(a)

(b)

FIGURE 10.32 Impact of grazing on vegetation. (a) This image of a fence line in the American southwest (Arizona) shows the difference between a plot that is heavily grazed (left) versus healthy grassland (right). (b) Overgrazing reduces the cover of vegetation on hillslopes, which can result in severe erosion when rain falls.

Overgrazing

Another way that humans have impacted the network of natural vegetation is through overgrazing of the landscape by livestock, such as cattle and sheep (**Figure 10.32a**). This impact is most extensive in arid landscapes that are extremely sensitive to disturbance, such as grassland, savanna, or scrub biomes in seasonally- or perennially-arid regions of the tropics and subtropics, for example, areas of north and sub-Saharan Africa, south-central China, and the American south-west (**Figure 10.32b**). Some of the potential impacts are weed invasion into disturbed areas, reduction in forest due to grazing of young saplings, and increased likelihood of more intense and widespread fires. Additionally, many areas of overgrazing occur in nations facing socio-economic or political strife, where farmers are trying to obtain livelihoods under conditions of dwindling resources. In such areas, the incentive to pasture animals at high densities has greatly increased grazing pressure on soils and vegetation. Climate change appears to be exacerbating the grazing pressure on soils and vegetation through increased evaporation and/or reduced rainfall. The combined grazing and climate change impacts are leading these world regions down a pathway toward desertification, rendering areas that were once arable into unproductive drylands. (We will discuss desertification in more detail in Chapter 18.)

Climate Change and Shifting Ranges

Climate change is having a major effect on the biogeography of plant communities by shifting the ranges in which species live. This is one consequence of greenhouse gases building in the atmosphere, which raise surface temperatures, pushing climate zones—and species distribution limits—poleward and upslope. There is growing evidence that many species, especially small, mobile groups such as spiders, butterflies, and beetles, are already migrating to higher latitudes and elevations as the climate warms.

This phenomenon is not new, however. In the past, species have adjusted their ranges northward and southward during the Quaternary with each episode of glacier advance and retreat. Paleoecological evidence tells us that several tree species have become extinct because of these natural shifts, presumably because of the challenges of forced relocation. For example, a recently discovered North American spruce species (*Picea critchfieldii*) that was widespread in the southeastern United States during the last glacial maximum (approximately 18,000 years ago) has since disappeared.

However, given the rapid rate of climate warming today, we expect much more rapid range shifts to occur. Some climate models predict that tree species ranges will shift northward by up to 700 km per century, forcing them to migrate 10 to 40 times faster than in the past! If species cannot keep pace with these unprecedented rates of shifting ranges, extinctions will occur.

FIGURE 10.33 Alpine plant species may be particularly sensitive to climate change. The diverse assemblage of herb and forb species on this mountain side in the Deosai plateau, Karakoram Himalaya (approximately 4,300 m elevation), risk running out of habitat as climate belts shift upslope.

A study led by Chris Thompson from the University of York in the United Kingdom examined the migration abilities of numerous taxa. His team concluded that between 15 percent and 37 percent of all species worldwide would become extinct by the middle of this century, simply because they will be unable to reach suitable future habitat.

Alpine species face a particular set of challenges as a result of warming climates (**Figure 10.33**). Mountains are landforms with a generally conical shape, such that the available land surface decreases as one travels upslope. Thus, alpine species will encounter ever-shrinking habitat over the coming centuries, and at some point they will essentially run out of room, becoming "stranded" on mountaintops with no place to go.

Assisted Migration Policies

Species are not equally at risk from shifting ranges—some move faster than others. Species most at risk are those with poor long-distance dispersal abilities, slow reproduction, and long life spans, as well as rare species or those that are specialized with respect to habitat requirements. These species can be collectively classified as "slow-movers." The sorts of species we expect to be effective at migration include many of the weedy, disturbance adapted, frequently non-native invasive species that are already filling up ecosystems and displacing native, rare, or specialized species.

To counteract the risks to slow-movers, some conservationists have suggested strategies to assist in their relocation—a policy known as *assisted migration* or *assisted colonization*. It is hoped that we might thus save species that perform essential roles in ecosystems, such as keystone predators that regulate herbivore populations or tree species that create the structure and microclimatic conditions within forest systems as well as supplying animals with food (e.g., fruits, nuts, leaves) and shelter (nesting cavities, perches, etc.).

However, this policy is not without controversy. Some scientists, conservationists, and members of the public have criticized the strategy for practical, ecological, and ethical reasons. For example, it has been argued that the focal species in any assisted migration program may represent a threat to species where it is relocated, taking up resources and possibly becoming invasive. There are also concerns about the feasibility of assisted migration given that it would involve considerable financial costs that might be better allocated toward protection of whole ecosystems rather than individual target species. Assisted migration has further been criticized for treating the symptoms of climate change rather than causes.

While there may be no easy fix to deal with the biodiversity impacts of climate change, much is at stake and we must examine solutions and act to reduce our impacts.

Visual Concept Check 10.3

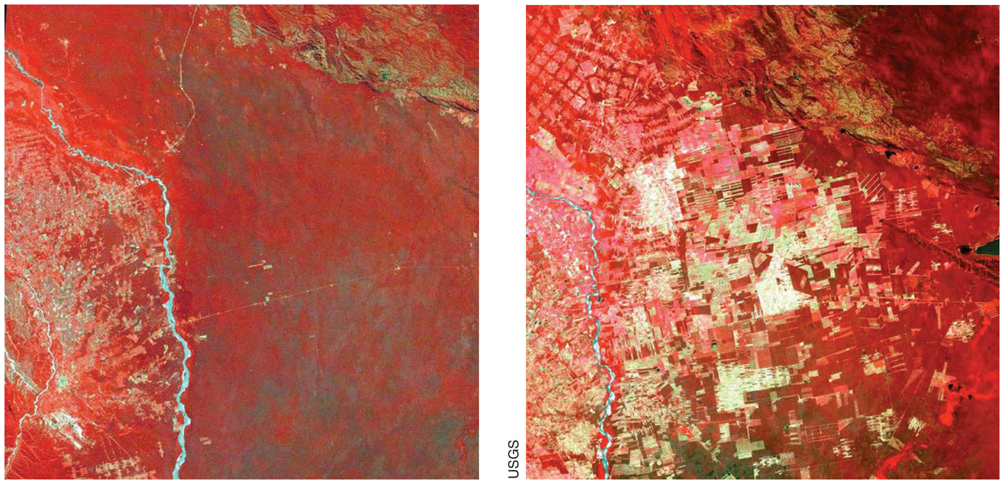
This pair of infrared satellite images is of the same region in the Amazon rainforest at different times. Remember that red on this kind of image represents vegetation. The (a) image was acquired in 1975, whereas the (b) image dates to 2000. The difference that you see reflects extensive deforestation along road networks in the region. Which one of the following statements is accurate with respect to the impact that this kind of deforestation has on global climate change?

a) Fewer trees will result in the production of more oxygen.

b) The amount of atmospheric carbon dioxide will increase because fewer trees are present to absorb it.

c) Global temperature should decrease given that fewer trees are present in the rainforest.

d) There will be less atmospheric carbon dioxide because trees produce carbon dioxide as a by-product of respiration.



USGS (a) USGS (b)