APPETITE FOR DESTRUCTION

About WWF
WWF is the world's leading independent conservation organisation. We're creating solutions to the most important environmental challenges facing the planet. We work with communities, businesses and governments in over 100 countries to help people and nature thrive. Together, we're safeguarding the natural world, tackling dangerous climate change and enabling people to use only their fair share of natural resources.

Food is at the heart of many key environmental issues WWF works on. Growing, producing and importing food contributes substantially to climate change. It's a driving force behind habitat and biodiversity loss. And it's a huge drain on water resources. That's why helping to develop a sustainable food system for healthy people and a healthy planet is one of WWF's priorities.

Find out more about our work at **wwf.org.uk/food**

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FOREWORD

At WWF we recognise the impact our food system has on biodiversity.

Duncan Williamson
Food Policy Manager, WWF

Through our work on sustainable diets, we know a lot of people are aware of the ramifications of a meat-based diet – its effect on water, land and habitats, and the implications of its associated greenhouse gas emissions. But few know the largest impact comes from the crop-based feed the animals eat. As we investigated why this is so we realised that for many, what we buy and eat is too far removed from the biodiversity it impacts upon.

As consumers we're disconnected from where our food comes from. Understanding where the feed supplied to our livestock industry comes from, and the impact this has on global biodiversity, is therefore a tall order. But, it's not something we at WWF want to shy away from. With this report, we hope to help people – in particular policy-makers and business leaders – make the initial connections between food, feed and biodiversity, and open a space to identify solutions.

Appetite for destruction is based on two reports prepared for WWF in 2016: *A risk benefit analysis of mariculture as a means to reduce the impacts of terrestrial production of food and energy* by ABP Marine Environmental Research Ltd, and *Environmental impacts of livestock feed* by 3Keel LLP. Producing these reports took us on a journey from farming the oceans to land-use change, through soy to our plates. It showed us that not only is business as usual not desirable, it won't be possible from a climate, water and land perspective. We'll need to go beyond production improvement and waste reduction and move into innovation and look at what we are eating, globally.

Biodiversity is disappearing at an astonishing rate due to the food we eat and the feed we supply our livestock industry, yet its key to a resilient food system.

In order to address this problem we'll need to communicate, convene and innovate. Already, WWF has a fantastic track record here. We've helped establish vital schemes directly relevant to food, feed and biodiversity – including the Roundtable on Responsible Soy (RTRS), the Roundtable on Sustainable Palm Oil (RSPO), and the Aquaculture Stewardship Council (ASC). And we've led the way on sustainable diets with our Livewell work.

Now, we're at the forefront of feed invitation. Project-X's FEED-X is a WWF programme which aims to help the aquaculture industry identify, test and scale-up new alternative feed ingredients, including insects and algae. It'll seek to drive consensus on the most scalable and sustainable feeds and accelerate the uptake of these ingredients.

We're a convening partner of the Protein Challenge 2040, an innovative coalition which addresses the complexities of our protein supply chain. Here our focus is on increasing consumption of plant-based protein, and scaling up sustainable feed innovations to meet the demand for animal protein.

Appetite for destruction is a vital piece of work that clearly sets out what we believe to be one of the biggest challenges to our food system and the threats this poses to global biodiversity. With this we invite actors throughout the food system to work with us to address these issues and deliver a healthy, biodiverse-rich future.

GLOSSARY, ACRONYMS AND ABBREVIATIONS

Agroecology: defined by the International Panel of Experts on Sustainable Food Systems as a form of farming that replaces chemicals with biology. It looks at the entire food system and promotes agricultural practices that are adapted to local environments and stimulate beneficial biological interactions between different plants and species to build long-term fertility and soil health

Algae: diverse group of photosynthetic organisms that range in size from single cells to large spreading seaweeds

Animal products: all food products from animal sources, including milk, eggs, cheese, chicken meat, beef, sausages, fish and seafood

Aquaculture: farming fish and shellfish either on land in tanks, rivers, ponds and lakes or in seas and along the coast

CO_2: carbon dioxide

Crop feeds: crops used in the production of animal feed, including maize, soy, sorghum and rice

DHA: docosahexaenoic acid, a nutritionally important omega-3 fatty acid

Eutrophication: excessive richness of nutrients in a lake or other body of water, which causes a dense growth of plant life and is harmful to species in the affected ecosystem

Extensive farming: farming system which uses small amounts of labour and capital in relation to land being farmed, producing a lower yield per unit of land in contrast to intensive farming

Fish: as used in this report, includes all fish and shellfish

Greenhouse gas emissions: emissions of gases such as carbon dioxide and methane that trap heat in the Earth's atmosphere and are the primary cause of climate change

IMTA: Integrated multi-trophic aquaculture, a synergistic approach to aquatic production where the waste products from one species provide feed or fertiliser for another

Intensive farming/intensification: usually used to describe a farming system that increases the output per unit of land area by increasing inputs such as fertiliser, feed and technology. In terms of animal husbandry, these systems are characterised by selected breeds, dense populations on limited land requiring manufactured food, water and medical inputs

Livestock: animals – including chickens, pigs and fish – raised and used for profit

Mariculture: fish and shellfish farmed in the sea and along the coast

Omega-3: a class of essential unsaturated fatty acids

Organic: agricultural systems with strict limits on the use of agrochemicals, instead relying on natural pest control and fertilisers. Other key elements include high animal welfare standards and the prohibition of routine use of antibiotics and genetically modified crops. Often used as an example of extensive farming

Pelagic fish: fish that inhabit the water column instead of the shore or seabed, such as anchovies, sardines and herrings

INTRODUCTION

WWF's vision is a future where people and nature thrive together. Ensuring that all people have easy access to sufficiently nourishing food is an essential part of this future. However, today's food system occupies ever more land, uses more freshwater resources, and contributes significantly to environmental degradation, habitat loss and climate change. These impacts in turn drive wide-scale biodiversity loss and extinctions, making once abundant species rare, and threatening the future of important ecosystems. The UK food supply alone is directly linked to the extinction of an estimated 33 species at home and abroad[1].

As well as undermining the nature that we depend on, today's food system is under pressure from a growing global population which is expected to surpass nine billion by 2050. Three billion people are set to enter the global middle classes[2,3,4], with a majority living in urban areas as we see the rise of 41 megacities with 10 million or more residents by 2030[5]. As people move from the countryside to cities and become wealthier, they tend to increase their calorie intake and move toward a Western-style diet with more meat, dairy and processed foods. With a growing demand for resource-intensive animal products comes an increased need for animal feed, putting further strain on land, water resources and biodiversity. As well as threatening the future of our living planet, this has serious implication for food security, health and well-being.

This report looks at the impacts of our current and anticipated consumption of animal protein – and in particular the often hidden impacts of animal feed. Tracing the trajectory of land use for feed production – in particular soy and maize – we make it clear that business-as-usual isn't an option. We investigate the link between feed and industrialised animal produce, with a focus on chicken, pork and fish. We link the increased use of feed to the reduced nutritional value of the animal products, before exploring solutions through changing diets and alternative feed production systems.

We believe it's possible to reconnect food production with nature and nutritional requirements, guaranteeing everyone affordable, nutritious and tasty food, as well as space for nature to thrive. But this will require fundamental changes in our food system, from production to consumption. **With this report, we invite businesses and policy-makers to work with us to create an enabling environment for a food system that works for people and planet, and reverse the rate of biodiversity loss.**

THE UK FOOD SUPPLY ALONE IS DIRECTLY LINKED TO THE EXTINCTION OF AN ESTIMATED 33 SPECIES AT HOME AND ABROAD

ANIMAL FEED – THE LINK BETWEEN FOOD, BIODIVERSITY AND HEALTH

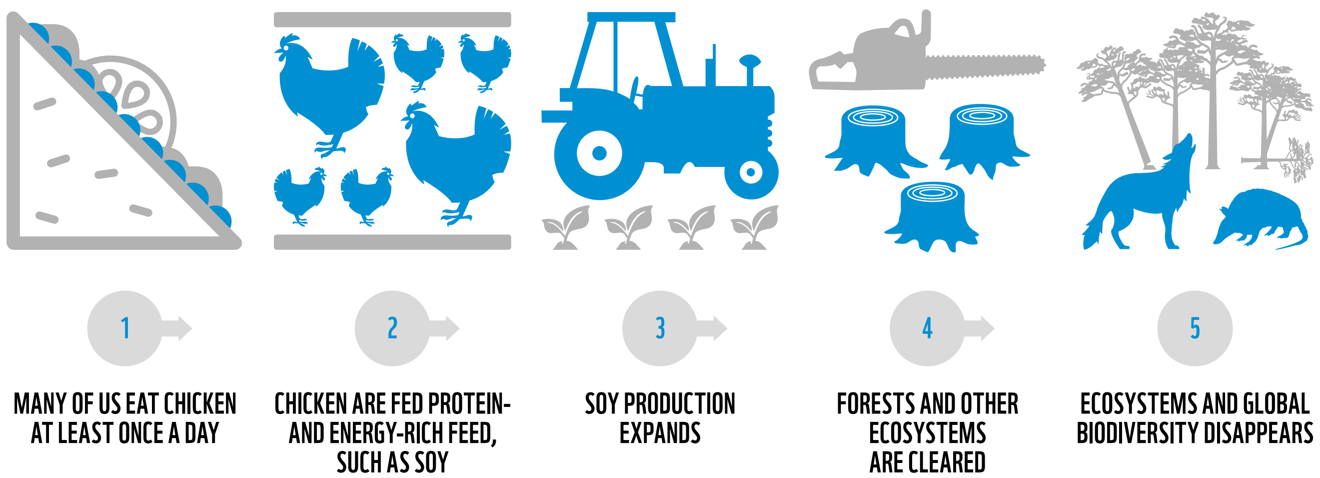
GROWTH OF THE FEED INDUSTRY

The global shift to a Western-style diet based on high amounts of animal products is changing the farming landscape away from grazing and fishing to intensive, industrialised production systems[6]. With this comes an increased need for protein- and energy-rich animal feed which allows animals to reach their slaughter weight more quickly. Today, **around 75% of soy and maize production worldwide is used in animal feeds, particularly for poultry and pigs**[7], with the top consumers of these feeds being China, the EU, USA and Brazil.

By looking at our animal protein consumption, we can see how this is linked to the continual expansion of feed production. While the UK nutritional guidelines recommend 45-55g of protein per day, the average UK consumption is 64-88g of which 37% is meat and meat products[8]. In other words, we consume almost twice as much as we need just from animal products – and this dietary trend is on the rise globally[12,9]. Our over-consumption of animal protein is made possible by an unequal share of land and water resources dedicated to producing animal products for developed countries[10]. As global populations grow, land and water inequality is set to deepen, with the richest quarter of the global population predicted to use three times more arable land per person than the rest by 2050[17].

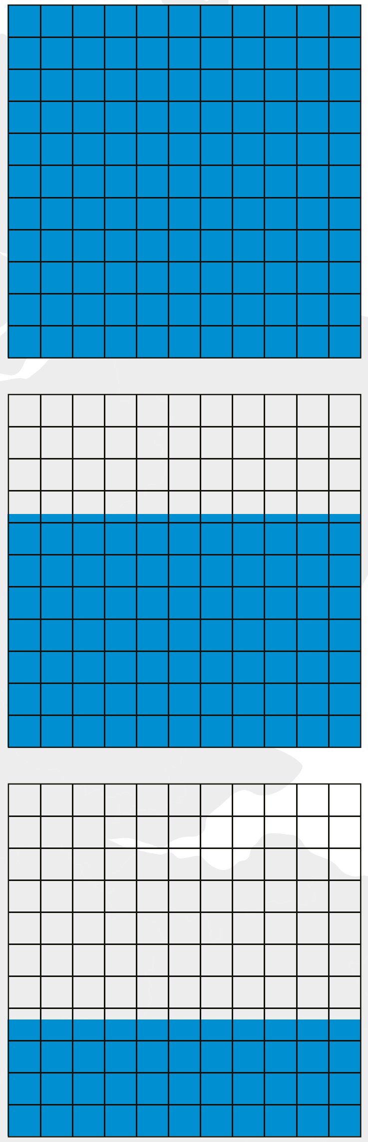
FOOD, FEED AND BIODIVERSITY

How the daily chicken sandwich causes global biodiversity loss



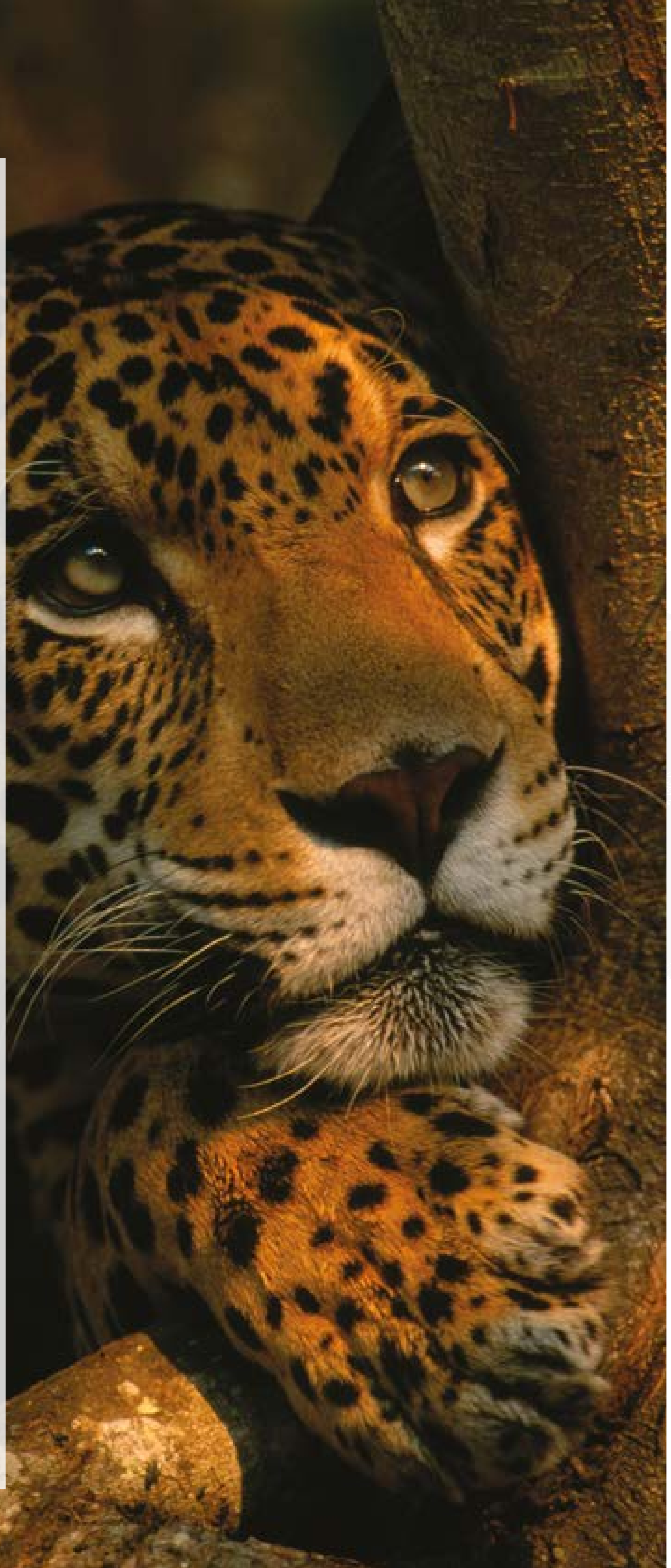
CONSUMPTION OF GLOBAL HECTARES

A productivity measure of available biocapacity and its demand



A large proportion of agricultural land is used for feed crop production. In Britain alone, livestock-related soy consumption required an area almost the size of Yorkshire in 2010[11]; and on average, each person in the UK consumes about one 'global hectare' of cropland and grazing land. In contrast in China, each person consumes only about two-thirds of a global hectare and in India only around one-third[12]. As countries like China and India prosper economically and more people enter the middle classes, their consumption of animal protein is rising. In China, meat consumption increased from 14kg per person per year in the early 1970s to 52kg in 2012; as a result, its soy consumption doubled in the last decade alone. India's meat consumption is much lower at an estimated 3.1kg per person per year in 2012, yet it is projected to increase to 18kg per person by 2050 (when the population is projected to reach 1.7 billion), mainly through an increase in poultry consumption[10].

BRITISH LIVESTOCK INDUSTRY NEEDED AN AREA THE SIZE OF YORKSHIRE TO PRODUCE THE SOY USED IN FEED



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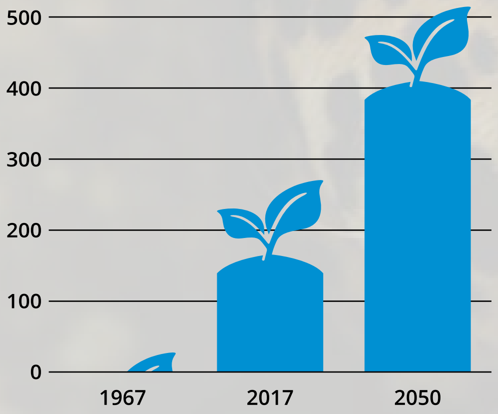
While it may be common knowledge that a meat-based diet has a larger environmental impact than a vegetarian or vegan one, few know that the largest environmental impact comes from the feed the animals eat. Soy, a key component of industrial farming systems, is a good example. It's such an important feed ingredient that the average European consumes approximately 61kg of soy per year, largely indirectly through the animal products that they eat like chicken, pork, salmon, cheese, milk and eggs[13,14]. Soy production has expanded more rapidly than any other global crop over the last 50 years, increasing from 27 million tonnes to 269 million tonnes, and continues to increase as demand for animal products rises: the UN Food and Agriculture Organization projects that global soy production could reach 515 million tonnes by 2050[15].

Soy production (million tonnes)



As soy fields expand, forests and other important ecosystems are cleared to make way. Soy fields have already replaced much of Brazil's Cerrado savannah – home to unique animals such as the jaguar, giant anteater and tapir. Soy has also contributed to the disappearance of most of the Chaco in Argentina and the Atlantic Forest in southern Brazil and eastern Paraguay. As arable land in China and the US becomes scarce and the demand for meat products fed on crops grows, so will the pressure to expand production into new areas – from the rainforests of the Amazon and the Congo Basin, to the savannahs and woodlands of eastern and southern Africa, to the Yangtze, Mekong and Ganges river basins. This threatens ecosystems that provide habitats for countless wild species and support the livelihoods of millions of people.

If the global demand for animal products grows as anticipated, it's estimated that agricultural land would have to expand by about 5% or 280 million hectares by 2030, to a total of 5.4 billion hectares[16]. That means agricultural land would need to expand across an area the combined size of Germany, Poland, the UK, France, Spain, Belgium, the Netherlands, Ireland, Portugal, Austria, the Czech Republic, Slovakia and Italy[17]. Soy and maize are expected to be responsible for the majority of this expansion, stimulated largely by increasing demand for poultry and pig meat in developing countries. By 2050, soy production would need to increase by nearly 80% to 390 million tonnes and more than 265 million extra tonnes of maize would be needed to feed all the animals destined for our plates[10].

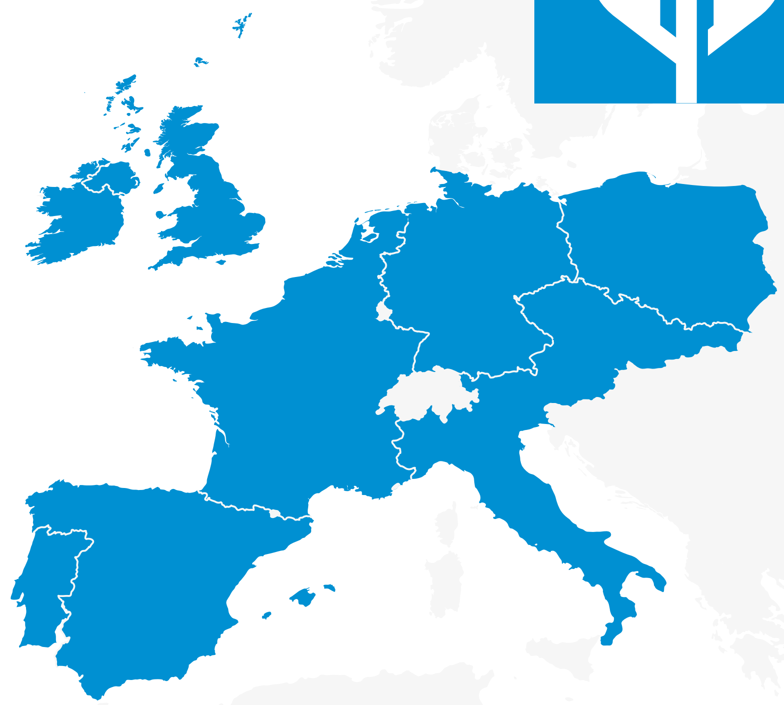
Already today agricultural land occupies about 38% of Earth's terrestrial surface[18]. Much of what remains is covered by deserts, mountains, tundra, cities and other types of land unsuitable for agriculture[19], as well as protected reserves and other important habitats. This limits the areas where agriculture could expand further or intensify[23,20]. However, under a business-as-usual scenario, **satisfying the escalating demand for animal products is not possible without converting huge land areas, such as forests, or changing land uses**. Such changes could have severe impacts on ecosystems, the biodiversity they support and the services they provide, and threaten food and water security for local communities. In countries with vulnerable governance structures, this could seriously undermine poverty alleviation and socio-economic development, especially if food production is further compromised by climate change[21].

Producing more on the same land is also a daunting challenge. While agricultural intensification has made animal products more accessible and affordable, decreasing the cost of animal products has driven demand, which in turn has increased production. The cumulative effect of intensification has meant increased environmental impacts such as land-use change, water depletion, soil erosion, species loss, and pollution from pesticide and fertiliser use[22,23,24].

THE GREEN REVOLUTION

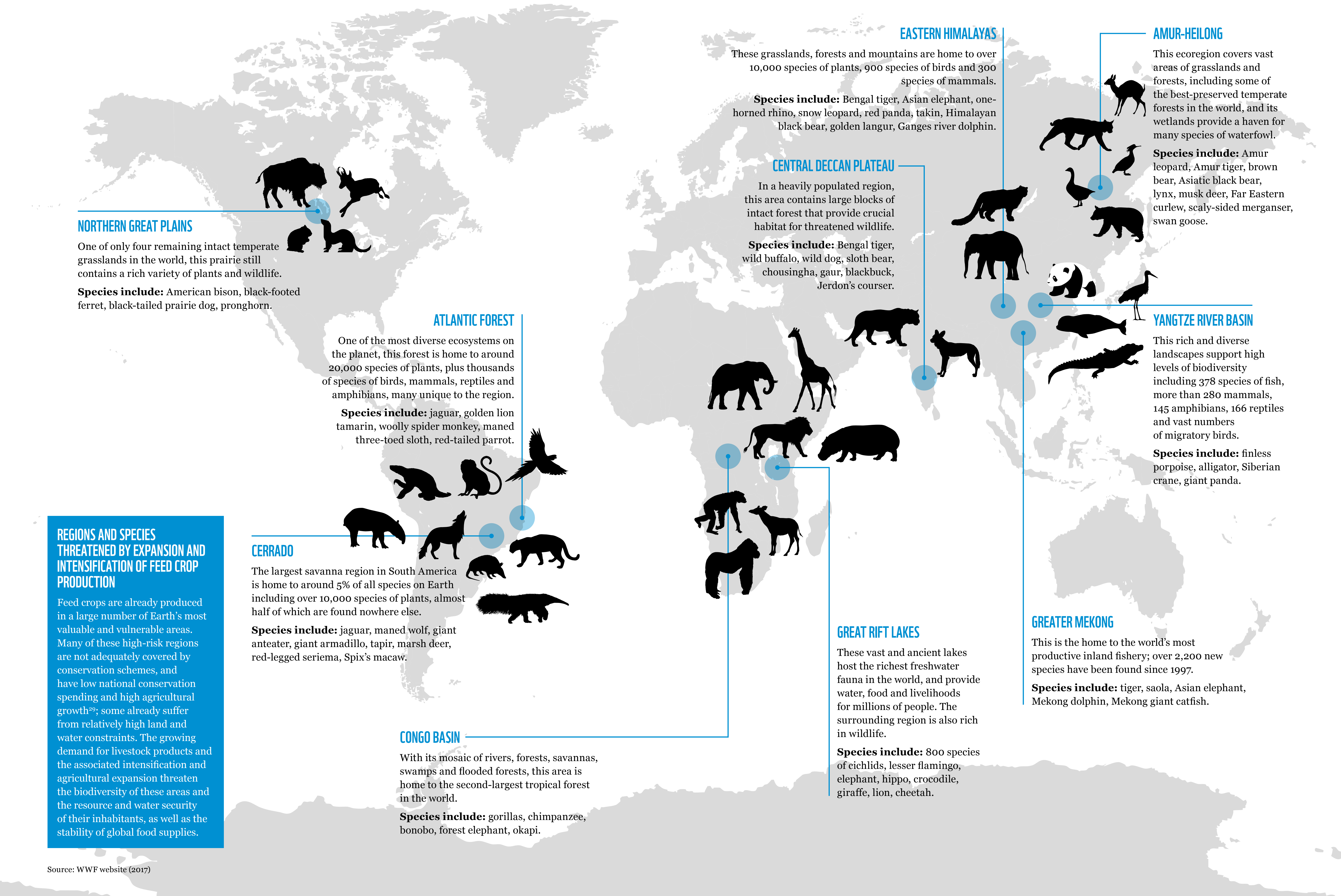
Beginning in the 1960s, the green revolution transformed global agriculture with the introduction of selectively bred, high-yielding varieties of wheat, rice and maize. Combined with chemical fertilisers and synthetic pesticides, yields increased dramatically. The larger quantities of food produced helped avert food crises, contributed to economic growth and alleviated poverty and hunger across the developing world. However, yield increases have slowed over the last 20 years[25].

IF THE GLOBAL DEMAND FOR ANIMAL PRODUCTS GROWS AS ANTICIPATED, IT'S ESTIMATED THAT AGRICULTURAL LAND WOULD HAVE TO EXPAND BY ABOUT 5% OR 280 MILLION HECTARES BY 2030, TO A TOTAL OF 5.4 BILLION HECTARES. AN AREA THE COMBINED SIZE OF GERMANY, POLAND, THE UK, FRANCE, SPAIN, BELGIUM, THE NETHERLANDS, IRELAND, PORTUGAL, AUSTRIA, THE CZECH REPUBLIC, SLOVAKIA AND ITALY



These impacts are more pronounced if intensification efforts concentrate only on producing more on less land through increasing other inputs such as fertilisers or water. This input-intensive production model's uniformity and reliance on chemical fertilisers, pesticides, unsustainable water abstraction and – in the case of intensive livestock and fish farms – preventive use of antibiotics systematically leads to negative outcomes and vulnerabilities[27]. Impacts on ecosystems can undermine the vital services that nature provides – from the microorganisms that cycle nutrients in the soil, to water supply and carbon sequestration.

These risks can have far-reaching consequences. For example, drought and water scarcity in Latin America are an immediate risk to the EU economy and food security as the European meat and dairy sectors are highly dependent on soy imports from locations already suffering from water constraints exacerbated by agriculture[26]. If agricultural production continues to grow according to a business-as-usual scenario, it could unbalance some of the major processes that maintain life on Earth as we know it: scientists believe we are already close to or even beyond safe limits in terms of biodiversity loss, climate change, water use and the nitrogen cycle[27,28]. Even with more efficient and productive agricultural practices, today's agricultural system simply cannot increase production on this scale without catastrophic impacts on natural ecosystems, water security, biodiversity and the climate.



NORTHERN GREAT PLAINS

One of only four remaining intact temperate grasslands in the world, this prairie still contains a rich variety of plants and wildlife.

Species include: American bison, black-footed ferret, black-tailed prairie dog, pronghorn.

ATLANTIC FOREST

One of the most diverse ecosystems on the planet, this forest is home to around 20,000 species of plants, plus thousands of species of birds, mammals, reptiles and amphibians, many unique to the region.

Species include: jaguar, golden lion tamarin, woolly spider monkey, maned three-toed sloth, red-tailed parrot.

CERRADO

The largest savanna region in South America is home to around 5% of all species on Earth including over 10,000 species of plants, almost half of which are found nowhere else.

Species include: jaguar, maned wolf, giant anteater, giant armadillo, tapir, marsh deer, red-legged seriema, Spix's macaw.

CONGO BASIN

With its mosaic of rivers, forests, savannas, swamps and flooded forests, this area is home to the second-largest tropical forest in the world.

Species include: gorillas, chimpanzee, bonobo, forest elephant, okapi.

GREAT RIFT LAKES

These vast and ancient lakes host the richest freshwater fauna in the world, and provide water, food and livelihoods for millions of people. The surrounding region is also rich in wildlife.

Species include: 800 species of cichlids, lesser flamingo, elephant, hippo, crocodile, giraffe, lion, cheetah.

EASTERN HIMALAYAS

These grasslands, forests and mountains are home to over 10,000 species of plants, 900 species of birds and 300 species of mammals.

Species include: Bengal tiger, Asian elephant, one-horned rhino, snow leopard, red panda, takin, Himalayan black bear, golden langur, Ganges river dolphin.

CENTRAL DECCAN PLATEAU

In a heavily populated region, this area contains large blocks of intact forest that provide crucial habitat for threatened wildlife.

Species include: Bengal tiger, wild buffalo, wild dog, sloth bear, chousingha, gaur, blackbuck, Jerdon's courser.

AMUR-HEILONG

This ecoregion covers vast areas of grasslands and forests, including some of the best-preserved temperate forests in the world, and its wetlands provide a haven for many species of waterfowl.

Species include: Amur leopard, Amur tiger, brown bear, Asiatic black bear, lynx, musk deer, Far Eastern curlew, scaly-sided merganser, swan goose.

YANGTZE RIVER BASIN

This rich and diverse landscapes support high levels of biodiversity including 378 species of fish, more than 280 mammals, 145 amphibians, 166 reptiles and vast numbers of migratory birds.

Species include: finless porpoise, alligator, Siberian crane, giant panda.

GREATER MEKONG

This is the home to the world's most productive inland fishery; over 2,200 new species have been found since 1997.

Species include: tiger, saola, Asian elephant, Mekong dolphin, Mekong giant catfish.

REGIONS AND SPECIES THREATENED BY EXPANSION AND INTENSIFICATION OF FEED CROP PRODUCTION

Feed crops are already produced in a large number of Earth's most valuable and vulnerable areas. Many of these high-risk regions are not adequately covered by conservation schemes, and have low national conservation spending and high agricultural growth[29]; some already suffer from relatively high land and water constraints. The growing demand for livestock products and the associated intensification and agricultural expansion threaten the biodiversity of these areas and the resource and water security of their inhabitants, as well as the stability of global food supplies.

Source: WWF website (2017)

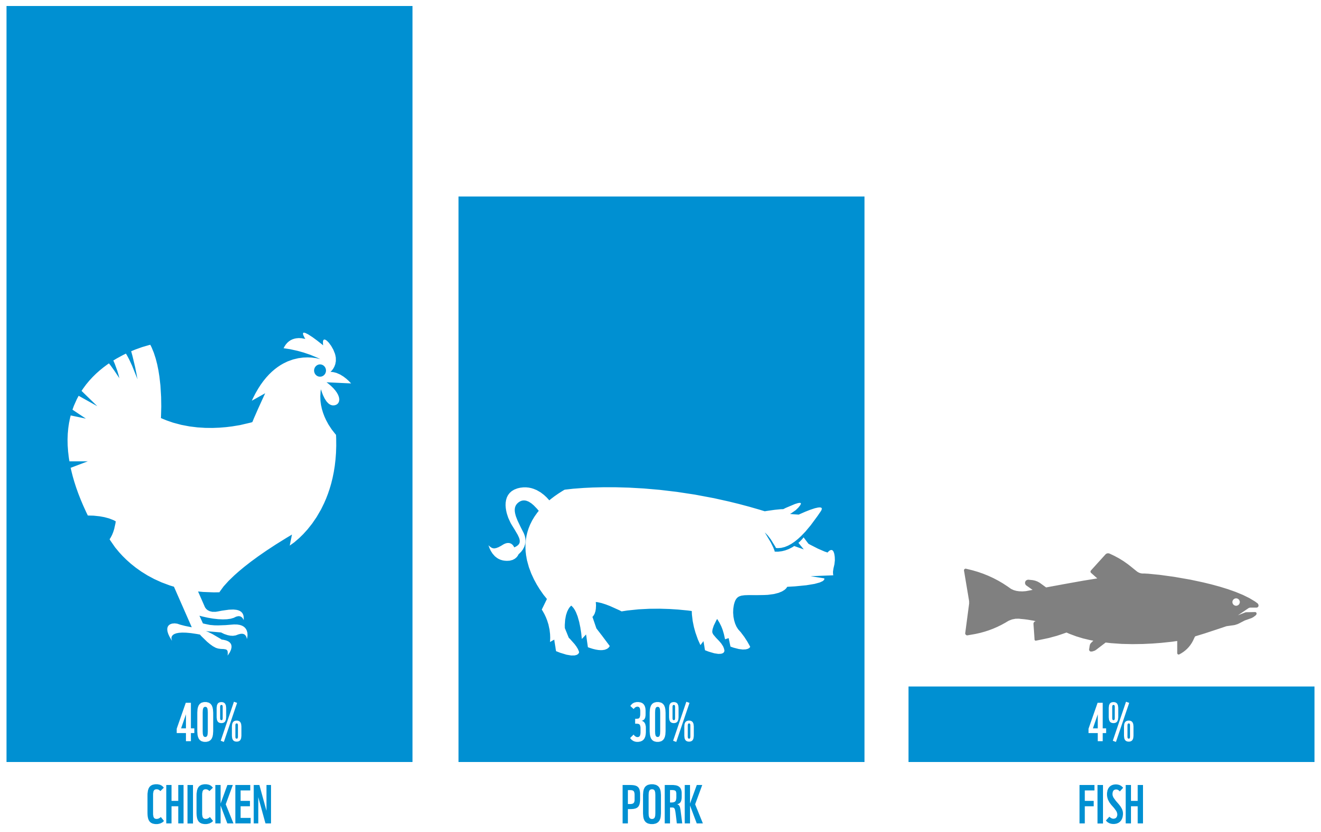
LINKING INDUSTRIALISED FOOD PRODUCTION AND FEED

The increasing global consumption of animal products, its impacts on nature and our health, and its large potential growth in the future, all bring our current food production system into question. The need to provide food and nutrition security for a growing global population makes the issue especially pressing, as the increase in protein or calories gained by feeding animals with crops that people could eat directly is small and considered inefficient. In fact, the calories from the crops currently used to feed animals could feed more than 3.5 billion people every year[30]. This section will give a brief overview of the current trends in livestock production and consumption around the world and their dependence on feed crops.

The spread of the Western diet combined with our sedentary lifestyles is closely linked to the rise in obesity, cardiovascular disease, type II diabetes, and a number of cancers.

Worldwide obesity has more than doubled since 1980, with direct health implications including impaired physical ability and psychological problems. An unhealthy diet is considered a risk factor for cardiovascular diseases such as high blood pressure, which in turn increases the rate of strokes. Poor diet is also related to the development of type II diabetes due to its link with obesity. And, according to the World Health Organization, about 30% of cancer deaths are linked to five leading behavioural and dietary risks: high body mass index, low fruit and vegetable intake, lack of physical activity, tobacco use and alcohol use[31].

GLOBAL FEED CONSUMPTION BY SECTOR



Chicken and pork – the largest feed eaters

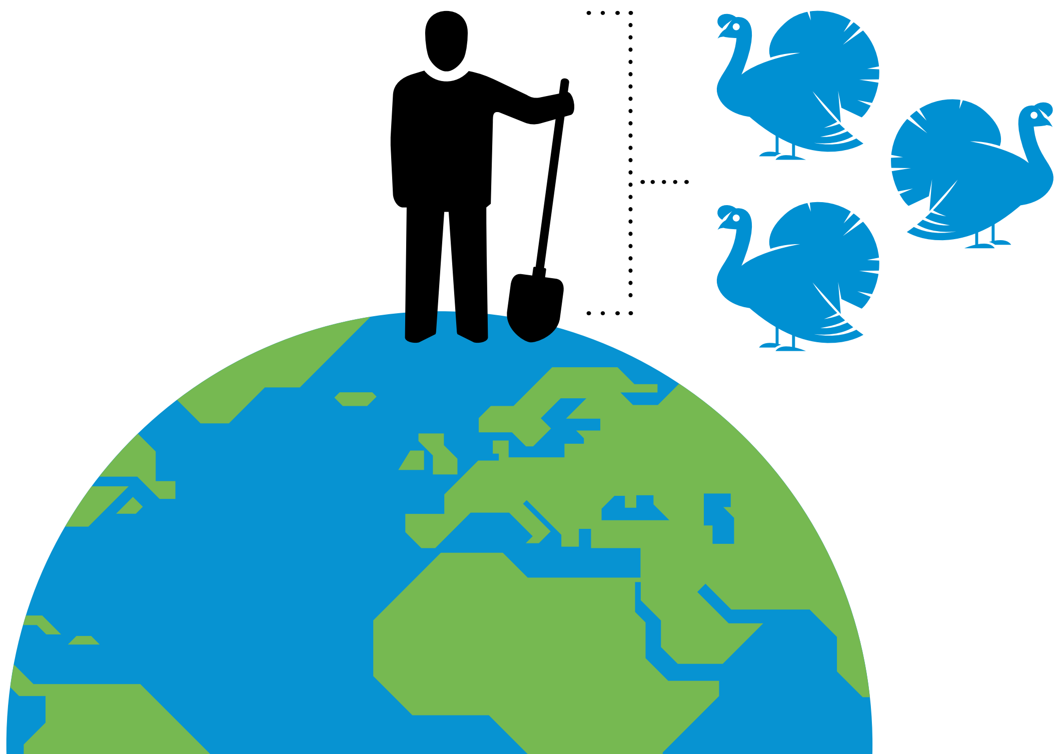
Globally, the biggest user of crop-based feed is the poultry industry in Asia-Pacific, Europe and North America, which is responsible for around 40% of global feed use[40]. While the consumption of ruminant meat (cattle, buffalo, sheep and goat) has declined over the last half-century and the consumption of pork is rising only slightly, the poultry industry has seen rapid growth due to new demand from China[32].

Poultry increased its share of world meat production from 15% in the mid-1960s to 32% by 2012 as per capita consumption increased threefold. In 2014, there were over 23 billion chickens, turkeys, geese, ducks and guinea fowl on the planet – more than three per person[33]. The rise of the chicken is attributed to the simplicity of its industrial production, while selective breeding has helped lower feed requirements per kilo of meat as chickens gain weight quicker.

Today, chicken meat accounts for 88% of global poultry meat production and intensive industrial systems produce 81% of all poultry meat globally[34]. In these industrial systems, birds are confined indoors either in a large open-room building or in cages and are fed entirely on feed. **They may receive over four times as much manufactured feed as in a system where chickens are allowed to roam free[35].** Poultry feed alone was responsible for approximately half of the entire annual soymeal imports to the UK in 2010[16].

The second largest feed crop consumer is the pig industry, which accounts for around 30% of the global total. It has grown steadily in the past decade and is forecasted to continue to climb to meet rising demand. In the UK, **pork is the second favourite meat after chicken, with each person eating on average 25kg a year in 2015[15].** That is nearly the whole recommended yearly intake for all meats. With the rapid expansion of the middle class in China, demand for pork has also escalated there. Today, over half the world's pork is produced and consumed in China. As pork production grows, it too is becoming increasingly industrialised and uniform, concentrated among a handful of large agricultural businesses.

In intensive production systems, pigs are kept indoors on bedding or slatted floors with their entire diet met by manufactured feeds. Crop feeds are also used in the extensive outdoor systems where pigs are allowed to engage in their natural rooting behaviours, although to a smaller degree.



23 BILLION CHICKENS, TURKEYS, GEESE, DUCKS AND GUINEA FOWL ON THE PLANET – MORE THAN THREE PER PERSON

© RUDOLF SVENSON / WWF

Seafood

Seafood plays an important role in food and nutrition security, poverty alleviation, general well-being and the traditions of many cultures. It accounts for 17% of animal protein consumed globally, and is the primary protein source for households in 21 countries[36]. More than three billion people obtain one-fifth or more of their animal protein from fish and other seafood.

Though the amount of seafood eaten varies greatly between countries – from 1kg per person in Ethiopia to over 70kg per person in Hong Kong in 2012[37], global consumption is on the rise, and is gaining more traction due to its nutritional value and health benefits. The global average consumption of fish per person per year has almost doubled in the last 50 years, from 9.9kg in the 1960s to 19.7kg in 2013[38].

As 90% of wild fish stocks are currently fully exploited or overfished[38], the rise in availability since 2000 is attributed mainly to a growth in aquaculture. Aquaculture, the cultivation of fish and shellfish on land and in the sea, produced 69.7 million tonnes of seafood in 2013[39]. Between 1990 and 2010, the aquaculture sector grew more than any other food production sector (an annual rate of 7.8% worldwide) and it's predicted to continue to grow as demand increases[36]. At present, just over half of all seafood for human consumption is farmed; Asia accounts for nearly 90% of global aquaculture production with China alone responsible for 62%[40].

Meeting projections for seafood demand in 2050 would require a 200% increase compared to 2012 levels, or an additional 271 million tonnes[41]. With wild fish stocks already under immense pressure, this increased demand would have to be met through aquaculture. Mariculture (fish, shellfish and algae/seaweed farming in the sea) is also growing steadily.

However, like other forms of industrial production, aquaculture can have negative environmental impacts, including pollution and habitat destruction. Further aquaculture production will have to be designed and managed in a way that minimises negative impacts on wildlife and the environment – including when it comes to feed.

As in other livestock production sectors, aquaculture has seen a shift towards industrialisation. Extensive and semi-intensive systems have become rare and intensive systems centred on crop-based formulated feeds are more common. **Wild-caught fish, mainly small pelagic fish, were the main source of feed for aquaculture in the past, but with wild fisheries already under immense pressure agricultural crops are increasingly used to meet the demand.** Virtually all shrimp are now fed manufactured feeds, as are most carp and tilapia.

Farming seafood is very efficient in terms of producing human food from feed. The conversion rate of dry feed to edible protein of some species, like salmon, is as good as 1:1. This means that feeding 1 tonne of feed to salmon produces nearly a tonne of food for people. This is much more efficient than the ratio for other animals, such as chickens (2:1) or pigs (3-4:1). And over half of all global aquaculture production is produced without requiring manufactured feed; shellfish, seaweeds and many freshwater fish species rely on natural cropping of microalgae in both freshwater and oceans.

However, in 2008, 60% of total aquaculture production was based on feed supplements – whether fresh, farm produced or commercially manufactured. As in other animal product sectors, soy and maize are the crops most used as feed in aquaculture; the sector used an estimated 4% of global feed crops in 2009. To grow these feeds, aquaculture indirectly used an additional 26.4 million hectares in 2010 – an area about the size of the UK. Still, aquaculture is a relatively small industry in comparison to the other animal products and occupies only about 1% of global agricultural land even when this additional crop-based land is included in its footprint. This will increase accordingly if aquaculture production doubles or triples by 2050 as is predicted.

ANIMAL FEED AND HEALTH

The loss of species and habitats is not the only outcome of our current animal protein consumption trajectory. Industrialisation has succeeded in producing more animal products faster but it has also affected the quality of our food in a way that has a knock-on effect on our health. Raising livestock on energy- and protein-rich crops has been linked to a decrease in the healthy omega-3 content of our animal products and an increase in their unhealthy saturated fat content[42].

OMEGA-3 FATTY ACID

The UK Department of Health and the World Health Organization recommend reducing saturated fats in diets and eating more unsaturated fatty acids, particularly omega-3. This is because higher amounts of saturated fats increase the risk of heart attack, stroke, type II diabetes and other diseases, whereas omega-3 fatty acids protect us against a number of diseases and psychological illnesses such as depression. Omega-3 fatty acids are necessary for numerous metabolic functions and healthy child development[43]. For example, the omega-3 fatty acid DHA is a key component of the human brain, cerebral cortex, skin and retina, and is necessary for their healthy functioning.

However, today's Western diet includes an inadequately low ratio of omega-3[44] to saturated fats – a problem exacerbated by the expansion of intensive animal husbandry. A drop in healthy omega-3 unsaturated fatty acids and a rise in saturated fats have been seen in products from livestock systems using manufactured feed[45,46,47,48], in essence producing less nutritious and more saturated fatty products. One study shows that the difference is so profound that you'd have to eat six intensively reared chickens today to obtain the same amount of the healthy omega-3 fatty acid found in just one in the 1970s[45]. Historically, the amount of DHA in chicken meat was comparable to that of wild birds and traditionally, poultry were a rare land-based source of omega-3, especially essential DHA. Today, chicken is no longer the 'lean and green' option: **the majority of calories from chicken come from fat as opposed to protein[49].**

This reduction in nutritional benefit is also seen in farmed fish. The omega-3 in farmed Scottish Atlantic salmon has decreased by half since 2006[50], and farmed carp and tilapia have much lower levels of omega-3 compared to their wild counterparts[39] – though these levels are still higher than chicken, and a single meal of carp can cover up to several days' requirement of these essential nutrients.

The relatively high omega-3 levels in farmed salmon and other farmed fish derive from the fishmeal or fish oil in their feed. Fishmeal and fish oil are also used to compensate for the reduced amount of omega-3 in other animal products, although nowadays the cost of fishmeal is prohibitively expensive outside fish and shrimp aquaculture. Fishmeal is largely derived from small pelagic fish that aren't otherwise used for human consumption. However, pelagic fish play a vital role in the marine food web, and many other fish, marine mammals and birds depend upon them. Coupled with the overexploitation of many fisheries, this limits the extent to which we can supplement livestock and farmed fish diets with fishmeal or oil. As it stands, fish and various vegetable oil sources won't be able to produce enough omega-3 to meet the future fatty acid needs of our growing global population[51].

Solutions are being developed to tackle this growing problem, from intensively produced naturally occurring microalgal species to GM soy enhanced with omega-3. However, solutions which simply focus on the nutritional content and avoid the environmental impacts of current animal production and demand fall short of addressing food security and sustainable development.

WHAT CAN BE DONE?

We already produce enough to feed the world[52,53,54]. It's overconsumption – especially of animal protein – by the global middle class, inequality, waste, and inadequate production and distribution systems that stand in the way of enough food for everyone and space for wildlife. To feed the world in a way our one planet can sustain, we need to consume and produce food differently.

The following section will explore the different dietary changes and the alternative feed innovations that are taking place. Finding less resource-intensive alternatives to current production systems is not just important because of the benefits to nature: with climate change expected to disrupt rainfall patterns in the already water-constrained areas from which many crop feeds are sourced, more resilient production is important to food security and the economic prospects of the livestock sector[28].

ADOPTING A HEALTHY, SUSTAINABLE DIET

Significant environmental benefits could be achieved by simply sticking to the nutritionally recommended amount of protein. In 2009, over a quarter of the world's population (1.9 billion people) lived in regions and countries that ate more animal and plant protein than is nutritionally recommended. As we saw above, the average UK citizen eats almost twice the amount of daily recommended protein just from animal products[55]. **If everyone reduced the amount of animal products that they ate to suit their nutritional requirements, then total agricultural land use would decline by 13%.** That means nearly 650 million hectares – or an area nearly 27 times bigger than the UK – would be saved from agricultural production[8]. Although the majority of this would be pastureland, the reduced demand for animal feed would decrease cropland by about 130 million hectares[8]. Sparing this total land area from agricultural use would avoid an equivalent of 168 billion tonnes of emissions of CO_2 from land-use change – or nearly four times the total global greenhouse gas emissions in a year[56].

WWF's Livewell Plates and six Livewell principles[57] are good guides to how to put this into action. They illustrate how we can ensure everyone gets their necessary nutritional requirements without a further increase in agricultural land area and still contribute to meeting the Paris Agreement commitment to keep global warming well below 2°C. Eating less animal protein would also make production systems with lower environmental impact and healthier, more nutritious outputs that much more practically and economically feasible.

EVERY LITTLE HELPS

Making small changes to our diets could make big differences. Beans and pulses cause less greenhouse-gas emissions and need less land and water than animal products: switching animal for plant protein – even one meal a week – would make a major contribution.

LIVEWELL PRINCIPLES

EAT MORE PLANTS

Enjoy vegetables and whole grains.

EAT A VARIETY OF FOODS

Have a colourful plate.

WASTE LESS FOOD

One third of food produced for human consumption is lost or wasted.

MODERATE YOUR MEAT CONSUMPTION, BOTH RED AND WHITE

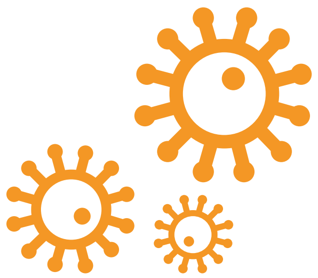
Enjoy other sources of proteins such as peas, beans and nuts.

BUY FOOD THAT MEETS A CREDIBLE CERTIFIED STANDARD

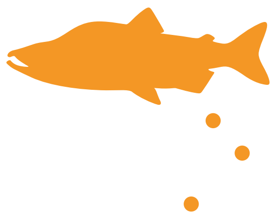
Consider MSC, free-range and fair trade.

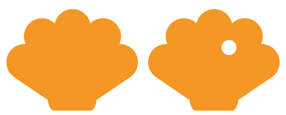
EAT FEWER FOODS HIGH IN FAT, SALT AND SUGAR

Keep foods such as cakes, sweets and chocolate as well as cured meat, fries and crisps to an occasional treat. Choose water, avoid sugary drinks and remember that juices only count as one of your 5-a-day however much you drink.



ALGAE ARE AN INTERESTING ALTERNATIVE FEED OPTION THAT COULD REDUCE THE PRESSURE ON LAND RESOURCES AND BIODIVERSITY





IMTA IS A SYNERGISTIC APPROACH TO AQUATIC PRODUCTION WHICH USES THE WASTE PRODUCTS FROM ONE SPECIES TO PROVIDE FEED OR FERTILISER FOR ANOTHER

FEED INNOVATIONS

Along with reducing our consumption of animal protein, we also need to produce feeds with lower resource requirements that don't compromise the nutritional content of animal products. New technologies and innovations are already happening; a few of the most developed are described below.

Algae

Algae can grow in a range of aquatic environments and come in either micro or macro form. Microalgae are microscopic, often independent single-celled organisms. Macroalgae, also known as seaweeds, are organisms formed from groups of cells which absorb nutrients from the surrounding aquatic environment through their whole surface. Algal growth is relatively straightforward, as they only need a basic form of energy (such as light and sugars), CO_2, water and a few inorganic nutrients to grow.

A variety of products and commodities are derived from farmed algae and seaweed, including human food, fertiliser, animal feed and medicinal products. Options to use algae as an aquatic source of biofuel are also being explored. As they require only a small fraction of the land area of feed crops, algae are an interesting alternative feed option that could reduce the pressure on land resources and biodiversity.

Microalgae

Due to the growing scarcity and rising costs of fish oil, microalgae are already cultivated and used as a feed in aquaculture. Microalgae may be processed into oil, or dried and fed whole, for example to molluscs and shrimp larvae. Microalgae contain high levels of omega-3, making them an exciting potential alternative to fish oil or fishmeal. While they vary in nutritional composition and digestibility, appropriate algae are already being identified. For example, feeding microalgae (*Schizochytrium* sp.) to tilapia instead of fish oil improved fish growth and the tilapia fillets also contained higher amounts of omega-3 DHA[58].

Further new research is also encouraging: recently, a new species of microalgae with high levels of omega-3 and other nutritional advantages was identified[59]. As it can grow in nitrogen-depleted conditions and at high temperatures it's suitable for growing easily throughout the year in tropical areas that have abundant sunlight. Such innovations could be an important solution for resource-constrained tropical countries.

Algal production can be very high if conditions are optimal, and they can provide added environmental services such as converting carbon dioxide to oxygen[60,61]. Algae can also reduce the environmental impacts of other farming methods (for example finfish farming) through bioremediation as part of integrated multi-trophic aquaculture (see below).

Macroalgae (seaweed)

In 2014, seaweed aquaculture made up 27% of total marine aquaculture production by volume, with an economic value of US$5.6 billion[38], and production is projected to increase further with growing demand. Currently, nearly all seaweed is produced by a few countries in Asia with over half of production in 2013 being attributed to China. Seaweed cultivation in the UK is limited and seaweed is usually wild harvested, although pilot seaweed farms are in development[62]. There are many varieties of seaweed, with differing results as an animal feed alternative. Generally, seaweeds have a lower concentration of protein and a lower amount of essential amino acids compared to plant crops[63], so a larger quantity would be needed compared to crop feeds to achieve similar results. However, further investigation is warranted; recent research found that seaweed (*Oedogonium*) of high quality with protein content similar to lucerne (a legume crop) could be produced in municipal wastewater systems, where it also helped purify water[64].

Feeding seaweeds could also have positive effects on meat nutrition and animal health. For example, feeding Chilean red seaweed to Atlantic salmon has been seen to increase salmon resistance to the salmon anaemia virus[65] – a highly infectious disease which can lead to significant fish mortality and economic losses.

Feeding seaweed to animals is not a new idea[66]. In many coastal regions, ruminants were fed seaweed during periods of feed scarcity; even today cattle can be seen eating seaweed on the shores of the UK. Feeding the right seaweed might even have more benefits. Recent research has shown that feeding seaweed to ruminants could reduce methane emissions that contribute to climate change[67,68]. For example, supplementing cattle diets with 2% of specific seaweed species could reduce cattle's methane emissions by up to 99%[69].

INTEGRATED AQUACULTURE

Integrated multi-trophic aquaculture (IMTA) is a synergistic approach to aquatic production which uses the waste products from one species to provide feed or fertiliser for another. A variety of IMTA studies have been conducted involving seaweed species combined with salmon, kelp with abalone, and red seaweed with scallop. This approach has potential benefits in terms of improving the final yield of both species, while reducing waste and pollution. However, it requires more technical knowledge and experience than single-species production, and the economics depend on demand for both species.

IMTA can act as a form of bioremediation, where one species is used to reduce or remove waste products or pollutants from another farmed species or system. For instance, the red seaweed *Gracilaria lemaneiformis* has been shown to efficiently remove high nutrient levels. In northwest Scotland research also showed that growth rates of seaweeds increased up to 61% near a salmon farm and removed up to 12% waste nitrogen released from the farm[70]. Opportunities to better manage environmental impacts in aquaculture can be seen around the world, particularly in China where monocultures of seaweed, fish and bivalves are cultivated in close proximity and seaweed aquaculture already plays a role in mitigating coastal eutrophication. It is calculated that increasing the seaweed area in these systems by 150% could remove close to all of the current phosphorus pollution in the water[71]. An even larger seaweed area could also remove the nitrogen pollution from agricultural and urban runoff[84].

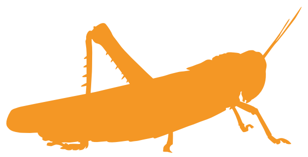
There is also potential to use IMTA in conjunction with electricity generation. For example, seaweed could grow from solar PV structures while fish swam protected underneath, or offshore wind farms could provide areas for aquaculture. Further research to establish appropriate species would be required, as well as the agreement of electricity companies. Nevertheless, if current aquaculture surface areas in use in the US were incorporated with appropriate solar technology, this could supply around 10% of total US energy consumption[72].

INSECTS AND FOOD WASTES

In some areas of the world insects are considered a delicacy. But flies, crickets and other insects could also reduce the mounting pressure on land and biodiversity if they are used as feed or food. Insects have a lower environmental impact than soy feed and animal products, producing the same amount of edible protein with less land, lower greenhouse gas emissions and similar amounts of energy[73,74]. Insects as feed show great promise too. When insects have been used to supplement livestock feed, feeding trials have revealed that piglets' gut health was improved, while chickens fed on insect protein (which is part of their natural diet) performed as well as those given current commercial feeds; **research also shows that insect meal could replace up to 50% of fish feed without affecting animal performance[75].**

However, feed is once again a critical factor in the calculated environmental impact. If the insects themselves are fed on crops like soy or maize, then the benefits are lost; the impact of feeding chickens on crickets fed on soy is comparable to current industrial chicken production[76]. Using local food wastes or by-products as insect feed can prevent this problem and add value to materials that would have ordinarily been disposed of.

Legislation is also being updated to allow for new developments. Until recently farmed insects were classed as 'farmed animals' and were not allowed to be fed to livestock due to the past BSE outbreak. However, new amendments to EU legislation mean that from July 2017 insect proteins were authorised for use as feed in aquaculture. While it's still not possible to feed pigs and poultry with insect-based feed, it's probable that this will be the next step following positive trial results.



FLIES, CRICKETS AND OTHER INSECTS COULD ALSO REDUCE THE MOUNTING PRESSURE ON LAND AND BIODIVERSITY IF THEY ARE USED AS FEED OR FOOD

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CONCLUSION

Over the past few decades, we've experienced a dramatic growth in intensive industrial farming coupled with an increased demand for protein- and energy-rich animal feed[77]. This has had a devastating impact on nature and our well-being.

Feed crops are already produced in a large number of Earth's most valuable and vulnerable areas. Growing global demand threatens the biodiversity of these areas and the resource and water security of their inhabitants. And, within an interconnected food system, these risks also affect the security of our food supply here in the UK.

Feeding animals with crops that could be eaten by humans is not only ineffective: it's also having a knock-on effect on our health as products from these intensively reared animals have been shown to have increased levels of unhealthy saturated fat. This perpetuates the negative impacts of the Western diet which is already linked to health concerns such as heart attack, stroke and type II diabetes.

We believe it's possible, and essential, to change food production systems and consumption patterns to secure enough nutritionally complete and environmentally sustainable food for everyone on Earth. Adopting a healthy, sustainable diet is one part of the solution: WWF's six Livewell principles form the basis of a sustainable diet and a well-functioning food system. But we also need to produce food and feed differently.

To make this a reality we invite business and policy-makers to work with us to:

- Increase access to healthy, sustainable food;
- Encourage a favourable market environment for healthy, sustainable food;
- Produce food in line with human nutritional requirements;
- Encourage livestock feed alternatives which reduce pressure on land and freshwater resources without compromising nutritional benefits;
- Ensure feed crops that are required for animal nutrition and health come from credibly certified sources.

We welcome the opportunity to work with business and policy-makers to create a food system which provides us with healthy food, sustainable feed, and thriving biodiversity.

WE WELCOME THE OPPORTUNITY TO WORK WITH BUSINESS AND POLICY-MAKERS TO CREATE A FOOD SYSTEM WHICH PROVIDES US WITH HEALTHY FOOD, SUSTAINABLE FEED, AND THRIVING BIODIVERSITY

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