

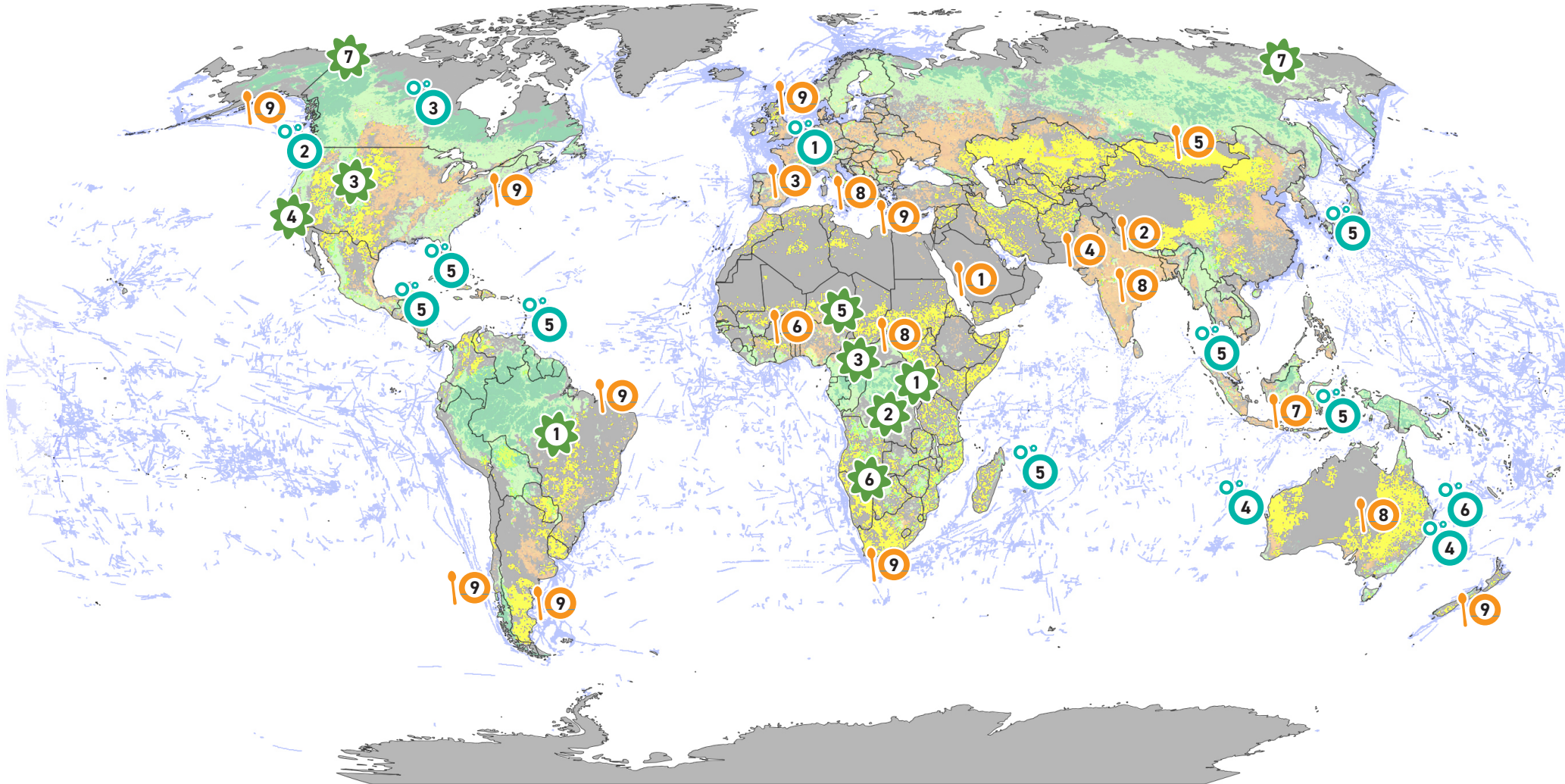
March 17, 2022

IPCC details a world afflicted by global warming

The most recent report from the U.N.'s Intergovernmental Panel on Climate Change highlights how human-caused climate change has affected ecological and socio-economic systems at global, regional and local levels. Ecosystems are under stress, species are changing their geographic ranges, seasonal life cycles are shifting their timing. For humans, global warming is negatively affecting water availability, food production, infrastructure and physical and mental health.

Disruption of ecological and agricultural systems

■ Intact forests
 ■ Degraded forests
 ■ Croplands
 ■ Pasture/range
 ■ Mixed use, deserts, ice, unspecified
 ■ Four days of fishing activity
 (Paths of fishing vessels recorded on March 21, June 21, Sept. 21 and Dec. 21, 2020)



Terrestrial ecosystems are stressed by heat and drought

As temperatures increase, boreal, temperate and tropical ecosystems are shifting to higher latitudes and elevations. Expanding aridity, drought and wildfires are contributing to forest degradation, reduced tree canopy and increased tree mortality — reducing forest biomass and its potential to store carbon.

TROPICAL FORESTS

1 Elevated carbon dioxide increased forest productivity, but that probably peaked in the 1990s. Rates of productivity increase have been slowing down in the central Amazon and in intact African forests, both of which are now seeing increases in tree deaths.

Warming increases water stress in trees, which accelerates the drying out of forest canopies. That contributes to deforestation, which leads to hotter and drier regional climates.

2 In Africa, rising temperatures have hampered fruit production, causing a decline in the body condition of fruit-dependent forest elephants

TEMPERATE FORESTS

3 Rising temperatures increased drought-induced tree mortality by as much as 20 percent between 1945 and 2007. Tree-damaging bark beetles have moved farther north and into higher elevations. They survive winter at sites where they previously would have died.

SHRUBLANDS and GRASSLANDS

4 In some areas, increased vegetation death is reducing vegetation cover.

5 In other areas, forest and woody shrublands are shifting to grasslands.

6 Woody plants are expanding into grasslands and savannas at a rate of 2.4 percent per decade in SW Africa, decreasing the occurrence of bird, reptile and mammal species that require grassy habitats.

Increased carbon dioxide, warmer and wetter climates, declines in burned area and fewer grazing herbivores have increased grass cover in some arid regions.

TUNDRA

7 Earlier snow and sea ice melt and longer growing seasons are altering tundra plant communities.

Aquatic ecosystems are warming and losing diversity

Ocean waters have become warmer and more acidic as dissolved oxygen levels fall. In bodies of freshwater, rising seas and higher water temperatures exacerbate problems with eutrophication, invasive species, overfishing, sedimentation and loss of wetland connectivity.

FRESHWATER

- 1** Increased water temperatures and hydrological changes have reduced stream biodiversity.
- 2** Lowland rivers are warming faster than high-altitude, coldwater streams.
- 3** Warming rivers and loss of glacial runoff have decimated some salmon fisheries.

Climate change has increased the flow of dissolved organic matter into rivers and lakes of boreal coniferous forests, causing waters to become brown. This accelerates upper-water warming and deep-water cooling, conditions that boost cyanobacteria growth.

OCEANS

Marine heatwaves have doubled since the 1980s and also increased in intensity. Ocean warming has changed the biogeography of organisms from phytoplankton to marine mammals.

Sea temperature changes have altered the timing of plankton blooms and the migratory and spawning patterns of fish and invertebrates, posing risks to fisheries, aquaculture and other coastal activities. Ocean animals — and fishers — are moving poleward, towards higher latitudes.

4 Marine heatwaves have caused abrupt shifts in marine ecosystems, leading to biodiversity loss and collapse of regional fisheries.

REEFS

5 Since the early 1980s, warmer waters have sharply increased the frequency and severity of mass coral bleaching events. Degraded reef ecosystems then become dominated by algae.

6 The Great Barrier Reef had three mass coral bleaching events between 2016 and 2020.

RISING SEAS

Sea level rise has accelerated from 1.7mm per year throughout most of the 20th Century to about 4 mm per year since 1993.

Sea level rise and other climate-related ocean changes are having adverse effects on saltmarshes, mangroves and vegetated dunes on sandy beaches.

Food systems are growing less productive

Crops, livestock, fishing and aquaculture are being undermined by climate change. Between 1983 and 2009, about three-quarters of the global harvested areas lost \$166 billion to drought, which contributed to food insecurity and malnutrition.

Weather extremes cut global cereal productivity by about 10 percent between 1964 and 2007.

Changes in temperature and precipitation have reduced corn, wheat and soybeans yields worldwide. Between 1980 and 2018, excess soil moisture cut rice, corn, soybean and wheat yields by 7 to 12 percent globally.

Rising temperatures affect pastoral systems, reduce herd mobility, decrease productivity, reduce access to water and feed and increase incidence of vector-borne diseases and parasites.

REGIONAL EXAMPLES

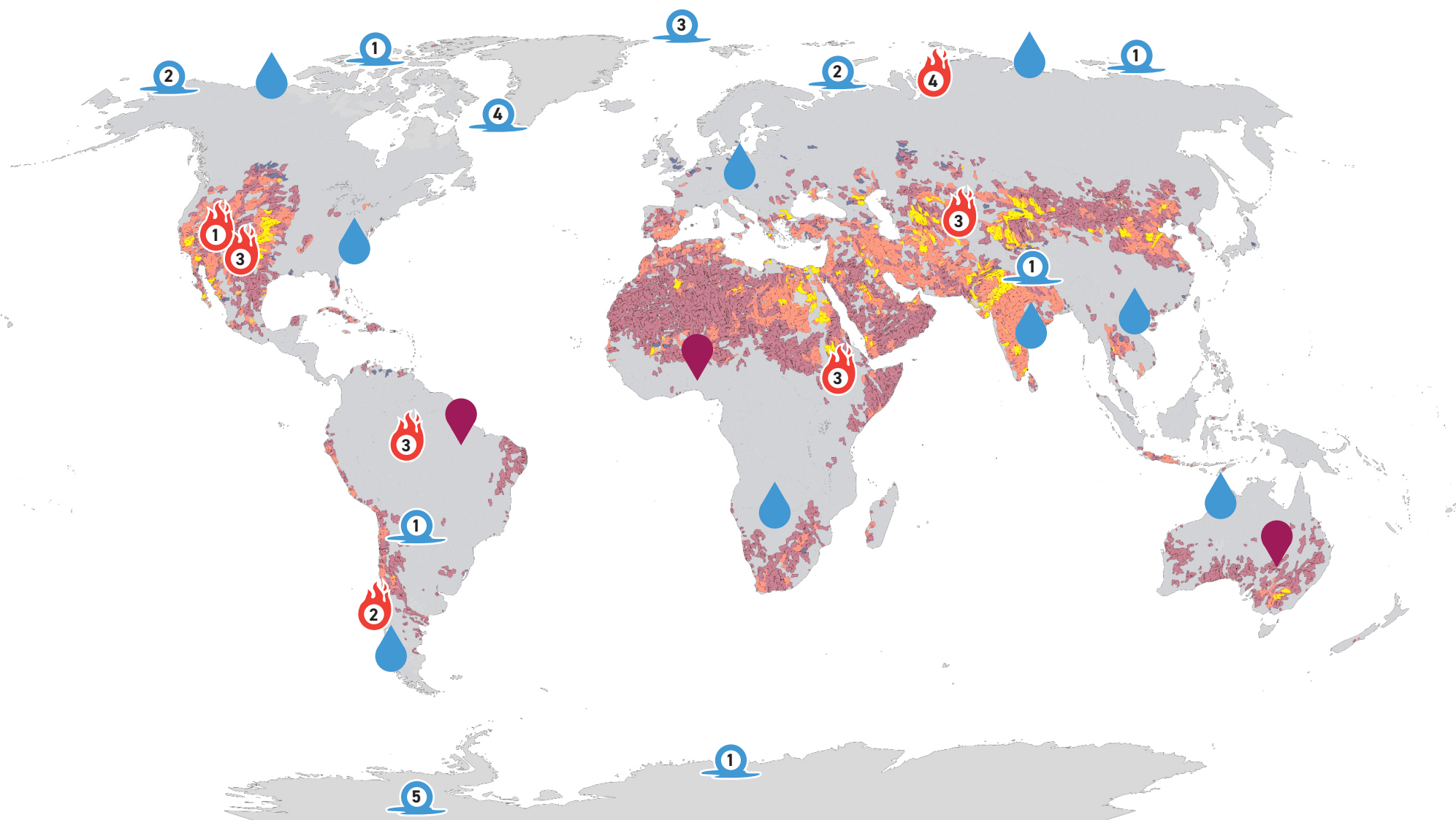
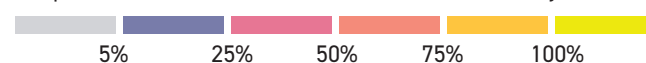
- 1** Moist soils and warm temperatures unleashed swarms of desert locusts that spread to other countries.
- 2** Abnormal seasonal changes have affected semi-domesticated fruits, and wild plants consumed as vegetables have declined in abundance.
- 3** Warming and climate variability are affecting apple acidity and texture and skin color in grapes.
- 4** Feed quality in grasslands has been negatively affected.
- 5** Grasslands are degraded; changing seasonality has increased the frequency of drought.
- 6** Drought and other climate conditions led to millet and sorghum yield to fall 20 percent and 15 percent, respectively, between 2000 and 2009.
- 7** Peatlands have turned from a carbon sink to a carbon source. Draining and burning peat swamp forests for oil palm plantations emitted 60 to 260 million metric tons of carbon per year between 1990 and 2015.
- 8** Major crop yields in semi-arid regions without irrigation are negatively affected by precipitation declines.
- 9** Fisheries catches from shelf seas are increasingly dominated by warm water species.

Intensity of heavy precipitation



Water depletion

The portion of available renewable water consumed by human activities.



Precipitation: Too little or too much

Climate change is altering the global water cycle, causing extensive economic damage and wide-ranging ecological changes, affecting hundreds of millions of people. In 2020, 7 million people were displaced due to natural disasters, including drought and floods. The primary driver of displacement: household water insecurity.

In many parts of the world, drought has become more frequent and severe, reducing crop yields, increasing wildfire risk and causing drinking water shortages, loss of life and billions of dollars in damages. Economic losses from drought, relative to GDP, are about twice as high in lower-income countries than in countries with higher incomes.

Many areas across the globe are experiencing increasingly recurrent extreme precipitation events, more frequent and extensive river flooding, changing patterns of streamflow, earlier spring floods, shifts in the timing and magnitude of ice-jam floods and changes in frequency and magnitude of snowmelt floods.

Soil moisture patterns are changing in response to higher temperatures and changes in precipitation.

Droughts, changes in the seasonality of river flows and increasing water temperatures have negatively affected production of hydro and thermal power.

Cold regions: Thawing rapidly

1 In high-latitude and high-altitude areas, glaciers, land ice and snow cover are shrinking and permafrost is thawing, substantially affecting ecosystems, irrigation, hydropower, water supply and the ways of life of animals and people.

The most cold-adapted species are declining in population and are contracting their ranges poleward, toward higher elevations and into deeper, cooler waters.

Sea-ice habitats for ice-dependent marine mammals and seabirds are rapidly disappearing.

2 In the Arctic, temperature increases are twice as high as the world average, and are most pronounced during the cold season when melting permafrost emits about 1.7 gigatons of carbon emissions. Thawing and drying permafrost habitats have increased fire frequency and emit more carbon to the atmosphere than they naturally remove through vegetative growth.

3 September Arctic sea ice volume declined by about 72 percent between 1979 and 2010.

4 In Greenland, warmer ocean waters have advanced farther north and warmer-water fish are moving in. The Greenland Ice Sheet lost more than seven times as much mass from 2010 to 2016 than from 1992 to 1999.

5 The Antarctic ice sheet lost four times as much mass from 2010 to 2016 than it did from 1992 to 1999.

Wildfires: Growing in extent and frequency

Increased temperature, aridity and drought have extended fire seasons and doubled the size of areas vulnerable to fires. Wildfires have become bigger and more frequent.

Drought, temperature increases and forest fragmentation interact to increase the number of fires in tropical forests.

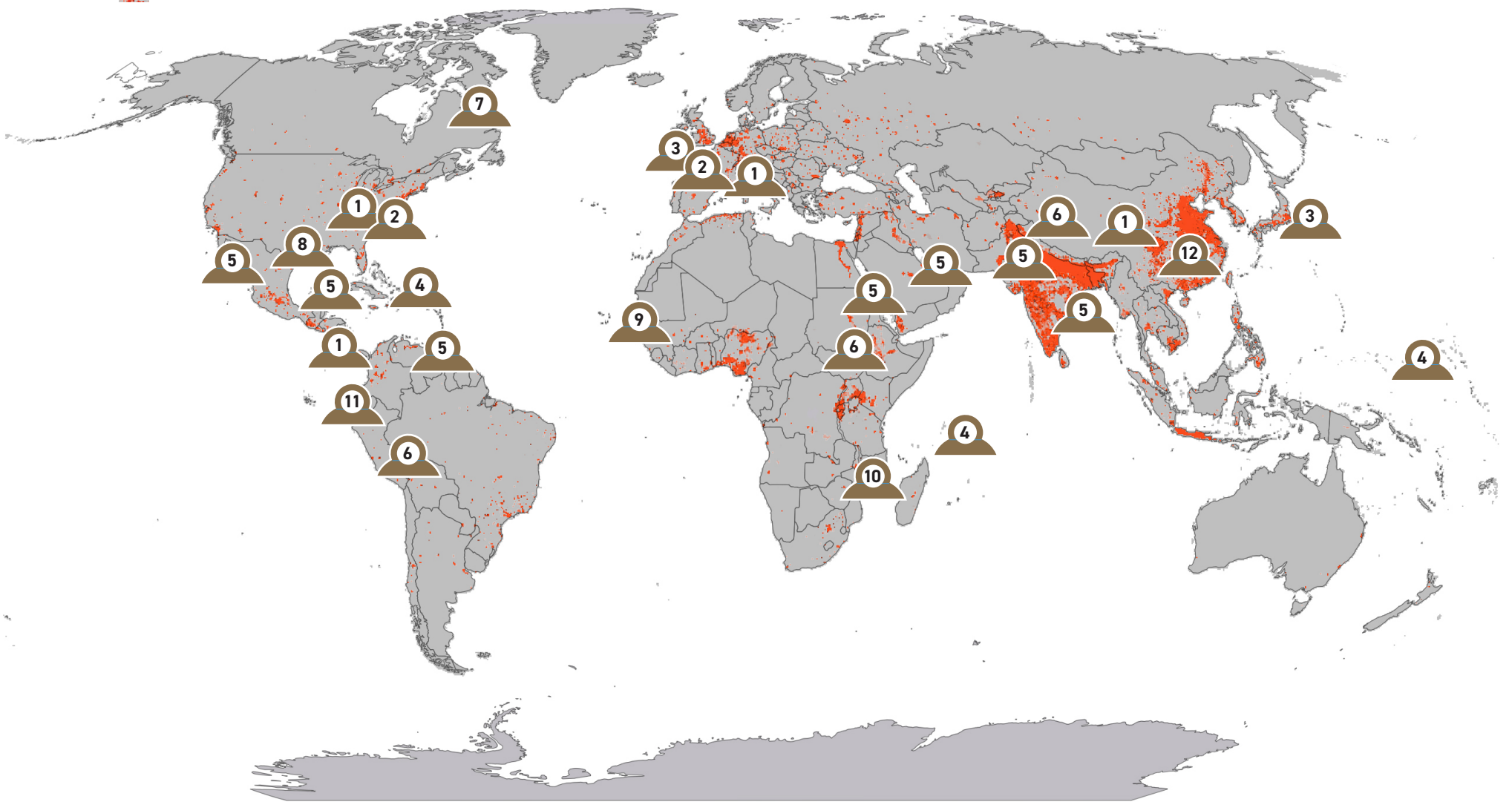
1 Fuel aridity and the extent of areas burned by wildfire have increased.

2 A megadrought increased the number, size and duration of large fires.

3 Four regions are experiencing significant increases fire season duration.

4 In the Arctic tundra and boreal forest, burned areas increased about 50 percent per year across Siberia from 1996 to 2015.

Population centers



Global warming increases human suffering

As many as 3.6 billion people are highly vulnerable to climate change. The world's 150 most-populated cities have experienced a five-fold increase in exposure to extreme heat events between 1980 and 2017.

Higher ocean temperatures are increasing human exposure to organic pollutants and mercury in marine plants and animals, and are driving increases in the prevalence of waterborne pathogens and harmful algal blooms.

Extreme weather events drive outbreaks of vector-borne and water-borne diseases, which disproportionately affect vulnerable populations such as women, children, Indigenous peoples, the elderly and people with lower incomes.

Higher temperatures, heavy rainfall and flooding have increased diarrheal diseases such as cholera, *Salmonella* and *Campylobacter*, and are linked to the spread of respiratory tract infections, dengue fever and neglected tropical diseases. Malaria is moving into higher altitudes.

Extreme events such as wildfires, violent storms and damaging floods trigger higher rates of mental illness.

- 1 Several regions are seeing increases in incidence of chikungunya virus.
- 2 Tick-borne Lyme disease and encephalitis are spreading in North America and Europe, respectively.
- 3 Heat stress events have led to significant death tolls and hospitalizations.
- 4 On small islands, sea level rise and coastal erosion create distress for local people, who are anxious about losing their culture to inundation.
- 5 In some regions, heat stress conditions approach the upper limits of labor productivity and human survivability.
- 6 Pastoralists must cope with water scarcity and degraded pastures along traditional migration routes.
- 7 Early snowmelt and increases in temperature and precipitation have caused a rapid decline in caribou herds, which are critically significant to Inuit culture.
- 8 Houston: A combination of urbanization and climate change nearly doubled peak water discharge during Hurricane Harvey.
- 9 Senegal: Rainy season is associated with an 84 percent increase in relative risk of childhood diarrhea.
- 10 Mozambique: An additional wet day per week can cause as much as a 2 percent increase in diarrheal disease.
- 11 Ecuador: Heavy rainfall after dry periods can increase cases of diarrhea by 1.5 per 1,000 people.
- 12 China: Floods are associated with a 22 percent rise in relative risk of diarrhea.