

Ecological Succession: How Ecosystems Rebuild

- Directional change in species, community structure, and ecosystem function
- Follows disturbance or new habitat formation
- Examples: lava flows, retreating glaciers, burned forests, abandoned farmland
- Guiding question: how do ecosystems reassemble after disruption?
- Succession differs from seasonal cycles and short-term fluctuations



Why Succession Matters in the Anthropocene



A foundational concept linking populations, communities, ecosystems, and landscapes



Key to recovery after wildfire, floods, and abandoned farmland



Shaped by human land-use history, not just ecological factors



Restoration needs successional mechanisms, not automatic recovery



An active global field with direct conservation and policy impact



Disturbance, Severity, and Biological Legacy

- Disturbance types vary by severity, frequency, and spatial extent
- Volcanic eruption, glacial retreat, wildfire, hurricane, flood, tillage, mining
- Biological legacy: surviving seeds, roots, resprouters, soil biota, deadwood
- Greater legacy means faster, more predictable recovery trajectories
- Interacting disturbances can redirect recovery; disturbance regimes shape species



Primary vs. Secondary Succession: A Continuum

- Primary succession: no soil, no legacy — lava, moraines, new dunes
- Secondary succession: soil and propagules survive — fire, flood, logging
- Same process, different starting points on a legacy continuum
- More biological legacy means faster recovery and shorter timelines
- Ambiguous cases like shallow tephra blur the line



Pioneer Species and Early Community Assembly



- Lichens, mosses, and fast-growing grasses colonize harsh, bare substrates
- Nitrogen-fixers like alder and lupine build soil fertility
- Pioneers share traits: rapid growth, high dispersal, short life cycles
- Weathering and organic matter turn bare rock into developing soil
- Examples: volcanic terrain, glacial forelands, abandoned fields



Lichen



Moss



Alder (nitrogen-fixer)

Mechanisms of Species Replacement

Facilitation



Tolerance



Inhibition



Facilitation, tolerance, inhibition: classic models, more continuum than categories



Competition and life-history trade-offs drive species turnover



Dispersal limitation and priority effects control arrival order



Ecosystem engineers and keystone species redirect successional pathways



Plant-soil and plant-herbivore feedbacks accelerate, slow, or divert succession

From Bare Rock to Forest: Primary Succession in Detail



Pioneer stage: lichen crust and moss colonize bare rock



Grasses, herbs, and shrubs build soil organic matter



Pioneer trees give way to late-successional, shade-tolerant species



Soil depth, nitrogen, and water-holding capacity rise over centuries



Case studies: Mount St. Helens, Hawaii, Glacier Bay, Alaska



Early phases can persist for very long periods



Alternative pathways arise from site conditions and arrival order



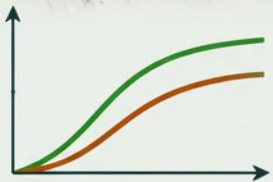
Secondary Succession and Human-Influenced Landscapes

- Recovery after fire, windthrow, flood, and farm abandonment
- Old-field succession: classic teaching model with strong regional variation
- Logged forests, mined lands, urban brownfields, and managed restoration
- Biodiversity, carbon storage, and ecosystem services shift during recovery
- Land-use intensity and socio-economic context shape both speed and direction

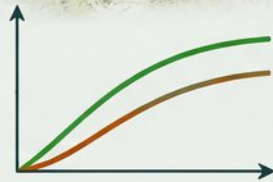
Disturbance today.
Renewal tomorrow.



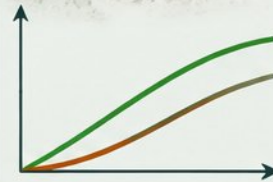
Fire



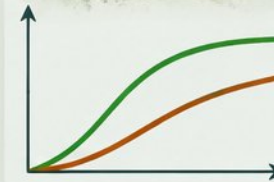
Windthrow



Flood



Farm abandonment



— Biodiversity (relative recovery)
— Carbon storage (relative recovery)

Time

Trajectories, Stability, and the Question of Climax

- Classic stages: pioneer, intermediate, late-successional, mature forest
- Climax community concept challenged by alternative stable states
- Patch dynamics and non-equilibrium views replace linear succession
- State-and-transition models and resilience thinking explain real trajectories
- Succession is directional but rarely deterministic; can diverge or arrest
- Key terms: resistance, resilience, regime shift, ecological threshold



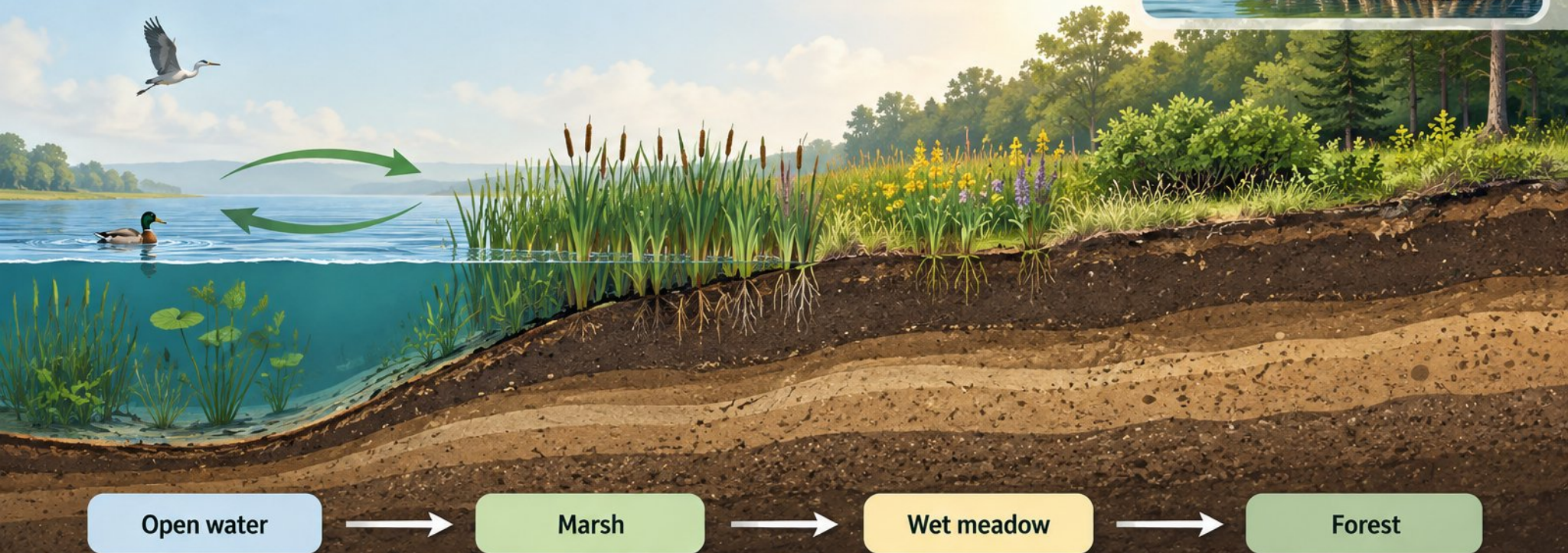
Succession in Aquatic and Wetland Systems

- Hydrarch succession: open water to marsh to wet meadow to forest
- Sediment buildup, nutrient loading, and falling water levels drive change
- Freshwater wetlands differ from coastal salt marshes and mangroves
- Human impacts: eutrophication, drainage, sea-level rise, invasive species
- Hydrology often makes wetland succession cyclic or reversible, not one-way

Coastal Salt Marshes



Mangroves



The Role of **Microbes** and **Soils** in Succession



Soil organic carbon and nitrogen rise; pH declines over succession



Microbial diversity peaks mid-succession, then slightly declines late



Fast-growing copiotrophs give way to slow-growing oligotrophic specialists



Soil biota drive plant establishment via nutrient cycling and feedbacks

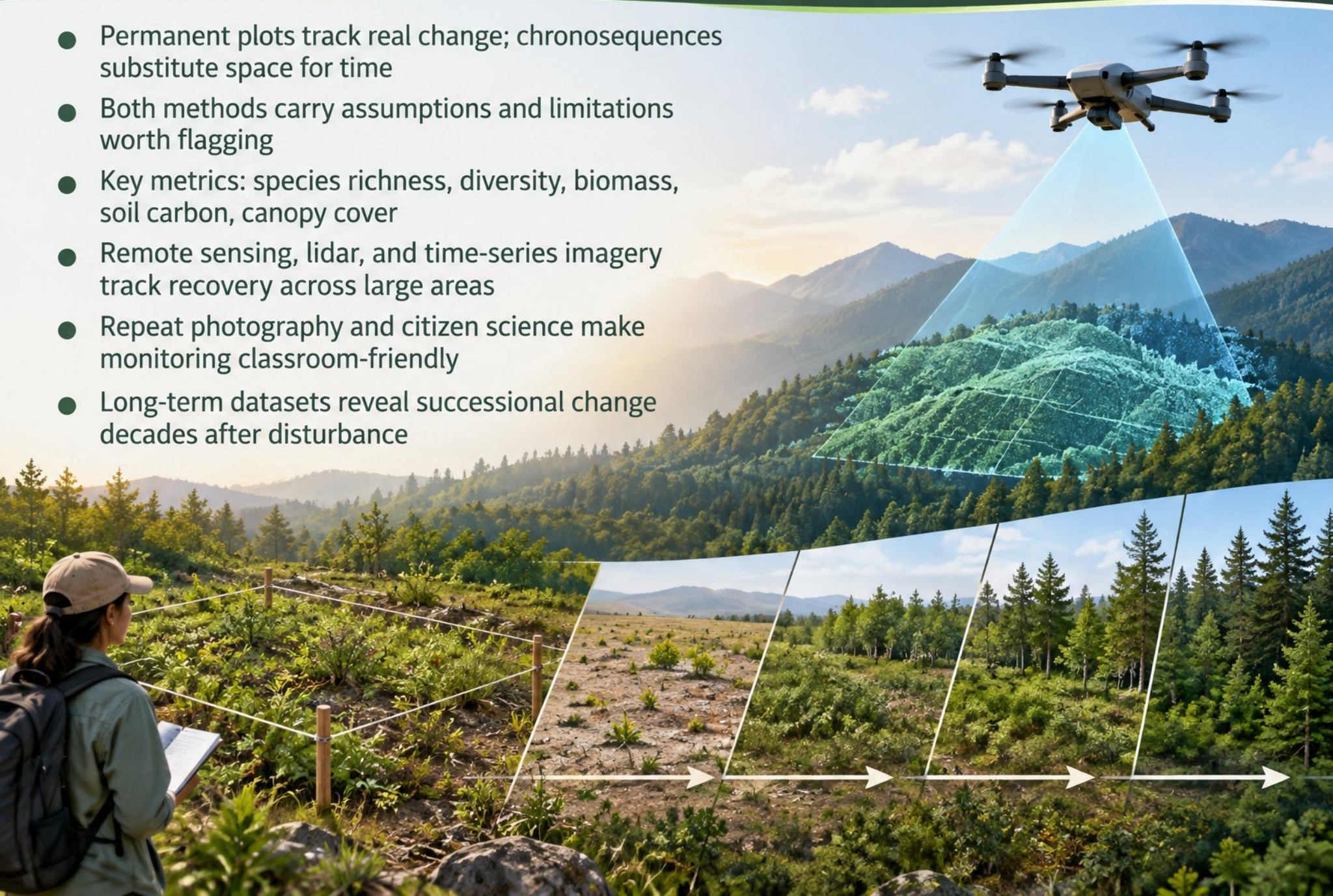


Belowground shifts are coupled with aboveground change



Measuring and Monitoring Succession

- Permanent plots track real change; chronosequences substitute space for time
- Both methods carry assumptions and limitations worth flagging
- Key metrics: species richness, diversity, biomass, soil carbon, canopy cover
- Remote sensing, lidar, and time-series imagery track recovery across large areas
- Repeat photography and citizen science make monitoring classroom-friendly
- Long-term datasets reveal successional change decades after disturbance



Teaching Succession:

Activities, Assessment, and Misconceptions



Correct myths: succession isn't always forest, linear, fast, or reversible



Field activities: transect surveys, photo comparisons, soil cups, tray simulations



Assessment: concept maps, data interpretation, scenario predictions, written explanations



Link succession to real decisions in restoration, land management, climate adaptation



Teach mechanisms to reveal dynamic, contingent, context-dependent ecological processes



Applying Succession Science: Restoration, Management, and Future Directions

- Succession is directional, not deterministic: disturbance, legacy, and context matter
- Restoration can accelerate, redirect, or work with natural succession
- Active intervention versus passive rewilding: choose by bottleneck stage
- Plan for biological legacies and alternative stable states
- Apply succession thinking locally: monitor, restore, adapt to global change

	Intervene	Work with Natural Succession
Active rewilding		
Passive rewilding		



PersonWise.

PersonWise • AI digital-human course platform



Scan the code or click anywhere to watch this course live, with voice Q&A

personwise.ai/t/d09343d1/public