Fossil Fuels Allow the Rest of Nature to Coexist with Humanity

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Earth is greener, mainly from FF related factors (70% CO2, 9% N-deposition, 8% climate change)

Figure 1. Spatial pattern of relative change of LAI due to CO2 fertilization during 1982 to 2009. The relative change of LAI in each pixel is derived from the ratio of the increment of LAI driven by elevated atmospheric CO2 to the 28-year average value of LAI simulated by model ensemble mean under scenario S1. Source: Figure S12, supplementary information from Zhu et al. (2016)
The Earth is more productive
[14% increase in gross productivity, 1982–2011]

Global land biological productivity may be 5% higher now than in pre-industrial times.

Source: IPCC AR5 WG2, Chapter 4, p. 293
Fossil fuels have forestalled massive habitat conversion and lowered risks to biodiversity

For context

- Habitat conversion — AKA, erroneously, as “habitat loss” — is generally recognized as the greatest current threat to ecosystems and biodiversity [see, e.g. Vié, J.-C. et al. (eds) 2009]
- Agricultural activities are the major cause of habitat conversion
How do fossil fuels reduce habitat conversion?

Increase productivity of the entire food and agricultural system
→ Less habitat conversion to meet food demand
→ More land for Rest of Nature
→ Reduced threat to ecosystems & biodiversity
How have fossil fuels increased food & agricultural productivity?

• Higher yields on the farm (through nitrogen fertilizer, pesticides, irrigation, agricultural machinery, CO2 fertilization, nitrogen deposition)
  – Net global primary productivity (NPP) may be 5% higher than the preindustrial level (IPCC AR5 WG2, Chapter 4, p. 293)
• Lower losses post-harvest and before crops/foods go to market shelves (via pest control, faster transport, refrigeration, plastic bags and containers)
• Fewer losses at markets, stores, homes restaurants, etc., and all points in-between (e.g., refrigeration, plastic bags and containers)
Global Habitat Conversion to Agricultural Uses (1700–2012)

Sources: Klein Goldewijk et al (2011); FAOSTAT (2015); Maddisson (2009).
How much land have fossil fuels saved for the Rest of Nature?

Calculation of **Lower Bound Estimate** of additional land needed to compensate for lost food, fiber & fuel production due to loss of fossil fuels:

- Consider only subset of fossil fuel dependent technologies enhancing productivity:
  - *Nitrogenous fertilizers*
  - *Synthetic pesticides*
  - *CO2 fertilization and nitrogen deposition*
- Assume productivity of additional cropland (on average) same as cropland currently in agricultural use (unlikely)
- Ignore that much of irrigation uses FF-powered pumps
- Ignore that FF have increased productivity of pasture land
  - *Globally pastureland is 2 times cropland*
Other sources of underestimation of land needed to compensate for loss of FF

Ignore that FFs have substituted for a variety of products that would otherwise divert land from the Rest of Nature:

• FF-derived synthetic fibers account for over 70% of global fiber production
• FF account for over 81% of Total Primary Energy Supply and would have to be replaced by lower energy-density renewables (unless nuclear becomes more popular)
• Plastics and other materials obtained directly or indirectly via FF have displaced timber and other vegetal based materials
Land saved by fossil fuels for Rest of Nature: Lower Bound Estimate for Cropland — 1

✓ **Nitrogenous fertilizers**, mainly from natural gas via Haber-Bosch process. Responsible for 48% of global food production (Erisman et al. 2008).

✓ **Synthetic pesticides.** Reduce losses in various food crops from 50–77% to 26–40% in the absence of any pesticides (Oerke 2006).

✓ **CO2 fertilization** from increases in Atmospheric CO2 from 277 ppm (preindustrial) to 400 ppm (current) increased food production 9–15% (based on IPCC 2013, and Idso 2013). [I’ll assume 10%.]
Land saved by fossil fuels for Rest of Nature:
Lower Bound Estimate — 2

Cumulative increase in food production from above 3 factors = 174%

To produce same quantity of food in the absence of fossil fuels:
• Global cropland area would have to be increased from 1.6 billion hectares to 4.3 billion ha.
• **Increase = 20.9% of global land area** (excluding Antarctica)
  • About the size of South America and Europe combined
  • FF have saved more land than ALL land conservation effort (12.5%) through 2009
Effect on potential species extinctions from reduced habitat conversion

• Barnosky et al. (2012) estimate that 43% of global terrestrial ecosystem has already been converted to human use

• Absent FF, we would need to convert at least 21% more land to agricultural uses to sustain humanity at its current level — total of at least 64%

• The added land conversion would have put ecosystems and species at greater risk.

• Barnosky et al.’s “tipping point” paper in *Nature* postulates a tipping point if land conversion exceeds 50%. **We would already have gone past that postulated tipping point!**
Effect of increased habitat conversion on magnitude of potential species extinctions

• Species at risk of extinction would have increased by 70–78%, based on the species-area relationship (SAR) (crude estimate)
Summary — 1

• Global ecosystem productivity has increased at least 14% since 1982, mainly from indirect effects of FF usage

• FF are responsible for at least 63% of global food production
Summary —2

If there were no fossil fuels:

• We would need at least an additional 2.7 billion hectares or 21% of global land area just to meet human needs (a gross underestimate)

• The postulated tipping point for global land conversion (at 50%) would have been exceeded

• Potential species extinction would have increased over 70%
Conclusion

- Fossil fuels have saved much of the rest of nature from humanity
- Without them, other species in much bigger trouble
Back-up slides
Fossil Fuels Have Saved Nature from Humanity

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Fossil Fuels Reduce Habitat Conversion & Biodiversity Losses

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Fossil Fuels Enhance Ecological Sustainability

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Three Dimensions of Sustainable Development

• Economically sustainable
• Environmentally sustainable
• Socially sustainable