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Perspective

Threats and Challenges Faced by Ecosystems as a Result of Climate Change

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PERSPECTIVE

In comparison to direct anthropogenic acts such as overharvesting and land use change that result in habitat loss, climate change has had a comparatively minor impact on ecosystems and biodiversity to date. The negative ecological effects of climate change are becoming more obvious and are very likely to intensify over the coming decades, indicating that their relative importance is shifting. Climate change is increasing precipitation variability and the likelihood of extreme dry and wet events on land, while long-term warming and increasing atmospheric water deficits are raising physiological and hydrological stress, as well as ecosystem flammability. Heat waves are becoming more often in the ocean, and long-term trends of acidity are putting many creatures and ecosystems under stress. Other anthropogenic stressors, such as deforestation, overfishing, invasive species, habitat fragmentation, and direct habitat degradation, interact to increase ecosystem susceptibility to climate change. Both the subtle effects on individual species within complex multi-trophic ecosystems and the more sudden consequences of ecosystem degradation make predicting the patterns and probability of biodiversity loss extremely difficult.

In light of ecosystem complexity and a significant gap in our knowledge of how specific species and interspecific interactions will respond to climate change, an adaptive ecosystem research strategy, in addition to adaptive ecosystem management, is required. There are many topics of ecosystem science about which we will not have enough knowledge in a reasonable amount of time. Ecosystems are changing so quickly in response to global change drivers that actual, system-altering changes have surpassed our research and modelling frameworks. It is necessary to implement new frameworks for modelling and monitoring highly dynamic complex systems. Improved methods for implementing adaptive ecosystem management in the face of uncertainty are required.

Long-term surveillance is also very important. It can reveal long-term changes that are difficult to detect due to shifting baselines, as well as providing early warning of species-specific vulnerability, ecosystem-wide loss, or tipping points. Long-term forest monitoring, for example, has produced valuable information about the biosphere carbon sink, which serves to decrease the rate of climate change, as well as its potential future route. Long-term monitoring is difficult to fund in an environment with short financing cycles, with a few notable exceptions, yet such ecological "weather stations" are necessary if we are to comprehend and counteract the changes that are occurring in the biosphere. Consider where climate science would be today if routine weather monitoring had not been extensively embraced in the twentieth century. Ecosystems have an important role in the climate system, particularly through their contributions to the carbon, water, and other biogeochemical cycles. Ecosystems may be a major source of human resilience and promote the adaptation of human societies to fast environmental change if they are sustainably managed in a way that draws on rigorous ecosystem and biodiversity science. In other words, ecosystems are not only sensitive to climate change, but they also have the potential to be valuable partners in addressing climate change adaptation and mitigation difficulties. Ecosystems have complicated responses to climate change, which are poorly understood and only partially accounted for in future ecosystem function and dynamics estimates. Habitat variety can produce micro-islands of resilience that can be sources of recovery following extreme events, and genetic variability can allow robust subpopulations to adapt and expand. Ecosystems in biodiversity hotspots may benefit from multitrophic interactions and trophic redundancy to recover from disturbances. Strategic conservation of critical sites in a protected area network, particularly those that maintain biodiversity in present and future climates, can improve landscape and seascape scale resilience and ecosystem services, including climate change mitigation (e.g. carbon sequestration).

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