Viewpoint: Conservation isn’t enough. We need technology to blunt the impacts of climate change

As a species, humans are fortunate in their adaptive capacity. The technologies that make us better equipped to live in a warming world — heating, air conditioning, drinking water infrastructure, and the like — are part and parcel to modernity, accessible to much, though still too little, of the global population. While we can expect these technologies to become more widespread in emerging economies, there will certainly be a multitude of socioeconomic and political challenges to overcome.

Non-human nature, by contrast, is sharply limited in its capacity to adapt to climate change, and even the best-case mitigation scenarios will put massive pressure on ecosystems. In a 2°C world, a full 25 percent of species are at risk of regional extirpation (double that in a 4.5°C world). Already, climate-related local extinctions have occurred in hundreds of species. These impacts are terrifying and poorly understood. There have been and will continue to be ecosystem thresholds that we can’t predict — such as the massive pine beetle outbreaks that decimated drought-stricken western forests — and biodiversity loss could be worse than projected.

The time is ripe for a conversation about how humans could help adapt the natural world through more direct forms of intervention, a conversation that does not sit comfortably with the values of traditional environmentalism, which regard such intervention with reflexive wariness.

To date, the conservation community has been understandably focused on protecting habitat and reducing emissions to shield non-human life from the impacts of climate change. And while adaptation in the natural world is not a new concept — there have been numerous studies and recommendations made in this space — direct, technology driven interventions such as translocation, genetic modification, biocontrols, and the use of human infrastructure to support ecosystems have not been part of the mainstream conversation.

Traditional conservation approaches are no longer enough

Climate change will amplify ecosystem stressors like disease, habitat degradation, and invasive species, and indeed already has. Research shows that the effectiveness of disease resistance genes may vary depending on the climate. Big blue-stem, the dominant grass species in tallgrass prairie ecosystems, had higher infection rates when exposed to larger but more infrequent precipitation events, and longer periods of drought. Pathogens may also shift their range as a result of changing conditions, as may also be true of needle blight, a fungal disease that impacts ponderosa pine.

Credit: Shutterstock

Restoring degraded habitat is becoming more challenging as a result of climate change. Elkhorn Slough National Estuarine Research Reserve, one of the largest tracts of tidal salt marsh on the West Coast, is the subject of ongoing research to determine the most effective way to restore and maintain the landscape in the face of sea level rise.

Invasive species are another threat being amplified by climate change. Many invasives are able to spread faster as the growing season is extended by earlier spring snowmelt and later fall frost onset. These harmful species are sometimes better able to match shifts in season timing than native species,for example, the invasive plant species purple loosestrife is now blooming in Massachusetts much earlier than its native counterparts. This resilience can be a serious problem as it enhances the ability of invasives to outcompete native species.

On top of amplifying existing stressors, climate change is also triggering more direct impacts in especially vulnerable ecosystems. Already, the majority of tropical coral reefs are projected to suffer significant losses even if global warming is limited to 1.5°C. The Great Barrier Reef suffered unprecedented bleaching events in 2016 and 2017, which damaged two thirds of the reef, and is in the midst of yet another — the third in five years — leaving little time for recovery.

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Likewise, kelp forests are being decimated by a series of connected events triggered by warming temperatures. These ecosystems — already weakened by marine heatwaves — are being devoured by booming populations of sea urchins, precipitated by warmer waters. In northern California, more than 90 percent of bull kelp was lost along 217 miles of coastline, and huge losses have also occurred off the coast of Japan, the Aleutian Islands, and Tasmania.

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Extensive terrestrial impacts are occurring as well. Globally, insect populations have plummeted, and worsening climate change could mean some 40 percent of all insect species could go extinct in the coming decades. This will negatively impact the numerous insectivores that depend on them as a food source, and it threatens agricultural sectors dependent on pollinators.

While mitigating climate change and minimizing these existing stressors will be critical first steps to ensuring ecosystems are best able to withstand the worsening impacts of climate change, they are no longer enough to counter the magnitude of the threat. We need to employ intentional and direct interventions in addition to existing strategies to ensure we pursue every opportunity to prevent biodiversity loss.

Translocation

As climate change begins to shift habitats and change the range that species occupy, protected lands and wildlife corridors — though critical tools — won't always be sufficient. While some species are able to traverse rugged landscapes and cover vast distances, the same cannot be said for many other plants and animals. Amphibians, small mammals, and other species that are endemic to isolated areas are especially vulnerable. If species are not able to naturally disperse as their ranges shift in a changing climate, wildlife managers may need to take a more active role in physically introducing them into new areas.

Historically, wildlife managers have focused on restoring species to their past ranges, and have reintroduced captive-bred individuals to boost endemic populations. But translocation can be used for more than these past practices. It can be used to move species that are unable to disperse naturally, or else can be used as a form of ecological correction by introducing a species to fill a void created by a local extinction of a different species.

The practice is controversial, as people worry that a translocated species will become invasive in its new habitat (or transfer new pathogens) and decimate the ecosystem as a result. Predator translocation is often the most expensive and controversial of these efforts, though it is also often one of the most valuable in terms of improving ecological health by controlling herbivore populations and slowing the spread of wildlife disease.

While there is a risk of unforeseen consequences, there have also been success stories. For example, in England, the marbled white butterfly was successfully translocated to previously unoccupied habitat and was able to establish a viable population without impacting other endemic species. And the Aldabra giant tortoise was introduced to Mauritian islands to replace an extinct Mauritian tortoise species and successfully fulfilled the same seed-dispersal and vegetation-control role the original species filled.

Genetic modification

Restoration efforts will be limited as a result of climate change. Setting funding aside for restoring sand dunes damaged by hurricanes and forests damaged by wildfires will help. But restoring ecosystems to their previous state may no longer be sufficient in some areas. As impacts worsen and vulnerable species are not able to adapt quickly enough on their own, scientists may be able to prevent local extinctions by intervening via genetic modification – either through genetic selection or engineering.

American chestnut allen breed ap

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The American Chestnut is a paradigmatic example of a species that will most likely require genetic modification before recovery efforts can be successful. These trees once grew up to 100 feet tall and had 10 foot diameter trunks. But in the early 1900s an imported fungus decimated the native Eastern chestnut forests — wiping out 99.9 percent of the species — and over 100 years later the species still hasn't recovered. That may change. By inserting a gene from wheat into a wild chestnut embryo, scientists are striving to give the vulnerable trees the ability to produce enzymes that detoxify the fungus, and these efforts have already begun to prove successful as modified experimental trees are able to withstand infection.

The black-footed ferret, another example, is extremely vulnerable to Sylvatic plague and suffers from a severe lack of genetic diversity. While captive breeding programs have been successful, these limitations make it difficult to establish populations in the wild. Genetic modification may make it possible to reintroduce lost genetic diversity and convert the vaccine for the Sylvatic plague into a permanent inheritable trait.

Genetic modification offers a host of opportunities to strengthen species that are being wiped out by worsening climate impacts as well. In forested areas damaged by bark beetle outbreaks and severe fires, it would be more effective to reforest with trees that are genetically predisposed to withstand infestations (or drought, or disease, depending on the threats identified in the region). Similar strategies are being employed across many tropical reefs, as scientists cultivate resilient lines of coral in the hopes that they will prove more resistant to the warmer temperatures and increased ocean acidification.

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The Svalbard Global Seed Vault

Such strategies could help ensure restoration investments are more secure against future impacts, highlighting the need for the field of conservation genetics as a backstop to the risk of future extinctions. Scientists can bank genetic material, map genomes, and reprogram tissue culture cells for genetic rescue efforts. The San Diego Zoo Institute for Conservation Research has a genetic bank with over 10,000 living cell cultures, oocytes, sperm, and embryos representing nearly 1,000 taxa, and the Svalbard Global Seed Vault holds over one million seed varieties in order to protect cultivated and wild plant biodiversity.

Human made infrastructure to support ecosystem function

Human infrastructure also has a role to play in conservation, especially for helping species adapt to changing precipitation patterns. In areas where changing precipitation patterns lead to more extreme rainfall events, certain manmade infrastructure can help manage runoff in order to avoid soil erosion in sensitive habitats, and can help protect the habitat of vulnerable species. For example, albatross in Tasmania are struggling to survive as chicks are killed by warmer temperatures and nests are washed away by sea-level rise and more frequent and severe precipitation events. Scientists are transporting artificial nests made of concrete and coconut fiber by helicopter to the nesting sites in order to increase the chicks' chances of survival. So far, scientists have found that pairs using the artificial nests had a 20 percent higher success rate than those using natural nests.

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Drought land

In ecosystems hit especially hard by drought we may be able to transport additional water to help maintain function. In Kenya, arid landscapes are predisposed to extended periods with little precipitation, but climate change is exacerbating poor land management to extend these dry periods even further — which could spell disaster for vulnerable wildlife. Further, lack of water increases conflict between wildlife and people as ranchers struggle to support their own herds. By installing boreholes, water pipes, strategic dams, and other human made infrastructure to bring water from aquifers to the surface and manage current supply, land managers can help ensure wildlife are able to survive changing precipitation patterns.

Biocontrols

Failed biocontrol efforts are often given as cautionary tales against ecosystem intervention. In the early 2000s, the US released non-native beetles to control the spread of an invasive plant called tamarisk. At the time, managers believed the beetle would only inhabit a limited range and would not be able to disperse widely — an assumption that proved untrue. The beetle did spread, with the unforeseen cost of decimating the habitat of the endangered southwestern willow flycatcher. There are numerous other stories, such as the extreme failures of cane toad introduction in Australia, and mongoose introduction in Hawaii.

But while there are risks associated with biocontrol interventions, there have also been remarkable success stories. The gypsy moth, which was first brought to the US to breed with the native silkworms, escaped through an open lab window in 1868 and began to decimate deciduous trees across North America. A fungus, found to infect the moths, was discovered in Japan and brought back to the US, and eventually a strain of the fungus was found to effectively spread through the moth population. A coordinated program called Slow the Spread Program (STS) was funded by Congress in 2000 and has reduced the spread of gypsy moths by more than 70 percent.

Using pathogens and predator species to control the increased spread of invasive species in the face of a changing climate raises several red flags. The thought of a disease jumping host species is almost as frightening as climate change itself, especially given the rapid spread of COVID-19, which scientists believe originated in a live animal market. But biocontrols have been used extensively in agriculture, and highly specialized pathogens and predator species are unlikely to expand beyond the intended target. Scientists are continuing to look for new tools to expand the use of biocontrols beyond the agriculture sector to the natural environment.

Expanding options for conservation

Healthy ecosystems increase human adaptive capacity. Healthy insect populations support the agriculture sector, healthy wetlands provide flood control and clean water, healthy forests provide stable long term carbon storage, and healthy oceans offer a critical source of protein for many developing countries. But as we observed above, humans are unique in our capacity to augment ecosystem services via direct, technology-driven interventions, which is why the impacts of climate change pose a far greater threat to wildlife and ecosystems than to people. Imported pollinators, engineered water infrastructure, and farmed seafood are just a few examples. We have only dimly begun to conceptualize the adaptive limits of the natural world, but we should employ all available tools to protect not just ourselves, but our non-human neighbors.

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