

Climate change is well known now as a major impact of humans on the planet. But climate change is only one of a wide range of ways in which humans are dramatically changing natural systems at the regional, continental and planetary levels.

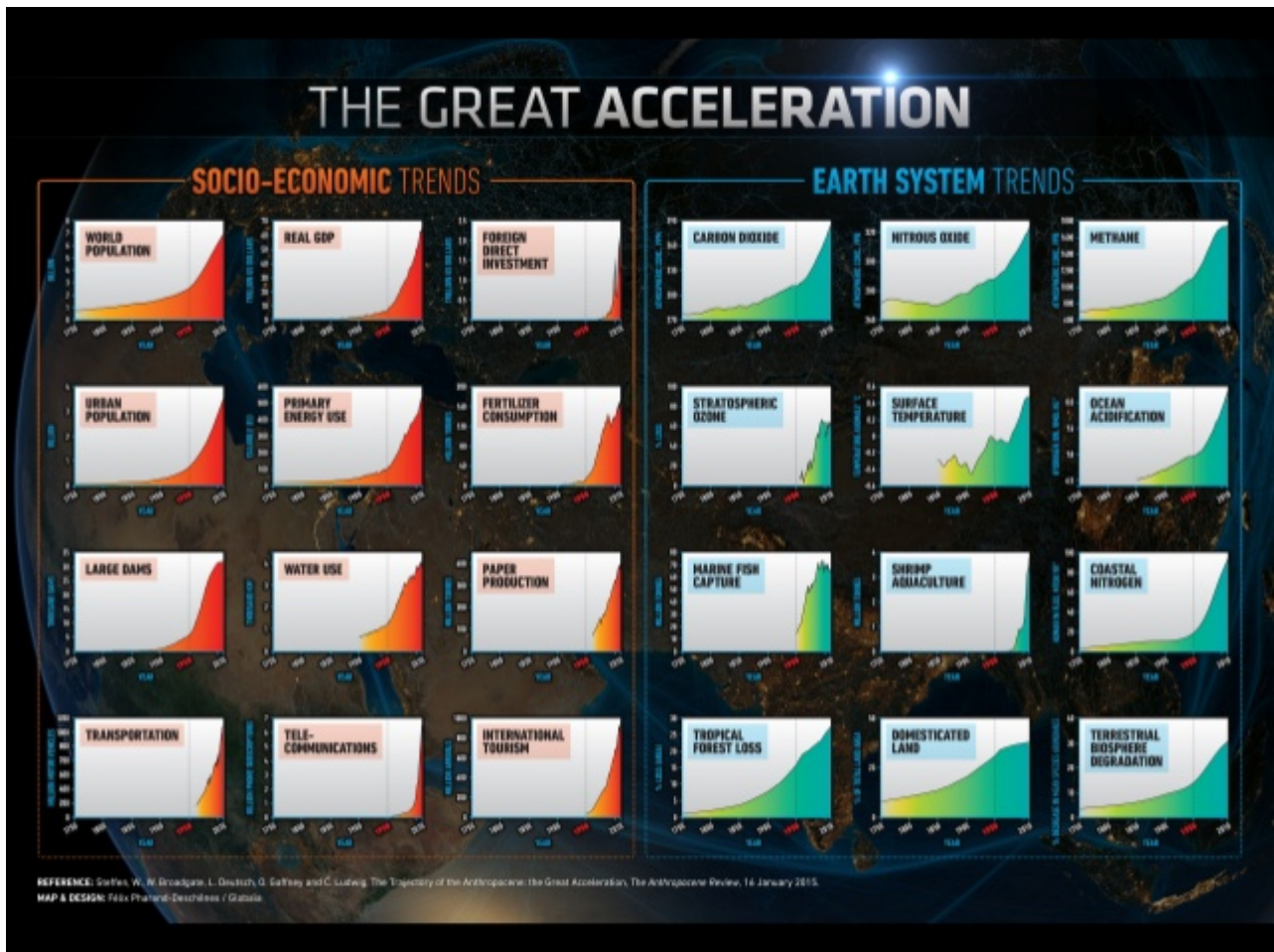
For instance, greenhouse gas emissions are the driver of anthropogenic climate change. But those same greenhouse gas emissions are also causing fundamental changes in our oceans - increased levels of carbon dioxide in the atmosphere produce increased levels of carbon dioxide in the oceans, which in turn makes the oceans more acidic. More acidic ocean water will have significant, perhaps devastating, impacts on marine life. For instance, more acidic oceans interfere with the ability of marine creatures to form calcium carbonate skeletons that they survive on. The result will be higher mortality rates for coral reefs, mollusks, and plankton in the ocean. Coral reef ecosystems are for fish reproduction and therefore human fisheries around the world. Phytoplankton are the basis for many of the food chains in the oceans and much of the photosynthesis on the planet.

Or take human changes to global nutrient cycles. Humans have mined huge amounts of phosphorus to fertilize crops around the planet; humans also have created novel ways to fix nitrogen from the atmosphere, again for crop fertilization. The result has been a large increase in the amount of nitrogen and phosphorus cycling through the soils, rivers, lakes, and oceans of the planet - increases on the order of eight to nine times background levels for phosphorus, and double for nitrogen. These increased nutrient flows produce dead zones in our oceans and lakes - the increased nutrient levels contribute to the growth of greater organic (plant) matter, which then decays and uses up oxygen in the water body. The dead zone in the Gulf of Mexico where the Mississippi River discharges the nutrients from upstream farms is now hundreds of square miles large. [A recent article in Science](#) found that these dead zones have quadrupled in size since 1950. At the extreme, high levels of nutrient inputs into our oceans could cause mass extinctions in our oceans, something that has occurred only a few times in the entire history of the planet.

There are more examples: Humans now have converted between one-third and one-half of the terrestrial surface of the planet to human-dominated landscapes such as cities or farms. Humans also appropriate about one-third to one-half of all the photosynthesis that occurs on the planet. Together, these impacts have increased the rates of species extinctions above background levels by about 100 to 1000 times.

These human changes to natural systems are occurring at an accelerating rate - both because of increased technological innovation, but also because of exponential population growth and economic growth. Some earth scientists have called this shift the "Great Acceleration." As a result, new changes are occurring at an increasingly rapid rate, and

many existing human impacts are increasing at an accelerating rate. The following charts do better than words can at explaining this (click [this link](#) for an expanded version of the slides in powerpoint format):



Next post I will explain the implications of these changes for human societies.

(A link to my law review article that is the basis for these posts is [here](#). That article has a lot of good citations for the summary I've given above, along with more details.)