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Press/Pulse: Explaining selective terrestrial extinctions at the Cretaceous/Palaeogene boundary

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Single-cause mass extinction scenarios require extreme conditions to generate sufficiently strong kill mechanisms. Such dire effects are commonly at odds with the taxonomic selectivity that characterizes most extinction events. In response, some researchers have proposed that the interaction of a variety of factors typify episodes of elevated extinction. Previous work (Arens & West 2008 Paleobiology 34:456-471) has shown that a combination of press and pulse disturbances increases the probability of elevated extinction. The press/pulse contrast is borrowed from community ecology, where researchers have long recognized that the ecological response to long-term stress differs from that of an instantaneous catastrophe. Scaled to the macroevolutionary level, press disturbances alter community composition by placing multigenerational stress on populations. Press disturbances do not necessarily cause mortality, but reduce population size by a variety of mechanisms such as curtailed reproduction. Pulse disturbances are sudden catastrophic events that cause extensive mortality. Either press or pulse disturbances of sufficient magnitude can cause extinction, however elevated extinction occurs more commonly during the coincidence of lower-magnitude press and pulse events.

The Cretaceous/Palaeogene (K/P) extinction is one of the best examples of a press/pulse extinction. Deccan Trap volcanism, which straddled the K/P boundary, altered atmospheric composition and climate. This episodic volcanism likely contributed to the climate instability observed in terrestrial ecosystems and exerted press stress. Pulse disturbance was produced by bolide impact, which punctuated the end of the Cretaceous.

The press/pulse mechanism also more effectively explains selectivity in terrestrial vertebrate and plant extinctions at the K/P boundary than do single-mechanisms scenarios. For example, why do environmentally sensitive vertebrates such as amphibians experience no extinction? And why do mire plants preferentially survive? Deccan Trap volcanism generated climatic warming and instability during the last 500 Ka of the Cretaceous. This resulted in extensive rearrangement of terrestrial floras. Dramatic cooling in the millennia immediately preceding the K/P boundary caused regional diversity loss and an apparent increase in vegetation heterogeneity. These changes, coupled with the spread of wetland ecosystems across the western interior of North America in the latest Cretaceous, exerted stress—press disturbance—on some elements of the biota, while favoring others. This press stress may have rendered lineages requiring well-drained or large homogeneous habitats endangered and vulnerable to extinction in the face of the terminal-Cretaceous bolide impact(s)—pulse disturbance. And, in fact, the impact's survivors were primarily wetland plants and animals.