation pattern across the Cretaceous-Paleogene mass extinction interval: A template for other extinction events. *Global and Planetary Change*, 122, 29-49, 2014.

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Van Der Putten W, Climate change, aboveground-belowground interactions, and species' range shifts. *Annual Review of Ecology, Evolution, and Systematics*, 43, 365-383, 2012.

Wagey BT, Paruntu CP, Tilaar FF, Kepel RC, Study of the morphology and genetics of the seagrass *Halophila ovalis* in the Wallace Line coastal waters on the Minahasa Peninsula, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 18(6), 2475-2487, 2025.

Walentowitz A, Lenzner B, Essl F, Strandberg N, Castilla-Beltrán Á, Fernández-Palacios J, Björck S, Connor S, Haberle S, Ljung K, Prebble M, Wilmshurst J, Froyd C, De Boer E, De Nascimento L, Edwards M, Stevenson J, Beierkuhnlein C, Steinbauer M, Nogué S, Long-term trajectories of non-native vegetation on islands globally. *Ecology Letters*, 26, 729–741, 2023.

Yulianda F, Sulistiono, Yulianto G, Rabiyanti I, Yudha FK, Salsabila FL, Shabira SA, Absor SU, Assessment of potential and challenges for sustainable resource utilization in the Biawak Island conservation area, Indramayu, West Java. *Aquaculture, Aquarium, Conservation & Legislation*, 18(3), 1381-1390, 2025.

Zapolska A, Serge M, Mazier F, Quiquet A, Renssen H, Vrac M, Fyfe R, Roche D, More than agriculture: Analysing time-cumulative human impact on European land-cover of second half of the holocene. *Quaternary Science Reviews*, 314, 108227, 2023.

Zhu K, Song Y, Lesage J, Luong J, Bartolome J, Chiariello N, Dudney J, Field C, Hallett L, Hammond M, Harrison S, Hayes G, Hobbs R, Holl K, Hopkinson P, Larios L, Loik M, Prugh L, Rapid shifts in grassland communities driven by climate change. *Nature Ecology & Evolution*, 8, 2252-2264, 2024.

Zu K, Wang Z, Zhu X, Lenoir J, Shrestha N, Lyu T, Luo A, Li Y, Ji C, Peng S, Meng J, Zhou J, Upward shift and elevational range contractions of subtropical mountain plants in response to climate change. *The Science of the Total Environment*, 783, 146896, 2021.

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