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Photo: Neil Entwistle University of Salford

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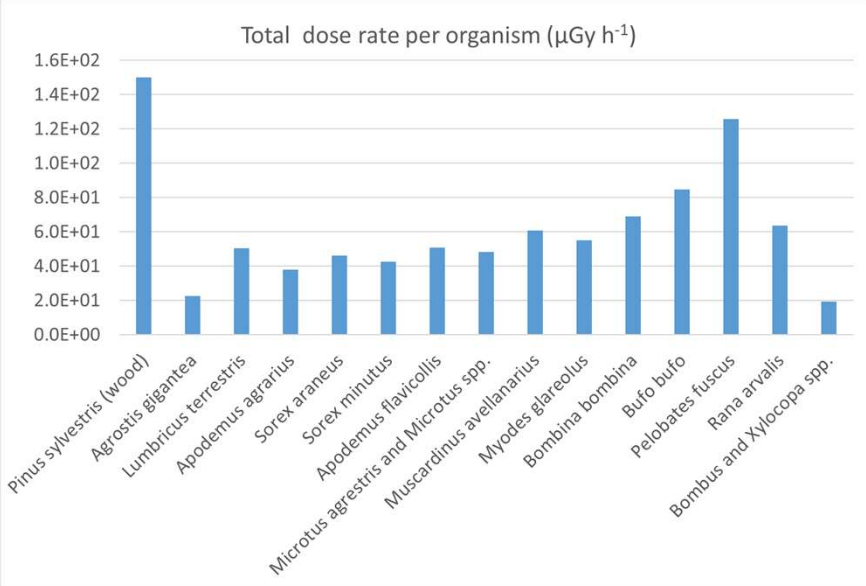
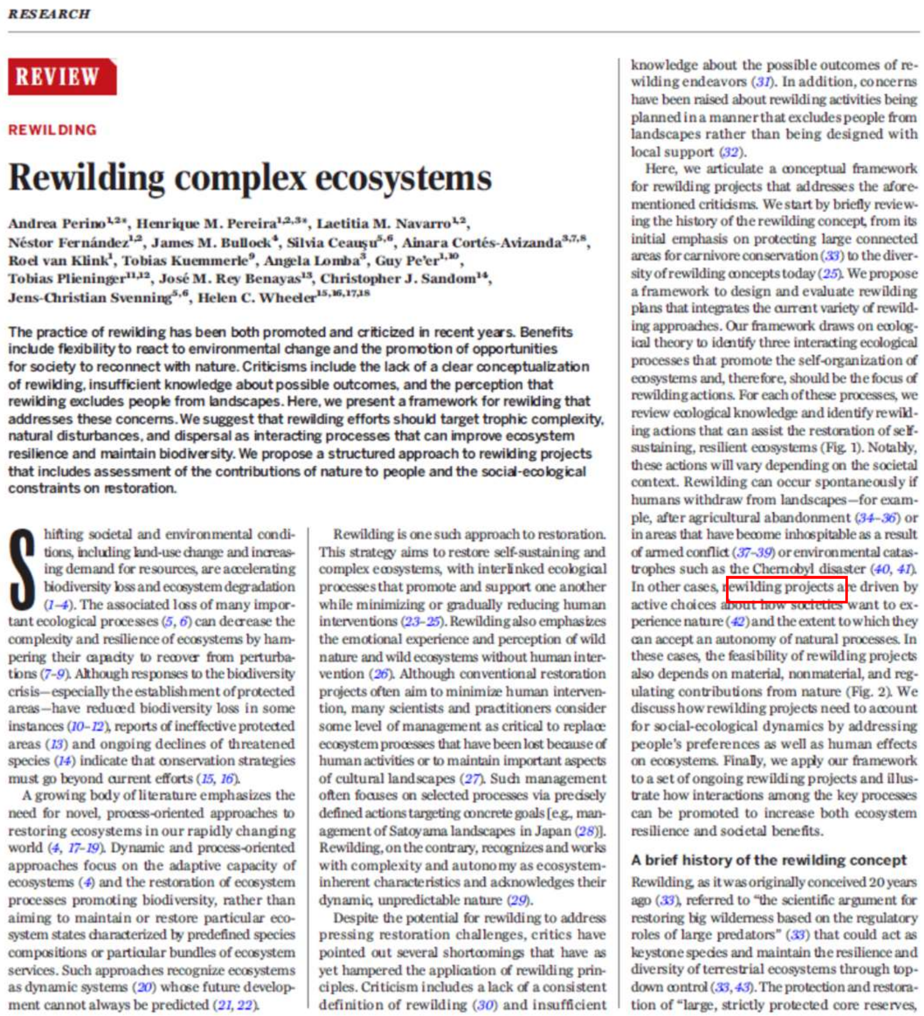
Chernobyl as a natural laboratory





RESEARCH

REVIEW

REWILDING

Rewilding complex ecosystems

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The practice of rewilding has been both promoted and criticized in recent years. Benefits include flexibility to react to environmental change and the promotion of opportunities for society to reconnect with nature. Criticisms include the lack of a clear conceptualization of rewilding, insufficient knowledge about possible outcomes, and the perception that rewilding excludes people from landscapes. Here, we present a framework for rewilding that addresses these concerns. We suggest that rewilding efforts should target trophic complexity, natural disturbances, and dispersal as interacting processes that can improve ecosystem resilience and maintain biodiversity. We propose a structured approach to rewilding projects that includes assessment of the contributions of nature to people and the social-ecological constraints on restoration.

Shifting societal and environmental conditions, including land-use change and increasing demand for resources, are accelerating biodiversity loss and ecosystem degradation (1–4). The associated loss of many important ecological processes (5, 6) can decrease the complexity and resilience of ecosystems by hampering their capacity to recover from perturbations (7-9). Although responses to the biodiversity crisis—especially the establishment of protected areas—have reduced biodiversity loss in some instances (10–12), reports of ineffective protected areas (13) and ongoing declines of threatened species (14) indicate that conservation strategies must go beyond current efforts (15, 16).

A growing body of literature emphasizes the need for novel, process-oriented approaches to restoring ecosystems in our rapidly changing world (4, 17-19). Dynamic and process-oriented approaches focus on the adaptive capacity of ecosystems (4) and the restoration of ecosystem processes promoting biodiversity, rather than aiming to maintain or restore particular ecosystem states characterized by predefined species compositions or particular bundles of ecosystem services. Such approaches recognize ecosystems as dynamic systems (20) whose future development cannot always be predicted (21, 22).

Rewilding is one such approach to restoration. This strategy aims to restore self-sustaining and complex ecosystems, with interlinked ecological processes that promote and support one another while minimizing or gradually reducing human interventions (23-25). Rewilding also emphasizes the emotional experience and perception of wild nature and wild ecosystems without human intervention (26). Although conventional restoration projects often aim to minimize human intervention, many scientists and practitioners consider some level of management as critical to replace ecosystem processes that have been lost because of human activities or to maintain important aspects of cultural landscapes (27). Such management often focuses on selected processes via precisely defined actions targeting concrete goals [e.g., management of Satoyama landscapes in Japan (28)]. Rewilding, on the contrary, recognizes and works with complexity and autonomy as ecosystem-inherent characteristics and acknowledges their dynamic, unpredictable nature (29).

Despite the potential for rewilding to address pressing restoration challenges, critics have pointed out several shortcomings that have as yet hampered the application of rewilding principles. Criticism includes a lack of a consistent definition of rewilding (30) and insufficient knowledge about the possible outcomes of rewilding endeavors (31). In addition, concerns have been raised about rewilding activities being planned in a manner that excludes people from landscapes rather than being designed with local support (32).

Here, we articulate a conceptual framework for rewilding projects that addresses the aforementioned criticisms. We start by briefly reviewing the history of the rewilding concept, from its initial emphasis on protecting large connected areas for carnivore conservation (33) to the diversity of rewilding concepts today (25). We propose a framework to design and evaluate rewilding plans that integrates the current variety of rewilding approaches. Our framework draws on ecological theory to identify three interacting ecological processes that promote the self-organization of ecosystems and, therefore, should be the focus of rewilding actions. For each of these processes, we review ecological knowledge and identify rewilding actions that can assist the restoration of self-sustaining, resilient ecosystems (Fig. 1). Notably, these actions will vary depending on the societal context. Rewilding can occur spontaneously if humans withdraw from landscapes—for example, after agricultural abandonment (34–36) or in areas that have become inhospitable as a result of armed conflict (37–39) or environmental catastrophes such as the Chernobyl disaster (40, 41). In other cases, rewilding projects are driven by active choices about how societies want to experience nature (42) and the extent to which they can accept an autonomy of natural processes. In these cases, the feasibility of rewilding projects also depends on material, nonmaterial, and regulating contributions from nature (Fig. 2). We discuss how rewilding projects need to account for social-ecological dynamics by addressing people's preferences as well as human effects on ecosystems. Finally, we apply our framework to a set of ongoing rewilding projects and illustrate how interactions among the key processes can be promoted to increase both ecosystem resilience and societal benefits.

A brief history of the rewilding concept

Rewilding, as it was originally conceived 20 years ago (33), referred to "the scientific argument for restoring big wilderness based on the regulatory roles of large predators" (33) that could act as keystone species and maintain the resilience and diversity of terrestrial ecosystems through top-down control (33, 43). The protection and restoration of "large, strictly protected core reserves,

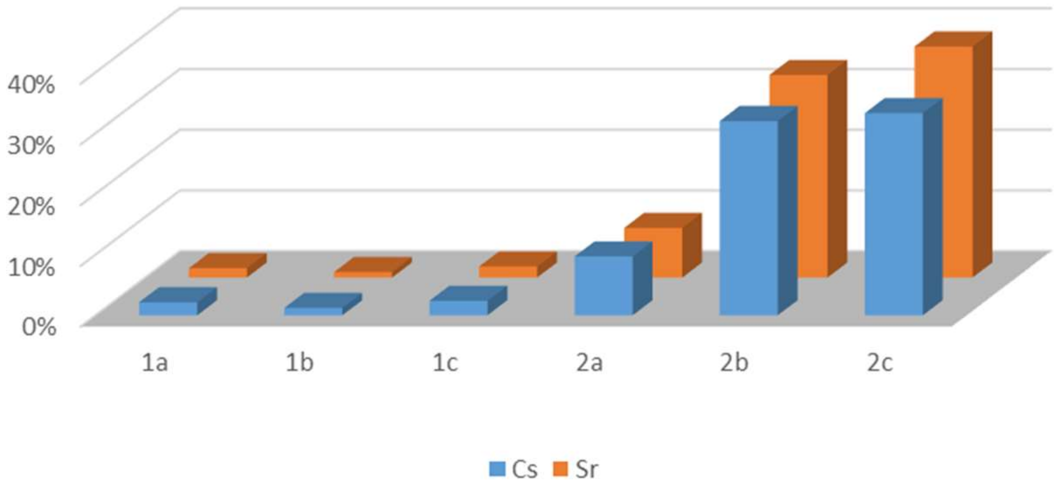
- Dose are still high enough that we might anticipate effects on wildlife
- Wide range of wildlife species
- Can study a range of radionuclides: Cs-137, Sr-90, Am-241, Pu-isotopes, I-129, U-isotopes, Tc-99, C-14
- Published studies contentious

https://radioecology-exchange.org/content/chernobyl-exclusion-zone

http://dx.doi. org/10.1126/science.aav5570

Do wildfires increase radionuclide mobility?

From 2018 fire: Percentage of radionuclide presented in m^2 as ash



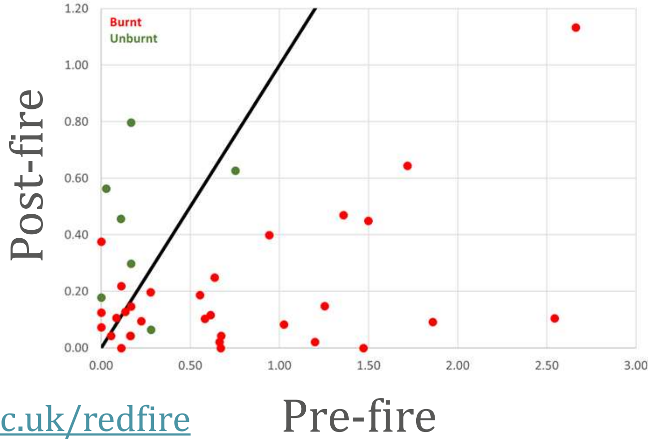
https://www.ceh.ac.uk/redfire

Impacts

Impact of large scale fires on wildlife

Radiation and fire – multiple stressors?

2016 Red Forest Fire



https://www.ceh.ac.uk/redfire

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