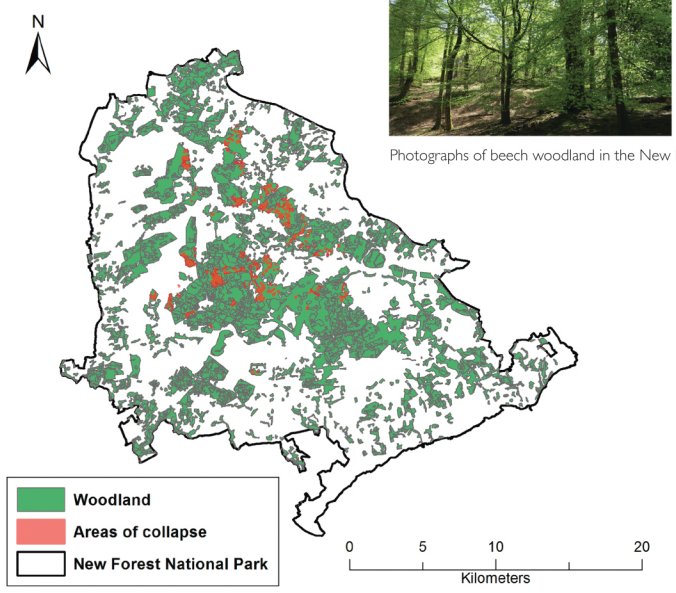
Gradients of stand dieback

Photographs of beech woodland in the New Forest along a dieback gradient.



Distribution of areas of native woodland undergoing dieback in the New Forest. Source: Peterken *et al.* (1996).

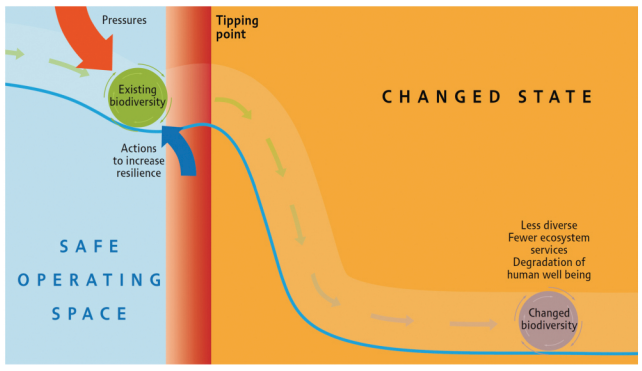
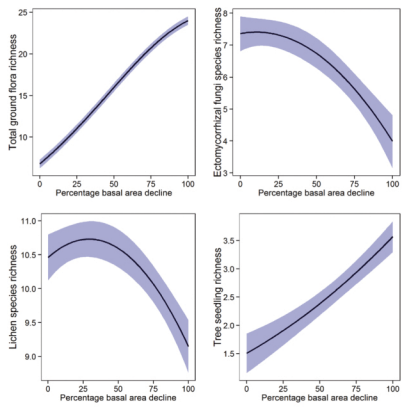
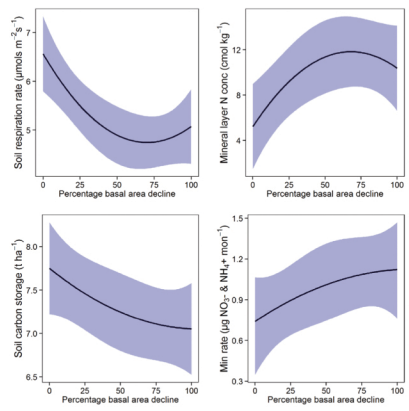


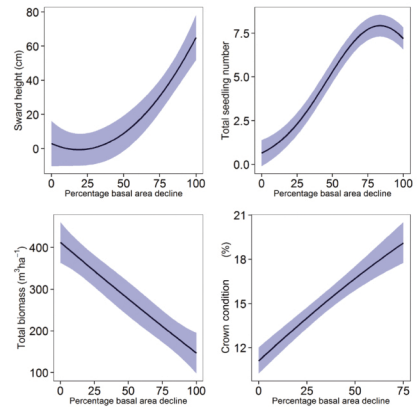
Illustration of tipping points. Source: Secretariat of the Convention on Biological Diversity



Relationships between tree basal area and species richness of different groups of organisms, in beech woodlands undergoing dieback. Source: Evans *et al.* (2016).



Relationships between tree basal area and different measures of ecosystem function, in beech woodlands undergoing dieback. Source: Evans *et al.* (2016).



Relationships between tree basal area and ecological condition, in beech woodlands undergoing dieback. Source: Evans *et al.* (2016).

How will large-scale tree mortality affect the many species that depend on these trees?

And how will it affect ecosystem function?

Field surveys have indicated that woodland areas undergoing stand dieback, as observed in Denny Wood, are widespread throughout the New Forest. This indicates that hundreds of mature trees are currently dying.

To answer such questions, we have examined the changes occurring in twelve ancient New Forest woodlands that are currently undergoing dieback. We established field plots along gradients where dieback is occurring. Each gradient ranged from intact areas, where many trees are present, to areas where the woodland canopy is now very open because trees have recently died. We surveyed the presence of plants, fungi, lichens and insects along these gradients. In addition, we examined how the ecosystem is functioning, by measuring soil respiration, nitrogen mineralisation and soil characteristics.

Our results identified some dramatic changes that happen as a woodland stand collapses.

We analysed the relationship between tree basal area, which declines as the stand undergoes dieback, and different measures of biodiversity and ecosystem function. In some cases the relationships we found are linear. In others, the relationships are better described by a curvilinear or threshold response. This suggests that as a woodland stand undergoes dieback, there may be feedbacks that can increase the rate of change, potentially leading to an ecological threshold or tipping point. Such tipping points have become a major concern at the global scale, because of their potentially large impacts on ecosystems and human well-being. Examples include the melting of the Arctic sea ice, widespread bleaching of coral reefs, and potential dieback of the Amazonian rain forest.

It can be extremely difficult for societies to adapt to rapid and potentially irreversible shifts in the functioning and character of an ecosystem. In most cases, ecosystem dynamics cannot be predicted with enough precision to provide advance warning of tipping points being approached. Such an understanding is needed to help develop appropriate management and policy responses. Our research highlights the value of studying gradients of ecological degradation for understanding the mechanisms underlying such transitions.

Why is beech dying in the New Forest? Evidence suggests that it is the combination of wetter winters and drier summers that is the main problem for this species. Increased waterlogging of the soil in winter impedes root growth, particularly on poorly drained soils. This then increases the susceptibility of the tree to summer drought. In addition, these processes can increase attack by pathogenic fungi, such as *Armillaria*, *Phytophthora* and *Ganoderma*. In contrast, other groups of fungi – ectomycorrhizal fungi – are of benefit to the tree by forming symbiotic associations with their root systems. Our results suggest that ectomycorrhizal fungi display an ecological threshold as the forest stand collapses. The loss of ectomycorrhizal fungi results in major modifications to water and nutrient exchanges, which could create a positive feedback that substantially lowers tree survival and growth.