River Court, Mill Lane, Godalming, Surrey, GU7 1EZ, UK
T: +44 (0)1483 521 950 Email: peter.stevenson@ciwf.org

# In Defence of Factory Farming

## How a ruinous system is kept afloat

A large edifice of scientific research and reports shows us that factory farming (industrial livestock production) imposes very poor welfare on animals, encourages the adoption of unhealthy diets and undermines the resources – land, water, biodiversity – on which the ability of future generations to feed themselves depends. And yet it survives. It doesn't just survive but thrives, conquering new realms. Even as I write it is busy industrialising dairy farming driving cows off the fields and into 'zero-grazing' systems where throughout the year they are kept indoors never getting out to graze.

How did this happen? Through the interweaving of many threads that justify and entrench factory farming, locking it into our food system.

**Sacrificing one's knights**
There are two knights in chess. Factory farming has three: veal crates, battery cages and sow stalls (known as 'gestation crates' in the U.S.). From the late 1980's a long battle took place in the EU to get these systems banned. Eventually this campaign was successful with bans coming into force in 2007, 2012 and 2013 respectively.

However, this achievement was to a degree tainted by some important omissions. The ban on battery cages applies only to barren cages. Farmers are free to use 'enriched' cages; indeed 58% of EU laying hens are kept in these cages which offer only marginal improvements in welfare as compared with barren cages.

The EU ban on sow stalls allows farmers to continue using them for the first four weeks of pregnancy. In addition the ban does not extend to farrowing crates which are even more restrictive than sow stalls. Sows are placed in farrowing crates 3-7 days before giving birth and are kept there until the piglets are weaned at 21-28 days of age. Despite the sow stall ban, many EU sows continue to be confined in stalls/crates for around 19 weeks each year.

Nonetheless the EU bans on veal crates, sow stalls and barren battery cages represent crucially important advances in animal welfare. However, despite these bans, huge swathes of factory farming remain intact. Chickens reared for meat (broilers) continue to be crammed - up to 50,000 at a time - into massively overcrowded sheds. Dairy cows are pushed to such high milk yields that many are utterly worn out after just three-four milk cycles and are prematurely culled.

Most fattening pigs in the EU are ruthlessly factory farmed in barren, overcrowded pens and are routinely tailed docked and teeth clipped without anaesthetic. Each year in the EU egg sector 360 million male chicks are killed when they are just one day old because they are the wrong gender to lay eggs and grow too slowly for the meat sector. But because they are forced to grow too quickly, around 1.5 billion EU broilers a year suffer from painful lameness. Over 300 million rabbits are farmed each year in the EU in cages that are little different from the battery cages that have been banned for hens. And so it goes on.

Clearly the industry did not willingly sacrifice its three knights; indeed, it strongly opposed all three bans. However, with barren battery cages, veal crates and sow stalls largely gone, it was able to give the impression that factory farming was a thing of the past. But in reality, as we have seen, it continues unchecked with most of its major elements still in play and much of the panoply of abuse intact.

**Legislation: genuine protection or window dressing?**
Some legislation is extremely helpful, for example the bans referred to above and the requirement for egg packs to be labelled as to farming method. Much legislation, however, is couched in extremely broad terms and is largely unenforceable. This point has indeed been made by the European Commission itself; it notes that some legislation contains "provisions that are too general to have practical effects ".[i]

The advantage of such legislation for policy-makers and the intensive farming sector is that it gives the appearance of there being a substantial body of legislation that protects farm animals. It allows officials to give assurances to the public that their concerns about the well-being of intensively farmed animals are groundless as these animals are protected by abundant regulations. However, when closely examined, much of this legislation, because of its broad general language, proves to be a facade, the thinnest of veneers, which provides no real safeguards for animals. It acts as a legislative fig leaf to cover the depredations of factory farming. It protects the politicians and the industry, not the animals.

**The role of science: giving a narrow ambit to what constitutes good welfare?**
When I first joined Compassion in World Farming the organisation was in the midst of a campaign to win a UK ban on sow stalls (these are so narrow that the sow cannot even turn round). I was surprised to find that we had to supply scientific proof that a sow may need or wish to have enough space to be able to turn round. Interestingly the burden of proof was on us to demonstrate this; the pig sector was not required to prove that confining sows in so small a space was acceptable from a welfare viewpoint.

It is of course essential that policy and legislation on animal welfare should be based on sound scientific research. However, the overwhelming pre-eminence accorded to scientific evidence has led to certain drawbacks. Ethical considerations are in danger of being crowded out. Moreover, science is only really interested in those factors that can be measured. Elements that do not lend themselves to measurement are in danger of being given insufficient weight or even of being ignored altogether.

This neglect of aspects that cannot readily be measured has resulted in an arguably restricted view of what constitutes good welfare. The areas that tend to be overlooked are brought to light in a prayer written by St Basil of Caesaria in the Fourth Century:

> "May we realize that they live not for us alone, but for themselves and for Thee and that they love the sweetness of life even as we, and serve Thee better in their place than we in ours".

And in our own time Lyall Watson has written in *The Whole Hog*:

> "I know of no other animals that are more consistently curious, more willing to explore new experiences, more ready to meet the world with open-mouthed enthusiasm. Pigs are incurable optimists and get a big kick out of just being".

Sweetness of life, enthusiasm: these do not readily lend themselves to measurement. But that does not diminish their importance.

Recently I watched a hen on the island of South Uist in Scotland. She was beautiful. Feathers full and healthy, gleaming in the sun. Her tiny chicks tentatively exploring their world but staying close to their mother. All of them were sheltered in a spacious run covered with wire to protect them from predators.

A sight which is completely absent in today's industrial farming. Here the eggs are removed from the hen and incubated and hatched artificially. The hen never sees her chicks and they never see their mother nor can they benefit from being raised and nurtured by her.

Industrially farmed pigs and poultry never experience fresh air, daylight or the warmth of the sun. They can never enjoy a cooling breeze or the movement of the wind. They can never feel the earth beneath their feet or search for tasty morsels. Much of life is denied to them.

I am not for one moment suggesting that we should ignore the science. Scientific evidence is a crucial element of animal welfare policy-making but it cannot tell us all that we need to know, all that we need to take into account when we consider our relationship with animals. We must be careful to pay heed to the areas which the scientific method is not so well equipped to address.

**A distorting economics**

Just as science has brought an overly mechanistic approach to our understanding of animal well-being, we have an economic system that takes certain costs into account while ignoring others. In both cases we see a partial truth but not the whole truth. Some costs of producing meat and dairy products – the provision of feed, housing and veterinary care - are borne by the farmer and hence by the end consumer. Other costs are 'on the house' being borne by taxpayers or future generations.

Industrial livestock production is totally dependent on feeding human-edible cereals to animals who convert them very inefficiently into meat, milk and eggs. This inefficiency results in more arable land as well as surface and groundwater being generally needed to produce a unit of nutrition from industrially produced meat than from meat derived from animals that are fed little or no human-edible crops. The feed crops needed for intensively farmed animals are themselves grown intensively leading to soil degradation and water pollution from the chemical fertilisers used to boost crop yields. Industrial farming's huge appetite for soy for animal feed leads to deforestation in South America which results in massive greenhouse gas emissions and loss of wildlife.

This environmental damage is paid for not by farmers and end consumers but by taxpayers and future generations who will be hampered in their attempts to produce food by water shortages, degraded soil and the biodiversity losses that accompany intensive crop production.

The high levels of meat consumption that have been made possible by industrial farming are having an adverse impact on human health. Overconsumption of animal protein can lead to obesity, diabetes, heart diseases and certain cancers.[ii] The cost of treating this disease burden is borne by the (in Europe) taxpayer funded health service not by agri-business which, through years of spending billions on advertising, has foisted a perverse food culture and unhealthy diets on the developed world and is now turning its attention to developing countries. None of the cost of treating this ill-health and the concomitant loss of production through absence from work is included in the price of industrially produced meat.

An economics that ignores environmental and health costs is misleading. Like a fairground mirror it distorts reality. It gives the false impression that industrially produced meat is cheap while in fact it is only cheap for end consumers; for society as a whole it is very expensive. A pricing system that disregards certain costs promotes unhealthy diets and inefficient, environmentally damaging ways of producing food.

If we are to develop an efficient economic system that properly reflects all the costs of producing industrial animal protein, its negative externalities (damage to health and the environment, poor animal welfare) must be internalised in the costs of meat and dairy production and thus in the price paid by consumers.

The UK Foresight report has stressed that "There needs to be much greater realisation that market failures exist in the food system that, if not corrected, will lead to irreversible environmental damage and long term threats to the viability of the food system".[iii] It also said that "the food system today is not sustainable because of its negative externalities. These are not included in the cost of food and hence there are relatively few market incentives to reduce them".

***Economic orthodoxy's impact on how we raise animals: knowing the price of everything and the value of nothing***

Traditionally a country's GDP (gross domestic product) has been regarded as the principal way of measuring and thinking about its economic progress. This has come to be seen as unsatisfactory as it gives equal value to, for example, a £million of arms and a £million of health services even though most would value the latter more highly.

In addition, GDP fails to capture social welfare and people's sense of well-being or lack of it. Its focus is on costs (though it ignores external costs) not on the benefits of economic activity. A recent study carried out for the European Commission points out that GDP and the "associated rise in material consumption is an imperfect compensation for a lack of satisfaction of basic needs, like community, serenity, clean air and direct access to nature. The problem is that the latter types of issues are not captured by GDP".[iv] Accordingly, alternative ways of measuring progress and hence informing public policy are being examined.[v]

Our food system, however, is still stuck in the old quantitative paradigm which fosters industrialisation of food production and very narrow ways of thinking about what constitutes success in our food system. This is exemplified by the limited range of factors generally taken into account by government and food industry reports. These focus on economic and performance data such as quantity of production, efficiency, costs and margins.

For example, pig sector annual reports include data on factors such as number of pigs reared per sow/per year, average weaning age, amount of feed consumed in producing each kg of meat and daily weight gain. Little or no attempt is made to cover the welfare of the animals, the nutritional quality of the food produced or its impact on natural resources. No attention, for example, is given to the detrimental impact of early weaning on piglet health, the associated need for regular antibiotic use, the resulting increase in antibiotic resistance and its cost implications as these are borne by the health service and future generations in the form of less effective antibiotics.

We need to develop ways of thinking about food and farming that no longer give precedence to quantitative factors but allows qualitative aspects (e.g. animal welfare, nutritional quality, avoidance of deforestation) to be given breathing space, to be properly valued (though not necessarily in monetised terms).

**The (blindfolded) consumer reigns supreme**

When challenged about the cruelty and environmental damage emanating from factory farming, food industry representatives tell us with a disarming smile that they are simply giving consumers what they want. This ignores the fact that over the last few decades the food industry has spent billions on advertising to forge certain 'wants' in consumers and build a food culture which prizes plentiful cheap convenient food and which, as in a three card

trick, cleverly diverts attention away from its damaging impact on our health, the environment and animal welfare.

Governments and the food industry are keen to ensure consumers do not have to confront the reality of today's animal farming. Misleading advertising, packaging and reports often use images showing pigs and chickens contentedly foraging in green fields and cows grazing on verdant pastures. These are designed to lull consumers into believing that all is well and serve to hide the hard reality that most EU pigs and poultry are kept indoors in overcrowded units throughout their lives and many cows are 'zero-grazed' never going out to graze. This painting of a reassuring picture that is far removed from the truth is profoundly dishonest and prevents consumers from making informed choices.

The EU Strategy for the Protection and Welfare of Animals 2012-2015 commits to increasing transparency and adequacy of information to consumers on animal welfare so that they can make clear purchase choices. The European Commission conference that launched the strategy was entitled "Empowering consumers and creating market opportunities for animal welfare". Compassion in World Farming and others have been calling for meat and dairy products to be labelled as to farming method. This would give consumers key information: it would tell them how the animals that provided the meat and dairy products on the supermarket shelf were reared. It would enable consumers to play a more active role in driving welfare improvements.

However, despite their talk of "empowering consumers", the Commission and the Member States have in general firmly opposed demands that meat and dairy products should be labelled as to farming method. They seem determined that consumers should be kept in the dark for fear that if they really knew of the miseries of much of today's animal farming, they would refuse to buy such products. So although we endlessly hear that consumers should be empowered to make informed choices, governments and industry insist that those choices be made while wearing a blindfold. The role of consumers is to consume, not to fret about the animals' well-being.

Nowhere is this seen more clearly than in the case of milk. When you look at the milk cartons in a shop you have no way of knowing if the milk comes from 'zero-grazed' or pasture-based cows. Consumers are simply not given the information that would allow them to choose which kind of dairy farming they wish to support (unless they buy organic which can be expensive for those on a tight budget).

**Donning the cloak of sentient beings**

It is just over 50 years since Ruth Harrison published *Animal Machines* which exposed the suffering inflicted on farm animals by industrialised farming. Animals are now recognised by the EU Treaty as "sentient beings" but nonetheless continue to be treated as animal machines.

This can be seen most clearly in the genetic selection of animals for ever higher productivity. This is having a devastating impact on animal well-being. The European Food Safety Authority has concluded that "long term genetic selection for high milk yield is the major factor causing poor welfare, in particular health problems, in dairy cows".[vi] A UK study into leg disorders in broilers found that, primarily due to high growth rates, 27.6% of the chickens had levels of lameness that are likely to be painful.[vii] The high productivity of modern laying hens causes osteoporosis which results in a high level of bone fractures.[viii] The pig industry's drive to increase litter size results in high mortality rates among the piglets. These animals are trapped just as much as those confined in cages; they are locked into their over-producing bodies and cannot escape the suffering that this involves.

The industry is determined to continue treating animals as machines. The UK pig industry runs a campaign for a 'Two-Tonne Sow' i.e. sows that, through their piglets, produce 2000

kg of pig meat per year. Animals are being cloned in some countries. The main objective of cloning is to produce genetically identical copies of the highest yielding cows and fastest growing pigs. Before long food from genetically modified farm animals may be on the market.

Time and again the focus is on maximising productivity with little thought being given to the animals' well-being (other than when driving the animals to such extremes leads to a breakdown in productivity). The use of animals as machines for maximising production continues to hold sway but is to a degree masked by the self-serving lip service paid by governments and industry to their legal status as sentient beings.

**The claim to efficiency**

The industry regularly asserts that cramming large numbers of animals into factory farms and pushing them to extreme levels of productivity is efficient.

However, industrial livestock production is inherently inefficient. This stems from its dependence on feeding human-edible cereals to animals. Studies, including a UNEP report, show that for every 100 calories that we feed to animals in the form of human-edible crops, we receive on average just 17-30 calories in the form of meat and milk.[ix] [x] A 2013 University of Minnesota paper indicates that the efficiency rates may be even lower for some animal products. It reports that for every 100 calories of grain that we feed to animals, we get only about 40 new calories of milk, 22 calories of eggs, 12 of chicken, 10 of pork, or 3 of beef.[xi]

A Chatham House study stresses that feeding grain to animals "represents a staggeringly inefficient use of resources".[xii] A 2013 FAO report points out that the feeding of cereals to livestock could threaten food security by reducing the grain available for human consumption.[xiii] Olivier De Schutter, until recently UN Special Rapporteur on the right to food, states that "continuing to feed cereals to growing numbers of livestock will aggravate poverty and environmental degradation".[xiv] It will aggravate poverty by pushing up cereal prices placing them out of reach for the world's poor.

Animals' inefficiency in converting human-edible crops into meat and milk brings other inefficiencies in its train. It is a wasteful use not just of the crops but of the land, water and energy used to grow them. Mekonnen and Hoekstra concluded that animal products from industrial systems generally consume more blue (surface and groundwater) and grey (pollution) water than animal products from grazing or mixed systems.[xv] They said that the anticipated further intensification of animal production systems globally will result in increasing blue and grey water footprints per unit of animal product; the authors state that this is due to the larger dependence on concentrate feed in industrial systems.

More arable land is generally needed to produce a unit of nutrition from industrially produced meat than from meat from animals that are fed little or no human-edible crops. Moreover, the need for huge amounts of crops to feed industrially produced animals has led to the intensification of crop production with the use of monocultures and chemical fertilisers and pesticides. These have eroded soil quality. The European Commission points out that "45% of European soils face problems of soil quality, evidenced by low levels of organic matter".[xvi] A new UK study reports that the soils resulting from years of industrial agriculture are of poorer quality than those of urban allotments.[xvii]

If industrial livestock production continues to grow, its need for feed crops will increase; this will lead to an expansion of global cropland at the expense of forests and grasslands. Deforestation would involve loss of wildlife, substantial greenhouse gas emissions and the erosion of indigenous livelihoods that accompanies deforestation.

Per unit of nutrition produced, industrial livestock production is more harmful to water, soil and wildlife and uses more arable land as well as surface and groundwater than grazing or

integrated crop-livestock systems. It would be hard to devise a more inefficient way of feeding people.

Only grazing on land unsuitable for crop production or utilizing crop residues, by-products and unavoidable food waste as animal feed can be considered as efficient. The benefit of raising animals on pastures or other grasslands is that they convert grass and other inedible vegetation into food that we can eat and are able to use land that is generally not suitable for other forms of food production. Moreover, semi-natural grasslands support biodiversity and store carbon.

The World Bank is extremely positive about integrated crop/livestock production.[xviii] The benefits of rotational mixed farming are that crop residues can be used to feed animals and their manure, rather than being a pollutant, fertilises the land and improves soil quality.

**The claim of necessity: we need to produce 70% more food by 2050**

Finally factory farming wraps itself in the cloak of virtue. We're the good guys come to feed the world. Its advocates tell us that 70% more food must be produced to feed the growing world population which is expected to reach 9.6 billion by 2050. And as we need to produce so much extra food, further industrialisation is inevitable.

This '70% more' message has become the prime driver of global food and farming policy. It is widely cited to justify industrial and technology-based solutions that respond to a challenge presented as a primarily quantitative one. The fixation with 70% more is such that policy makers tend to give insufficient attention to the danger that mounting industrialisation will undermine the natural resources – land, soil, water, biodiversity – on which our ability to produce food depends.

But what if it's not true? What if we don't need to produce 70% more? Then current policies, with their focus on a massive increase in production, would be based on a false premise.

De Schutter has said that "We live in a world which, if we managed our resources adequately, could feed almost twice the planet's population. We produce the equivalent of 4500 calories per person per day. That's twice as much as the daily need of 7 billion inhabitants".[xix]

It is clear that more than enough food is already produced to feed the anticipated world population in 2050 of 9.6 billion. The real challenge lies not so much in producing more but in wasting less, and ensuring a more equitable distribution of food and agricultural resources.[xx] As will be explained below, over 50% of global crop calories are lost or wasted or otherwise used in ways that do not contribute to the human food supply.

A 2014 report by the High Level Panel of Experts on Food Security and Nutrition states that worldwide 25% of food calories are lost or wasted post-harvest or at the distribution/retail and consumer levels.[xxi] In addition, 9% of global crop calories are used for biofuels and other uses.[xxii]

The University of Minnesota paper referred to earlier calculates that 36% of the world's crop calories are fed to animals but, as explained above, only 17-30% of these calories are returned for human consumption as meat or milk.[xxiii] The effect of this is that 70-83% of the 36% of the world's crop calories that are used as animal feed are wasted; they produce no food for humans. This means that 25-30% (70-83% of 36%) of the world's crop calories are being wasted by being fed to animals.

In total, therefore at least 59% of the world's crop calories are wasted:

- 25% post-harvest or at the distribution/retail and consumer levels
- 9% in use for biofuels and other non-food uses

- 25-30% by being fed to animals.

UNEP has also looked at the waste entailed in feeding human-edible crops to animals. It calculates that the cereals which, on a business-as-usual basis, are expected to be fed to livestock by 2050, could, if they were instead used to feed people directly, provide the necessary food energy for over 3.5 billion people.[xxiv] If a target were adopted of halving the amount of cereals that, on a business-as-usual basis, would be used for feed by 2050, an extra 1.75 billion people could be fed.

Increased production may be needed in certain regions or specific cases but, in light of the various forms of loss and waste referred to above, the claim that a 70% increase in global food production is needed by 2050 substantially overestimates the quantity of extra production needed.

And so necessity, the last refuge of factory farming, crumbles. We do not need to produce huge amounts of extra food; we simply need to use what we produce more wisely.

**Conclusion**

An interlinked web supports factory farming and allows it to thrive. This web comprises many strands: legislation that appears strong on paper but in practice often proves illusory, a deceptive economics that by sleight of hand can make the costly appear cheap and a scientific orthodoxy that tends to restrict our view of what constitutes good animal well-being. Further support comes from claims to efficiency that bear little scrutiny, a questionable assertion that we need to produce 70% more food and avowed respect for animals as sentient beings while treating them as machines which if fine-tuned will be ever more productive. As a result industrial livestock production appears to be locked in to our food system.

We urgently need fresh thinking that allows us to develop a food system that provides healthy food, restores and enhances the natural resources on which agriculture depends and respects the animals that provide our meat, milk and eggs.

---

[i] European Union Strategy for the Protection and Welfare of Animals 2012-2015. COM(2012) 6 final/2

[ii] European Commission, 2012. Consultation Paper: Options for Resource Efficiency Indicators http://ec.europa.eu/environment/consultations/pdf/consultation_resource.pdf

[iii] Foresight. The Future of Food and Farming (2011). Final project report. The Government Office for Science, London.

[iv] van den Bergh J. and Antal M., 2014. Evaluating Alternatives to GDP as Measures of Social Welfare/Progress Working Paper no 56

[v] *Ibid*

[vi] Scientific Opinion of the Panel on Animal Health and Welfare on a request from European Commission on welfare of dairy cows. *The EFSA Journal* (2009) 1143, 1-38.

[vii] Knowles, T. G., Kestin, S. C., Haslam, S. M., Brown, S. N., Green, L. E., Butterworth, A., Pope, S. J., Pfeiffer, D. and Nicol, C. J., 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. Plos one 3 (2): e1545. doi: 10.1371/journal.pone.0001545.

[viii] Laywell: Welfare implications of changes in production systems for laying hens: Deliverable 7.1

[ix] Lundqvist, J., de Fraiture, C. Molden, D., 2008. Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain. SIWI Policy Brief.
SIWI.http://www.siwi.org/documents/Resources/Policy_Briefs/PB_From_Filed_to_Fork_2008.pdf

[x] Nellemann, C., MacDevette, M., Manders, et al. (2009) *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. United Nations Environment Programme, GRID-Arendal, www.unep.org/pdf/foodcrisis_lores.pdf

[xi] Cassidy E.M *et al*, 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. University of Minnesota. Environ. Res. Lett. 8 (2013) 034015

[xii] Bailey R *et al*, 2014. Livestock – Climate Change's Forgotten Sector. Chatham House.

[xiii] Gerber, P, 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

[xiv] http://www.srfood.org/images/stories/pdf/officialreports/20140310_finalreport_en.pdf

[xv] Mekonnen M and Hoekstra A, 2012. A global assessment of the water footprint of farm animal products. Ecosystems.: DOI: 10.1007/s10021-011-9517-8

[xvi] Communication from the Commission on the European Innovation Partnership 'Agricultural Productivity and Sustainability'. 29.2.2012. http://ec.europa.eu/agriculture/eip/pdf/com2012-79_en.pdf

[xvii] Edmondson *et al*, 2014. Urban cultivation in allotments maintains soil qualities adversely affected by conventional agriculture. Journal of Applied Ecology 2014, 51, 880–889

[xviii] Minding the stock: bringing public policy to bear on livestock sector development, 2009. World Bank. Report No. 44010-GLB

[xix] http://www.lepoint.fr/environnement/nous-pourrions-nourrir-deux-fois-la-population-mondiale-et-pourtant-09-09-2014-1861529_1927.php

[xx] The Economist, February 26th 2011. The 9 billion-people question. A special report on feeding the world. http://www.mcgill.ca/files/globalfoodsecurity/The_9_billion_people_question.pdf Accessed 4 November 2014.

[xxi] HLPE, 2014. Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014.

[xxii] Cassidy E.M *et al*, 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. University of Minnesota. Environ. Res. Lett. 8 (2013) 034015

[xxiii] Cassidy E.M *et al*, 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. University of Minnesota. Environ. Res. Lett. 8 (2013) 034015

[xxiv] Nellemann, C., MacDevette, M., Manders, et al. (2009) *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. United Nations Environment Programme, GRID-Arendal, www.unep.org/pdf/foodcrisis_lores.pdf