

Table 18-7 | Observed impacts of climate change reported since AR4 on terrestrial ecosystems, over the past several decades, across major world regions, with descriptors for: (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Terrestrial ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Tree density decreases in Western Sahel and semi-arid Morocco	Section 22.3.2.1; Gonzalez et al. (2012); Le Polain de Waroux and Lambin (2012)	Medium	Major	Change in precipitation	Changes due to land use	Medium
	Range shifts of several southern plants and animals: South African bird species polewards; Madagascar reptiles and amphibians upwards; Namib aloe contracting ranges	Table 22-3; Foden et al. (2007); Raxworthy et al. (2008); Hockey and Midgley (2009); Hockey et al. (2011)	High	Major	Warming	Changes due to land use	Medium
	Wildfires increase on Mt. Kilimanjaro	Table 22-3; Hemp (2005)	Medium	Major	Warming; drying	No change	Low
Europe	Earlier greening, earlier leaf emergence and fruiting in temperate and boreal trees	Section 4.3.2.1; Menzel et al. (2006)	High	Major	Warming	No change	High
	Increased colonization of alien plant species in Europe	Section 4.2.4.6; Table 23-6; Walther et al. (2009)	Medium	Major	Warming	Some invasion	Medium
	Earlier arrival of migratory birds in Europe since 1970	Section 4.2.4.6; Table 23-6; Møller et al. (2008)	Medium	Major	Warming	No change	Medium
	Upward shift in tree line in Europe	Section 18.3.2.3; Table 23-6; Gehrig-Fasel et al. (2007); Lenoir et al. (2008)	Medium	Major	Warming	Changes due to land use	Low
	Increasing burnt forest areas during recent decades in Portugal and Greece	Table 23-6; Camia and Amatulli (2009); Hoinka et al. (2009); Costa et al. (2011); Koutsias et al. (2012)	High	Major	Warming; change in precipitation	Some increase due to land use	High
Asia	Changes in plant phenology and growth in many parts of Asia (earlier greening), particularly in the north and the east	Sections 4.3.2.1 and 24.4.2.2; Figure 4-4; Ma and Zhou (2012); Panday and Ghimire (2012); Shrestha et al. (2012); Ogawa-Onishi and Berry (2013)	High	Major	Warming	No change	Medium
	Distribution shifts in many plant and animal species, particularly in the north of Asia, upwards in elevation or polewards	Sections 4.3.2.5 and 24.4.2.2; Figure 4-4; Moiseev et al. (2010); Chen et al. (2011); Jump et al. (2012); Ogawa-Onishi and Berry (2013)	High	Major	Warming	No change	Medium
	Invasion of Siberian larch forests by pine and spruce during recent decades	Section 24.4.2.2; Kharuk et al. (2010); Lloyd et al. (2011)	Medium	Major	Warming	No change	Low
	Advance of shrubs into the Siberian tundra	Sections 4.3.3.4, 24.4.2.2, and 28.2.3.1; Henry and Elmendorf (2010); Blok et al. (2011)	High	Major	Warming	No change	High
Australasia	Changes in genetics, growth, distribution, and phenology of many species, in particular birds, butterflies and plants in Australia	Table 25-3; Chambers (2008); Chessman (2009); Green (2010); Kearney et al. (2010); Keatley and Hudson (2012); Chambers et al. (2013b)	High	Major	Warming	Fluctuations due to variable local climates, land use, pollution, invasive species	High
	Expansion of some wetlands and contraction of adjacent woodlands in southeast Australia	Table 25-3; Keith et al. (2010)	Medium	Major	Change in precipitation; warming	No change	Low
	Expansion of monsoon rainforest at expense of savannah and grasslands in north Australia	Table 25-3; Banfai and Bowman (2007); Bowman et al. (2010)	Medium	Major	Change in precipitation; increased CO ₂	No change	Medium
	Migration of glass eels advanced by several weeks in Waikato River, New Zealand	Table 25-3; Jellyman et al. (2009)	Medium	Major	Warming	No change	Low

Table 18-7 (continued)

	Terrestrial ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
North America	Phenology changes and species distribution shifts upward in elevation and northward across multiple taxa	Section 26.4.1; Parmesan and Galbraith (2004); Parmesan (2006); Kelly and Goulden (2008); Moritz et al. (2008); Tingley et al. (2009)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Increased wildfire frequency in subarctic conifer forests and tundra	Section 28.2.3.1; Mack et al. (2011); Mann et al. (2012)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Regional increases in tree mortality and insect infestations in forests	Section 26.4.2.1; Van Mantgem et al. (2009); Peng et al. (2011)	<i>Medium</i>	Minor	Warming	No change	<i>Low</i>
	Increase in wildfire activity, fire frequency and duration, and burnt area in forests of the western US and boreal forests in Canada	Box 26-2; Gillett et al. (2004); Westerling et al. (2006); Girardin et al. (2013)	<i>High</i>	Minor	Warming; change in precipitation	Changes due to land use and fire management	<i>Medium</i>
South and Central America	Increased tree mortality and forest fire in the Amazon	Section 4.3.3.1.3; Phillips et al. (2009)	<i>Medium</i>	Minor	Warming	No change	<i>Low</i>
	Degrading and receding rainforest in the Amazon	Sections 18.3.2.4, 27.2.2.1, and 27.3.2.1; Etter et al. (2006); Nepstad et al. (2006); Oliveira et al. (2007); Wassenaar et al. (2007); Killeen et al. (2008); Nepstad and Stickler (2008)	<i>Low</i>	Minor	Warming	Deforestation and land degradation	<i>Low</i>
Polar regions	Increase in shrub cover in tundra in North America and Eurasia	Section 28.2.3.1.2; Tape et al. (2006); Walker et al. (2006); Henry and Elmendorf (2010); Blok et al. (2011); Elmendorf et al. (2012); Tape et al. (2012)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Advance of Arctic tree-line in latitude and altitude	Section 28.2.3.1.2; AMAP (2011); Hedenäs et al. (2011); Van Bogaert et al. (2011)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Loss of snow-bed ecosystems and tussock tundra	Section 28.2.3.1.2; Björk and Molau (2007); Molau (2010a); Hedenäs et al. (2011); Callaghan et al. (2013)	<i>High</i>	Major	Warming; change in precipitation	No change	<i>High</i>
	Impacts on tundra animals from increased ice layers in snow pack, following rain-on-snow events	Section 28.2.3.1.3; Callaghan et al. (2011); Hansen et al. (2013)	<i>Medium</i>	Major	Change in precipitation; warming	No change	<i>Medium</i>
	Changes in breeding area and population size of subarctic birds, due to snowbed reduction and/or tundra shrub encroachment	Molau (2010b); Callaghan et al. (2013)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Increase in plant species ranges in the West Antarctic Peninsula and nearby islands over the past 50 years	Section 28.2.3.2; Fowbert and Smith (1994); Parnikoza et al. (2009)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Increasing phytoplankton productivity in Signy Island lake waters	Quayle et al. (2002); Laybourn-Parry (2003)	<i>High</i>	Major	Warming	No change	<i>High</i>
Small islands	Changes in tropical bird populations in Mauritius	Section 29.3.2; Senapathi et al. (2011)	<i>Medium</i>	Major	Change in precipitation	No change	<i>Medium</i>
	Decline of an endemic plant in Hawai'i	Krushelnicky et al. (2013)	<i>Medium</i>	Major	Warming; change in precipitation	No change	<i>Medium</i>
	Upward trend in tree lines and associated fauna on high-elevation islands	Section 29.3.2; Benning et al. (2002); Jump et al. (2006)	<i>Low</i>	Minor	Warming	No change	<i>Low</i>