Supplementary Material

Actions to halt biodiversity loss generally benefit the climate

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Content :

Table S1 : Literature references supporting Table 1

Post2020 action targets	Biodiversity measures	Effects on climate change mitigation	Reliability of mitigation outcome
T1. Biodiversity-inclusive spatial planning addressing land/sea use change, retaining intact and wilderness areas	Avoiding degradation of permafrost areas	Cahoon et al. 2012; Falk et al. 2015; te Beest et al. 2016; Schmitz et al. 2018; Beer et al. 2020	Falk et al. 2015; Schmitz et al. 2018
	Avoided deforestation	Gullison et al 2007; Johnson et al., 2019 ; West et al., 2019	Ekawati et al 2019 ; Gizachew et al 2017
T2. Restoration of at least 20% of degraded ecosystems, ensured connectivity and focus on priority areas	Reforestation, avoided degradation of forests	Mackey et al 2020; McNicholl et al 2018 ; Romijn et al 2011 ; Sileshi 2016 ; Kemppinen et al 2020 ; Bond et al 2019; Abreu et al 2017	Mackey et al 2020 ; Laurance et al 2016 ; Queensland Dept Science, Information and Technology and Innovation 2017 ; McNicholl et al 2018 ; Sileshi 2016 ; Kemppinen et al 2020 ; Lewis et al 2019 ; Stevens et al 2017 ; Abreu et al 2017 ; Panfil & Harvey 2015
	Coastal restoration	Pendleton et al 2011; Stankovic et al. 2021; Lovelock and Duarte 2019; Pendleton et al 2012; Hoegh-Guldberg et al. 2019 a,b	Hoegh-Guldberg 2019b; Lovelock and Duarte 2019; Pendleton et al 2011; Bayraktarov et al. 2020
	Restoring degraded semi-arid ecosystems	Chappell et al 2016, 2019; Yusuf et al 2015 ; Fensholt et al 2012	Byron-Cox 2020 ; Yusuf et al 2015 ; Gosnall et al 2020
	Restoring inland wetlands	Spencer et al. 2016; Pangala et al. 2017	Gallego-Sala et al. 2018; Pangala et al. 2017
	Biodiversity offsets	Sonter et al. 2020; Ermgassen et al. 2019; Sonter et al. 2020	Bull and Strange 2018; Ermgassen et al. 2019
T3. Well-connected and effective system of protected areas, at least 30% of the planet	Expanding networks of protected areas and corridors	Melillo et al., 2016; Shi et al., 2020; Dinerstein et al., 2020; Jantz et al., 2014	Dinerstein et al., 2020
T4. Recovery and conservation of species of fauna and flora	Rewilding with large terrestrial mammals	Schmitz et al. 2018; Hooper et al. 2012	Schmitz et al. 2018; Hooper et al. 2012
	Rebuilding marine megafauna	Mariani et al. 2020 ; Lavery et al. 2010 ; Roman and McCarthy 2010 ; Passow and Carlson 2012 ; Heithaus et al. 2014 ; Atwood et al. 2015 ; Wilmers et al. 2012	Pershing et al. 2010 ; Atwood et al. 2015
T5. Sustainable, legal and safe harvesting, trade and use of wild species	Sustainable fishing	Mariani et al. 2020 ; Sala et al. 2021 ; Atwood et al. 2020 ; Saba et al. 2021	Mariani et al. 2020 ; Sala et al. 2021 ; Atwood et al. 2020 ; Saba et al. 2021
T7. Reduced pollution from all sources, including excess nutrients, pesticides, plastic waste	Reducing pollution from excess nutrients	Rabalais et al. 2014 ; Naqvi et al. 2010	Engle 2011 ; Jahangir et al. 2016
T9. Ensured benefits, incl. food security, medicines, and livelihoods, through sustainable management of wild species	Sustainable harvesting of wild species	Mariani et al. 2020 ; Sala et al. 2021 ; Atwood et al. 2020 ; Saba et al. 2021	Mariani et al. 2020 ; Sala et al. 2021 ; Atwood et al. 2020 ; Saba et al. 2021
T10. All areas under agriculture, aquaculture and forestry are managed sustainably, through biodiversity conservation and sustainable use, and increased productivity and resilience	Biodiversity friendly agricultural systems	Leippert et al., 2020; VanBergen, 2020; Wanger et al., 2020 ; Creed et al., 2018	Smith et al., 2020a; Tamburini et al., 2020
	Intensive vs less intensive agriculture	Van Meijl et al 2017; Balmford et al 2018	reliability depending on dietary preferences; Van Meijl et al 2017
	Combatting woody plant encroachment	Stevens et al., 2017; Bond & Midgley, 2012; Wigley et al., 2020; Ministry of Environment and Tourism, 2011	Smit et al., 2016; Creed et al., 2019; van Wilgen et al., 2012

T12. Increased area of, access to, and benefits from green/blue spaces for health and well-being in urban areas	Increasing benefits from biodiversity and green/blue spaces in urban areas	UN DESA, 2018; UNEN, 2020; SCBD, 2012; Chan, 2019; Beatley, 2016; Epple et al, 2016; Enzi et al., 2017; Wong et al., 2003; Alhashimi et al., 2018; Yu, 2020; WHO, 2016	Epple et al., 2016; Enzi et al., 2017; Alhashimi et al., 2018; Wong et al., 2003
T14. Biodiversity values integrated into policies, regulations, planning, development, poverty reduction, accounts and assessments at all levels and across all sectors	Mainstreaming biodiversity	Huntley & Redford, 2014; Redford et al., 2015; Trumper et al., 2014 ; Smith et al. 2020b	Redford et al., 2015; de Leon, 2010
T15. Dependencies and impacts on biodiversity assessed in all businesses, negative impacts halved, for sustainable extraction and production, sourcing and supply chains, use and disposal	Sustainable food production and supply chains	Albrecht et al. 2020 ; Pretty et al. 2018 ; Bajželj et al., 2014 ; Gustavsson et al., 2011 ; Xiao et al. 2017 ; Duarte et al. 2017 ; Vijn et al. 2020 ; Froehlich et al. 2019 ; Mariani et al. 2020 ; Sala et al. 2021 ; Atwood et al. 2020 ; Saba et al. 2021	Phalan et al. 2011 ; Smith et al. 2020a ; Froehlich et al. 2019 ; Duarte et al. 2017 ; Mariani et al. 2020 ; Sala et al. 2021
T16. People are informed and enabled to make responsible choices, to halve the waste and reduce overconsumption of food and other materials where relevant	Sustainable consumption patterns	Kuuluvainen et al 2019 ; Heilmayr et al 2020 ; Jia et al. 2019	Kuuluvainen et al 2019 ; Heilmayr et al 2020 ; Jia et al. 2019
T18. Redirect, repurpose, reform or eliminate incentives harmful for biodiversity in a just and equitable way	Eliminating incentives harmful for biodiversity	Coady et al., 2019; Franks et al., 2018	OECD, 2019

Table S2 : Literature references supporting Figure 1 and Table 2 (CC : climate change ; NCP : Nature's Contributions to People)

	Case study	main biodiversity measures	impacts on biodiversity	impacts on CC Mitigation	impacts on other regulating NCP	impacts on material NCP	impacts on non-material NCP
CS1	Kailash Sacred Landscape Conservation and Development Initiative	Kotru et al., 2020; Sharma et al 2010; Zomer and Oli, 2011	Kotru et al. 2020	Uddin et al. 2015; Zomer et al., 2014	Badola et al., 2017; Liniger et al., 2020	Badola et al. 2017; Tewari et al., 2020; Thapa et al., 2018; and Chaudhary et al., 2020	Adler et al., 2013; Pandey et al., 2016; Nepal et al 2018
CS2	Cultural landscapes in Central Europe	Tieskens et al. 2017; Bengtsson et al. 2018	Tieskens et al. 2017; Bengtsson et al. 2018	Bengtsson et al. 2018	Bengtsson et al. 2018	Schaub et al. 2020	Tieskens et al. 2017; Bengtsson et al. 2018
CS3	Irrigated rice terraces and forests in South-East Asia	Dominik et al. 2018; Settele et al. 2018	Dominik et al. 2018, Settele et al. 2018	Saunois et al 2016; Zhang et al. 2020	Sattler et al. 2020	Settele et al. 2018	Settele et al. 2018
CS4	The Coral Triangle Initiative	Kleypas et al. 2021; Warren et al. 2018; Alongi 2014; Alongi & Mukhopadhyay, 2015)	Hoegh-Guldberg et al. 2009; Kleypas et al. 2021; Alongi 2014; Alongi & Mukhopadhyay, 2015; Williams et al. 2017	Stankovic et al. 2021; Kleypas et al. 2021; Lovelock and Duarte 2019; Hoegh-Guldberg et al. 2009; Alongi 2014; Alongi & Mukhopadhyay, 2015); Hoegh-Guldberg et al. 2019a,b	Stankovic et al. 2021; Quevedo et al 2021	Linggi et al. 2019; Anugrah et al. 2020; Quevedo et al 2021	Hoegh-Guldberg et al. 2009; Chan et al. 2019
CS5	Biodiversity-friendly cities and urban areas	Friess et al, 2015; Everard et al., 2014; Alongi 2014; Alongi & Mukhopadhyay, 2015)	Friess et al, 2015; Everard et al., 2014; Alongi 2014; Alongi & Mukhopadhyay, 2015)	Alongi 2014; Alongi & Mukhopadhyay, 2015; Alongi et al., 2016; Bulmer et al., 2020; Donato et al., 2011)	Friess et al., 2015	Alongi et al., 2016	Alongi et al., 2016; Alongi & Mukhopadhyay, 2015;
CS6	The Sundarbans (India-Bangladesh)	IUCN, 2017; Awty-Carroll et al., 2019; Mukul et al., 2019; IUCN, 2020	IUCN, 2017; Awty-Carroll et al., 2019; Mukul et al., 2019; IUCN, 2020	Sannigrahi et al., 2020a, b	Sannigrahi et al., 2020a, b	Uddin et al., 2013; Hossain et al., 2016	
CS7	Southern Ocean South Georgia Island	Barnes et al., 2011; Trathan et al., 2014	Hogg et al., 2011; Trathan et al., 2014	Barnes & Sands, 2017	Trathan et al., 2014; Cavanagh et al., 2021	Trathan et al., 2014; Cavanagh et al., 2021	Trathan et al., 2014; Cavanagh et al., 2021
CS8	Marine Biodiversity Beyond National Jurisdiction, South Orkney Islands	Trathan & Grant, 2020	Trathan & Grant, 2020	Barnes et al., 2016	Grant et al., 2013; Cavanagh et al., 2021	Grant et al., 2013; Cavanagh et al., 2021	Grant et al., 2013; Cavanagh et al., 2021
CS9	Bush encroachment Southern Africa	Joubert et al., 2012; Smit et al., 2016	Stevens et al., 2017	Ministry of Environment and Tourism, 2011); Bond et al., 2005, Stevens et al., 2017	Ministry of Environment and Tourism, 2011; Bond et al., 2005, Stevens et al., 2017	Creed et al., 2019; McNulty et al., 2018	van Wilgen et al., 2012
CS10	Amazonian rainforest	Soares-Filho et al 2010; Joly et al 2018; Scarano et al 2018	Ribeiro et al 2016; Joly et al 2018	Soares-Filho et al 2010; Hall 2008: Malhi et al	Hall 2008; Castello et al 2013; van Soesbergen &	Scarano et al 2020; Goulding et al	Soares-Filho et al 2010, Pires et al 2019; Joly et al 2018

				2008;Phillips et al 2017	Mulligan 2014; Joly et al 2018	2019; Joly et al 2018	
CS11	Pleistocene Park, Northeastern Siberia	Zimov 2005; Kintisch, 2015	Beer et al., 2020	Cahoon et al., 2012; Falk et al., 2015; te Beest et al., 2016; Schmitz et al., 2018	Macias-Fauria et al., 2020	Macias-Fauria et al., 2020	Kintisch, 2015; Macias-Fauria et al., 2020
CS12	African peatlands	Dargie et al., 2019)	Dargie et al., 2017, 2019; Fay and Agangna 1991; Rainey et al, 2010; Inogwabini et al. 2012; Riley and Huchzermeyer 1999	Dargie et al., 2017, 2019; Hooijer et al., 2010; Könönen et al., 2016	Dargie et al., 2019	Dargie et al., 2019; Jauhiainen et al. 2012	Dargie et al., 2019

Table S3 : Full description of case studies supporting Figure 1, Table 2 and section 3. Biodiversity and conservation objectives are described, as well as the potential effects on climate change mitigation, the main nature's contributions to people, the trade-offs and synergies between multiple uses and functions of the ecosystems, and when relevant the main governance challenges, underlying cross-sectoral and transboundary aspects.

Case Study number	Description
CS 1	Kailash Sacred Landscape Conservation and Development Initiative
	Biodiversity conservation and climate change impact mitigation or adaptation are important environmental management interventions in the Himalayan landscape. Conserving biodiversity through a (transboundary) landscape approach has been getting traction in the Hindu Kush Himalayas. With conservation and development objectives, Kailash Sacred Landscape (KSL) Conservation and Development Initiative was launched in 2010 covering 31,000 km^2 inhabited by 1,300,000 people among Nepal, India, and China (Tibet Autonomous Region) (Zomer & Oli, 2011). This landscape is vitally important for biodiversity conservation and ecosystem services (high altitude forests, rangelands, and globally threatened species - snow leopard (*Uncia uncia*) and Himalayan musk deer (*Moschus chrysogaster*); sacred sites for pilgrimage from Nepal and India: Mount Kailash and lake Mansarover; and source of water for Asia's four major rivers: the Indus, the Sutlej, the Brahmaputra, and the Karnali (Uddin et al., 2015; Zomer & Oli, 2011). Restoration of forest and rangelands (Uddin et al., 2015), protection of endangered species and their habitats (Sharma et al., 2010), sustainable (farm) land management practices (Aryal et al., 2018; Liniger et al., 2020), heritage protection and cultural tourism (Adler et al., 2013; Pandey et al., 2016) were promoted as a way to conserve biodiversity, provide or generate ecosystem services (Nepal et al., 2018), mitigate climate change (through carbon sequestration), and support livelihoods. Recent review of the landscape initiative indicated that the transboundary landscape approach was successful in establishing biodiversity corridors, adopting approaches to ecosystem management and conservation, and also contributing to household incomes (Kotru et al., 2020). In particular, the initiative contributed to conservation of snow leopard and musk deer – flagship threatened species of the region. Restoration of forests and rangelands and sustainable management of farmlands contributed to climate change mitigation through carbon sequestration. The effect on regulating ecosystem services through landscape restoration include protection of water sources and rejuvenation of springs in the landscape, which contributed to increased availability of water (Liniger et al., 2020; Badola et al., 2017). Honey and associated pollination services are also forest by-products. It is important to note that shifting snowlines, rapid melting of snow, and formation of glacier lakes are significant risks of climate change in the KSL, affecting water availability and livelihoods of thousands of communities that rely on water supplied by the major rivers originating at KSL. Medicinal plants, forest products (such as honey) and fodder by replacing invasive alien species are some of the key provisioning services generated in the KSL through restoration activities (Chaudhary et al., 2020; Thapa et al., 2018). The age-old pilgrimage to Kailash and Mansarovar (mainly) by Hindus is a non-material cultural and spiritual service offered by KSL. The increased tourism activities in KLS could potentially have trade-offs between household livelihood support (through tourism, hotel and trekking services) and climate change impacts (through waste generation and forest degradation for fuel and other purposes). Raising environmental awareness and developing sustainable tourism practices will help to minimise the unintended impacts of tourism. Climate change modelling in the KSL found that an upward shift in elevation of bioclimatic zones, decreases in area of the highest elevation zones, and large expansion of the lower tropical and subtropical zones can be expected by the year 2050 (Zomer et al., 2014). This change would indicate a major threat to biodiversity and a high risk of extinction for species endemic to these strata, or adapted to its specific conditions, especially for those species which are already under environmental pressure from land use change and other anthropogenic processes. For example, the decline in production of caterpillar fungus (*Ophiocordyceps sinensis*) - a highly valued, commercially traded medicinal plant in the region - is attributed to both overharvesting and climate change (Hopping et al., 2018), affecting livelihoods of local people. Conservation and sustainable development in KSL need to be tailored and modified considering the changing climatic conditions and shifting bioclimatic zones, ecoregions and species ranges in the landscapes. In addition, to achieve the twin goals of biodiversity conservation and climate change mitigation, apart from site specific interventions, policy and practice coordination among key stakeholders (government agencies, I/NGOs, local people) is needed to upscale the positive learnings from KSL to other part of the Hindu Kush Himalaya (Kotru et al., 2020).

CS 2	Cultural landscapes in Central Europe
	Biodiversity conservation in European cultural landscapes is heavily based on moderately used landscapes (Tieskens et al., 2017). A core component are wet and dry grasslands which harbour the highest diversity of many insects (with many endangered species), especially flower visiting groups which often are also pollinators. Maintaining high diversity requires grazing by or mowing for cattle, sheep, goats. Especially cattle are a well-known methane source and thus biodiversity conservation has some negative climate impacts (but low stocking densities, which are required for the habitat management, should be quantitatively negligible), more importantly, such open areas are not available for carbon sequestration through (re)forestation. The areas are culturally/economically important as a source of high-quality meat (beef), culturally for recreation (nature's beauty), economically as insurance for sustainable pollination under modified ecosystem states (e.g., pollinator replacement in crops under climate change).
CS 3	Irrigated rice terraces and forests in South-East Asia
	Conservation of natural forests in mountains of higher elevations in SE Asia (Indonesia, Vietnam, Philippines) guarantees water supply for the complex irrigated rice terrace systems, especially in areas with more pronounced dry seasons. As stability of terraces is dependent on continuous water supply, this continuity during dry seasons is guaranteed through the buffered (seasonally balanced) runoff of forests. In order to maintain these forests and their diversity the direct dependence of the land use system upon these is an important incentive for their preservation. The downside of the maintenance of the irrigated terraces is the methane they produce, the positive component is the diversity of human cultures, varieties and a contribution to food security (Settele et al., 2018). Irrigated rice agriculture has evolved over centuries and led to a well-balanced food web in paddies with an insect diversity even higher than in many (pristine) temperate forests. This diversity reduces the risk of pest outbreaks and stabilizes yield. Pesticides normally rather cause pest problems than solving them - and replacing irrigated rice with upland crops also puts stable production at risk. This often is combined with environmental pollution. Maintaining biodiversity in irrigated rice ecosystems stabilizes yields, but methane is a negative by-product of these systems, which often also act as wetland conservation sites within the Ramsar Convention.
CS 4	The Coral Triangle Initiative (CTI)
	A quarter of the world's marine biodiversity is concentrated in an approximately triangular region shared by six countries (Malaysia, Indonesia, Philippines, Timor-Leste, Solomon Islands and Papua New Guinea) (Veron et al., 2009). This region also is home to hundreds of millions of people who live largely coastally and depend on marine ecosystems for food and income (Foale et al., 2013). Both people and ecosystems are being threatened by a number of local (e.g., pollution, over-fishing) and global (e.g., sea-level rise, ocean warming and acidification) stressors (Burke et al., 2012). Sea level rise is a considerable challenge with ecosystems such as mangroves and seagrass beds, where shoreward migration can be thwarted by coastal development by humans leading to ‘coastal squeeze’ (Mills et al., 2016). Due to the rising impacts from these threats, and demonstrable decreases in the health of coastal ecosystems throughout the Coral Triangle, Indonesian President Susilo Bambang Yudhoyono and the other leaders of the 5 CTI nations proposed a multilateral partnership in 2007 to safeguard the coastal resources of the CTI along with the many coastal communities and economies. The CTI was one of the first marine transboundary conservation and socioeconomic initiatives, establishing large integrated zoning across the six countries (Weeks et al., 2014). Since 2007, the six CTI nations have worked collectively towards designating priority seascapes, applying ecosystem-based fisheries management, conservation planning, marine protected area networks, marine protected areas, marine reserves and multiple-use zoning, and actions to preserve threatened species (Asaad et al., 2018). Increasingly, regeneration and restoration projects have begun to replant mangrove forests with reciprocal benefits in terms of biodiversity and climate mitigation (reforestation, storage of carbon in stabilised sediments (Loh et al., 2018; Thorhaug et al., 2020; Alongi et al., 2016) and activities which benefit biodiversity (habitat for biodiversity, fisheries, nursery grounds). These benefits have the potential to stabilise coastal populations and reduce poverty, helping maintain biodiversity, protect people (Guannel et al., 2016), and healthy coastal economies under climate change (Hoegh-Guldberg et al., 2009). The actions taken by the Coral Triangle initiative are expected to affect a range of ecosystem services as well as biodiversity. For example, actions taken to protect mangrove, coral reefs and seagrass ecosystems, and thereby biodiversity, also lead the preservation of regulating NCPs such as the provision of fish habitat, removal of sediment, nutrients and pollutants from water running into coastal areas, as well as the maintenance of soils and muds, protection from storms and coastal wave stress.

	Other actions are expected to impact material NCPs, such as food and fisheries, fuel for fires, medicinal products, among other contributions (Friess et al., 2020). Many of the ecosystems along the coastlines of the Coral Triangle also play significant roles in the culture of many communities that occupy the coastal areas of the Coral Triangle. These non-material contributions are extremely valuable even though the strict economic evaluation of such benefits is often impossible (Barbier, 2017).
CS 5	Biodiversity-friendly cities and urban areas
	Safeguarding mangrove ecosystems in cities can conserve the rich biodiversity that resides in them as well as assist in climate change adaptation and mitigation. It is increasingly being demonstrated that blue carbon ecosystems including mangroves, seagrass meadows, intertidal mud flats, saltmarshes, etc., play a major role in aquatic carbon fluxes and hence, contribute greatly to global climate change mitigation (Bulmer et al., 2020). However, these coastal marine ecosystems in particular mangroves, coral reefs, etc., are also most profoundly affected by and vulnerable to climate change that cause sea-level rise and habitat destruction. These effects have a large negative impact on carbon sequestration and carbon stocks. It has been shown that even in a highly densely populated city like Singapore, mangrove forests that account only for a very small amount of Singapore's area can play a disproportionate role in carbon storage across the urbanized area compared to other urban forest types (Friess et al., 2015). Benefits of fringing mangrove ecosystems have also been documented in Mumbai, India (Everard et al., 2014). Upscaling from a city level, the carbon storage capacity in Indonesia's coastal wetlands including mangrove ecosystems and seagrass meadows is of global significance (Alongi & Mukhopadhyay, 2015). Coastal forested ecosystems including mangroves may store more than three times that of terrestrial forests (Alongi, 2014; Alongi & Mukhopadhyay, 2015; Donato et al., 2011), hence, helping in the mitigation of carbon emissions and augmentation of carbon stock. This could contribute to the offsetting of carbon emissions by anthropogenic activities associated with urbanisation, like residential, commercial and industrial land use. Hence, the higher carbon storage per unit area of mangroves compared to other vegetation types argues strongly for the conservation of mangroves in urban areas where trade-offs are crucial in decision-making. In addition to carbon sequestration throughout the year and acting as a carbon sink, mangroves contribute multiple benefits, including provision of habitats for biodiversity, coastal protection, food sources and roosts for migratory birds, nurseries for marine organisms, recreation, education, etc. This demonstrates how nature-based solutions like safeguarding and restoration of mangroves in coastal cities contribute significantly and synergistically to biodiversity conservation and climate mitigation (Alongi, 2014; Alongi & Mukhopadhyay, 2015).
CS 6	The Sundarbans (India-Bangladesh)
	The Sundarbans is the world's largest mangrove forest stretching over 10,263 km^2, located at the delta of the rivers Ganga, Brahmaputra and Meghna between Bangladesh (~60%) and India (~40%), which contains four protected areas designated as UNESCO's World Natural Heritage sites (one in India and three in Bangladesh). The biodiversity of this area, Bangladesh side alone, includes 355 species of birds, 49 species of mammals including Bengal tiger, 87 species of reptiles, 14 amphibians, 291 species of fish, and 334 species of plants (Mukul et al., 2019). It also serves as a large sink of CO_2. The Sundarbans is home to about 7.2 million people, half of which are landless and are dependent on rain-fed agriculture and provisioning services from mangroves for livelihoods (e.g., timber, honey, fish) (IUCN, 2017, 2020; Sannigrahi, Pilla, et al., 2020). While mangrove extent in the Sundarbans has remained stable to date with very little net loss, an overall negative trend was observed (Awty-Carroll et al., 2019). A part of highly degraded mudflats has been restored by the extensive utilization of native grass species (Begam et al., 2017). Habitat services, gas regulation, carbon sequestration, and disturbance regulations (e.g., against cyclones and storm surge) are often evaluated to be the most important ecosystem services (Sannigrahi, Pilla, et al., 2020; Sannigrahi, Zhang, et al., 2020), but the provisioning services (e.g. timber, fish) and cultural services (e.g. tourism) are often prioritized in practice for revenue generation for locals (Uddin et al., 2013). Similarly, non-food ecosystem services such as water availability and quality have deteriorated since the 1980s while improved food and inland fish production contributed to reducing the population below the poverty line (Hossain et al., 2016). There are trade-offs between the pursuit of material benefits for local livelihood and regulating benefits (climate mitigation and water quality) through mangrove conservation. Recently, the mangroves and wildlife of the Sundarbans are becoming increasingly vulnerable to the combination of natural and anthropogenic direct drivers such as cyclone, sea-level rise, soil and water salinization, and flooding, industrial and urban development, embankment construction, aquaculture development and poaching of wildlife (Mehvar et al., 2019; Mukul et al., 2019; Sánchez-Triana et al.,

	2018). Among the total loss of 107 km^2 of mangroves between the year 1975 and 2013, 60 % was lost due to water erosion and 23 % was converted to barren lands, and the potential CO_2 emission due to the loss and degradation of mangroves was estimated to be 1567.98 ± 551.69 Gg during this period (Akhand et al., 2017). The Sundarbans stretch across two countries and socioeconomic activities in one country, whether within or outside of the Sundarbans, affects the ecosystems and ecosystem services of the Sundarbans in the other. Although the importance of transboundary cooperation has been recognized and the Memorandum of Understanding between Bangladesh and India on Conservation of the Sundarbans was signed in 2011, there has been no formalized joint management and surveillance protocol of the protected areas implemented to date (IUCN, 2017, 2020).
CS 7	Southern Ocean South Georgia Island
	South Georgia is a remote (UK overseas territory) island at the northernmost limit of the Southern Ocean, in the Atlantic sector. It is an extremely important site for biodiversity being a critical site for many whales, seals and many seabirds, including the most important site for iconic species such as the Wandering Albatross (Rogers et al., 2015). There are very few non-indigenous invaders, most species are endemic, and there are more species known than around Galapagos (Hogg et al., 2011; Rogers et al., 2015). Two key biodiversity-focused change action measures at different scales have changed species survival prospects and climate mitigation potential. The global moratorium on whaling has particular significance at the baleen whale hotspot of South Georgia. Those waters are key feeding grounds and have just revealed recovery levels, e.g., of blue whales (Calderan et al., 2020) which are also key carbon stores. The fishery (e.g., for Patagonian Toothfish) around SG has become one of the most tightly restricted. Very few vessels are accepted for licensing in the fishery, each is tracked, has an observer and unique hooks (so their presence in seabirds can be traced). This limited fishery now takes place in one of the world's largest Marine Protected Areas. With no bottom trawling or shallow longlining, the high surface productivity can be converted to benthic carbon storage, with crucially high genuine sequestration potential (Barnes & Sands, 2017). Such work has shown that seabed biodiversity hotspots are coincident with those of blue carbon storage and sequestration potential. The Marine Protected Area created around South Georgia is one of the world's biggest and encapsulates a hotspot of endemism, population of endangered iconic species (e.g., wandering albatross), an important carbon sink of oceanic productivity and one of the tightest regulated fishery and tourism industries. In many ways it represents a model of minimising impacts on biodiversity and ecosystem services in a climate change hotspot.
CS 8	Marine Biodiversity Beyond National Jurisdiction, South Orkney Islands
	Approximately 60% of ocean is area beyond national jurisdiction (ABNJ), but because most of this is remote ocean or polar land it can be societally 'out of sight and mind'. Such areas hold 50% of oceanic primary productivity and an important fraction of the planet's biodiversity and very significant current and future climate mitigation in the form of carbon storage. Global to local initiatives (within jurisdiction) have attempted to reduce biodiversity threats. For example, plastic waste reduction can have a disproportionately high (positive) effect in the high seas, as it is a massive sink. Specific actions focussed beyond ABNJ have included the recent establishment of High Seas Marine Protected Areas, such as south of the South Orkney Islands and part of the Ross Sea, both in the Southern Ocean (Trathan et al., 2014). Such areas could be major targets of emerging mesopelagic fisheries and marine mining. The aim has been to safeguard unique and important areas with high seabird, seal and cetacean concentrations but also have anomalously high richness of endemic invertebrates and strong ecosystem services. The South Orkney Islands are a polar hotspot of carbon capture and storage, and unlike lower latitude hotspots, this is a rare and valuable negative feedback on climate change (Barnes et al., 2016). Thus, protection of the South Orkney islands has added climate mitigation value beyond the natural capital of existing blue carbon storage because climate-forced glacier retreat and sea ice losses are increasing phytoplankton blooms (Arrigo et al., 2008) and consequently benthic carbon storage (Barnes et al., 2016) there. Safeguarding hotspots of biodiversity and carbon sequestration is particularly difficult when it requires unanimous agreement from multiple nations, so there are few high seas protected areas – despite representing much of planet Earth. Amongst the world's first, around the South Orkney Islands, has >1200 species across 24 phyla, most are endemic, only two are non-native and it is a recognized polar carbon sequestration hotspot, due to highly productive ecosystem services.

CS 9	Bush encroachment, Southern Africa
	Disturbance-driven tropical ecosystems generally have much lower standing biomass than is potentially the case in the absence of disturbance (Bond et al., 2005). Wildfire and browsing pressure maintain these systems in an “open” condition, and has done so for millennia, resulting in the iconic grassland and savanna landscapes and forest-averse diversity of tropical Africa, South America, and Australasia. Substantial conservation effort is associated with maintaining high value nature-based tourism in Africa (in a range of areas), but this applies to a lesser extent on other continents. A substantial portion of these lands have been targeted by aspirational afforestation programs, creating, in certain areas, a conflict between mitigation and biodiversity outcomes on a global scale (as well as with implications for forest-water interactions). In some of these regions, a poorly understood mix of management actions and climate change drivers, including (but not limited to) increasing CO_2 fertilization of tree growth, is leading to the conversion of these open ecosystems to a state of bush encroachment (Stevens et al., 2017), with, amongst other impacts, reduced palatability and grazing capacity. Experimental efforts using extreme fires and mechanical harvesting have been tested as a way of reversing these trends (Joubert et al., 2012; Smit et al., 2016). The expected effects on biodiversity include reduced success of multiple species dependent on open, disturbance driven systems. Examples include the plains fauna of Africa, with clear direct impacts already visible for vulture, cheetah, and a myriad of smaller grassland bird species. Birds of woodlands and forests appear to be increasing in abundance in these regions. There are potentially substantive mitigation implications. In Namibia, for example, the extent of natural afforestation by bush encroachment is sufficiently large to offset national fossil fuel emissions (Ministry of Environment and Tourism, 2011). Maintenance of these open ecosystems will ensure the persistence of disturbance driven habitats, with important effects on landscape level water use (e.g., Creed et al., 2019) and the maintenance of lower intensity wildfire regimes. Open ecosystems also provide multiple material services centered on subsistence livelihoods, including extensive grazing and thatching, and the irreplaceable cultural elements associated with these lifestyles. Afforestation using non-indigenous tree species, in order to generate higher growth rates, has been shown to degrade almost every ecosystem service mentioned above, leading to woody plant invasions, drying up water flows, intensifying fire regimes, reducing biodiversity, and destroying historical livelihoods (Creed et al., 2019; McNulty et al., 2018). Recognition of the natural cooling effects of high albedo, and the plethora of ecosystem services under threat in tropical open ecosystems would provide opportunities for sustainable management of these systems for both local and global benefit. In South Africa, active removal of woody encroachers has created millions of job opportunities and slowed encroachment and protected endemic diversity over hundreds of thousands of hectares (van Wilgen et al., 2012).

CS 10	Amazonian rainforest
	The Amazon rainforest is more than a case; it is key to understanding the biodiversity-climate interlinkages at a global scale. The region harbours an impressive number of species, provides ecosystem services that operate at the planetary scale, many of them directly related to climate (i.e., carbon storage, water cycling), across nine countries where around 30 million persons live with different cultures (Joly et al., 2018). The Amazon is responsible for delivering all sorts of ecosystem services, despite essential gaps in the scientific literature (Pires et al., 2018). Forest products, such as ‘açai’, are responsible for mobilizing more than US$ 1.5 billion y^{-1} (Scarano et al., 2020), but with an unexplored potential. Although recent estimates predict that the biome has around 82% of its original vegetation (Lapola et al., 2014), it is quickly losing its ability to provide services (Solen et al., 2018). Deforestation is the most critical threat to the biome and triggers several processes that speed up its degradation (i.e., forest fires, ‘savannization’, drought) (Barlow et al., 2020; Nobre & Borma, 2009). In 2020, Brazil registered a total of 76.674 km^2 lost due to fire in the biome, which is equivalent to the area of Panamá. Deforestation in the biome is centred in the Brazilian portion and along the Andean piedmont caused mainly by the expansion of cattle and soybean production (Malhi et al., 2008). Although around 29% of the biome is in protected areas in Brazil, including indigenous lands, its management fails in preventing deforestation (Joly et al., 2018). The biome faces other critical land-use pressures that can compromise the biodiversity therein and climate-related services. The building of big dams is expected to cause a substantial increase in the carbon dioxide (81 to 310 Tg of CO_2) and methane release (9 to 21 Tg of CH_4) (de Faria et al., 2015). It is expected that in specific conditions, carbon emission of such a ‘clean energy’ production can be compared to fossil-based power plants (de Faria et al., 2015; Fearnside, 2016). Mining is another driver of change in the biome that threatens biodiversity and human livelihood (Rosa et al., 2018). Thus, to conserve and manage protected areas, restoring degraded lands and strategic land planning in the region are identified as the main actions able to protect biodiversity and ecosystem services, at the same time as promoting climate mitigation (Soares-Filho et al., 2010). Ensuring efficiency in the implementation of these protected areas is conditional on promoting such mitigation impact (Brienen et al., 2015; Phillips et al., 2017). For example, planning in the establishment of dams in the region could effectively reduce carbon emission and present better cost-benefit strategies (Almeida et al., 2019). In this sense, the role of local and indigenous people is fundamental to protect forest areas and ensure those benefits (Joly et al., 2018). Land degradation in indigenous lands is lower than in other categories of protected areas, and it is the most effective land tenure in reducing carbon emissions (Soares-Filho et al., 2010). The participation of traditional and indigenous people on the decision processes will help to protect the Amazon and reach the ambitious planetary environmental targets in the coming years.

CS 11	Pleistocene Park, Northeastern Siberia
	Pleistocene Park (PlPark) was established to re-wild the mammoth steppe in the Kolyma river lowland north of the Arctic Circle near Chersky, Northeastern Siberia (Kintisch, 2015; Zimov, 2005). It was revealed that simultaneous prevention or at least postponement of permafrost thawing can be achieved. In 1996, a 2000-hectare area was fenced, and different herbivores (elk, moose, reindeer, yakutian horses, musk oxen, yaks and bison) were introduced into this park in order to study their effect on plant species composition, vegetation productivity, and soil temperature regime (Beer et al., 2020). PlPark and the associated Northeast Science Station, in addition to the scientific advances made by the staff, provide a year-round base for international research in arctic biology, geophysics and atmospheric physics and serve as a teaching lab for undergraduate and graduate students (Kintisch, 2015). There is also a potential for employment and new tourism economies (Macias-Fauria M. et al., 2020). Winter grazing and movements by the animals compact snow, thereby substantially decreasing the thermal insulation efficiency of snow. This allows much colder freezing of soil in winter, hence colder overall mean annual soil temperature. In the PlPark, an herbivore density of 114 individuals per km^2 led to an overall average reduction of snow depth by 50%. The mean annual difference of soil temperature at 90 cm depth inside and outside the PlPark is −1.9 °C (Beer et al., 2020). Large herbivores grazing pressure on Arctic tundra ecosystems can have a positive effect on carbon dynamics by changing the plant species composition—including tundra herbs and shrubs, and boreal trees—by selectively foraging. Decrease in shrub cover and leaf area increases summer albedo (Cahoon et al., 2012; Falk et al., 2015; Schmitz et al., 2018; Beest et al., 2016), however it decreases CO_2 uptake (Schmitz et al., 2018) and decrease shading of the soil surface, so increases soil temperature. Megafauna in the Arctic promote grass establishment in slowly growing wet moss/shrubby tundra and allows a revival of a sustainable, highly productive ecosystem. Besides, grasses reduce soil moisture more effectively than mosses through high rates of evapotranspiration (Macias-Fauria et al., 2020). This process already takes place in PlPark. Establishment of high productivity grasslands on the big territory can be a long-term sustainable mechanism for absorption of GHGs from the atmosphere and carbon storage by soil, hence contributing to carbon sequestration in the Arctic. However, CH_4 release by large animals could have a negative effect on carbon cycle (Falk et al., 2015; Schmitz et al., 2018). Benefits and trade-offs of large herbivores grazing for climate change mitigation in the Arctic depend on ecosystem type, grazing pressure, time scale and/or grazer community (Falk et al., 2015; Ylänne et al., 2020). To better understand and quantify interaction of all the processes involved, future monitoring and research is needed (Macias-Fauria et al., 2020). Soil cooling effect, albedo increase, and additional carbon sequestration may prevent or at least postpone permafrost thawing. Such ecosystem management practices could be scaled up in Arctic permafrost areas and play a significant role as an ecosystem-based solution for global climate change mitigation strategy.
CS 12	African peatlands
	African peatlands are located mainly in African tropical forests where high rainfall and limited drainage support the accumulation of peat deposits. The peatlands of the central Congo Basin cover roughly 145,500 km^2 and store about 112.2 $GtCO_2e$ of carbon (Dargie et al., 2017). The peatlands support unique and iconic biodiversity, much of which is undocumented (e.g. fish, plant and invertebrate species), but including well documented populations of large vertebrates like lowland gorilla, forest elephant, chimpanzee, and bonobo (Fay & Agnagna, 1991; Inogwabini et al., 2012; Rainey et al., 2010), and smaller vertebrates including monkeys and dwarf crocodile (Riley & Huchzermeyer, 1999). These lands sustainably support indigenous populations that rely on small scale agriculture and fishing (Dargie et al., 2019). Current land use change includes active drainage and deforestation, which reduces carbon stocks above and below ground (Hooijer et al., 2010; Könönen et al., 2016), and can introduce wildfire (Jauhiainen et al., 2012). While indigenous use appears sustainable, new concessions for palm oil production that may be encouraged by international funding and incentives, new road development, hydrocarbon exploration, and planned water transfer schemes in the Congo Basin (Dargie et al., 2019) induces significant degradation of this carbon store. Only 11% of peatlands (16,600km^2) is located within nationally recognised protected areas. (Dargie et al., 2019) propose that conservation and mitigation objectives could be supported by climate, biodiversity and development funding, with clear synergistic benefits between these apparent in this case study.

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