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Plant mass extinctions – absent, or masked by their phylogenetic structure?

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Global compilations of stratigraphic ranges of fossil plants do not show sharp declines in species diversity like those defining the major mass extinctions in the animal fossil record. The apparent absence of mass extinctions in plants has been attributed to individual and population-level resistance to environmental shocks; individuals regrow after major tissue loss, and populations survive bad conditions as spores or seeds in the soil. If the absence of global mass extinctions in plants reflects the resistance of individuals and populations to perturbations, then low species extinction levels should also be observed in local, high-resolution studies. This is not the case, however: studies of the P-Tr, Tr-J, and K-Pg boundaries demonstrate high levels (≥50%) of plant species extinction in local sections. The apparent conflict between high extinction levels at small scales and low extinction levels globally can be resolved if the probability of extinction of species is uncorrelated with their membership in higher clades. In this scenario, diverse higher taxa would likely survive even if a high proportion of total species went extinct. Extinctions would be seen only in taxonomically detailed studies of local sections because at larger temporal, spatial, and taxonomic scales the extinction would be masked by the rapid appearance during the recovery of new species closely related to the extinct ones. We explored this idea through simulations in which we varied the intensity and phylogenetic selectivity of extinctions. Extinctions were modeled as selective with respect to ecological traits that had been simulated to evolve on a phylogeny. We varied the correlation of these ecological traits with the phylogeny, from absent (as in a star phylogeny), to strongly coherent. We found that extinction probabilities of larger clades increased with both species-level extinction rate and higher phylogenetic coherence of the ecological traits. Nevertheless, large clades had high survival except when both species-level extinction and phylogenetic coherence of the ecological traits were high. Simulating ecological traits as more complex (by adding more ecological dimensions) also increased the extinction rate of large clades, perhaps because additional axes allow for tighter phylogenetic clumping in ecospace. We conclude that large clades would survive high levels of species extinction if the ecological traits on which extinction acts are poorly correlated with phylogeny, a pattern that is qualitatively consistent with the fossil record of plants.