

# Ecosystems, Ecosystem Services, and Biodiversity

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## Key Message 8.1

### Climate Change Is Driving Rapid Ecosystem Transformations

Climate change, together with other stressors, is driving transformational changes in ecosystems, including loss and conversion to other states, and changes in productivity (*very likely, high confidence*). These changes have serious implications for human well-being (*very likely, high confidence*). Many types of extreme events are increasing in frequency and/or severity and can trigger abrupt ecosystem changes (*medium confidence*). Adaptive governance frameworks, including adaptive management, combined with monitoring can help to prepare for, respond to, and alleviate climate change impacts, as well as build resilience for the future (*medium confidence*).

## Key Message 8.2

### Species Changes and Biodiversity Loss Are Accelerating

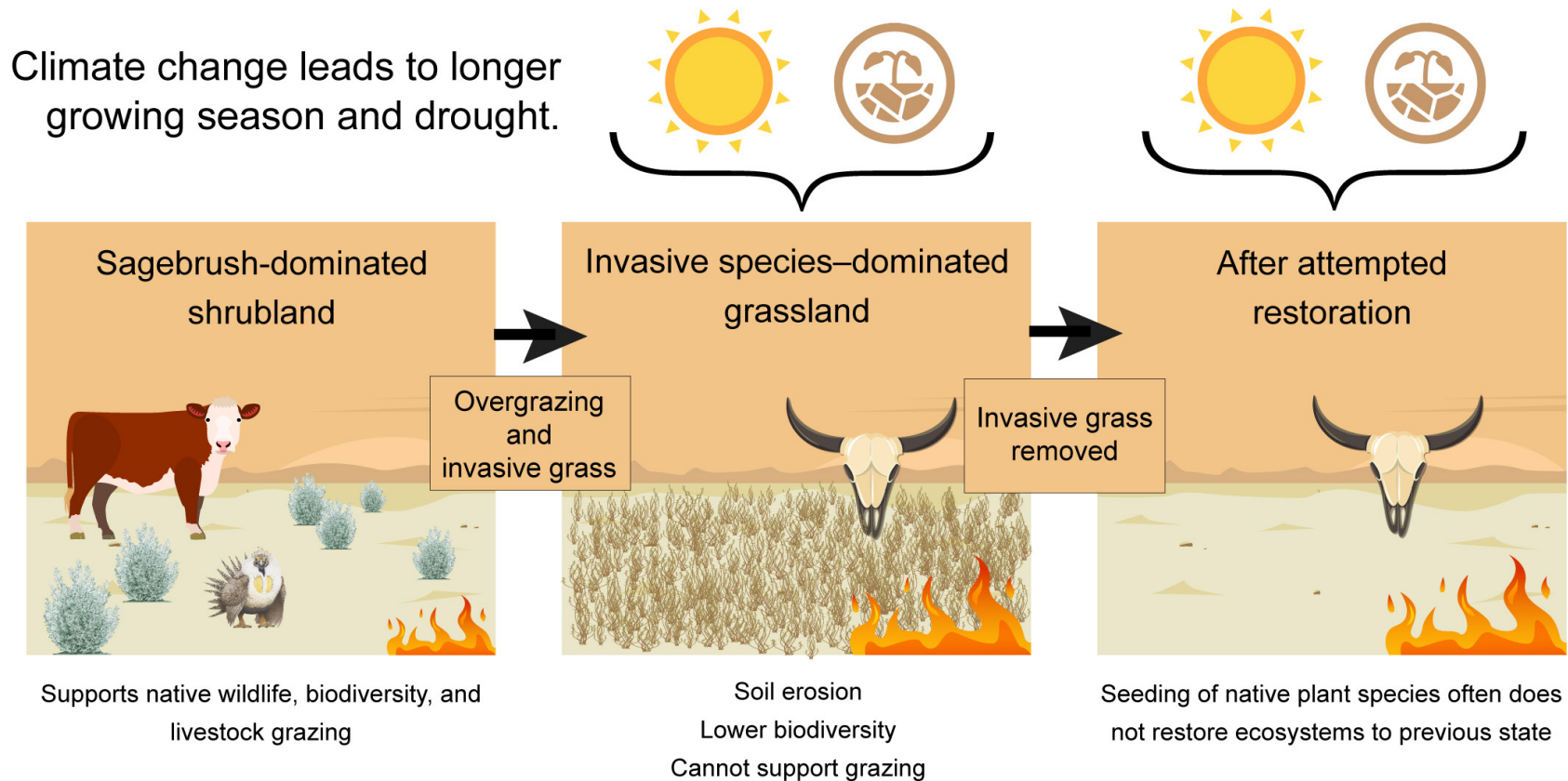
The interaction of climate change with other stressors is causing biodiversity loss, changes in species distributions and life cycles, and increasing impacts from invasive species and diseases, all of which have economic and social consequences (*very likely, high confidence*). Future responses of species and populations will depend on the magnitude and timing of changes, coupled with the differential sensitivity of organisms; species that cannot easily relocate or are highly temperature sensitive may face heightened extinction risks (*very likely, high confidence*). Identification of risks (e.g., extreme events) will help prioritize species and locations for protection and improve options for management (*very likely, high confidence*).

## Key Message 8.3

### Impacts to Ecosystem Services Create Risks and Opportunities

Climate change is having variable and increasing impacts on ecosystem services and benefits, from food production to clean water to carbon sequestration, with consequences for human well-being (*very likely, high confidence*). Changes in availability and quality of ecosystem services, combined with existing social inequities, have disproportionate impacts on certain communities (*very likely, high confidence*). Equity-driven nature-based solutions, designed to protect, manage, and restore ecosystems for human well-being, can provide climate adaptation and mitigation benefits (*likely, medium confidence*).

## Abrupt Changes in Ecosystem State



**Climate change interacts with other stressors to cause synergistic effects, and resulting ecosystem changes can be abrupt and difficult to reverse.**

**Figure 8.6.** In the western US, drought and longer, hotter growing seasons combined with invasive grasses and overgrazing have transformed sagebrush shrublands past a tipping point into annual grasslands that experience more frequent wildfires and no longer support native biodiversity and livestock grazing. Removing invasive grasses and seeding with native plants often does not restore the original shrubland ecosystem (Svejcar et al. 2023). Adapted from Foley et al. 2015 [CC BY 4.0]. See full chapter for detailed citations.

### Recommended Citation

McElwee, P.D., S.L. Carter, K.J.W. Hyde, J.M. West, K. Akamani, A.L. Babson, G. Bowser, J.B. Bradford, J.K. Costanza, T.M. Crimmins, S.C. Goslee, S.K. Hamilton, B. Helmuth, S. Hoagland, F.-A.E. Hoover, M.E. Hunsicker, R. Kashuba, S.A. Moore, R.C. Muñoz, G. Shrestha, M. Uriarte, and J.L. Wilkening, 2023: Ch. 8. Ecosystems, ecosystem services, and biodiversity. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. <https://doi.org/10.7930/NCA5.2023.CH8>