SMOKE ON WATER

COUNTERING GLOBAL THREATS FROM PEATLAND LOSS AND DEGRADATION

Global Peatlands Initiative

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COUNTERING GLOBAL THREATS FROM PEATLAND LOSS AND DEGRADATION

A RAPID RESPONSE ASSESSMENT
REVISED EDITION

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Foreword

More than 180 countries have peatlands but we are only just starting to understand their role in both climate change and our efforts to curb it. Peatlands cover less than three percent of the Earth's surface but are the largest terrestrial organic carbon stock – storing twice as much carbon as in the world's forests. In fact, greenhouse gas emissions from drained or burned peatlands account for five percent of the global carbon budget. This first report from the Global Peatlands Initiative highlights why the threat to peatlands from agriculture, forestry, resource extraction and infrastructure development is a threat to the climate.

The Global Peatlands Initiative was created in 2016 because of the urgent need to protect these valuable assets. Leading experts and institutions are now working together to prevent this enormous carbon stock being emitted into the atmosphere. There is still uncertainty about the precise carbon stock value of peatlands because their extent, status and dynamics have never been globally mapped with sufficient accuracy. However, this report shares the knowledge of 30 experts and contributors from 15 organizations to explain both the need and the opportunities to rapidly protect and restore them.

Healthy peatland ecosystems are important to societies everywhere. While many European nations are beginning to see their peat resources as a vital carbon pool, recent discoveries elsewhere are pushing us all into action. For example, last year, an international team of scientists mapped the world's biggest tropical peatland in Cuvette Centrale in the Congo Basin. It contains around 30 gigatonnes of carbon, which is as much as the United States economy emits in 15 years. And, earlier this year, I travelled to Indonesia to learn more about the impact of repeated peatland fires and the ambitious strides the country is taking to tackle them. For people like Thrmrin, a Malay elder, this is not about scientific or political progress; it's about lifting his community out of poverty. Although Thrmrin's grandparents were poor, learning English let him work as a guide, showing tourists the peatland and lake being restored by the community. Now the village has a school and they are proud to share the culture with visitors, so his own grandchildren have a much brighter future ahead.

Thrmrin

I hope that the knowledge and experiences shared in this report will be a practical support for the many governments, businesses and communities working to restore and protect our peatlands. If they succeed, it won't just be the thousands of people who live near them that benefit, it will be the seven billion people who live on a planet that desperately need protection from the impact of climate change.

Erik Solheim
Under-Secretary-General of the United Nations
and Head of UN Environment

The Cuvette Centrale is the world's biggest tropical peatland, located in the Congo Basin. It contains around 30 gigatonnes of carbon, which is as much as the United States economy emits in 15 years.

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Executive summary

Peatlands are among the world's most underappreciated natural treasures. Found on every continent, these waterlogged ecosystems are among the most important carbon reservoirs on the planet.

Composed of thick peat layers of partly decomposed organic material that may have formed over thousands of years, peatlands are highly effective at storing carbon.

If properly maintained, peatlands are wet – it is this waterlogged nature that gives them many of their unique and valuable characteristics, and makes them some the most efficient terrestrial ecosystems in storing carbon. On average, each hectare of peatland holds 1,375 tonnes of soil carbon – about 10 times more than normal mineral soil (Joosten & Couwenberg, 2008; Parish et al. 2008).

While covering only three percent of the Earth's land mass, they contain as much carbon as all terrestrial biomass combined, twice as much as all global forest biomass, and about the same as in the atmosphere.

Despite the fact that peatlands are often seen as mostly unproductive land, they offer incredible value beyond their carbon storage ability. They provide many "ecosystem services" such as flood control, water purification and habitats for unique and varied biodiversity. Peatland ecosystems support a wide range of plants, birds and animals, including endemic and endangered species – such as the orangutans found in the tropical peatlands of South East Asia, bonobos and western lowland gorillas found in the Congos and the Aquatic Warbler of central and northern Europe. They are also a home to a wide range of native foods, economically important trees, and the peat itself has a long history as a source of fuel.

Peatlands have so far been identified in 180 countries and they occur extensively in both the northern and tropical zones of our planet. They usually form in depressions where water permanently accumulates, either sustained by rainwater or underground sources. A lack of oxygen in the waterlogged environment slows decomposition of organic matter, leading to the accumulation of peat layers. However, across the globe peatlands are under threat from drainage and burning for agricultural, forestry and development uses. Fifteen percent of reserves are currently understood to be either destroyed or degraded.

In this state, peatlands release the carbon historically locked within the layers of decomposed organic matter. They are thought to contribute up to five percent of the global annual CO_2 emissions. Half the world's peatland emissions come from Southeast Asia where high rates of deforestation, drainage and high temperatures speed up decomposition of the drained peat. Managing the remaining global peatlands is therefore an urgent issue that requires increased research to create a comprehensive inventory of their location and size.

Draining and clearing land for agriculture has been the main threat to peatlands. Historically, Europe has seen the greatest drainage but its expansion has now largely stopped. However, the clearing of tropical peatlands is expanding rapidly, both for agriculture and, in the case of Indonesia, the relocation of landless people to manage population growth and increasing urbanization. Initially, the organically rich peat soil can be highly productive but the generally low level of nutrients means they are quickly exhausted.

Draining peatlands is a method often used to maximize agricultural use of the soil, but this leaves them vulnerable to fire which can significantly increase greenhouse gas emissions. Peat fires can burn for a long time and the smoke carries particulate matter into the atmosphere which can adversely affect human health. Drained peatlands also subside. In coastal areas, this subsidence can lead to salt water intrusion leaving the land completely unproductive and potentially leading to the contamination of the water table.

Ultimately, peatland drainage can have adverse long term economic and social impacts that are more significant than the initial short-term benefits received from land conversion.

Climate change is leading to increasing temperatures, longer and more intense dry seasons and changes in patterns of cloud cover, rainfall and fire frequency. All of this is likely to increase pressure on peatland ecosystems, especially on those that are already degraded.

Yet peatlands can play an important role in climate change mitigation by providing secure long-term storage of carbon. However, to allow them to play this role requires putting an end to their drainage and restoring already degraded peatland areas.

There are a growing number of initiatives around the globe that aim to make peatlands productive without the need for draining. These include the sustainable production of

food, such as fish, feed for animals, fibre and fuel. Peatland management needs to allow for multiple users and activities that are compatible with conservation and restoration. This requires focused action that includes: the development of effective international and national policy, the establishment of fiscal mechanisms and frameworks to support research and conservation activities, and the development and adoption of best practice management.

To help achieve these outcomes, this report assesses the extent of peatlands in the tropics, the threats they face and the action being taken to preserve them.

Main Messages

1. Peatlands are important to human societies around the world. They contribute significantly to climate change mitigation and adaptation through carbon sequestration and storage, biodiversity conservation, water regime and quality regulation, and the provision of other ecosystem services that support livelihoods.

2. Immediate action is required to prevent further peatland degradation and the serious environmental, economic and social repercussions it entails. Existing options to tackle the issue vary, and for that reason implementation should be regionally adapted to local environmental, economic and social needs and characteristics.

3. A landscape approach is vital and good practices in peatland management and restoration must be shared and implemented across all peatland landscapes to save these threatened ecosystems and their services to people.

4. Local communities should receive support to sustainably manage their peatlands by preserving traditional non-destructive uses and introducing innovative management alternatives.

5. A comprehensive mapping of peatlands worldwide is essential to better understanding their extent and status, and to enable us to safeguard them. Research and monitoring should be improved to provide better maps and tools for rapid assessment and transparent use of them to underpin action and multi-stakeholder engagement.

Introduction

If we want to protect forests and life on land, safeguard our oceans, create massive economic opportunities, prevent even more massive losses and improve the health and well-being of the planet, we have one simple option staring us in the face: climate action.

– UN Secretary-General, Antonio Guterres (31.05.17)

The world's peatlands are under threat from drainage for development ranging from conversion for use for agriculture, forestry, resource extraction and infrastructure development and this has enormous implications for climate action. On average, peatlands hold 137,500 tonnes of carbon per square kilometre (1,375 tonnes per hectare) making them the most carbon dense of any terrestrial ecosystem in the world (Joosten & Couwenberg, 2008). In other words, the amount of carbon held in a single hectare of wet peatland is equivalent to the annual emissions of 1,400 passenger cars.

Global Peatlands Initiative

The Global Peatlands Initiative (GPI) is an international partnership formed in 2016 to save peatlands as the world's largest terrestrial organic carbon stock. The Initiative partners are working to improve the conservation, restoration and sustainable management of peatlands to protect this critical ecosystem and to prevent the carbon it stores from being released into the atmosphere. Peatlands are unique ecosystems that have a critical role in the landscape and provide essential ecosystem services. Drawing attention to peatland issues and helping countries and partners to understand and make evidence-based decisions about their management will enable the Initiative to contribute to several Sustainable Development Goals by reducing greenhouse gas emissions, maintaining ecosystem services and securing lives and livelihoods while improving people's' ability to adapt to change.

This Rapid Response Assessment is a key step on the road toward the Initiative making an impact and advancing climate action. It focuses on raising awareness and stimulating an exchange between decision makers and stakeholders on the importance of peatlands and the contributions they make to climate, people and the planet.

Seen from this perspective, peatlands are one of our greatest allies in the fight against climate change. By conserving and restoring peatlands we can reduce global emissions and revive and conserve this natural carbon sink.

Peatlands in pristine condition lock in carbon, however, degraded peatlands are strong net emitters of greenhouse gases. These emissions continue as long as the peatland remains drained and the peat continues to oxidize. This process can last for decades or centuries and is very different from the instantaneous emissions that come from clearing forests. Conserving pristine peatlands, as well as restoring and improving the management of peatlands and other organic soils, contributes to the reduction of greenhouse gas (GHG) concentrations in the Earth's atmosphere. Peatlands are also important for food security and poverty reduction (FAO & Wetlands International, 2012).

Current greenhouse gas emissions from drained or burning peatlands are estimated to be up to five percent of all emissions caused by human activity – in the range of two billion tonnes of CO_2 per year. If the world has any hope of keeping the global average temperature increase under two degrees Celsius then urgent action must be taken to keep the carbon locked in peatlands where it is – wet, and in the ground to prevent an increase in emissions. Furthermore, already drained peatlands must be rewetted to halt their ongoing significant emissions. However, this is not as simple as it seems. Knowing the location of peatlands continues to be a challenge.

What are peatlands?

Peatlands are known by many names, including the English terms mire, marsh, swamp, fen and bog. The variety in terminology reflects the diversity of peatland habitats and ecosystems (Rydin & Jeglum 2013). Whereas peatlands can simply be defined as "land with peat", there is currently no globally accepted standard how much organic material "peat" should contain or how thick the layer of peat should minimally be.[1] Both the diversity and the lack of a common standard have made it difficult to identify and collate data and information about them.

Even though they look different, all peatlands share a common feature: they have a surface layer of peat which has been formed because permanently waterlogged conditions have prevented the complete decomposition of dead plant material (Joosten & Clarke, 2002).

> Peat is a substance that is largely composed of plant remains (vascular plants and mosses) which are only partly decomposed due to an absence of oxygen in a water-saturated environment.

Peat is a compact, high density carbon store that, if managed properly, can be a win for climate action. Historically – and in modern times – wetlands have been seen as wastelands to be drained and converted for more useful purposes, such as agriculture. Development meant draining and in some parts

1. Varying with country and scientific discipline, peat has been defined as requiring a minimal content (by dry weight) of 5, 15, 30, 50, or 65% of organic material, whereas peatlands have been defined as having a minimum thickness of 20, 25, 30, 40, 45, 50, 60 or 70 cm of peat (Joosten et al. 2017).

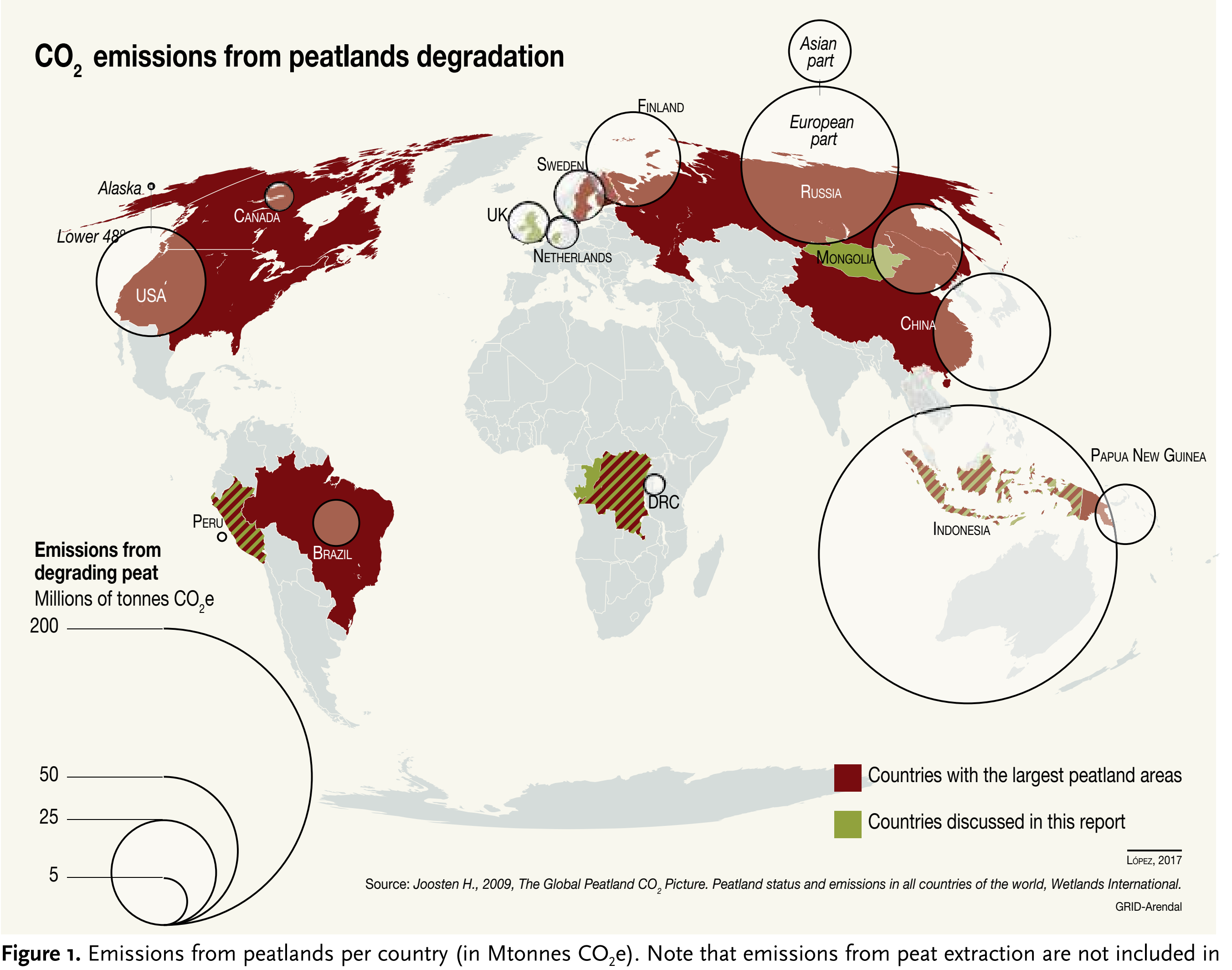


Figure 1. Emissions from peatlands per country (in Mtonnes CO_2e). Note that emissions from peat extraction are not included in the calculations for European countries.

of the world this idea is still prevalent. The phrase "drain the swamp" has even become a political metaphor. It is vitally important to recognize that peatlands are not wastelands but essential ecosystems that deliver unquantified benefits, and that protecting them or using them with care does not impinge on development. Developmental choices need to consider that while peatlands represent a relatively small area of overall landmass, they have a disproportionately large carbon storage capability and other benefits that they deliver to climate, people and the planet.

The map in Figure 1 only tells part of the story because it only reflects emissions from biological oxidation of peat – emissions from fires are not included. Fires, such as those in Russia and Indonesia, contributes another 30 percent to these emissions.

Biological oxidation of peat occurs only when peatlands are drained and degraded. When the water level is lowered, the peat is no longer water saturated, oxygen enters the peat and microorganisms break it down. Previously well-preserved carbon and nitrogen are then released as greenhouse gases into the atmosphere, and as nitrate to the surface water. Only 15 percent of the world's peatlands have been drained yet they are responsible for five percent of all global anthropogenic greenhouse gas emissions (Joosten, 2015).

Where are peatlands found?

Peatlands are globally important ecosystems and are found in an estimated 180 countries (Parish et al., 2008). Although we know that peatlands are found all over the world, there is no comprehensive mapping of their locations. This is because many peatlands have not been recognized as such and have yet to be properly mapped. To ensure peatlands remain intact, better knowledge and maps are needed on their typology, location and extent.

Figure 2 does not reflect the true global extent of peatlands because of the challenges faced in finding and defining them. The consensus among scientists is that there are extensive areas of undiscovered and unreported peatlands. Recent modelling studies indicate that there could be three times more tropical peatlands than current estimates (Gumbricht et al., 2017). This is supported by the recent documentation of huge areas of previously unquantified and unclassified peatlands in Africa and South America. In early 2017, scientists announced that they had mapped the largest peatland complex in the tropics – the Cuvette Centrale swamp forest in the Congo Basin – estimated to cover 145,000 km^2 and containing more than 30 billion tonnes of carbon (Dargie et al., 2017). Similarly, peatlands mapped in the lowlands of the Peruvian Amazon in South America are estimated to cover 120,000 km^2 containing an estimated 20 billion tonnes (Lähteenoja et al., 2011).

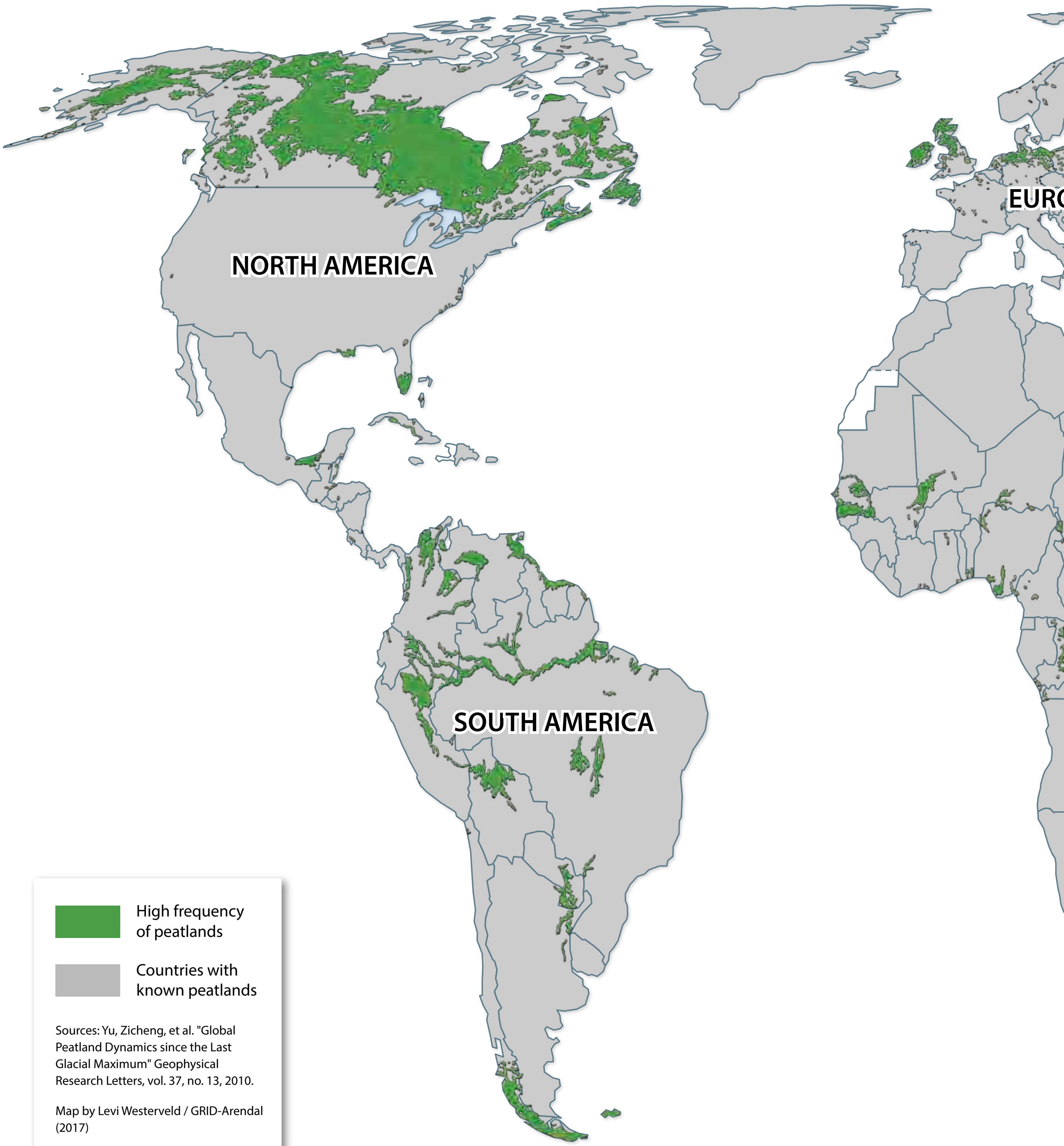


Figure 2. Distribution of global peatlands.


OPE
ASIA
AFRICA
OCEANIA

In September 2015 the world laid out an ambitious Agenda for Sustainable Development and a set of aspirational Sustainable Development Goals (SDGs) to "end poverty, protect the planet, and ensure prosperity for all" (UN, 2015). However, the increase in fire vulnerability of peatlands in countries like Indonesia and Russia has major impacts on their ability to meet the SDGs. This means that these and other countries with degraded peatlands will have to examine the best options to prevent further emissions while pursuing their options for sustainable development, including agricultural expansion and economic development, in order to achieve all of the SDGs. Peatlands must be treated as lands with a high climate mitigation potential that also offer strong opportunities for climate adaptation, biodiversity conservation and contribute significantly to sustainable development. (Wetlands International, 2015) (See appendix for additional information on the SDGs and peatlands.)

Tables 1 and 2 list the top 20 countries in terms of estimated peatlands extent and peat carbon.

Smoke on water

It is important to not be distracted by discussions about definitions and organic soil classifications, or the lack of comprehensive peatland maps. The message is clear: any amount of peat is significant and efforts need to be made to preserve it in an intact state.

This rapid response assessment is a call to action by the Global Peatlands Initiative. Both established and emerging science sends us a message to act now and to make the right policy and developmental choices.

It is an urgent call to decision-makers to acknowledge the importance of peatlands.

It is a call to actors to identify and halt actions that drive the degradation of peatlands, a call to policy makers to take note and inspiration from the solutions and innovations presented here.

It is a call to join in the Global Peatlands Initiative and chart a way forward for solid climate action – for the people and the planet.

Table 1. Top 20 countries with the largest peatland areas[2,3] (Adapted from Joosten 2010).

	Country	Peat area (sq. km)
1	Russia	1 375 690
2	Canada	1 133 926
3	Indonesia	265 500
4	USA	223 809
5	Finland	79 429
6	Sweden	65 623
7	Papua New Guinea	59 922
8	Brazil	54 730
9	Peru	49 991
10	China	33 499
11	Sudan	29 910
12	Norway	29 685
13	Malaysia	26 685
14	Mongolia	26 291
15	Belarus	22 352
16	United Kingdom	17 113
17	Germany	16 668
18	Republic of Congo	15 999
19	Zambia	15 410
20	Uganda	13 640

Table 2. Top 20 countries with the largest peat carbon stocks (Mtonnes C) 2008[4] (Adapted from Joosten 2010).

	Country	Peat carbon stock
1	Canada	139 819
2	Russia	124 762
3	Indonesia	48 993
4	USA	26 454
5	Papua New Guinea	5 427
6	Brazil	4 934
7	Malaysia	4 926
8	Finland	4 802
9	Sweden	4 535
10	China	2 924
11	Norway	2 023
12	Germany	1 830
13	Venezuela	1 799
14	Sudan	1 796
15	United Kingdom	1 583
16	Republic of Congo	1 451
17	Mexico	1 345
18	Uganda	1 198
19	Belarus	1 184
20	Democratic Republic of the Congo	1 079

2. This table does not include recent discoveries in the Congo Basin and Peru.
3. To provide a uniform standard, the data concern peatlands with a minimum peat depth of 30 cm (historically based on ploughing depth). This criterion excludes many (sub)Arctic and (sub)alpine areas with a shallow peat layer.
4. This table does not include recent discoveries in the Congo Basin and Peru.


Russia


China


Latvia


Kenya


Tasmania


Mongolia

Focus on Mongolia – Peatlands fulfilling a need

Mongolia is mainly associated with steppes and deserts but also has a surprisingly large expanse of peatlands (Joosten et al., 2012). In its dry continental climate Mongolian peatlands fulfill many important ecological functions: they feed rivers, maintain humid and highly productive habitats, and prevent soil erosion and the thawing of permafrost.

All of this contributes to biodiversity conservation as well as human livelihoods (e.g. timber and non-timber forest products) (Joosten et al., 2012; Minayeva et al., 2005a; Narangerel et al., 2017). Peatlands also help maintain groundwater levels which are crucial for forest ecosystems and crop production (Minayeva et al., 2005b). In Mongolia's highland areas, peatlands are critical to sustaining the permafrost as they are the only source of water and river flow (Assessment Report, 2017).

Despite their importance, Mongolia's peatlands are poorly represented in global inventories of peat resources (Minayeva et al., 2005), and the little research that has been done on them has typically been conducted by Mongolian, Russian and German scientists, with the result that little information is available in English (Minayeva et al., 2016). It is estimated that Mongolian peatlands contain about 750 megatonnes of carbon and that degraded areas emit 45 megatonnes of CO_2 per year (Parish et al., 2008).

In terms of their distribution, peatland coverage varies across the country with most being concentrated in the northern, central and the most easterly areas. A detailed mapping of their extent across the country was initially carried out in the 1950s, and historically an estimated 1 percent or 27,200 km^2 of Mongolia was covered in peatlands (Minayeva et al., 2005b). This is thought to have declined by 60 to 80 percent since then, depending on the region.

Peatlands are mostly found in areas with permafrost (Figure 3). They are associated with both lower slopes and highland areas within the steppe, forest steppe and taiga belt ecosystems, and in river valleys in the lowland steppe (Minayeva et al., 2016). Half of the country's peatlands are covered sedge fens, which provide highly productive pastures (Minayeva et al., 2016).

Over 400 species of vascular plants have been reported within Mongolian peatlands, which represents about 18 percent of all plant species recorded in the country (Minayeva et al., 2016; Parish et al., 2008). Peatlands are also home to significant sites along bird migration routes (flyways), and are thus important for many species including the critically endangered Siberian crane (*Leucogeranus leucogeranus*). Peatlands also host other areas of international importance for the conservation of biodiversity with mammals, birds, reptiles and amphibians, including those threatened with extinction, found in peatland forests (Narangerel et al., 2017).

Peatland use and conservation in Mongolia

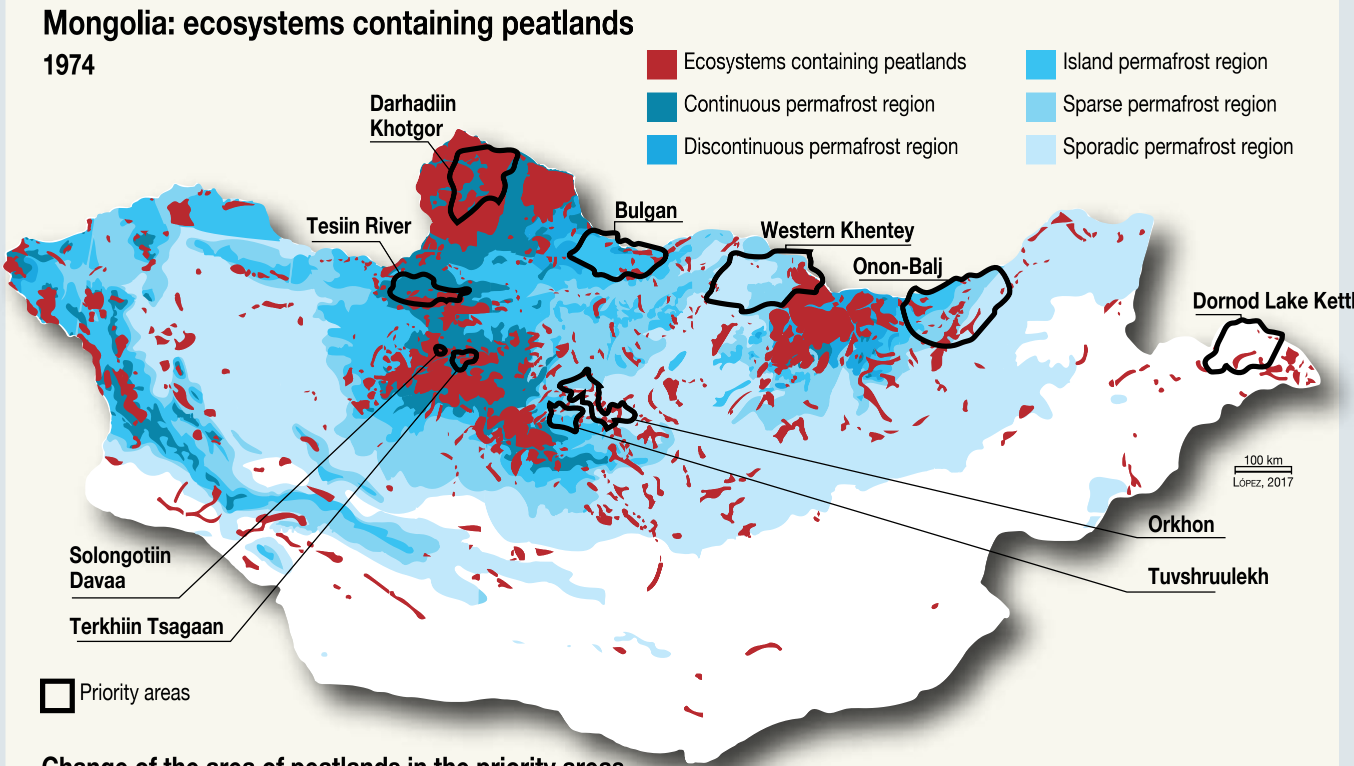
Given that some of the most productive lands in the country are found on peat soils, peatlands are mainly used as arable lands and for grazing (Assessment Report, 2017). Disturbance from road construction, upstream mining and dam construction are increasing the vulnerability of peatlands throughout the country. The largest problem is that thawing permafrost, which is initially caused by human activities such as mining or by rising temperatures, accelerates peatland degradation. The amount of land affected has alarmingly doubled during the last 50 years (Jambaljav, 2016). There is an absence of detailed knowledge about peatlands' diversity, distribution and natural functions in Mongolia – the kind of information needed to support sound management decisions.

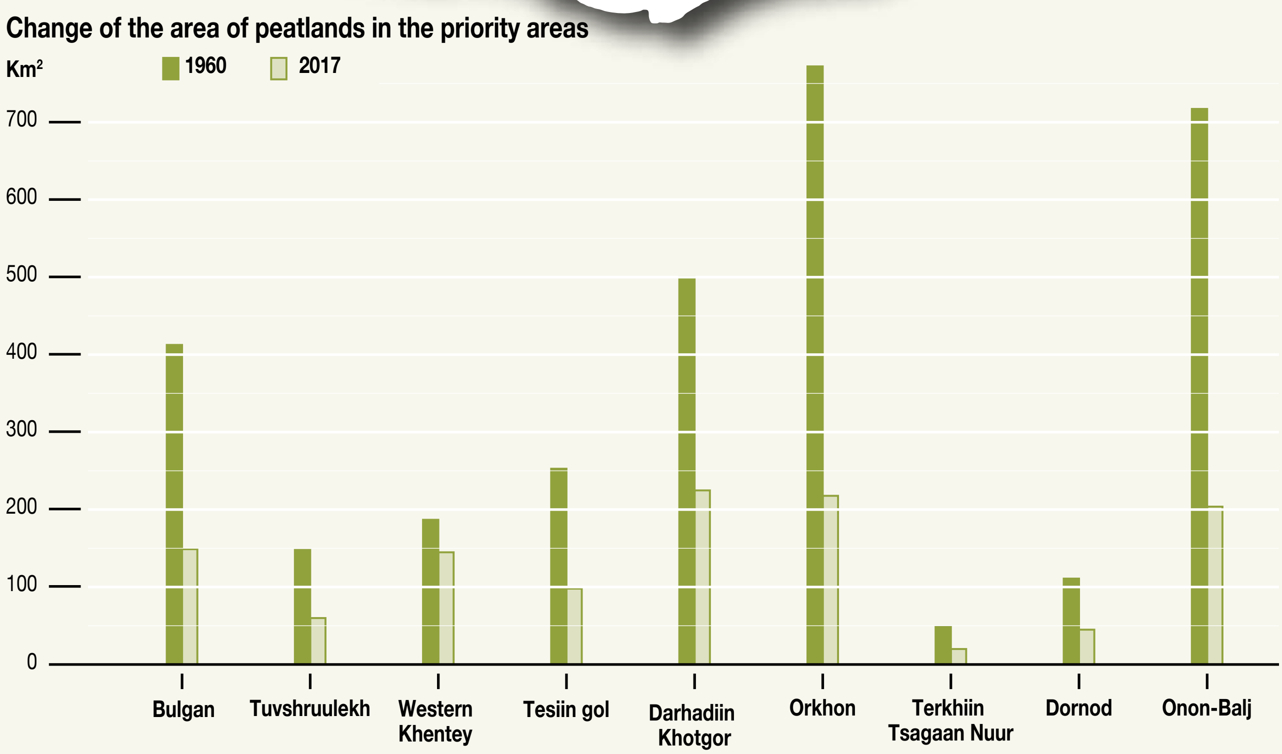
The particular hydrology of peatlands means that they are increasingly vulnerable to degradation arising from climate change, however current management planning does not tend to take this into account (Parish et al., 2008). The rapid degradation of other pastures has led to a further migration of cattle to peatlands and increasing overgrazing followed by a dramatic loss of pasture productivity (Punsalmaa et al., 2008). The combination of overgrazing, human-induced fires, permafrost thaw and climate change has resulted in thousands of hectares of fens turning bare and dry (Joosten et al., 2012). All this adds up to peat contributing to greenhouse gas emissions exacerbated by climate change (Assessment Report 2017).

Mongolia is currently making efforts towards a green development pathway, but it is yet to make specific provisions for the management of peatlands. The country is part of the UN-REDD Programme, an initiative that seeks to reduce emissions from deforestation and forest degradation in developing nations (REDD+) (Ministry of Environment and Programme, 2016; Narangerel et al., 2017). Carbon stocks within forest peatlands are accounted for under REDD+ and this could foster their protection in the long term.

Recognizing the crucial role of peatland ecosystem services for the sustainability and livelihoods in the country, the Mongolian government developed a Strategic Plan for Peatlands in Mongolia with the technical assistance of the Asian Development Bank. The plan integrated key national conservation strategies and activities related to climate change (Assessment Report, 2017). About 40 percent of Mongolia's peatlands are protected by nature reserves and Ramsar sites[5] (Minayeva et al., 2016) but their management plans are yet to address the specific requirements of these ecosystems. An important step forward are the guidelines for peatland use introduced in the Har Us Nuur National Park Ramsar site (Western Mongolia) (Joosten et al., 2012).

5. Ramsar is the oldest modern global intergovernmental environmental agreement. Its purpose is to protect wetland habitats especially for migratory birds.





Sources: *Gravis G.F. et al., 1974, Geocryological conditions of Peoples Republic of Mongolia.; Minayeva T, et al., 2004, Peatlands in Mongolia: the typical and disappearing landscape. Peatlands International, 2:44–47; Minayeva T. et al., 2016, Highland Peatlands of Mongolia, in Finlayson C.M. et al. (eds.), The Wetland Book, Springer Science+Business Media Dordrecht.*

GRID-Arendal

Figure 3. Distribution of peatlands and permafrost in Mongolia. Permafrost is thawing due to human activities like fire and mining operations as well as climate change. This accelerates peatland degradation and increases the amount of greenhouse gases being released into the atmosphere.

Because of our education, we believe some people are foresters, other people are agronomists, other people are biologists, and other people are fisheries managers … and then we all go in different directions. But when we talk about peatlands, we have to work together to understand each other. Because that's the only way to understand what peatlands are all about and how to manage them. If we all go in different directions, we are wasting our time because we are losing the opportunity to work together to best manage them.

– Dennis del Castillo, Director, Forest Management and Environmental Service Program, Peruvian Amazon Research Institute (IIAP)[6]

6. Interview posted on https://blog.cifor.org/50114/dennis-del-castillo-of-peruvian-amazon-research-institute-peatlands-are-seen-as-wastelands?fnl=en. Accessed 1 August 2017.

Why peatlands are important

The previous section introduced the subject of peatlands and pointed to the enormous benefits that undrained peatlands deliver. Besides climate benefits, these unique wet environments support a huge range of specialized plant and animal species, including many that are rare or endangered. Peatlands also support the livelihoods of millions of people and, because they act like giant filters, they help control and purify water.

Peatlands form where climate, bedrock and relief create areas with permanent water saturation. They either develop in shallow waters over layers of lake sediments (this is called terrestrialisation) or directly on mineral soils (known as paludification). There are two major types of peatlands:

1. Bogs which are only fed by rain. Bogs are therefore nutrient poor, acidic, and often elevated over the surrounding mineral soil, and
2. Fens which are also fed by water coming from mineral soil/bedrock and are usually less acid and richer in nutrients.

The key benefits that peatlands provide include:

Carbon storage

Peat is formed when organic matter accumulates faster than it decomposes due to the lack of oxygen in waterlogged conditions. Peatlands are the most carbon dense of any terrestrial ecosystem in the world (Joosten & Couwenberg, 2008; Urák et al., 2017). Ecosystems sequester and store carbon in different ways, such as in living biomass, litter or humus in upper layers of mineral soils. Most of these carbon pools are not permanent and carbon will be released back to atmosphere over relatively short cycles. Beside these pools, however, the peat layer of peatlands provides – if not disturbed – a unique, permanent store for carbon. Keeping this carbon in the ground is crucial if the world is to meet the target of the Paris Climate Change Agreement to keep the global average temperature increase under two degrees Celsius.

To get there, policymakers need to recognize the usefulness of peatland conservation and restoration as a way of mitigating climate change.

Supporting unique and critically threatened biodiversity

Peatlands are home to unique biodiversity and many specialized and endangered species have adapted to live there. For example, about 37 percent of all vascular plants in the peatlands of the Yamal Peninsula in Siberia and 10 percent of all fish species within Peninsular Malaysia are only found in peatland ecosystems (Parish et al., 2008; Joosten et al., 2012).

Tropical peatlands support a wide range of unique, threatened and/or endemic species, including 31 species of tropical lowland rainforest trees known as dipterocarps across Southeast Asia (Joosten et al., 2012) and five of the six species of great ape. The latter are the western gorilla (*Gorilla gorilla*), chimpanzee (*Pan troglodytes*), bonobo (*Pan paniscus*), Bornean orangutan (*Pongo pygmaeus*) and Sumatran orangutan (*Pongo abelii*). The orangutans are highly threatened, in part due to peatland degradation and conversion (Ancrenaz et al., 2016; Singleton et al., 2016).

The breeding habitat of the Aquatic warbler (*Acrocephalus paludicola*), Europe's only globally threatened songbird, is restricted to specific peatland habitats in central and eastern Europe (Tanneberger et al., 2011).

Peatlands are also home to many species of high economic value, including hardwood trees such as ramin (*Gonystylus bancanus*).

Sumatran orangutan

Aquatic warbler

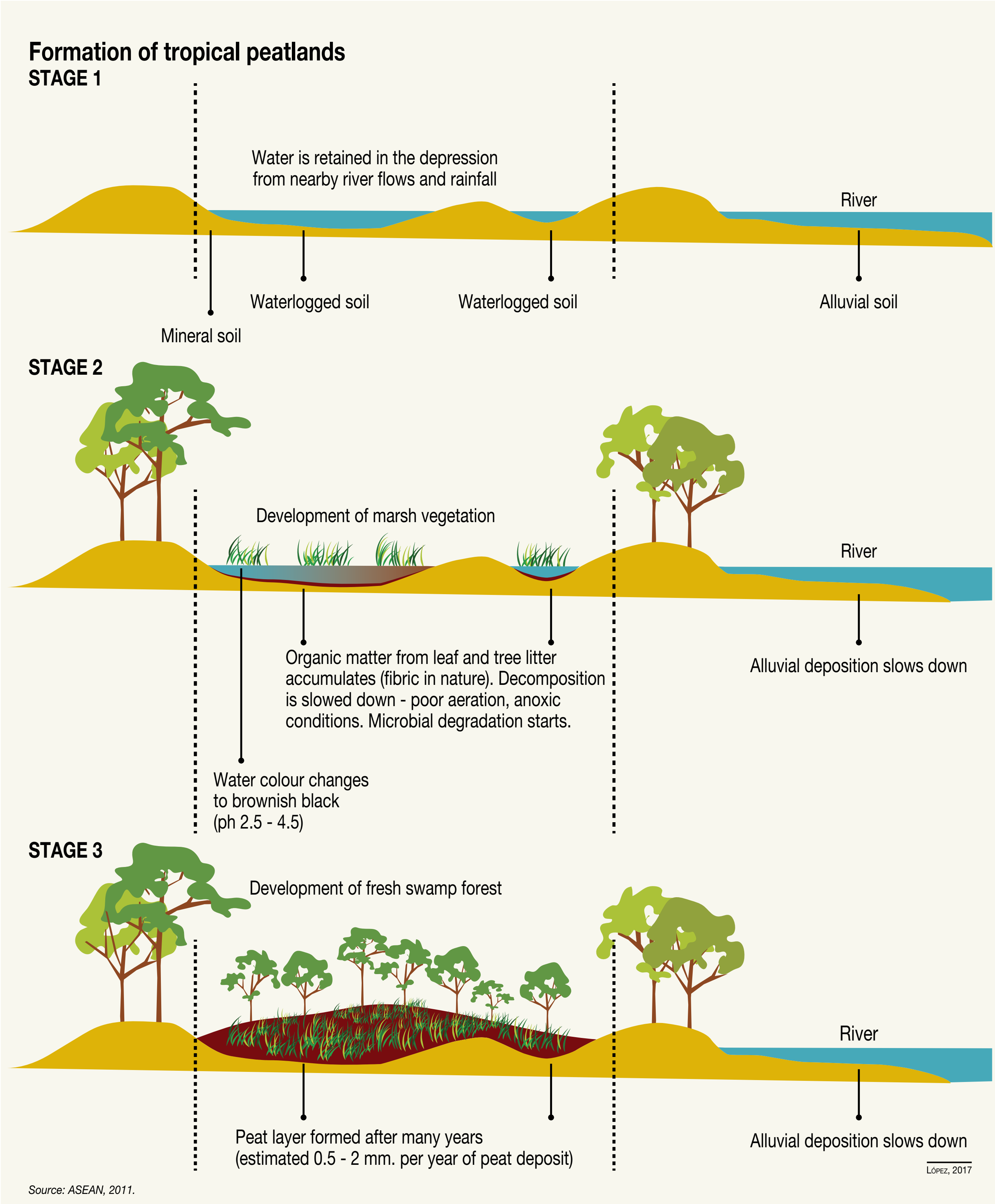


Figure 4. How peatlands are formed.

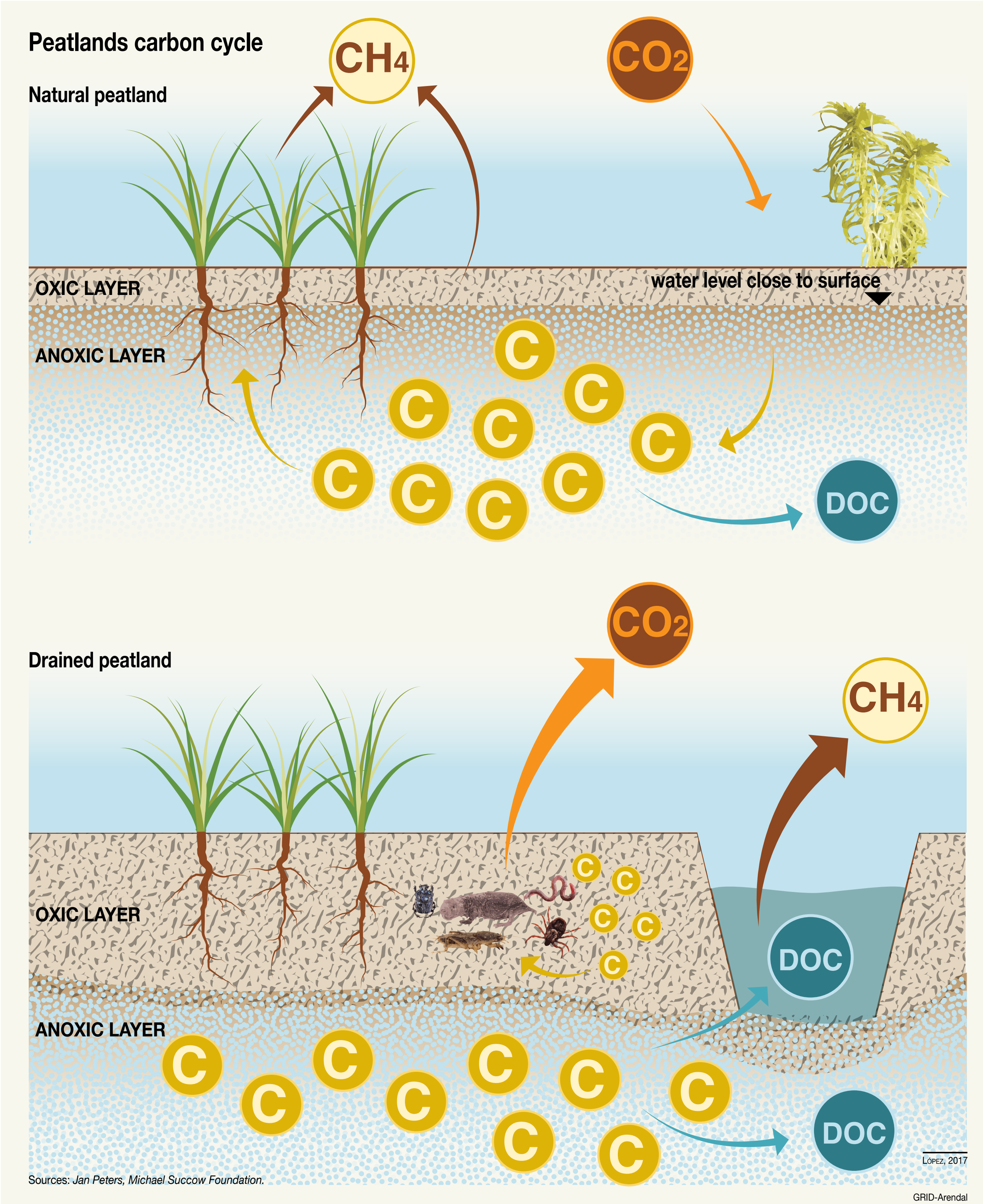


Figure 5. Peatlands carbon cycle.

Supporting the water cycle

Natural peatlands are integral to regional hydrology because, depending on season and peatland type, they regulate hydrology by slowing down the flow of water and gradually releasing it. Tropical peat swamp forests, for example, retain water over the surface in the rainy season and allow it to slowly drain away. In this way, peatlands provide a steadier supply of drinking and irrigation water and have a stabilising effect on hydrology by attenuating the effects of peak discharge during flooding events.

Peatlands also exert a cooling effect on local climate during hot periods through evaporation and cloud formation. This makes the regions where peatlands are found more resilient to droughts and floods. Furthermore, peatlands play a vital role in the retention of pollutants and nutrients and in water purification. This helps to counteract eutrophication of bodies of water like lakes, rivers and even seas lower down in the catchment areas. Coastal peatlands keep the freshwater close to the coast and thus prevent salt water intrusion.

Supporting livelihoods

Peatlands have supported the health and wellbeing of people for thousands of years (Joosten & Clarke, 2002; Rieley, 2014). Pristine peatlands in boreal and temperate regions are a source of berries, mushrooms and medicinal plants, and in the tropics provide an even wider variety of non-timber forest products. Drained peatlands are used for arable agriculture, for grazing sheep and cattle, and for forestry. The peat itself has been and is being used as a fuel, as growing media or even as a construction material to build and insulate houses. When examining the question of livelihoods, it is important to distinguish between sustainable and unsustainable development practices. The latter includes all drainage-based use, such as mass conversion to plantations, an activity which turns peatlands into wastelands that ultimately undermine social, environmental and economic wellbeing.

As a cultural landscape and archive

Peatlands have long been an inspiration for art, religion, leisure and educational activities (Rieley, 2014) because of their special characteristics – they are relatively inaccessible, wet, misty lands, often in places where most people rarely roam.

Peatlands provide a glimpse into our past and are home to some of the most evocative archaeological discoveries of the last decade, including a 4th millennium BCE footpath, the 'Sweet Track' in the Somerset Levels, England (Bain et al., 2011). The preserved bodies and pollen grains conserved in peat show that people have interacted with these important places for thousands of years.

Peatlands also record environmental change. By continuously depositing peat, they record their own history and that of their wide surroundings in systematic layers, making them into an archive that tells us much about past changes to landscape and climate (Bain et al., 2011).

Due to the different ecosystem functions of peatlands, they are often recognized in national and international policies and strategies but rarely directly addressed because they cover a relatively small proportion of land area. Often, they are only included indirectly together with similar habitats like swamps and floodplains which neglects their special properties and functions. The use of peatlands is also often governed by conflicting ministerial mandates and regulations.

Several multilateral conventions take peatlands into account, such as the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, and the United Nations Convention to Combat Desertification (UNCCD). Since different sectors and functions of peatlands are tackled by these conventions, there is an urgent need to develop common strategies to better integrate climate change mitigation, biodiversity conservation and land use management of peatlands. A few of these global approaches are outlined in Section 4.

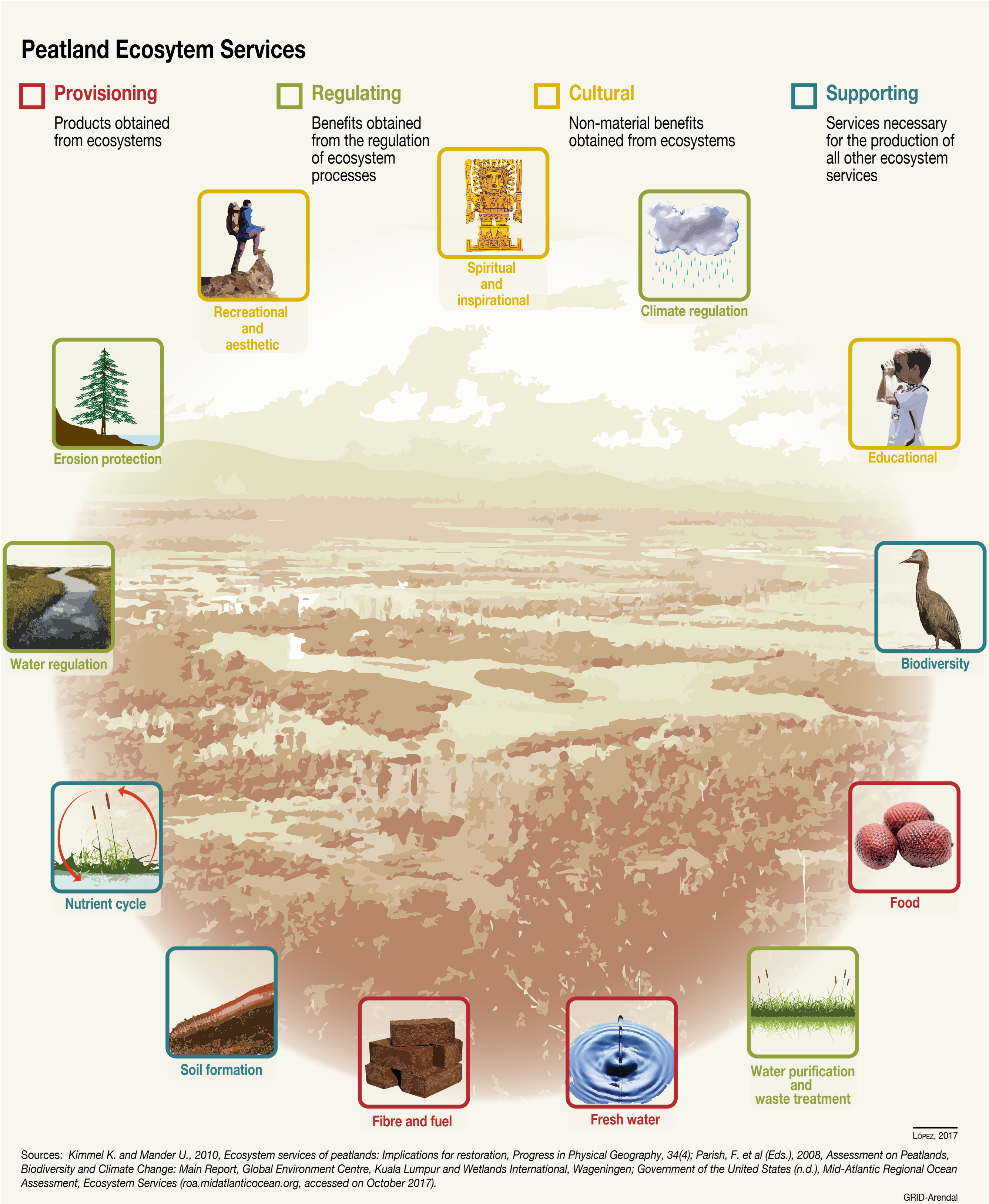


Figure 6. Peatlands provide vital ecosystem services for people and the environment.

Focus on the Congo Basin – Latest research shows many peatlands remain "undiscovered"

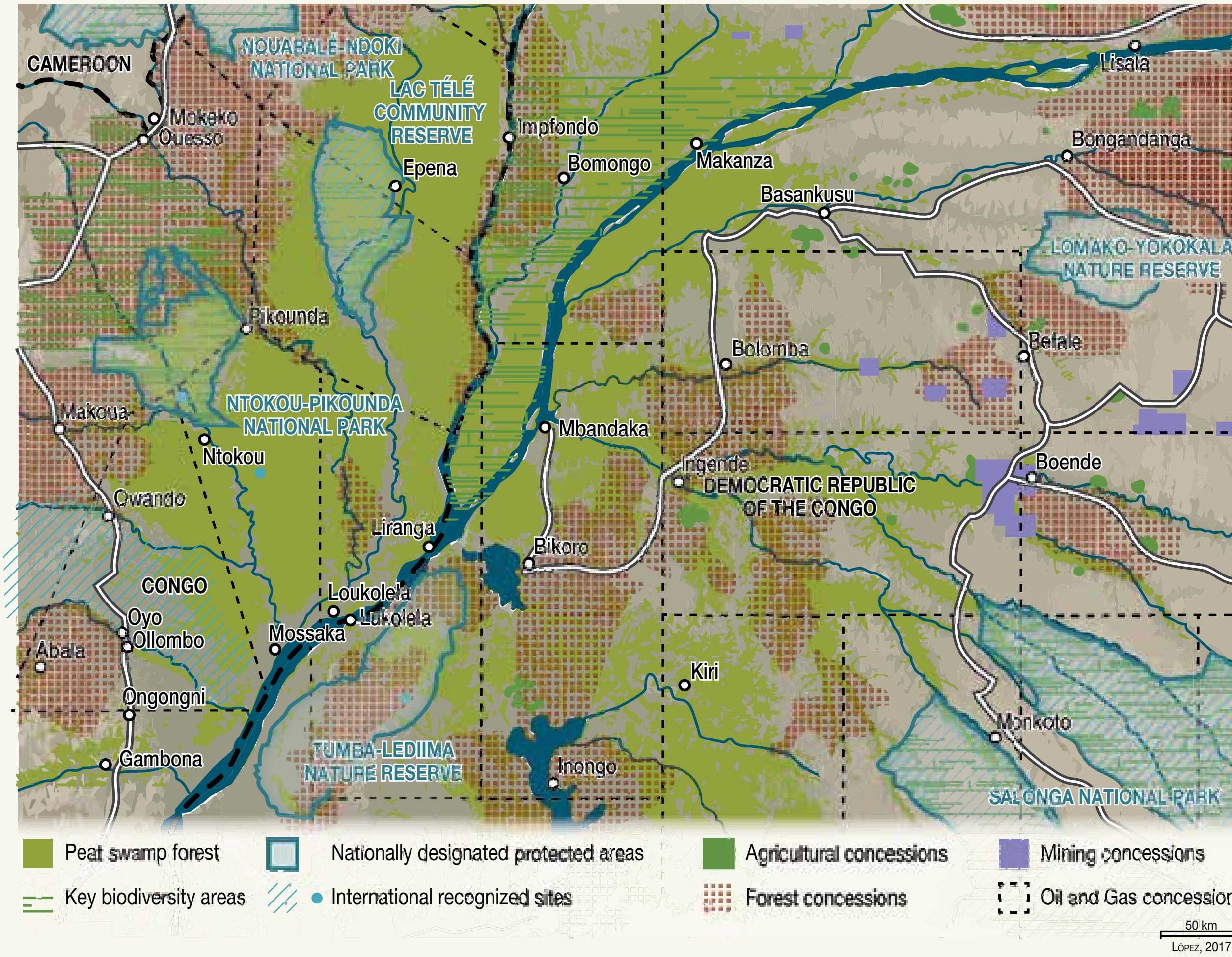
The low-lying depression covered by swamp forest known as the Cuvette Centrale is in the centre of the Congo Basin. Despite its size, the peatlands of the region have received little research attention until now. Recently, scientists mapped the world's most extensive tropical peatland complex beneath the forest floor. At around 145,500 km^2, it is five times larger than originally estimated and bigger than England (Dargie et al., 2017). Peat swamp forest vegetation observed in the field permitted peatland extent to be estimated through remotely sensed mapping. Fieldwork confirmed the presence of extensive peat deposits (maximum depth of 5.9 meters).

When area estimates were combined with measurements of peat depth, bulk density and carbon concentrations, it was estimated that the peatlands hold about 30 billion tonnes of carbon – equal to over 15 years of carbon dioxide emissions of the United States and similar to the above-ground carbon stock of the entire forests in Congo Basin (Verhegghen et al., 2012). These numbers increase the best estimate so far of global tropical peatland carbon stocks by 36 percent, to 105 billion tonnes. They place the Democratic Republic of the Congo and the Republic of Congo behind Indonesia as the second and third most important countries in the tropics in terms of peatland area and carbon stocks.

The peatlands of the Congos are globally significant, and in their near-pristine state they are an important source of ecological stability for the entire region, a valuable carbon store and home to unique flora and fauna. The Congo Basin boasts 10,000 species of tropical plants of which 30 percent are unique to the region. It is also home to several endangered species including forest elephants, chimpanzees, bonobos, and lowland and mountain gorillas. Besides these higher primates, the region is rich in other species – 400 other mammals, 700 different kinds of fish and 1,000 species of birds are found here (WWF n.d.).

People have inhabited the Congo Basin for more than 50,000 years and today's population of 75 million people relies on it for shelter, food and fresh water. There are nearly 150 distinct ethnic groups in the region, and many continue ancient hunter-gatherer lifestyles, meaning their lives and well-being are intimately linked with the health of the forest, much of which stands on peatlands (WWF n.d.).

Congo Basin: extent of peatlands and threats



Sources: *Miles L. et al., 2017, Carbon, biodiversity and land-use in the Central Congo Basin Peatlands, UN Environment World Conservation Monitoring Centre (UNEP-WCMC) and University of Leeds.*

Figure 7. Peatland areas and threats in the Cuvette Centrale region of the Congo Basin.

While currently intact, the central Congo Basin peatlands and their carbon stocks are highly vulnerable to land use change (Haensler et al., 2013). Large areas of the Cuvette Centrale are designated as Ramsar sites, covering most of the peatlands, with several other protected area designations. On the other hand, most of the region is also covered by proposed or current concessions for logging, mining and oil and gas development, including the expansion of the road network which could increase access to previously remote locations (see figure 7).

Other possible threats include agricultural expansion into untouched areas leading to deforestation, peatland drainage and overall ecosystem degradation. Furthermore, some regional climate projections forecast reduced annual rainfall and stronger dry seasons that could also lead to peatland drying and drainage (Miles et al., 2017).

The Republic of Congo has recognized the role of peatland carbon stocks in the country's forest reference emission level, and are looking into REDD+ and other planning and investment mechanisms as a potential tool to promote the conservation of the forested peatlands. It is also considering the expansion of the Lac Télé Community Reserve to protect further areas of forested peatlands. For example, the draft of its National REDD+ Strategy aims to ensure that agro-industrial concessions are not granted near wetlands or forests with high biodiversity value.

Keeping this massive store of carbon in the ground is an urgent priority and the only way to make this happen is to ensure that any development is approached in a sustainable manner.

Threats – Peatlands under pressure

While peatlands are under pressure from a range of human activities, drainage is the immediate and most wide-ranging global threat to the integrity of these ecosystems. Humans have long exploited the world's peatlands with over 65 million hectares estimated to have been affected by our activity (Joosten et al., 2012). We have taken peatlands for granted, often seeing as them unproductive or even hostile land to be drained when desired for human use. Records dating back as far as the eighth century show that large-scale drainage for agricultural purposes occurred in the Netherlands.

We now have a better understanding of the huge impacts of peatland drainage on carbon storage, water regulation, biodiversity conservation and other ecosystem services, and the resulting economic, environmental and social costs. As well as having "nearly irreversible" effects on peat structure and the ecological services peatlands provide (Oleszuczuk et al., 2008), draining peatlands substantially increases fire risk and can lead to significant loss of soil productivity and even land loss through subsidence.

Drainage for agriculture

Agricultural expansion has been the main driver of change in peatlands around the world (Joosten & Clarke, 2002). Peat soils need to be drained to make them cultivable and this releases nutrients in the short term. However, the soil can rapidly oxidise, dry and degrade leading to low fertility and ultimately low productivity (FAO, 2014). Drainage may involve ditches or larger canals, and gullies that form spontaneously in mountain peatlands (Evans et al., 2005). Where peatland drainage has resulted in soil degradation, yield reductions have led to the abandonment of large areas (FAO, 2014). Nowadays, there is very little new peatland drainage in boreal and temperate zones (Rieley, 2014) due to declines in crop production and increasing costs (Parish et al., 2008; Hooijer et al., 2012, 2015). However, the area being drained in the tropics is dramatically increasing with Southeast Asia leading the way.

Europe has seen the greatest area of peatland drainage of any continent (Parish et al., 2008). Hungary, Greece, the Netherlands and Germany were among the top European countries reporting the use of drained peatlands for agriculture (Joosten & Clarke, 2002). An estimated 38,600 km^2 have been drained for agriculture in the former Soviet Union (Inisheva, 2005; FAO, 2014). Large areas rendered unproductive have now been abandoned and are susceptible to fires in dry summers.

Peatlands in North America have been used to grow cranberries, vegetables, sugar cane, rice and fodder (Joosten, 2002) but they have been less affected by drainage (Joosten, 2010).

In China, peatland drainage for agricultural expansion started around 200 years ago, and almost all peatlands have been degraded by crop production or grazing (Joosten et al., 2012).

Large-scale land-use change in tropical peatlands only started during the mid-twentieth century and large areas remain undisturbed (Parish et al., 2008; FAO, 2014; Dargie et al., 2017). In South America and Central Africa, the expansion of road networks followed by commercial agriculture or forestry appears to be an emerging threat for the largely undisturbed tropical peatlands (Dargie et al., 2017; Roucoux et al., 2017).

This would follow the pattern seen in Southeast Asia where peat swamp forests have been targeted for agricultural expansion mainly for palm oil and forestry projects, for pulp wood production and relocation programmes (Hooijer et al., 2010, 2015; FAO, 2014). Over 90 percent of peat swamp forests in western Southeast Asia have been disturbed (Miettinen et al., 2017). In the past 30 years, substantial drainage in both Malaysia and Indonesia has been undertaken to allow plantation development, driven by the demand for palm oil, timber and paper (Miettinen et al., 2017; FAO, 2014).

In Indonesia, an additional factor is that population growth and urbanization have increased demand for new agricultural land (FAO, 2014). Much peatland conversion resulted from a national programme for relocating millions of landless people (FAO, 2014), which ended in 2015. The typical approach by these new small landholders has been to use fire to clear land and temporarily boost its fertility. Fire is also widely used in commercial agriculture.

Commercial forestry

Commercial forestry, which is prevalent across Scandinavia, North America, the countries of the former Soviet Union, the United Kingdom, and Southeast Asia, is the second greatest cause of land-use change in peatlands (Parish et al., 2008; Joosten et al., 2012). Globally, commercial forestry has claimed more than 120,000 km^2 of peatlands, mainly within boreal and temperate regions where the land is drained to

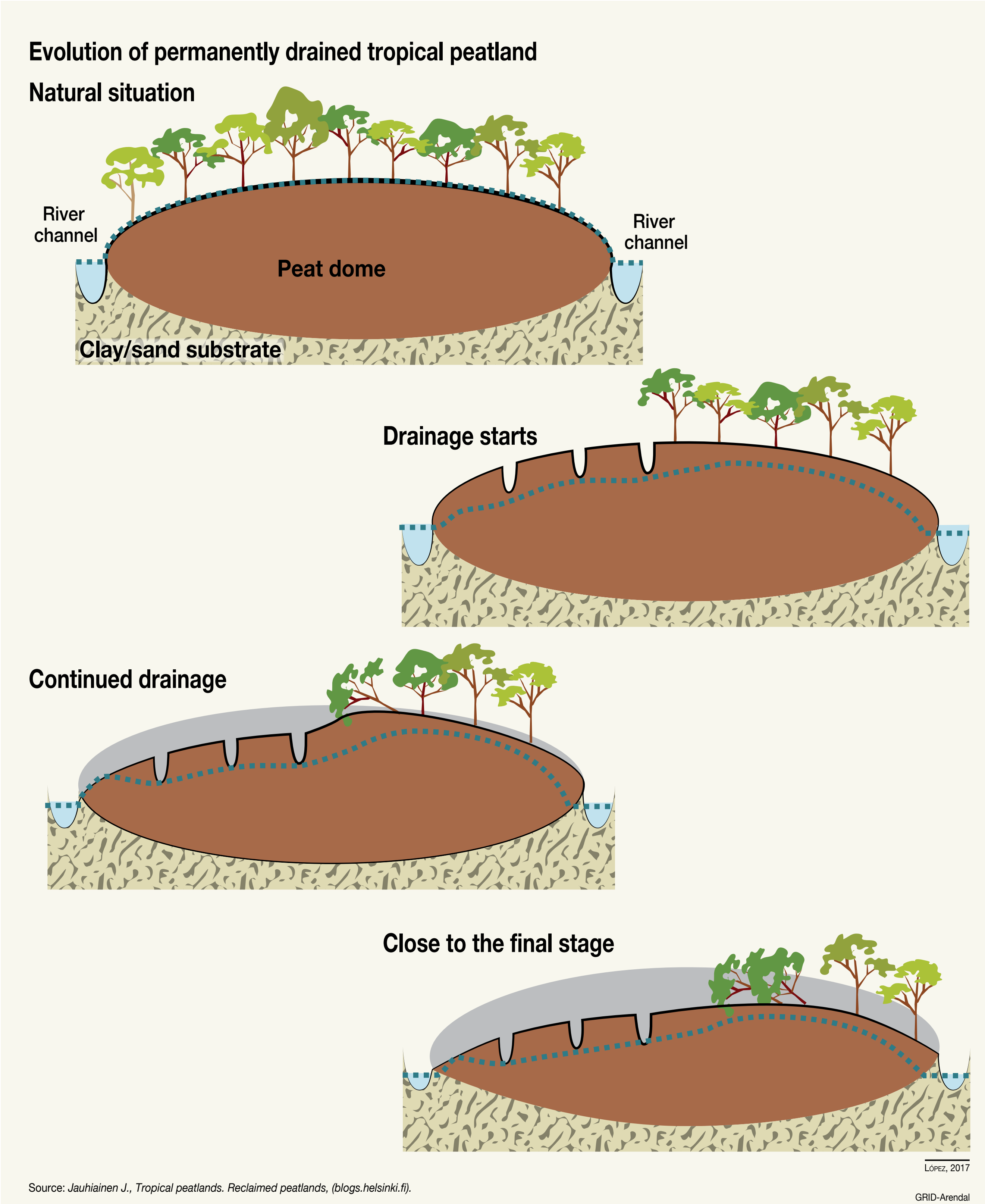


Figure 8. What happens when tropical peatlands are drained.

improve tree growth and intensive wood-production (Parish et al., 2008; FAO, 2014). In the tropics, forested peatlands are often subject to selective logging or clear-cutting (FAO, 2014), and this is exacerbated by the digging of canals to open up access to the forest and to transport logs. However, the removal of trees and their roots allows water to flow more rapidly from the peatland, as well as exposing the peat surface to the drying heat of the sun.

Peat extraction and usage

Though the mining of peat for fuel and other purposes affects only a small proportion of the world's peatlands, its regional impacts are significant (Joosten & Clarke, 2002; Liikanen et al., 2006; Parish et al., 2008). Peat has been a source of energy for over 2,000 years (Parish et al., 2008). It was used on a large scale by households in temperate and boreal regions until the introduction of coal at the end of the 19th Century, and was later taken up by industries to generate electricity and heat (FAO, 2014). Another major use of peat is as a raw material for producing growing media for professional horticulture and for home gardening. Smaller volumes are used for construction material, insulation, textiles, cosmetics and the production of various chemicals (Joosten et al., 2012). Before 1990, the largest users of peat energy were the countries of the former Soviet Union, but today most peat is extracted in the European Union, notably Finland, as well as in Canada (Minayeva & Grundling, 2010; FAO, 2014).

Infrastructure development

On a similar scale to peat extraction, infrastructure development such as the construction of new roads has a significant impact. For example, in Brunei one of the last-surviving pristine peat swamp forests in Southeast Asia is threatened by the development of an oil pipeline and its service road which drains the middle of a peat dome and slowly desiccates the peat and forest. The conversion of peatlands in coastal areas, including mangroves and saltmarshes, to meet urban development and waste disposal needs also furthers their demise (Parish et al., 2008). Peatlands are also being impacted by the development of wind farms in some European countries, and oil and gas exploitation infrastructure in North America, Russia, Nigeria and Western Amazonia (Joosten & Clarke, 2002).

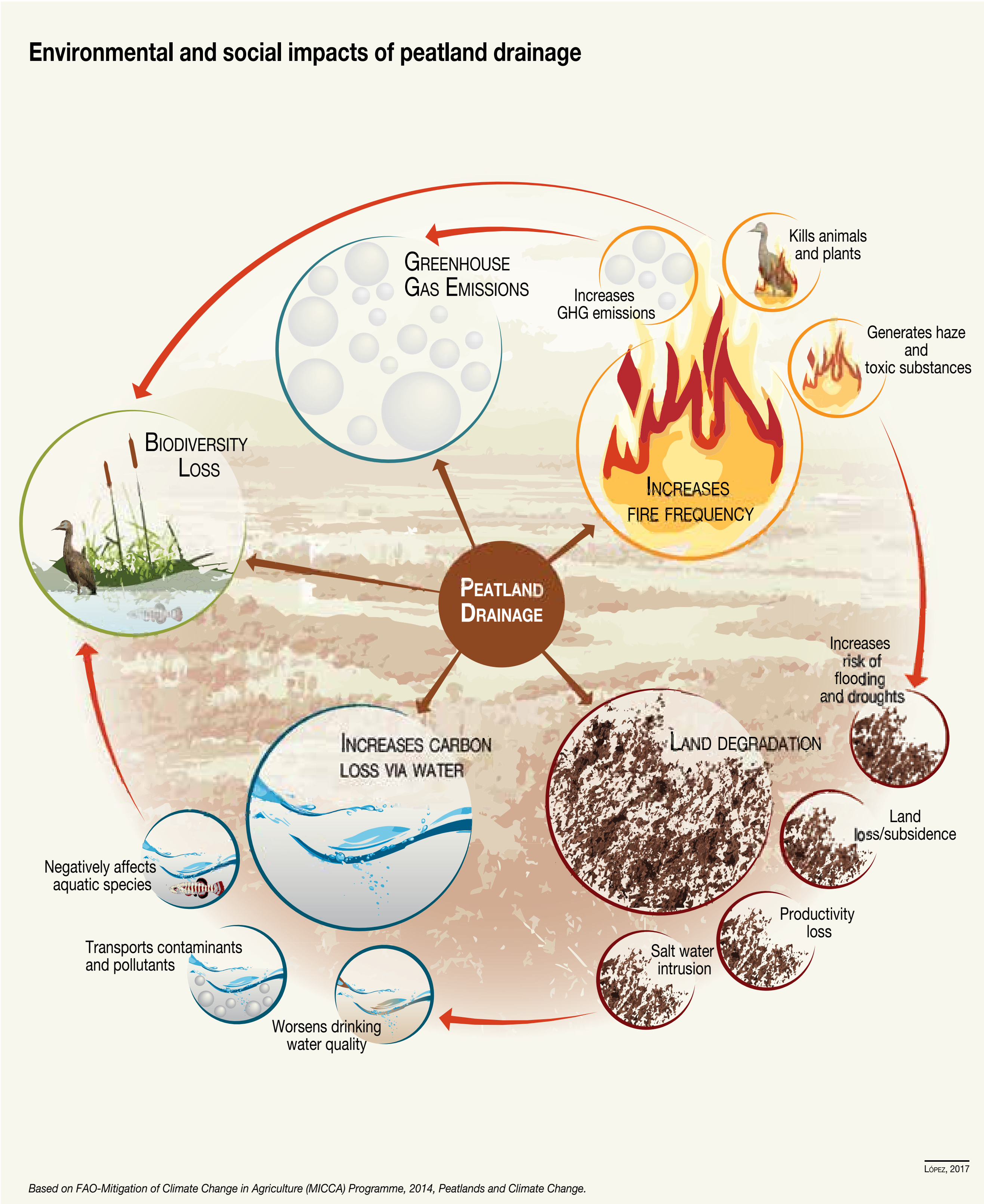


Figure 9. An illustration of the environmental and social effects of peatland drainage.

Effects of peatland degradation

Many human activities in peatlands cause changes in ecological processes, ecosystem structure and species composition (Limpens et al., 2008), usually as a result of drainage and the destruction of native vegetation (Parish et al., 2008). The social and environmental impacts can continue for decades or even centuries, with huge economic consequences. These result in land loss from subsidence, fires and their associated haze, reduced water quality, loss of unique biodiversity, loss of the potential for the sustainable use of peatlands (paludiculture), as well as a contribution to global warming caused by loss of peat carbon stocks.

Greenhouse gas emissions

When peatlands are drained, peat comes into contact with air and oxidation of organic matter starts releasing the accumulated carbon and nitrogen into the air. In this way peatlands are converted from long-term carbon reservoirs into sources of greenhouse gas emissions that can continue for decades and beyond (Limpens et al., 2008; Parish et al., 2008; Joosten, 2010; Urák et al., 2017). Once drained, peatlands become vulnerable to more frequent and deeper fires, which make a substantial contribution to greenhouse gas emissions.

Half the world's peatland emissions come from Southeast Asia where a combination of deforestation, deep drainage and high temperatures boosts peat decomposition and the incidence of fires (Joosten et al., 2012; Biancalani et al., 2014). For example, in 2015, Indonesia experienced, "the year's worst environmental disaster" (The Guardian, 2015) which, following an exceptionally dry year brought on by a particularly strong El Niño weather system, saw emissions from peat fires alone reach between 1.5 to 1.75 $GtCO_2e$, more than the entire total annual emissions of Japan for that year (World Bank, 2015; Field et al., 2016; UNFCCC, 2017). This trend continues globally with large and uncontrollable fires every dry season.

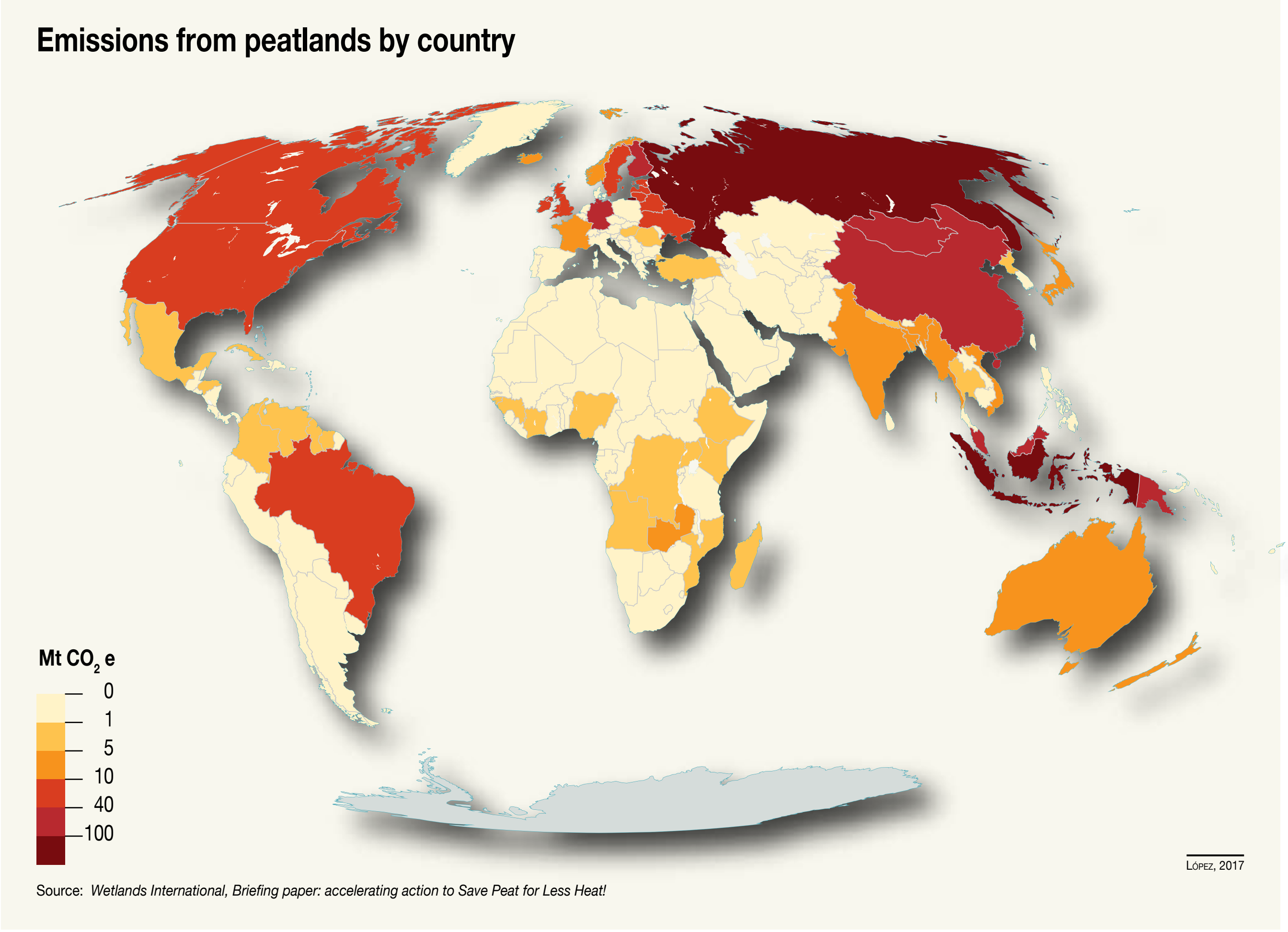


Figure 10. Countries with the most peatland and highest carbon dioxide emissions due to peatland degradation.

While representing only 0.4 percent of the world's land, drained peatlands emit nearly five percent of global CO_2 (Joosten, 2015). Peatland fires contribute over the long run an average of 0.5–0.6 $GtCO_2e$ of this amount, leading to total peatland emissions of over 2 $GtCO_2e$.[7]

Fire and haze

It is estimated that 15 percent of global peatlands have been drained and are used for agriculture, livestock and forestry. Drained peatlands are highly prone to fires, which are particularly difficult to extinguish, and have a range of impacts. In dried peat soils, fires used to control vegetation can easily get out of hand and can penetrate the ground to depths near the water table where the fires can remain undetected. They can continue to smolder below ground, lasting several months even following days of rain and under snow cover, and spread over long distances (Abel et al., 2011; Betha et al., 2012; Davies et al., 2013; Marlier et al., 2015b). Large-scale peatland fires following drainage have been reported in Western Europe, Russia and Southeast Asia (Boehm & Siegert, 2001; Parish et al., 2008; Joosten et al., 2012; Gaveau et al., 2014a, 2014b; Page & Hooijer, 2016).

Smoke from peatland fires can generate a haze that contains dangerous levels of particulates termed "black carbon", trace metals, polycyclic aromatic hydrocarbons (PAHs) and nitrated PAHs (Betha et al., 2012; Marlier et al., 2015b). These increase the risk of cardiovascular diseases, respiratory conditions and cancer (Betha et al., 2012; Page and Hooijer, 2014; Haikerwal et al., 2015; Adams et al., 2016). The haze can reduce air quality over long distances and spread across national borders. In 2010, peatland fires in Central European Russia caused a disaster that forced millions of people to move

7. This figure is roughly equivalent to emissions from 232 million passenger vehicles being driven for a year. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

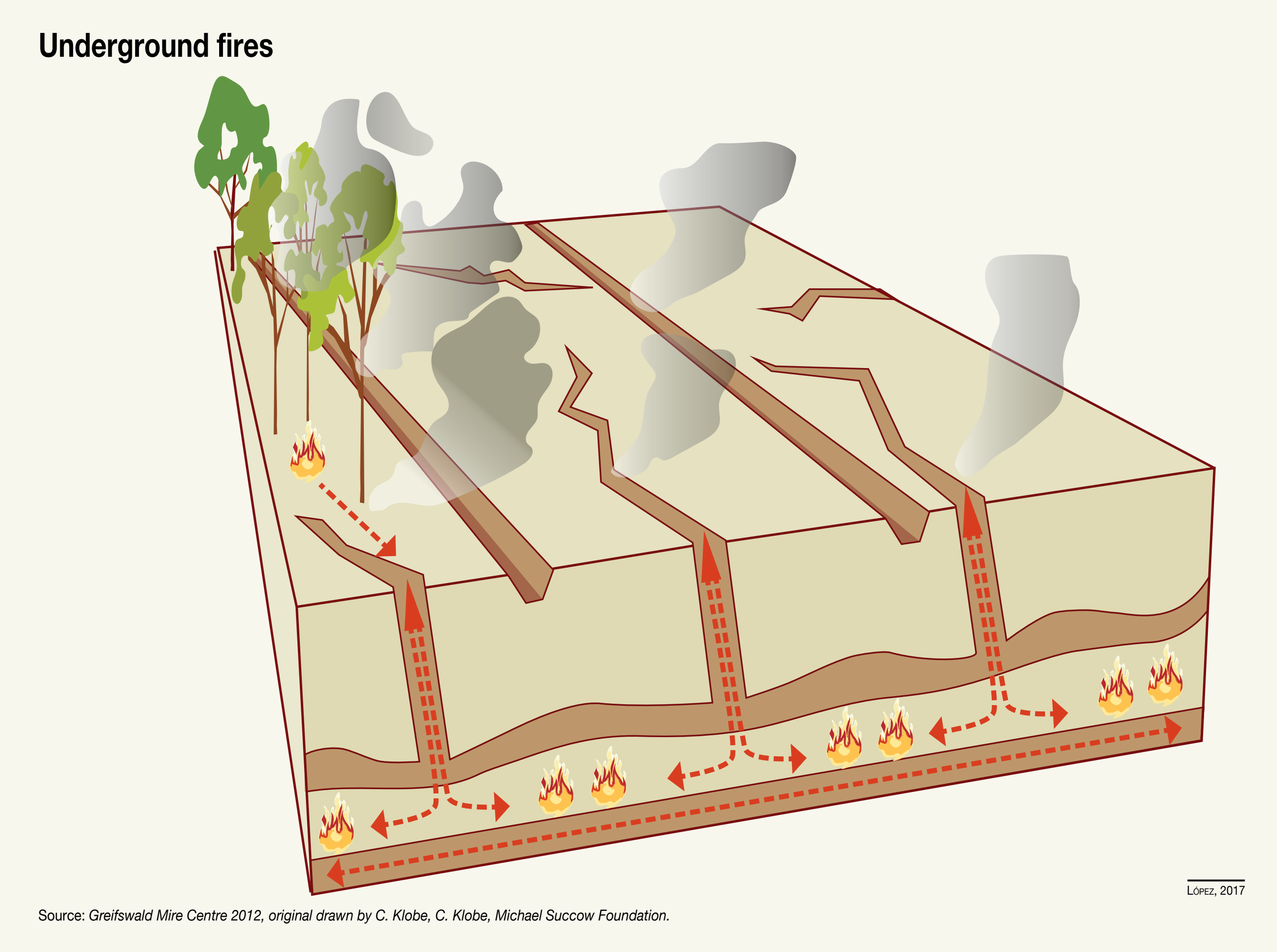


Figure 11. The spread of peatland fire from the surface to subsurface [original drawn by C. Klobe, Michael Succow Foundation].

from their homes and provoked a partial shutdown of air transportation because of dense smoke covering thousands of square kilometres reducing visibility (Gilbert, 2010).

Water pollution

Peatland drainage also increases the release of carbon and nitrogen into the water (Charman, 2002; Holden, 2005). Degraded peatlands, eroded due to vegetation clearance, drainage, peat mining or gully formation, cause downstream water pollution. The dissolved and particulate organic carbon can significantly reduce water quality and affect the solubility, transport and toxicity of heavy metals and organic pollutants. Arsenic and lead contamination of drinking water from peatland erosion has been studied in the United Kingdom and may be especially problematic where these metals are concentrated in burnt ash (Rothwell et al., 2011; Clay et al., 2016). These heavy metals were originally deposited by industrial and vehicle emissions and are now slowly being released. The added carbon clouds acidify the runoff water, and changes the local freshwater ecology with an impact on drinking water quality and fish production. Siltation from eroding peat can also be problematic for hydropower facilities.

Soil subsidence and water regulation

Subsidence (height loss) of drained peatlands has had a severe economic impact on agriculture, infrastructure and urban areas all over the world. As the water from the peatland is drained away, the peat body partly collapses under its own weight, the peat breaks down into smaller parts allowing it to stack denser, and the organic matter oxidizes, i.e. disappears into the air. The height loss through collapse happens quickly and is large (e.g. 30 cm per year), whereas oxidation is a slower but persistent process which is responsible for 1–2 cm subsidence per year in temperate areas (Erkens et al., 2016). In tropical regions, in the first five years after drainage, peatland subsidence is typically 1–2 metres. In subsequent years, it stabilizes to a constant 3–5

Focus on Indonesia – Tackling peatland fires

In 2015, El Niño triggered fires in Indonesia that destroyed around 17,000 km^2 of forest and plantations according to the Indonesian Ministry of Environment and Forests (Jakarta Post, 2015). The smoke blackened the sky over Borneo and Sumatra and parts of neighbouring Malaysia and Singapore.

The Indonesian Agency for Meteorological, Climatological and Geophysics estimated that 43 million people in Indonesia alone were exposed to the haze, with half a million treated for respiratory illnesses related to air pollutants (The Wall Street Journal, 2015). Six provinces declared a state of emergency when the number of active fires reached 127,000, the highest level recorded since 2003 (World Resources Institute, 2015a; The Wall Street Journal, 2015). The regional economy was affected with the cost to Indonesia alone estimated at USD 16.1 billion (Glauber and Gunawan, 2015). In addition to carbon dioxide, peatland fires release the greenhouse gas methane, which is approximately 30 times more potent as a heat-trapping gas.

The low oxygen content of peatlands results in partial burning of the organic matter and high loads of particles, contributing disproportionally to haze. On the worst days, greenhouse gas emissions from Indonesia's fires exceeded those being released by the US economy as a whole (World Resources Institute, 2015b).

In August 2015, the sky was yellow. We were starved of oxygen. We couldn't breathe ... Our eyes burned. We couldn't sleep. We couldn't run. Where would we run to? The sky was dark. The air was poison.[8]

In recent years, major peatland fire events occurred in 2006, 2009, 2013, 2014 and 2015, with states of emergency being declared in five Indonesian provinces as the fire season got underway in August 2017. This points to a long-term dramatic increase in fire vulnerability in drained Indonesian peatland landscapes. Fires are typically lit during the dry seasons on cleared or degraded forest lands to expand agricultural plantations. They are also used to open access to fishing pools, wildlife and other resources (Chokkalingam et al., 2007).

8. Emmanuela Shinta of the Indigenous Dayak people and Ranu Welum Foundation describing the effect of Indonesian peatland fires at the Global Landscapes Forum, 18 May 2017, Jakarta.

Indonesia's peatland fires are a major cause of international concern due to their contribution to global warming, and more immediately, their effects on human health and the economies of adjacent countries. Under the ASEAN Agreement on Transboundary Haze Pollution signed in 2002, ratified by Indonesia in 2015, the 10 country members of the Association of Southeast Asian Nations (ASEAN) agreed to work together to monitor and tackle the problem.

The increase in fire vulnerability has major implications for Indonesia's ability to meet the Sustainable Development Goals and other global commitments. As Indonesia strives to break the cycle of peatland fires, it is looking into and trying out options to promote sustainable agriculture and economic development while working hard to restore peatland hydrology.

In 2011, the Indonesian Government established a moratorium on the new conversion of primary forest and of peatlands more than three metres deep, and has renewed it several times since (Murdiyarso et al., 2011; Austin et al., 2014).

In 2016, President Joko Widodo extended the moratorium to cover all peatlands and instructed companies to restore the hydrology of damaged peatlands urgently. It established the Peatland Restoration Agency (Badan Restorasi Gambut – BRG) to coordinate and drive the ambitious goal to restore 20,000 km^2 of degraded peatlands by 2020 (World Bank, 2017).

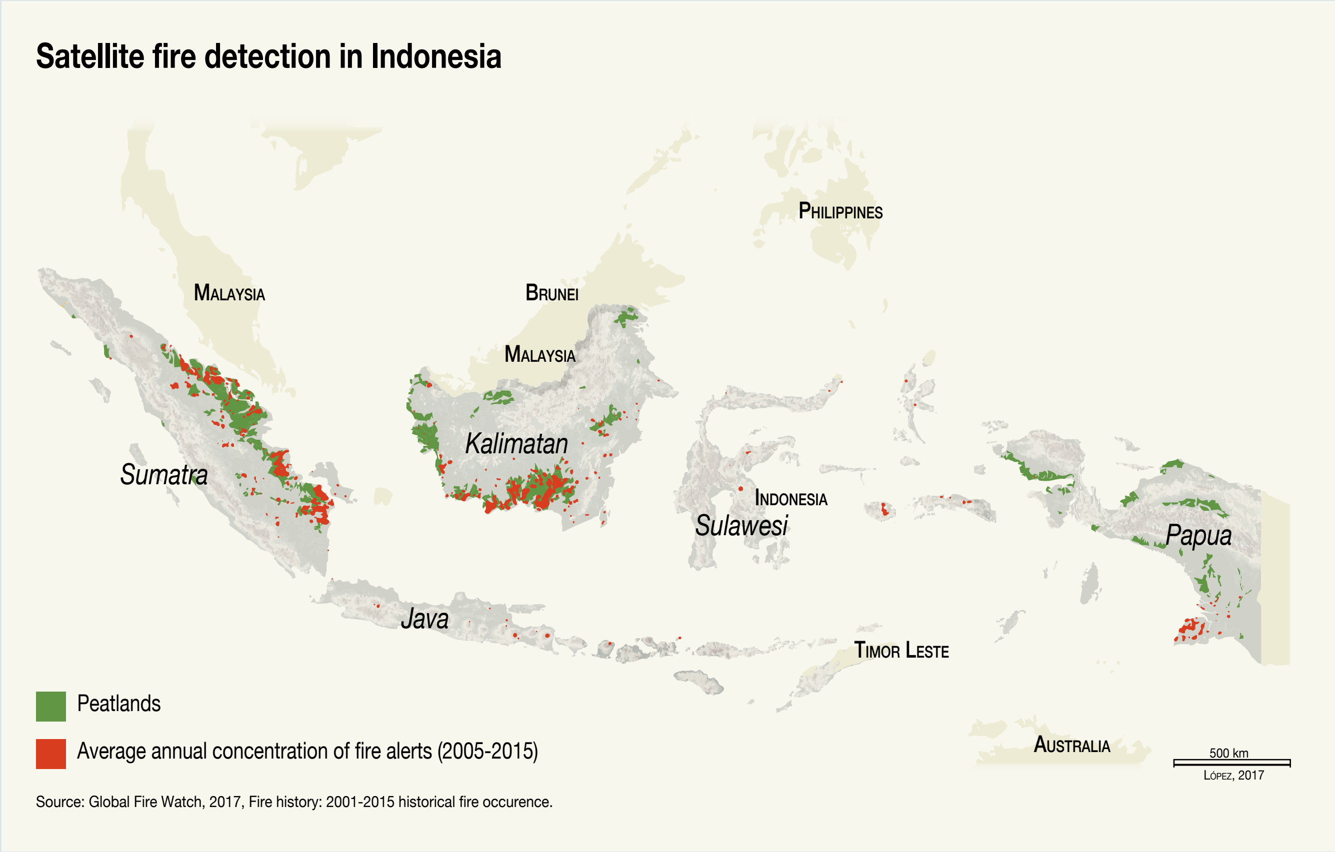


Figure 12. Fires detected by remote sensing in Indonesia.

cm per year, resulting in a subsidence of 2–3 metres over 25 years and 4–5 meters within 100 years (Fornasiero et al., 2002; Hooijer et al., 2012; Page and Hooijer, 2014; Epple et al., 2016).

As a result, relative water levels in the peatlands will rise again (the water level does not rise, but rather the land subsides), eventually flooding the peatland, unless it is drained deeper, thus again speeding up subsidence. This process is a vicious cycle which causes drained peatlands to be slowly bogged down. In many areas of the world, peatland heights are close to sea level (e.g. in Southeast Asia, Northwestern Europe, Florida and California). There, the subsiding areas become prone to flooding and exposure to acid sulfate soils, saltwater intrusion, spoiling the area for agriculture (Fornasiero et al., 2002; Page et al., 2002; Hooijer et al., 2012, 2015; Page and Hooijer, 2014; Boersma, 2015).

In the Netherlands, coping with the effect of land subsidence on underground infrastructure in peatland soils requires an annual investment of up to 250 Euros per capita (Boersma, 2015). That's greater than the annual gross domestic product of each of the world's poorest 28 countries. Subsidence has led some Dutch cities to be as much as eight metres below sea level (FAO, 2014). Another study estimated the potential cost of repairing the Netherlands' damaged infrastructure to be as high as 5.2 billion Euros up to 2050 (PBL, 2016).

In Malaysia, in the Rajang Delta, subsidence already affects the productivity of 29 percent of the area. It is also impacting 24 percent of the Kampar Peninsula in Indonesia. Subsidence is expected to increase in both areas to the extent that nearly all peatland in the area will be lost, much of it within decades (Hooijer et al., 2015; Hooijer et al., 2015a).

However, subsidence is not just a threat in coastal areas. For example, if drainage channels were to be constructed in the Congo Basin, salt water intrusion would not be an issue, but subsidence would quickly make the area undrainable again. In some countries, large parts of the mineral soils below peatlands have the potential to become acid sulfate soils. Hence, even when flooding in peatland areas does not occur prior to the loss of peat, the exposure of the mineral soil may create acid sulfate conditions, thus rendering all forms of productive land-use impossible.

Biodiversity

Vegetation clearance, drainage and burning are also major causes of biodiversity loss within peatlands across the world (Osaki & Tsuji, 2016). These practices change ecosystem structure and species composition, reducing their capacity to recover from future disturbance (Turetsky et al., 2014; Osaki & Tsuji, 2016).

In the United Kingdom, peatlands have been historically sidelined in the broader quest for economic development. Some argue that without active policy intervention, lowland raised bogs – a priority habitat under the European Habitats Directive – could be lost from the UK entirely (Lindsay, 1993). This would have a devastating impact on endangered wildlife such as the 'vulnerable' large heath butterfly (*Coenonympha tulllia*), the 'rare' white-faced darter (*Leucorrhinia dubia*) and mire pill beetle (*Curimopsis nigrita*). Their habitat has already suffered rapid destruction from commercial peat extraction and drainage of land for agriculture.

Peat extraction for horticultural growing media involves the complete removal of existing vegetation and the steady removal of the peat body (Lindsay, 1993) exposing a moonscape-like landscape denuded of life. An example of this is the Chat Moss bog in Manchester. The license for extraction from the bog ended in the early 2000s, and although the peat mining company applied for further planning permission to continue, it was refused by the local planning authority in 2011 (BBC, 2012). A requirement for the extraction company to restore this site exists, although the site remains in a poor condition.

Peatlands in a changing climate

Climate change has emerged as a significant threat to peatland ecosystems, because it exacerbates the effects of drainage and increases fire risk (Turetsky et al., 2014). It exposes peatlands currently protected by permafrost to thawing and possible increased methane emissions and loss of carbon, and the associated sea-level rise increases the risks of coastal erosion and salination of freshwater peatlands (Whittle & Gallego-Sala, 2016). While this report focuses on tropical peatlands, it is worth remembering that permafrost peatlands also hold a vast amount of carbon, which may be released as CO_2 or much more potent but shorter-lived methane and nitrous oxide (Hodgkins et al., 2013; Voigt et al., 2017).

Climate change alters the carbon cycle within intact and degraded peatlands. Moisture protects peat from being broken down. Warmer conditions speed up this decay and dry out peatlands at a faster rate. Likely climate changes across the world include increases in mean surface temperature, more intense dry seasons, changes in the cloud cover patterns, increased rainfall and fire frequency (Charman et al., 2013). Drained peatlands are already much drier and will be less resilient to the impact of these changes. Keeping peatlands intact is thus a key strategy to increasing ecosystem-based resilience and adaptation to climate change.

There is some evidence from existing degraded sites that under a warming scenario, permafrost peatlands would collapse and be inundated with freshwater. An Arctic fen habitat would develop and begin to form peat again (Swindles et al., 2015). The overall climate implications are uncertain as methane will be released at the same time that carbon dioxide is sequestered. Salination driven by sea-level rise would reduce the ability of peatlands to store carbon, trigger changes in the biota and reduce their capacity to provide ecosystems services on which people depend (Whittle & Gallego-Sala, 2016). Tropical peatlands, especially those across Southeast Asia, are thought to be the most vulnerable to this threat due to subsidence (Whittle & Gallego-Sala, 2016). Nonetheless, the impact of future sea-level rise could be superseded by anthropogenic disturbance of these ecosystems (Whittle & Gallego-Sala, 2016).

Economic impacts

The unsustainable use of peatlands worldwide has had significant impact on human societies and our economies. These effects are long lasting with a price paid across many generations that largely supersedes the short-term initial benefits of their conversion. Modern economies within the Northern Hemisphere suffered these impacts early, with poverty levels in communities associated with degraded peatlands in Western Europe being often higher than for other agricultural populations (Parish et al., 2008).

Today, conflicts continue to arise given the myriad of stakeholders and interests often involved in the use and management of these ecosystems (Parish et al., 2008). Unsustainable use of peatlands is driven by a lack of knowledge and/or recognition of their value as key habitats for wildlife, crucial providers of ecosystem services for human development, but also due to governance issues and the immediacy of land demands (Parish et al., 2008). Agricultural subsidies can also help to overestimate the economic benefit derived from peatland exploitation.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Solutions – Moving ahead

The overriding solution to ensuring the conservation of peatlands is relatively simple: keep them wet. Or, if they have been drained, rewet them.

In view of the threats to peatlands and their great importance in delivering multiple benefits and ecosystem services there is an urgent need for global leadership that ensures their restoration, protection, ongoing conservation and sustainable use. Saving our global peatlands is ambitious, but achievable. Our aspiration must be to:

- Conserve remaining undamaged peatlands to keep carbon locked in the ground and to provide vital habitat for endangered species while providing essential services and multiple benefits to people. Peat in these systems will continue to accumulate and sequester carbon from the atmosphere, assisting in the mitigation of climate change.
- Prevent the further release of carbon emissions from eroding and decomposing peat, and therefore exacerbating climate change. Do this by working toward stopping damaging practices involving drainage or excavation of peatlands and by taking action to rewet and restore degraded peatlands.
- Find an economic incentive for re-wetting. An example is by developing business cases for peatland water and climate regulation services and/or looking at livelihood options that use alternative crops (agricultural, trees and other biomass) that can cope with naturally high water levels (paludiculture) where possible to provide direct economic returns.

By maintaining peatlands in their natural state, or rewetting drained peatlands, carbon remains in the ground, providing an important carbon store. Peatlands do not need to be drained to be productive. Developing management techniques and looking at sustainable uses such as ecotourism is essential and will help to maintain the peatlands in a wet condition. For example, about 400 species have been identified for Indonesian peatlands that have an economic potential. These include sago for the production of starches, purun grass for basketry, tengkawang which produces edible oil, jelutung which produces natural rubber and rattan for basketry and furniture (Giesen, 2013).

Rewetting

Rewetting peatlands is an essential step in their restoration. Peatlands rely on waterlogged conditions for their survival. This prevents the decomposition of plant material and leads to the formation of peat and the carbon assimilated in the lifetime of the plant being stored in the soil.

When these wet conditions are removed or altered, the peat is exposed to oxygen which reacts with the carbon and leads to its oxidation and the preserved plant material is lost in the form of carbon dioxide (Lindsay et al., 2014). Rewetting peatlands halts this process and therefore the release of carbon dioxide. Depending on the restoration activities and external conditions, the peatland may also once again start to accumulate peat over time.

Reduction in greenhouse gas emissions is not the only gain. In the case of Russia – for example, the Russian-German cooperation project 'Restoring Peatlands in Russia' – for fire prevention and climate change mitigation' plans to rewet 700 km^2 of drained peatlands in the hope of also reducing their vulnerability to fires, following severe peat fires in 2002 and 2010 (Sirin et al., 2017).

Focus on Indonesia – Peatland restoration

The new Indonesian policy focuses on restoring degraded peatlands and prohibits new activities that damage the hydrological functions of peatlands, including drainage and conversion to plantations. The Peatland Restoration Agency's restoration efforts focus on seven provinces: Riau, Jambi, South Sumatra, Papua, and West, East, and Central Kalimantan. It classifies Indonesia's peatlands into four categories based on the topography, presence of drainage canals and recent fires.

Under the Paris Climate Change Agreement, Indonesia pledged to reduce its projected emissions by 29 percent by 2030 against a business-as-usual baseline scenario, and up to 41 percent subject to international assistance and financial support (Krisnawati et al., 2015). The new policy is ambitious and requires far-reaching changes in land-use management practices, and requires enormous collaborative efforts to implement and enforce it. Recognizing this, Norway is providing support to Indonesia through a USD 50 million grant, half of which will be disbursed when the monitoring and enforcement plan is created.

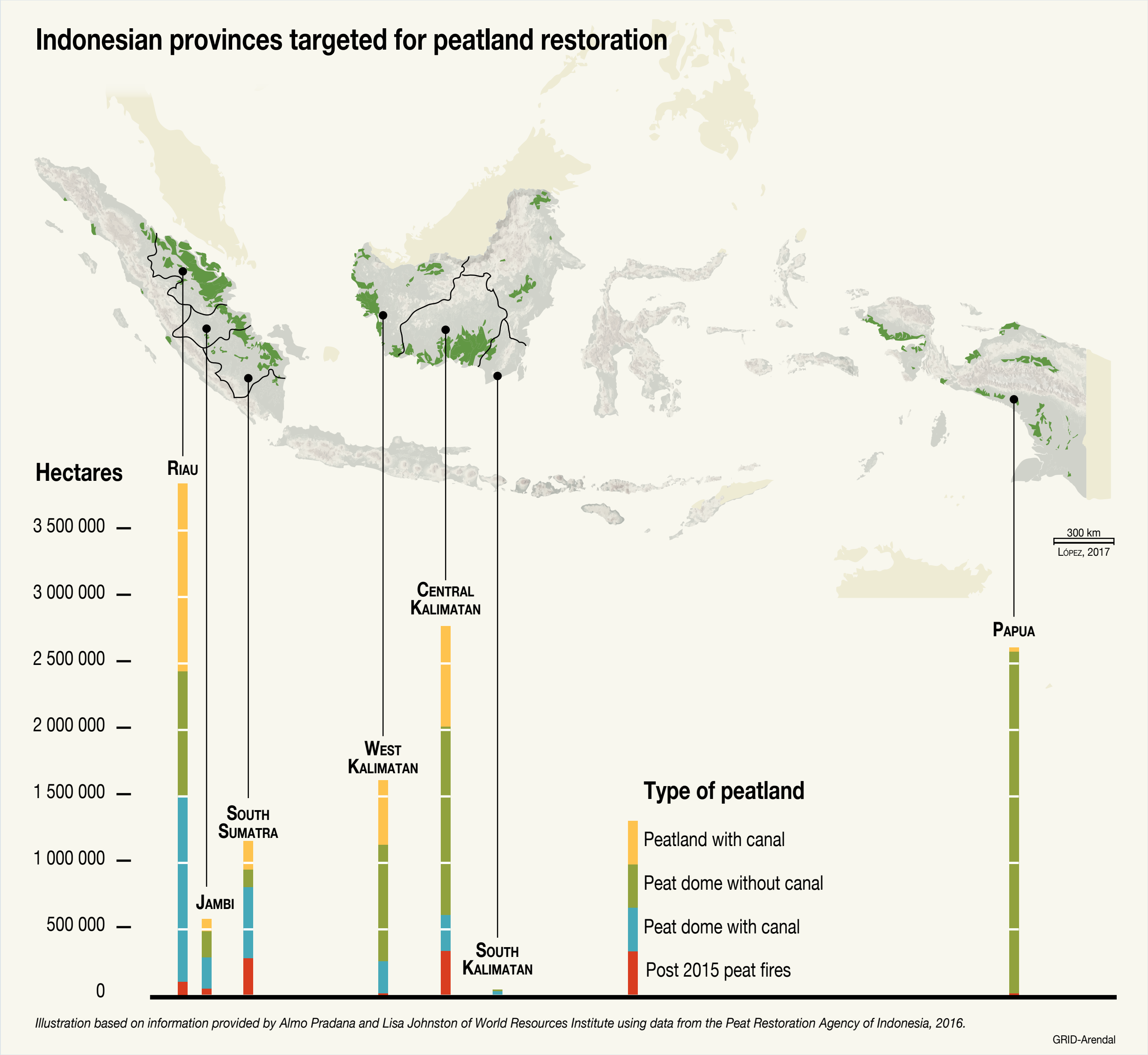

Figure 13. Indonesia has targeted several provinces for peatland restoration.

Protecting Peatlands in Riau

About a two-hour drive from Pekanbaru, the capital of Riau Province on the Indonesian island of Sumatra to Siak Sri Indrapura, lies the ancient capital of the Malay kingdom of the same name. Small villages dot the windy road which undulates over a landscape dominated by palm oil plantations. Riau is rich in natural resources like petroleum and natural gas. It is home to rubber and oil palm plantations and has also seen extensive logging and peatland degradation. Like other parts of Indonesia, fires in past years have affected the local people and their health.

Siak district is home to large peat domes and Riau Province alone has approximately 4,600 km2 of peatlands, many of which are located on forestry and plantation company concessions. A peatland management plan was created in 2009 enabling the government to take a landscape level view, and to treat the peatlands as an entire system. H. Alfredi, Vice District Head of the region, said the district government "has designated several areas proposed as peatland protection or conservation zone, in addition to designating areas as wildlife reserves, biosphere reserves, and Zamrud National Park." These areas include a number of peat domes (Alfredi, 2017).

A few kilometres from the capital, the district government and the national Peatland Restoration Agency have been working with local people to dam some of the thousands of kilometres of drainage canals that cut through the region. This is designed to raise the water level to keep the peatlands wet and reduce the number of fires.

"We can already feel the benefits," Alfredi said. "Forest and land fire incidents have dropped in the last five years." Traditional Malay teachings on "the relationship between man and the environment" underlie the regional approach, he said. These include "an indication that one is trustworthy – he or she does not destroy forests and nature." Not destroying nature indicates "one that thinks carefully," he said.

Paludiculture and sustainable management techniques

The sustainable management and use of peatlands is a relatively new area of scientific research (FAO, 2014; Joosten, 2014). For centuries, communities in many parts of Europe cultivated reeds in wet peatlands for thatching, while in Asia starch is produced from sago palms to make noodles and cookies. Paludiculture is one of the emerging management techniques that produces biomass from wet and rewetted peatlands in a way that maintains the peat body and the ecosystem services that the peatland provides. It may also facilitate carbon accumulation, produce food and feed for animals, fibre and fuel, and support the generation of other raw materials, as well as help reduce fire frequency and prevent land subsidence (Joosten, 2014; Schröder, 2014).

Other sustainable management techniques could include the cultivation of fish or the pursuit of ecotourism. Another option where rewetting is not possible is the adoption of adaptive management that avoids over-drainage, soil tillage and the use of fertilisers to reduce GHG emissions (FAO, 2014).

Due to the complexity and unique nature of peatlands around the globe, further research and customized pilot studies are required to identify appropriate paludiculture and peatland management options for different regions and to monitor the long-term impacts on food security, resilience, livelihoods and climate change. It is also vital to learn from traditional uses of wet peatlands and to provide a platform for knowledge and exchange between communities, the private sector and government. To advance understanding in this area incentives, technical advice and funding is required for testing and evaluating sustainable peatland management practices and associated development of investment options and viable alternative livelihoods.

Recognizing benefits

Whether protecting pristine areas or restoring degraded peatlands, the climate mitigation and adaptation benefits achieved through their conservation has important outcomes. It contributes to the implementation of the Paris Agreement on Climate Change and supports the achievement of the Sustainable Development Goals. It also supports the implementation of other global environmental instruments such as the Convention on Biodiversity Aichi Targets which focus on the fact that healthy and functioning ecosystems are essential for human well-being.

After centuries of degradation, European peat resources are now starting to be seen by their respective governments as an important organic carbon pool for which protection efforts need to be made to prevent further losses. Developing countries have an opportunity to leap frog and skip the destructive stages that saw countries learning the tough lessons about the impact of peatland degradation and destruction. Achieving a new sustainable approach to the management of peatlands requires focused action, with developed countries providing both the support and resources required to help lead the change. This focused action can be divided into five main areas, all of which require capacity building, outreach and awareness raising:

1. Development of policies and plans that take into account the need to sustainably manage peatlands, to protect and conserve them as appropriate and consider the full cost of their degradation and loss.
2. Land use planning and developmental decisions need to recognize and value the ecosystem services and multiple benefits that peatlands provide by acknowledging the importance of peatlands for climate change, biodiversity, water, heritage and attaining the sustainable development goals.
3. Ensure the necessary legal and fiscal arrangements are in place to support new research and to invest in and fund sustainable peatland management pathways. These must also include private sector funding and investment opportunities to support (drainage-free, sustainable) livelihoods.
4. Create and or strengthen institutions that can coordinate and collaborate between sectors and stakeholders to ensure that synergies are created and that good practices within countries and across the globe in peatlands management are made available and shared.
5. Invest in peatlands research to fill the information, data and knowledge gaps and support evidence-based decision making while fostering innovation in sustainable peatland management.

Policy

Peatland biodiversity has been recognized for some time. Ecosystem service benefits of peatlands are becoming increasingly known, leading them to feature in some of the world's high-level environmental regulations and agreements (Stoneman et al., 2016), which are summarized in Table 3. Some countries have been setting their own approach to tackling threats to peatlands with varying success to date within the framework established by these international agreements.

One of the earliest global agreements to recognize peatlands was the Ramsar Convention (1971). Since 1996 the Convention has specifically acknowledged half of the world's wetlands as peatlands. This led to the development of a global action plan for the wise (sustainable) use and management of peatlands with the 'Guidelines for Global Action on Peatlands' adopted in 2002. This allowed different stakeholders from the public and private sectors to collaborate with a focus on five priority themes:

1. Improvement of knowledge on global peatland resources
2. Education and public awareness
3. Policy and legislative instruments
4. Wise use of peatlands
5. International cooperation.

Table 3. International agreements applying to peatlands

Agreements	Detailed plans	Requirements
Ramsar Convention	• Strategic Plan 2016–2024 • Global Action Plan for Peatlands	• Conservation and wise use of all wetlands through local, regional and national actions and international cooperation. • Establish and manage a network of protected sites. • Recognition of ecosystem services provided by peatlands and their role in sustainable development. Requirement to maintain, restore and wisely use.
UN Convention on Biological Diversity (CBD)	• Strategic Plan for 2011–2020 and the Aichi Targets	• Peatland ecosystems are to be restored and safeguarded for the provision of essential services and contribution to carbon stocks. The loss of their biodiversity is to be halted. • Adverse impacts related to the use of biological resources are to be avoided or minimized. Their conservation and sustainable use should be integrated into national decision-making. • Incentives, including subsidies, which are harmful to biodiversity are to be eliminated, phased out or reformed by 2020.
UN Framework Convention on Climate Change (UNFCCC)	• Kyoto Protocol, REDD+, LULUCF, etc. • Paris Climate Change Agreement	• Protect and enhance carbon reservoirs and account for losses/gains from peatlands. • Make available national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases.

2030 Agenda for Sustainable Development	• Sustainable Development Goals	• Peatland conservation overlaps with the majority of Sustainable Development Goals, but those listed below are particularly pertinent:
		  • SDG 6: Ensure availability and sustainable management of water and sanitation for all
		  • SDG 12: Ensure sustainable consumption and production patterns
		  • SDG 13: Take urgent action to combat climate change and its impacts
		  • SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

IUCN World Conservation Congress, 2016	• Motion 046: Securing the future of global peatlands	• States to place a moratorium on peat exploitation until their legislation is strengthened to ensure peatlands are protected or managed through wise use principles. • States to give appropriate consideration to the importance of the preservation of peatlands when implementing activities to reduce deforestation and forest degradation.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	• CITES Strategic Vision 2008–2020	• Recognizes that wild fauna and flora are an irreplaceable part of the natural systems of the earth and must be protected.

The efforts of various countries, peatland specialists and NGOs led to the adoption of a new “rewetting of drained organic soils” activity under the UNFCCC Kyoto Protocol. Following a request by the UNFCCC, the Intergovernmental Panel on Climate Change developed practical guidance how to account for these activities. This led to a voluntary compensation scheme for peatland restoration activities under the Kyoto Protocol.

The latest decision by the parties to the Ramsar Convention (Resolution XII.11) pragmatically summarizes the implications for the Convention on peatlands, climate change and wise use (Ramsar, 2015). It calls for a limit on activities that lead to drainage of peatlands that may cause subsidence, flooding and the emission of greenhouse gases. It urges greater international cooperation, technical assistance and capacity building to address this. Parties are called on to use their national inventories to map the distribution of peatlands to determine the extent to which they sequester carbon – a useful step in the context of identifying Nationally Determined Contributions to fulfill the Paris Climate Change Agreement.

Further policy guidance is being prepared by the Ramsar panel to provide advice on practical methods for rewetting and restoring peatlands. It is also working on guidelines for inventories of peatlands at a national scale and their designation under the Ramsar Convention. This is a specific contribution to the implementation of Ramsar’s 2016-2024 Strategic Plan and its contributions to achieving the Sustainable Development Goals.

A 2010 review into progress towards the Convention on Biological Diversity (CBD) objectives also reinforced the need to conserve and restore peatlands while CITES and the Convention on the Conservation of Migratory Species of Wild Animals (CMS Bonn Convention) encourages signatories to protect the habitat of endangered or migratory species, for example the Bornean orangutan or the aquatic warbler Acrocephalus paludicola, a migratory passerine bird living mainly in Belarusian peatlands (Stoneman et al., 2016).

Central to current action on peatlands is the UNFCCC which focusses on action to mitigate climate impacts from anthropogenic greenhouse gas emissions and specific commitments under the Kyoto Protocol to reduce emissions and account for land use, land-use change and forestry (LULUCF) activities. Current agreement texts include the need to account for all significant carbon stores, and mitigation activities that include wetland drainage and rewetting. The REDD+ framework also helps reduce peatland emissions.

These international agreements reinforce one important message – to ensure peatlands, their biodiversity and ecosystem services are conserved and restored to a functioning state. They send a clear message to individual governments that strong action is required. To deliver on their commitments, governments must develop or strengthen their own policies to encourage peatland restoration and responsible management.

An FAO report (FAO & Wetlands International, 2012) recommended these policies include strategic planning to protect peatlands from damaging activities, the removal of perverse incentives that fuel further damage, increased government and private sector investment, and ongoing support for implementing projects, monitoring, research and knowledge exchange. In addition, coordination and cooperation across government sectors is necessary to secure the ecosystem benefits, with healthy, functioning peatlands as a shared goal rather than maximizing the delivery of individual services (Bain et al., 2011).

More work and analysis is needed to understand the different global agreements and processes to identify the most effective pathways to stimulating and enabling governments to act. Effective processes that provide guidance and offer funding to support peatland restoration, management and land use planning would lead to a greater impact and successful uptake.

Legal and fiscal environment

Effective funding mechanisms are essential to achieving large-scale peatland conservation. Historically, peatlands have been undervalued because there is a disconnect between the ecosystem services they provide, their accounted value and the support given for their management. For this reason, peatlands can be viewed as a repository of largely un-priced public goods of international value (Hubacek et al., 2009).

Table 4. Mechanisms to support peatland conservation

Instrument	Description	Peatland examples
Direct state control	Public ownership of land, with areas managed by public bodies.	• Staatsbosbeheer, The Netherlands • State Forestry Service, Malaysia
Legal regulations	Government regulation includes prohibited activities, licenses and permits, planning, implementation and monitoring requirements and delivery of conservation objectives.	• Law of the Republic Indonesia No. 32: Regarding Environmental Protection and Management – requires environmental permit for industrial activities and Environmental Impact Assessments to be carried out • UK Site of Special Scientific Interest (SSSI) – protected by law to conserve wildlife
Grant / Contract	A payment to deliver agreed work. Can be from government, charitable body or other organization.	• EU LIFE Programme • Government of Canada – National Wetland Conservation Fund
Government subsidy	Financial aid provided by the government for an activity that promotes policy.	• EU Common Agricultural Policy
User fee or visitor permit	Visitor entrance fees e.g. national parks.	• Peatlands Park, Ireland
Voluntary donation	Sum of money given to deliver charitable purpose.	• Member of the Burns Bog Conservation Society, Canada
Private investment	Private company or individual providing payment usually in return for a benefit.	• Utility company – investment in peatland restoration to reduce the cost of drinking water treatment, the United Kingdom
Tax incentive	Reduction or exemption from a tax normally liable in return for delivering a service.	
Payment for Ecosystem Services (PES)	Financial incentive for managing land in a certain way.	• REDD+ mechanism • UK Peatland Code, German MoorFutures, Katingan peatland restoration project, etc.

Public policies need to develop funding mechanisms to ensure the restoration and sustainable management of peatlands, which in turn will maintain their ecosystem services long into the future (Bain et al., 2011). There is also a need to explore new ways of tackling the core issue of funding large peatlands, especially in developing countries, given public expenditure constraints. Governments need to be able to consider the options, and cost effectiveness needs to be considered against perceived economic opportunity costs. Some of the traditional and more experimental fiscal mechanisms to support peatland conservation are described in Table 4.

Creating a market to finance peatland management

Given the scale involved, private financing and access to capital resources are necessary to enable governments to rise to the challenges they face. In the United Kingdom, the development of the Peatland Code looks to facilitate a market where private investors, motivated by corporate social responsibility, are given assurance that their investment in peatland restoration will return verifiable climate benefits, as assessed by an independent validation and verification body. Funding obtained provides cost-effective peatland restoration

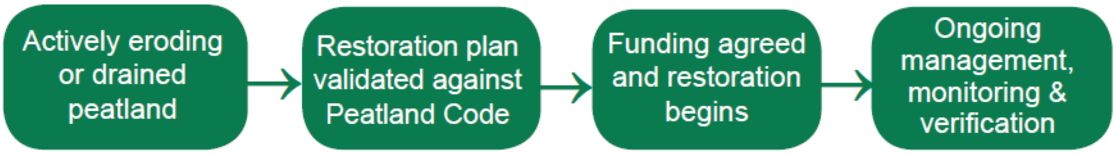

Figure 14. How funding is received through the UK Peatland Code (IUCN – UK Peatland Programme, 2017).

and ensures the management and maintenance of restoration projects over a minimum 30-year contract. Any private funds received can help complement government-funded restoration to achieve a bigger impact.

It builds on the experience of peatland restoration in Germany through the MoorFutures standard. Launched in 2011, the standard supports peatland restoration in northeast Germany. It was developed based on the Wetland Restoration and Conservation (WRC) guidance of the VCS (Verified Carbon Standard). The carbon standard itself has several peatland methodologies in place for tropical regions as well as for temperate zones. (Joosten et al., 2016).

Indonesia is also taking a different approach, with support from the Global Green Growth Institute (GGGI), an inter-governmental organization that supports government partners in their transition towards economic growth that simultaneously achieves poverty reduction, social inclusion and environmental sustainability. The Institute and the Ministries of Development Planning, Environment and Forestry and Indonesia's Peatlands Restoration Agency are working together to develop an integrated business model in collaboration with implementing agencies for peatlands restoration. Under this model, government investment is committed to protecting and restoring the core zones of peatlands (in financial and political terms). This in turn will build investor confidence and channel private capital towards sustainable economic activities in the outer zones of the peatland area.

These activities include restoration work combined with commodity and/or service-based projects with farming communities. Examples include agroforestry or non-timber

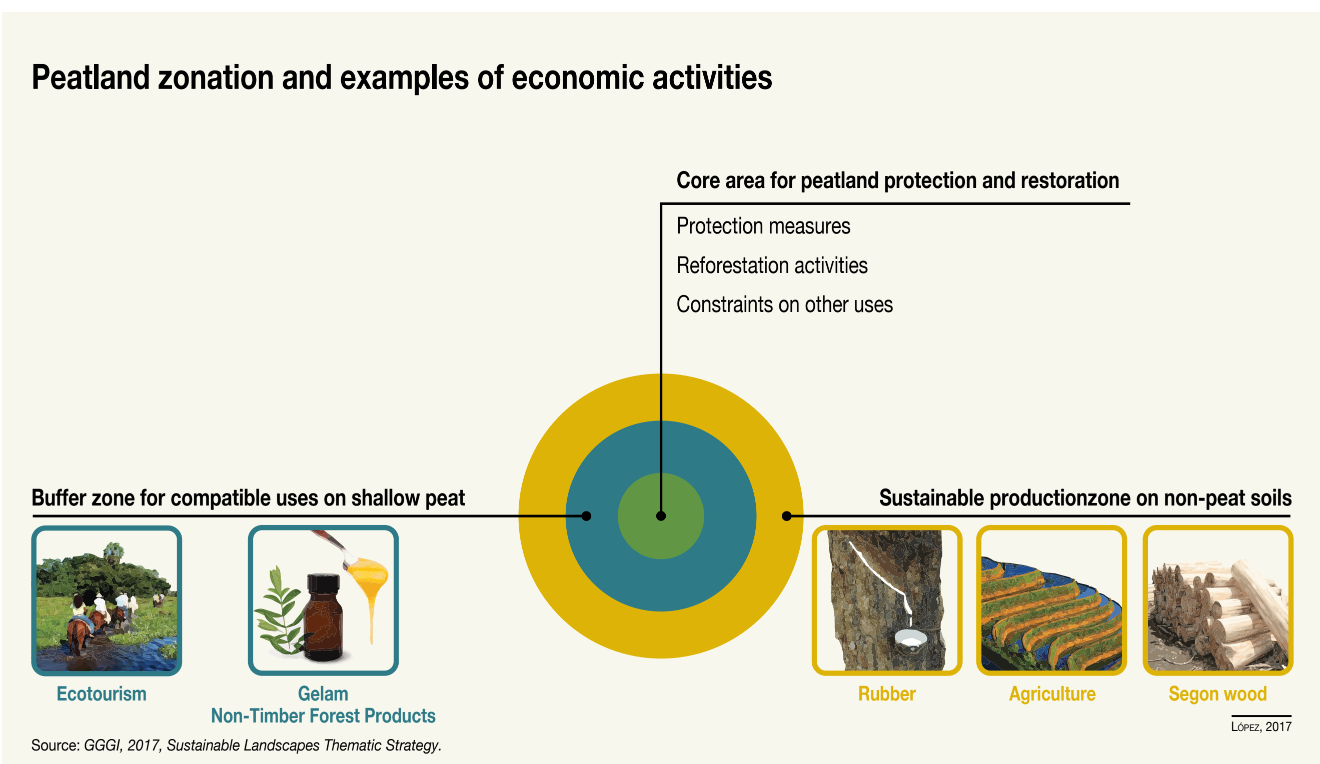

Figure 15. Innovation can be achieved when public and private capital are used to create a common vision for peatland management through a landscape approach.

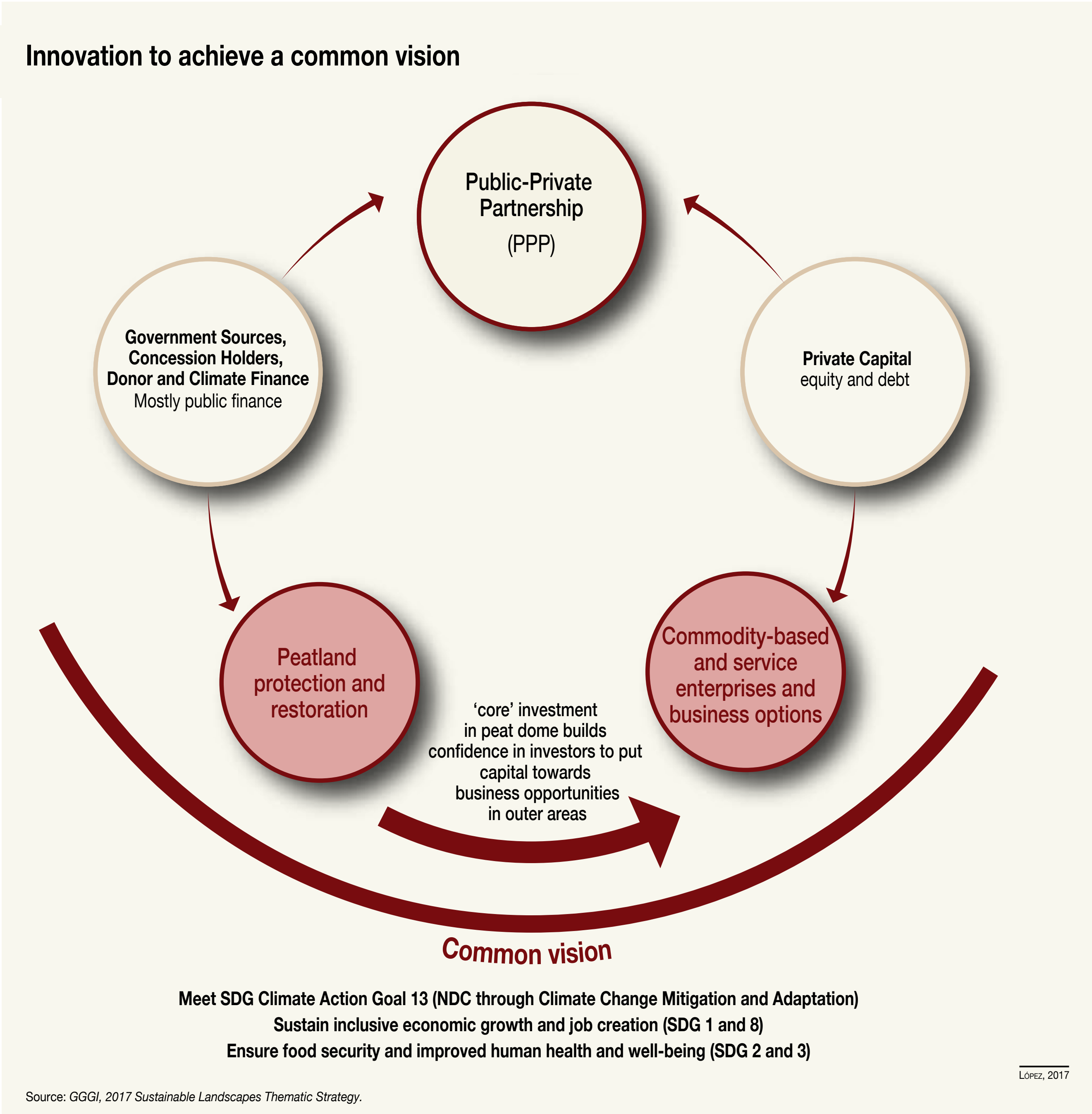

Figure 16. The integrated business model in Indonesia where the core zone receives government protection while permitting compatible economic activities in the outer zones.[9]

forest products, as well as payment for ecosystem services, such as reducing emissions. Currently, there is limited capital flow for income-generating projects on peatland landscapes, so it is hoped this initiative will demonstrate the gains to be made and build investor confidence, while benefiting community livelihoods and supporting job creation.

9. Under Indonesian law, development is prohibited in peat with a depth of greater than three metres (Wetlands International and Tropenbos International, 2016). However, to ensure sustainability, intensive use should be restricted to shallow peat of around one metre or less in depth. Regardless of depth, any use of peat soils should be compatible with maintaining water levels high enough to prevent decomposition and fire. This applies to both the buffer and core zones.

Table 5. Institutional framework to help deliver peatland conservation

Framework		Example: Scotland	Example: Indonesia
Global	Overarching global agreements, countries have signed up to deliver	United Nations: UNFCCC & Paris Agreement	United Nations: UNFCCC & Paris Agreement
Regional	Agreements and legislation pertinent to a geopolitical area	European Union: Habitats Directive; Common Agricultural Policy; Water Framework Directive	ASEAN: Agreement on Transboundary Haze Pollution
National	Country-level legislation and agreements	Scottish Government: National Peatland Plan and Climate Change Act – 250,000 ha (2500 km^2) of peatlands restored by 2032	Indonesian Presidential decree (1/2016) establishes Peat Restoration Agency (BRG) & Regulation 57/2016 on peatlands
Local	Local partnerships and communities with a vested interest	Peatland Action – restoration project on the ground, delivered by regional officers	BRG is working with Kemitraan partnership in 259 villages to develop "peat care villages"

An institutional framework for coordinated action

Significant gains can be achieved on multiple global agreements by acting now. In fact, peatlands should be considered low hanging fruit in terms of achieving climate change mitigation, adaptation and biodiversity conservation objectives. However, to make these gains coordinated and focused, policy and funding mechanisms need to be integrated to bring about change. In short, peatlands must become a collective priority from the top to the bottom of the institutional framework.

While regional and national plans are important, success on a global-scale will require global action and approaches, which filter down the institutional framework to delivery on the ground. The Ramsar Convention offers technical advice that can be implemented by many countries, especially those in the developing world.

Advice and research

Research is needed to underpin the intervention areas and enable good advice and decision-making. This report has looked at the importance of peatlands from a number of angles and discussed why keeping existing peatlands intact is urgent for both the planet and people who live with them. To meet the sustainable development goals, we need to understand the values of peatland ecosystems and the role they play in our sustainable future. The knowledge exchanged on peatlands and their importance must lead to efforts to reduce their destruction, restore them, conserve them, and sustainably manage them.

The end product of this new awareness and understanding must be better land use planning, decision-making and management of all forms of human activity. Europe has lost a large percentage of its peatlands, although awareness is growing in how to keep the rest in place. There is a chance for countries like the Democratic Republic of the Congo, Republic of Congo and Peru, where much of the peatlands are intact, to become the early adopters of an enlightened and climate-friendly approach to keeping peatlands intact, to keep the biodiversity alive and to keep the carbon they contain in the ground. To achieve this, a good starting point would be to continue research and development of technologies and approaches and to share good, evidence-based and traditional knowledge practices. This would build on the existing knowledge base and fill the gaps in knowledge that need to be addressed so that peatlands conservation, management and sustainable use can be refined and improved as we go along.

Mapping challenges

There is no comprehensive and precise global map of peatlands, organic soils or soil organic carbon. Peatlands are diverse and used in very different ways. This hampers the extrapolation of results and requires high resolution mapping. In the tropics, even very large peatlands await (re-) discovery and confirmation (Dargie et al., 2017) with the focus on forested lowland peatlands obscuring, until now, the diversity and extent of those at high-altitudes.

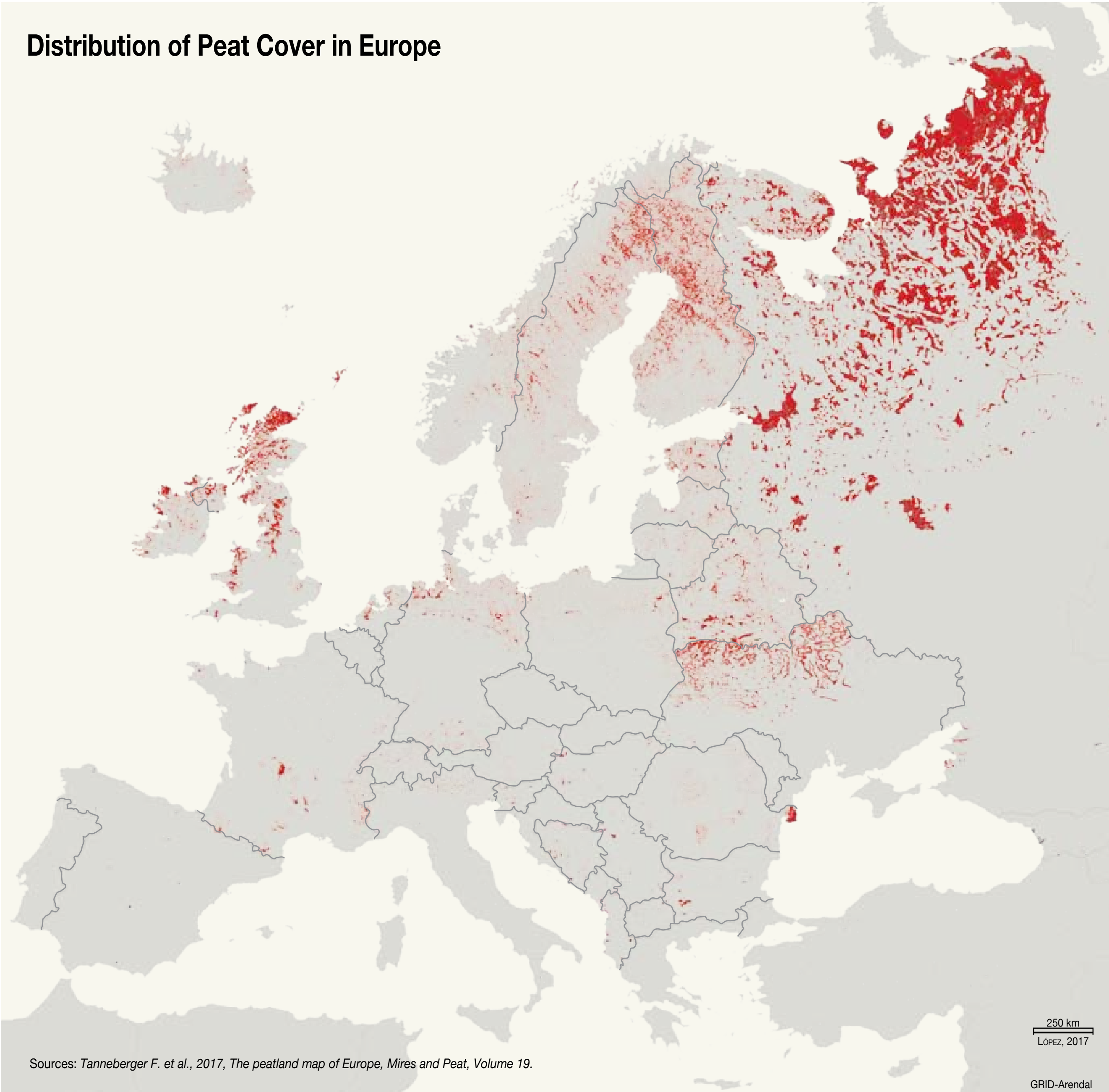

Figure 17. Peat distribution in Europe.

A good high-resolution remote sensing map to identify long-term waterlogged areas (as a sign of the possible existence of peatlands) in tropical lowlands is currently the expert system model for mapping tropical wetlands and peatlands (SWAMP, 2016; Gumbricht et al., 2017). But this dataset has poor coverage of higher altitude peatlands and seems to overestimate the extent of peatlands in regions where peatlands and non-peat wetlands are closely linked, requiring further field data for verification and validation.

Additional studies are required in South America and could lead to this region being identified as the most peatland-rich continent in the southern hemisphere (Gumbricht et al., 2017). Large and numerous small tropical peatlands are known or expected in the lowlands of western Amazonia, the Pantanal, the humid Chaco and Parana, the coastal areas of the Guyanas and Venezuela, and along the Brazilian Atlantic coast, whereas large peatlands are known from southern Chile and Argentina (e.g. Fuego-Patagonia).

Many coastal peatlands in tropical Asia have been deforested and drained for decades and await further identification and mapping (e.g. Bangladesh, Myanmar, Vietnam and Cambodia). The actual extent of peatlands and organic soils in Papua New Guinea (which has the seventh largest peatland area in the world) is also unclear.

In addition, a major mapping challenge will be the numerous smaller peatlands that are spread along coastal areas, river floodplains and lake shores in the tropics, such as those in sub-Saharan Africa.

In the countries that make up the European Union, the picture is different. Contemporary peat resources have been estimated using data provided by the European Soil Information System managed by the Joint Research Centre (JRC). The data are collected by participating countries and harmonized within the European Soil Data Centre hosted by the JRC (Montanarella et al., 2006). A detailed map of peatlands in Europe was recently published by Tannerberger et al. (2017).

Satellite imagery has recently grown in importance due to the increased interest in peatlands and organic soils in the framework of the international climate change negotiations and the related land use, land use change and forestry discussions. Despite rapidly developing remote sensing technology, accurate peatland mapping still faces a number of issues. There is also a need to collate reliable geo-referenced peatland soil profiles to provide the sufficient ground data for calibration and validation of remote sensing-based mapping and modelling approaches. Making more high resolution satellite imagery freely available will help meet these challenges.

Opportunities also exist to integrate fragmented legacy data and maps of peatland occurrences to prepare 'peatland probability maps' as starting points for national peatland inventories (Barthelmes et al., 2016). Awareness raising and knowledge exchange will be useful in encouraging more countries to produce a national inventory. At the same time techniques to foster innovation, such as the 'Indonesian Peat Prize' contest, could lead to new and improved peatland mapping technologies and methodologies.

Research needs

While it is possible to achieve progress in peatland conservation now, this report has highlighted a number of research gaps that need to be filled to accelerate this. These

can be summarized into five main areas of need for peatlands to support the UN Secretary General's call for Climate Action. These needs will vary between countries:

1. Better understanding of the state and extent of global peatlands – this information is necessary to better inform peatland management for climate change mitigation and provision of ecosystem services.
2. Improved understanding of the contribution of peatlands to greenhouse gas fluxes – sequestration and emissions.
3. Better understanding of the costs and benefits of peatland restoration for delivering ecosystem services, and the opportunity costs of a 'do nothing' or 'business as usual' approach.
4. Monitoring the state of peatlands and research into appropriate restoration techniques suited to different types and locations, with knowledge exchange playing an important part.
5. Consistent methodologies in peatland research to enable better evaluation and comparison of published studies.

The Global Peatlands Initiative is an effort to establish a much-needed network where academics, practitioners and policy-makers work together to identify research needs and develop solutions. Strengthening this network will ensure the relevance of any work conducted and the swift integration of results into practical delivery. This structure will also enable knowledge exchange and sharing of good practice to better inform peatland restoration, sustainable use and conservation work in the future.

Focus on Scotland – Bringing about a change

Sphagnum moss remembers. It recalls the touchdown of each lark that tumbles down upon its surface, the slightness of that weight recorded in the tendrils of each stem. It anticipates the appetites of flock which graze upon that wasteland when the rare haze of summer-heat crisps heather.
(Murray, 2013)

Vast parts of Scotland are covered in peatlands, with total land cover amounting to around 20 percent or 20,000 km^2, an area roughly the same size as Wales. Most of these peatlands are found in the relatively remote uplands of the north and west but many of Scotland's cities, towns and villages also have peatlands on their doorsteps.

Peat as a resource

For many centuries, Scotland has regarded its peat as a key resource. Crofters – people who occupy and work a small landholding often as a tenant paying a basic rent (a fairly unique social system that operates for the most part in the Scottish Highlands and Islands) – have historically relied on peat as a source of energy. Extracting it from allocated peat banks is a back-breaking chore, although it is typically done for personal consumption and therefore on a small-scale.

Peat in Scotland also continues to be extracted for the single malt whiskies that Scotland is famed for. Their distinctive flavour is a result of drying the malted barley used for distilling over peat-fires, with the "peatiness" determined by the amount of time that the barley grain is exposed to the peat smoke. Demand has grown for this smoky taste, boosting both production and distribution, which has also fueled an increased demand for peat.

Since the 1960s, the UK horticultural industry has used peat as its preferred growing medium. As a result, areas of Scotland have been subjected to industrial scale peat extraction. In recent years, competition from Ireland and the Baltic States supplying peat for this industry has meant that demand from Scotland has decreased, however there are still some areas where extraction occurs.

Bringing about change

In addition to extraction, greater damage has been inflicted on large swathes of Scottish peatlands through a range of historic land management practices including drainage for grazing, afforestation, establishment of wind farms and moorland burning. Pollution and wildfires have also had a harmful effect, leading to the loss of key peat-forming vegetation and the onset of peat erosion (Van der Waal et al., 2011). Estimates point to 70 percent of Scotland's blanket bog and 90 percent of raised bog being damaged to some degree, contributing to climate change, reduced drinking water quality and loss of habitat for rare species including the black grouse.

To reverse the trend and return Scotland's iconic peatland landscapes to functioning ecosystems, the Scottish Government decided to act. Publishing its National Peatland Plan in 2015, the government agency, Scottish Natural Heritage (SNH), set out a vision to see peatlands in a healthy state with ongoing management to secure and maintain the multiple ecosystem services they provide. This has been supported by the country's Climate Change Plan (currently in draft form) which sets out how the country intends to meet its emission reduction targets from 2017-2032. The plan identifies the restoration of 2,500 km^2 of peatlands by 2032 (an annual restoration target of 200 km^2) as one of its measures.

To achieve a step change in peatland management, the Scottish Government has established the Peatland Action project with a fund of £8 million for Scotland-wide restoration in 2017-18. This project provides guidance and works with private landowners and communities to identify land for restoration and to promote the benefits of healthy peatlands for wildlife, tourism, fisheries and the water industry.

Several distilleries have also been trying to reduce their peat consumption in recent years to lessen their environmental impact. This has led to the innovation of new techniques to use the smoke more efficiently as well as supporting the restoration of peatlands in areas of Scotland working with SNH and environmental charities. Meanwhile, in the horticultural industry, the UK government has introduced voluntary targets to phase out the use of peat in horticulture with the aim of ending commercial extraction in the UK, and ending its part in shipping the problem elsewhere by importing peat. Finally, extraction of peat for fuel has become less common as standards of living have increased, although the tradition is still continued in some of the northern regions of the country.

By working with local communities and businesses, the Scottish Government through Peatland Action has been able to restore 100 km^2 to date (large areas of which is on private land) with a number of new projects signed up for the coming year.

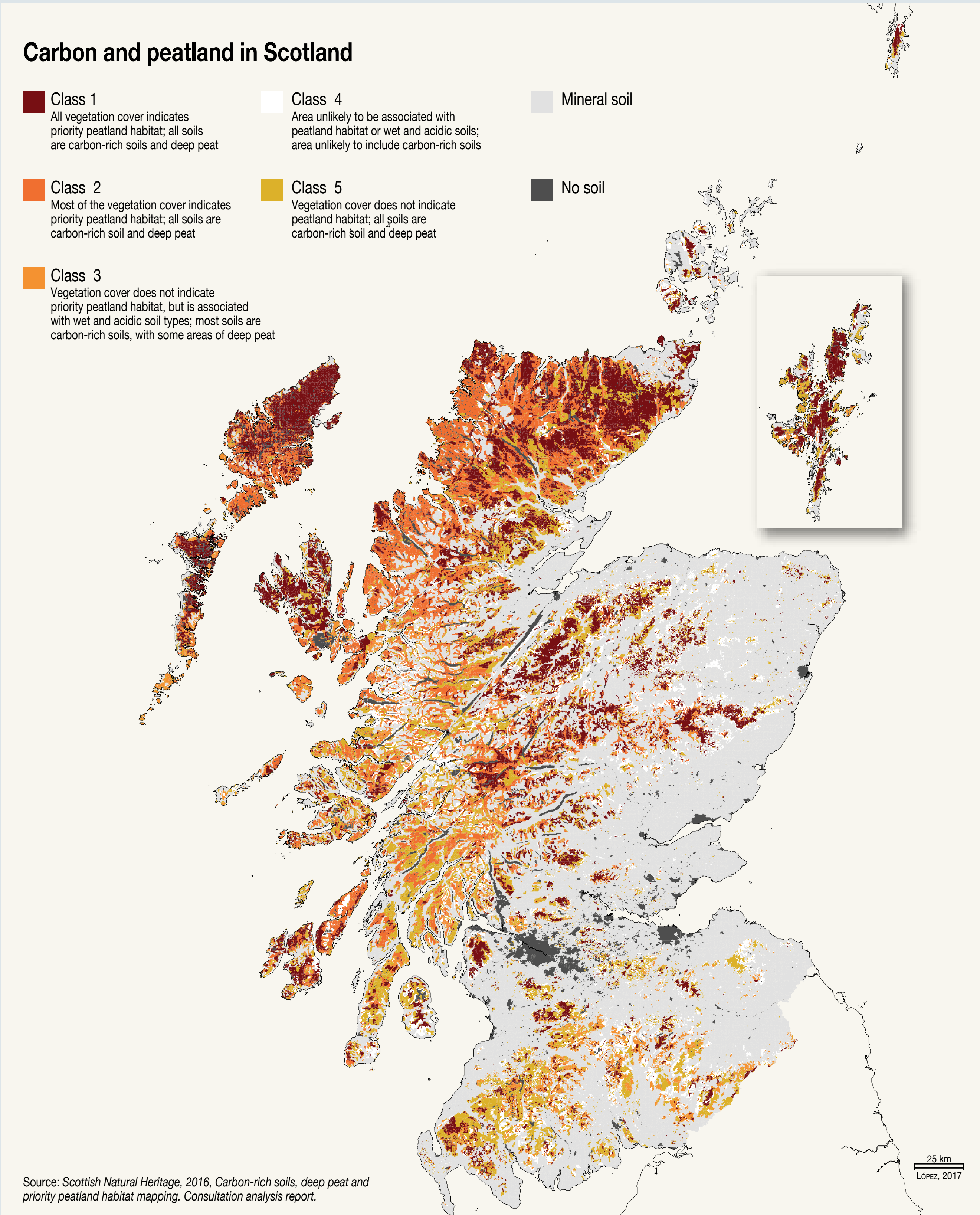

Figure 18. Distribution of peatlands and carbon in Scotland.

Focus on Peru – The importance of peatlands for people in the Amazon

A substantial part of the world's peatlands is located in Peru (CIFOR, 2014), mainly in the Amazon basin as well as in the Andes. Peruvian peatlands have an "extremely important ecological, economic and social role" and are found in large wetland ecosystems which can also include swamps, lakes, rivers and floodplains (CIFOR, 2014).

The Peruvian Andes are dotted with scattered peatlands called "bofedales" that form 3,000 metres above sea level (Maldonado Fonkén, 2010). Several types have been identified in at least six regions of Peru (CIFOR, 2014). They are relatively small in size with an estimated overall area of 5,500 km^2 or approximately 0.4 percent of Peru's surface area (MINAM, 2012). Peat thickness measurements indicate that bofedales can be seven metres thick with a high organic carbon content (Maldonado Fonkén, 2014).

Despite heavy use, the vegetation of bofedales has adapted. Pristine peatland areas remain, and their biodiversity value is high and home to threatened species like the Junin Grebe (*Podiceps taczanowskii*). They also provide a habitat within which wild animals find water, shelter, food and nesting sites (Maldonado Fonkén, 2010).

However, Peruvian peatlands have been degraded through intensification of traditional management systems. In recent years, several national and international efforts to assess peatlands have increased the knowledge about their extent, thickness and importance for the livelihoods of Peruvians. This, it is hoped, will improve the sustainability of land use planning and permitting, as well as peatland management as a whole.

Fruit of the peatlands

The Research Institute of Peruvian Amazonia (IIAP) estimates that approximately five thousand families depend on the fruit of the aguaje and other fruit trees such as the ungurahui, huasaí and muru muru which grow in the peatlands of the Peruvian Amazon. Aguaje, which has high levels of vitamin A and E, is eaten raw or extracted (in the form of oil and pulps) and turned into products by the cosmetic, juice and nectar industries. The peatlands in this area include aquatic ecosystems that contain a large diversity of fish that, in addition to ensuring local food security, provide the main income to indigenous communities.

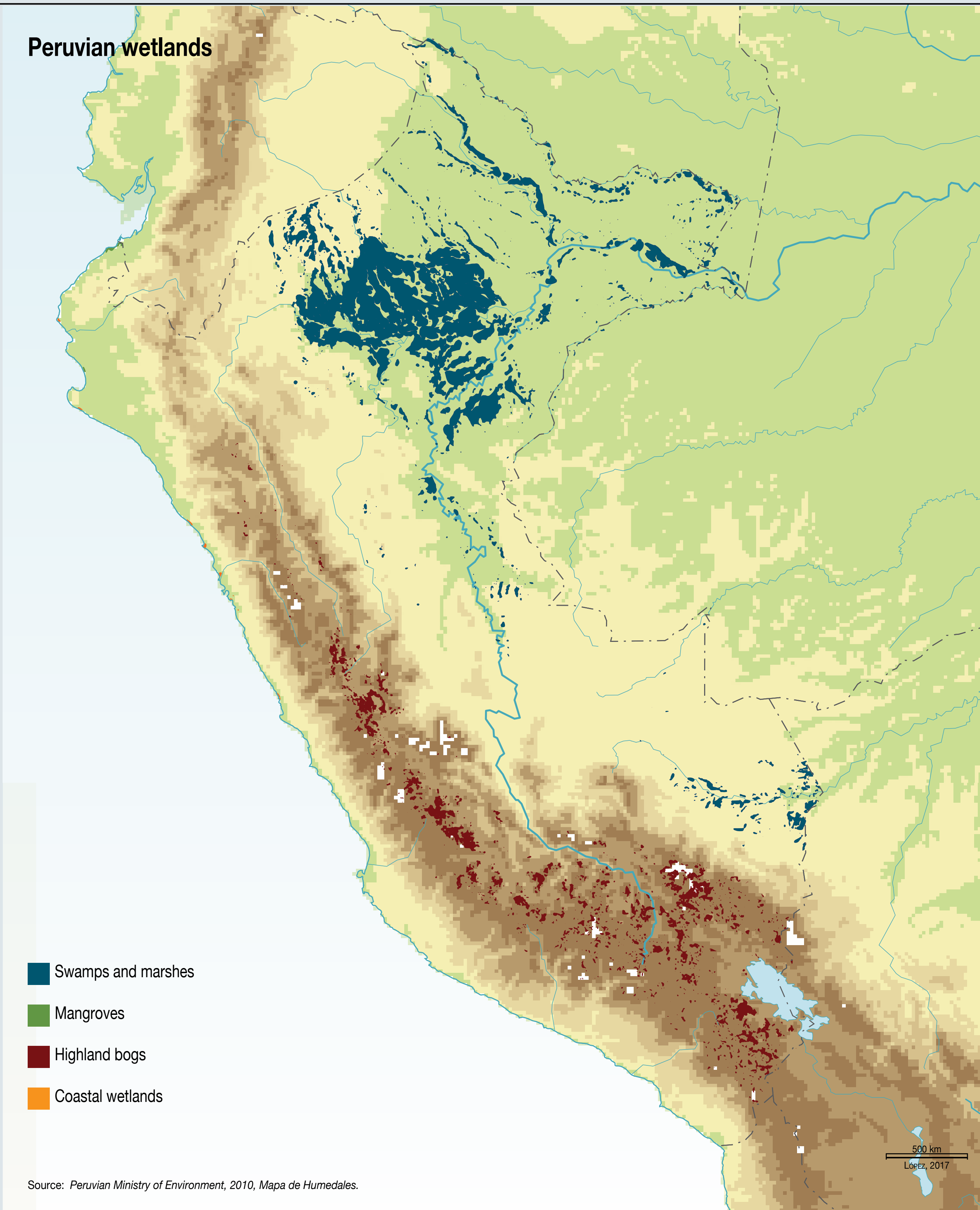

Figure 19. Wetland areas in Peru.

In pre-hispanic times, most highland peatlands were managed by local populations for livestock grazing and water use and have since become cultural landscapes. In fact, there is evidence that bofedales helped determine the location of human settlements when the region was populated 5,000 years ago. It is also believed that the local practice of irrigating pasturelands could have helped to create some of the bofedales. Local populations manage the water systems within bofedales and fertilize them as part of their livestock management practices (Verzijl & Guerrero, 2013), and fence and rotate grazing lands (Maldonado Fonkén, 2014). Andean peatlands are also used to grow food for native alpacas and llamas, and for horses, cattle and sheep (Maldonado Fonkén, 2010).

Threats and Solutions

While Peru's Amazon peatlands are nearly intact, they face a wide range of threats. These include "degradation from the large-scale clearing of aguaje palm trees for fruit, illegal logging and palm oil plantation expansion" (Green Climate Fund, 2016; Gimore, Endress and Horn, 2012) as well as drainage for rice paddies, mining and infrastructure expansion. Reduced tree cover exposes peat and increases evaporation from the soil surface which increases greenhouse gas emissions that go undocumented.

Given their importance to local livelihoods and climate change mitigation, there is clear need for action to safeguard Peru's peatlands. Though actions have been taken to protect the country's wetlands, peatlands have yet to receive the same level of attention. The Wetland Conservation Strategy published in 2105 identifies peatlands only within the Andean region but not in the Amazon. The strategy – la Estrategia Nacional para la Conservación de Humedales en el Perú – led to the creation of a national committee to monitor its implementation, as well as the Ramsar Convention (Government of Peru, 2013). The National Committee is tasked with the overall monitoring of the wetlands in line with the Ramsar Convention but does not specifically monitor peatlands. Additionally, the National Strategy on Forests and Climate Change (published in 2016) does not mention peatlands and even promotes wetland drainage. Nor are peatlands mentioned in the National Strategy on Climate Change (published in 2015).

There are, however, a number of options for sustaining the country's peatlands. Peruvian legislation identifies bofedales as fragile ecosystems (Maldonado Fonkén, 2014) and recommends conserving or protecting them from mining and infrastructure development in ecological and economic zoning regulations. In the Amazonas, the IIAP has called for better protection for lowland peatlands due to their ability to store large amounts of carbon. This could be achieved, for example, by extending the boundaries of the Pacay Samiria National Park.

Another avenue could be the UNFCCC's Green Climate Fund, which is designed to help developing countries meet climate change mitigation and adaptation targets and which has already funded projects in the country. For example, the Peruvian Trust Fund for National Parks and Protected Areas received US$ 9 million in 2016 for a five-year project "focused on entrusting indigenous communities in the northern Peruvian province of Datem del Marañón to manage their wetland resources in ways that do not release the large amount of greenhouse gases stored in the region's peatlands." The project places "indigenous communities at the forefront of sustainable land-use reforms to cope with a changing climate" and is expected to avoid emissions of 2.6 million tonnes of CO_2 equivalent (Green Climate Fund, 2016).

The trust fund supports indigenous "bio-business" activities that include harvesting salted fish, producing smoked meat, extracting aguaje pulp from palm trees, and tapping Dragon's Blood trees for their resin which is used in anti-inflammatory medicine (Green Climate Fund, 2016).

Recommendations

Despite the uncertainties of international politics and the withdrawal of the United States from the Paris Climate Change Agreement, commitments to safeguard the world's peatlands are being made and action is being taken. For example, one piece of good news last year was that Indonesia is leading the way by committing to restore a significant portion of its peatlands. This is expected to reduce its greenhouse gas emissions and cut the number of large scale fires that have plagued Indonesia in recent years. At the same time, recent discoveries of large peatlands in the Congo Basin and Peru, highlight the importance of finding, mapping and preserving them.

Despite being found in 180 countries peatlands are not foremost in the minds of policy makers. They should be though – and they need to be high on the climate change agenda because they store massive amounts of carbon. For many years, scientists have been waging a lonely struggle, pointing to the need to preserve them to prevent billions of tonnes of additional greenhouse gases escaping into the atmosphere and further driving up emissions.

But peatlands are important for other reasons in addition to their contributions to reducing the effects of climate change. They are essential components of complex ecosystems which support a wide and often fragile array of plants and animals upon which people rely for their economic, social and cultural wellbeing.

The simple message in this rapid response assessment is that we must protect peatlands wherever they are and learn to use them sustainably before they are damaged through our actions of bisecting them with roads for oil, gas and mineral exploration or forestry, drained and used in other unsustainable ways.

The following recommendations are meant to raise awareness about the critical importance of peatlands. They are priority areas that can be dealt with now to preserve peatlands, conserve biodiversity and take action on climate change. There are two categories of recommendations: immediate and longer term. Both are essential.

Recommendation 1: Policy must send a clear message to protect and conserve peatlands for the multiple ecosystem services that they provide and must link delivery of climate change, biodiversity, water, heritage and development objectives. Specifically, it is recommended that

- Policies include strategic planning to protect peatlands from damaging activities, and

- Coordination and cooperation across government sectors must be made a priority to secure ecosystem benefits, rather than maximizing the delivery of individual services.

Recommendation 2: Act now to conserve intact peatlands, keep carbon in the ground and achieve "quick wins" in the areas of protection, sustainable use and restoration by:

- Safeguarding and preserving natural peatlands from degradation. This includes restricting new agricultural, exploratory and industrial activities that threaten their long-term viability. Countries with peatlands should create land use policies that favour conservation and protection and keep them wet. Establish protected areas and Ramsar sites to preserve valuable natural peatland sites and their ecosystem services for the future involving local communities and stakeholders.

- Rewetting and restoring where peatlands are degraded to conserve biodiversity, reduce greenhouse gas emissions and replenish freshwater resources. Industrialized countries should lead in their own areas and give support to developing countries to protect and restore peatlands through rewetting, for example through market mechanisms, enhancing sustainability criteria of imported goods produced on peatlands.

- Managing peatlands where economic activities are taking place in a sustainable and climate smart, i.e. wet, way. Peatland ecosystems can be managed for water and climate regulation and ecotourism. Paludiculture is also an example of responsible management and can provide in sustainable livelihoods and downstream production chains.

- Following adaptive management practices where full rewetting is not possible.

- Addressing social issues, such as local communities' right to use natural resources and their traditional uses. Open dialogue, prior consent, fair negotiation and social legitimacy from the local to the national level are necessary to implement any climate-responsible strategies. Support is needed to assist communities to sustainably use peatlands and develop alternatives to destructive practices.

In the longer term,

- Policies include strategic planning to protect peatlands from damaging activities,

- "Perverse incentives" that lead to damage should be removed, and

- Coordination and cooperation across government sectors needs to be made a priority to secure ecosystem benefits, rather than maximizing the delivery of individual services.

Recommendation 3: The necessary fiscal arrangements must be put in place to support new research and fund conservation and management activity, discourage damaging activities and ensure the restoration and good management of peatlands into the future. These arrangements must assist governments that are unable to pay for extensive research, restoration or other activities. In these cases, private sector involvement is required.

Recommendation 4: Channel funding for responsible peatlands policy development and management through international mechanisms such as the Nationally Determined Contribution framework, REDD+ and Nationally Appropriate Mitigation Actions (NAMAs) under the UN Framework Convention on Climate Change. Accounting for carbon stocks within forested peatlands under REDD+ could foster long-term protection.

Recommendation 5: Create an institutional framework built around coordinated action to ensure good practices across the globe in peatland management. As part of this, ensure involvement of local communities in the development and implementation of sustainable management plans.

Recommendation 6: Improved management and protection requires that the research and knowledge gaps identified in this report be addressed, especially the following requirements:

- Develop a better understanding of the state and extent of global peatlands to inform better peatland management for climate change mitigation and provision of ecosystem services,
- Improve understanding of the contribution of peatlands to greenhouse gas fluxes.
- Increase understanding of the costs and benefits of restoration of peatland ecosystem services, and the opportunity costs of a 'do-nothing' or 'business-as-usual' approach.
- Monitor and research appropriate restoration techniques suited to different peatland types and locations, with knowledge exchange playing an important part.
- Use consistent methodologies in peatland research to enable better evaluation and comparison of published studies.
- Provide a platform for communities, companies and government for exchange of lessons learned on sustainable alternatives for rewetted peatlands across the globe.

Recommendation 7: Governments, industry and other stakeholders must invest in raising awareness about the importance of peatlands at a global, national and regional level if new land use planning policies and management ideas are going to be effective and benefit all.

Recommendation 8: Ensure there is open dialogue, fair negotiation and social legitimacy from the local to the national level to implement any climate-responsible strategies. Millions of people rely on peatlands or land that has been converted from peatlands for their food, water and livelihoods. Support is needed to assist communities using peatlands to manage them sustainably and develop livelihood alternatives to halt and cease destructive practices.

Glossary

Acid sulfate soil	Soil containing iron sulfide minerals that form naturally in waterlogged conditions. If the soil is drained or exposed to air by lowering the water table, the sulfides react with oxygen and become sulfuric acid leading to extremely acid, unproductive soil.
Bog	A peatland only fed by precipitation
Fen	A peatland that receives water that has been in contact with mineral soil or bedrock
LULUCF	Land Use, Land Use Change and Forestry, a sector under the United Nations Framework Convention on Climate Change
Mire	A peatland in a state of active peat formation and accumulation
Paludification	Peat accumulation which starts directly over a formerly dry mineral soil
Paludiculture	Cultivation of biomass on wet and re-wetted peatlands in a way that the peat stock is long term preserved
Peat	A substance largely consisting of (partly decomposed) remains of plants (vascular plants or mosses)
Peatland	Land covered by peat
REDD+	A mechanism under the UNFCCC aimed at reducing emissions from deforestation and forest degradation by conservation and sustainable management of forests and enhancement of forest carbon stocks in developing countries
Terrestrialization	The accumulation of sediments and peats in open water
UNFCCC	United Nations Framework Convention on Climate Change

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Appendix

Impacts of fire and haze, peat degradation, and ecosystem restoration on selected SDGs

SDG	Impacts of fire and haze	Impacts of peat degradation	Impacts of peatland restoration
1. End poverty in all its forms everywhere	– Loss of environmental services impacting the livelihoods of communities dependent on them. – Health shocks from the haze impacting household incomes. – Slowdown in economic and human development further aggravating poverty and health.	– Land subsidence and flooding of degraded areas decreases agricultural land and productivity, reducing income. (Hooijer et al., 2012) – The loss of natural capital of peatlands due to fires diminishes incomes of communities dependent on peatland ecosystems, fresh water, timber and non-timber forest products.	– Improved peatland ecosystems and sustainable agricultural yields ensure sustainable livelihoods, additional income, and food security, increasing resilience to economic, social and environmental disasters from fires, floods, and climate shocks.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	– Drought, fires and haze prevent successful yields and planting of crops, hampering food security and increasing hunger and malnutrition. – Decreased agricultural productivity resulting in reduced incomes, slower economic and human development. – Burned areas decrease biodiversity and increase risks of disease and pests, impacting food security. (Jakarta Post, 2015)	– Land subsidence and flooding causes loss of agricultural land, leading to decreasing agricultural yields, and weakened food security. – Increased pressure on land, scarcity due to flooding and degradation, preventing the improvement and implementation of sustainable agriculture practices which further promotes monoculture plantations.	– Improved ecosystem function, water regulation and agricultural practices increase yields and ensure resilient and sustainable food production, decreasing hunger and malnutrition. – Organic peatland soils can be used productively and sustainably by developing paludiculture. (FAO & Wetlands International, 2012)
3. Ensure healthy lives and promote well-being for all at all ages	– Fires have led to alarming levels of air pollution including carbon monoxide, ammonia, cyanide, formic acids and formaldehyde. (CIFOR, 2015) – Negative health impacts from the haze include respiratory tract infections, lung disease, and cancer. (CIFOR, 2015)	– Degradation of peatlands and their biodiversity decreases the quality of the environment, increased insecurity, and impacts on well-being. – Land subsidence and flooding puts the lives of those living in coastal lowlands at risks. (Hooijer et al., 2012)	– Reduced risks of environmental and social hazards lead to improved well-being, a cleaner environment, water availability, smaller risks of diseases and improved livelihood options.
13. Take urgent action to combat climate change and its impacts	– GHG emissions from peatland fires are enormous and of global significance. For example, they contribute to an estimated 40–45 percent of Indonesia's total GHG emissions. (Hooijer et al., 2014). For 2015, overall emissions from Indonesia (largely from peatlands) were 1.75 billion t CO_2e.[11]	– Oxidation of peat leads to the continuous release of GHG. Drained peatlands are currently responsible for 5% of the global anthropogenic GHG emissions (Joosten, 2015). – Degraded peatlands are susceptible to erosion and loss of organic matter increases carbon losses (Moore et al., 2013) contributing to climate change.	– Significant reduction of GHG emission from fire and soil. – Intact peatlands are an important carbon store, holding over 550Gt of carbon worldwide. (Jaenicke et al., 2008)
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	– Fires destroy ecosystems and biodiversity and haze endangers wildlife. Over a third of the world's wild orangutans are at risk due to food shortages and the poisonous haze. (The Guardian, 2015b) – The smouldering peat and subsequent dried out lands expose tree roots, makes the peat and forest vegetation unstable – Subsequent subsidence leads to tree falls and causes the loss of large forest areas.	– Clearing and drainage of peatlands alter the characteristic hydrological functions of peatlands and reduce their ability to provide ecosystem functions. (Dommain et al. 2016) – Current land use on peatlands (oil palm and acacia) requires substantial drainage, leading to further degradation. (Hooijer et al. 2012) – Loss of biodiversity of peatland ecosystems and threating the habitat of unique and endangered wildlife.	– Ensures the conservation and restoration of biodiversity, and limits the extinction of wildlife. – Increased environmental resilience reducing the impacts of environmental disasters and climate change. – Maintaining and managing the water table on peatlands which will significantly reduce fire incidence, accumulate natural capital and increase resilience of communities dependent on peatland ecosystems. (Hooijer et al., 2012; Moore et al., 2013; Hooijer et al., 2014)

11. See: www.globalfiredata.org/updates.html

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