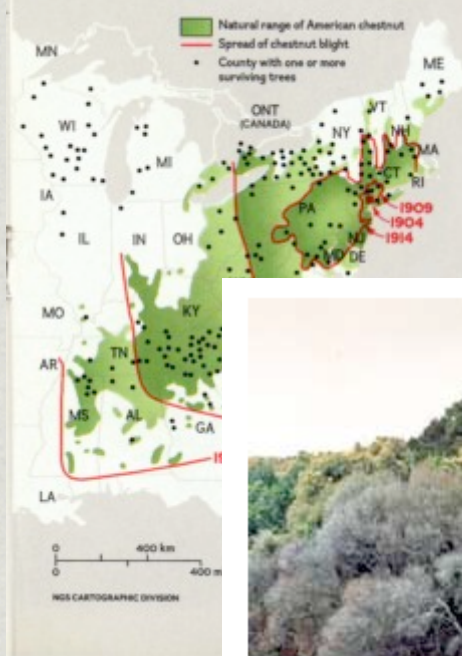
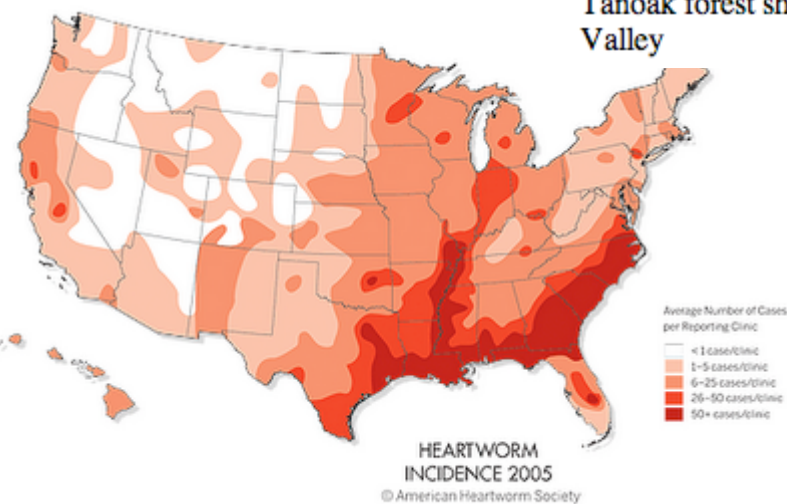


American chestnut blight

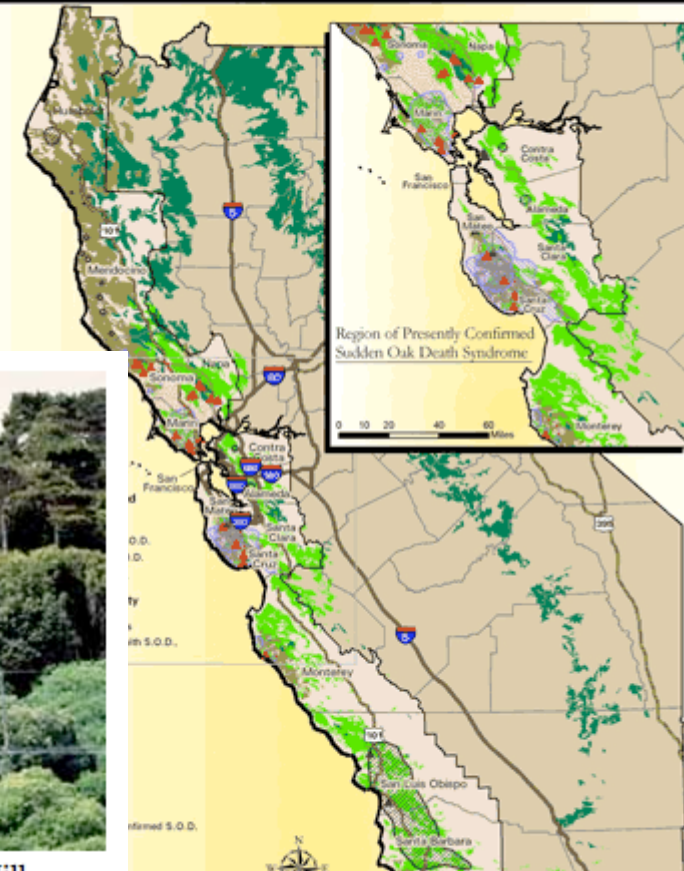


Tanoak forest showing different stages of dieback in Mill Valley



Distribution of Oak Mortality in California

Reported Oak Mortality and Confirmed Cases of Sudden Oak Death



Sudden Oak Death: An International Epidemic?

California's oaks are dying by the thousands from a disease known as Sudden Oak Death. Now, the pathogen that causes the disease has been linked to infestations of rhododendron shrubs in Europe and in a California nursery, suggesting that international trade is spreading the destructive fungus.

A newly discovered fungus threatens critical oak habitat in California. Until recently, the pathogen, a member of the genus *Phytophthora*, the same group that caused Ireland's great potato blight of 1845-1850, was known only to infect California's coast live oaks, black oaks, and tanoaks from Sonoma County to Big Sur.

Cotton boll weevil, Asian long-horned beetle,
Mountain pine beetle, Gypsy moth, Citrus canker,
European Corn borer, HIV/AIDS...

Like the “death by a thousand cuts,” each invasion weakens the ecosystem and consumes limited economic resources while providing no positive contributions.

But these are little problems.

Back to the big ones.

Have you heard of Planetary Boundary Research?

Jon Foley: How far can we go without breaking the system?

“Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change,...”

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Planetary Boundaries

To avoid catastrophic environmental change humanity must stay within defined 'planetary boundaries' for a range of essential Earth-system processes, argue Johan Rockström and his co-authors in a *Nature* Feature. If one boundary is transgressed, then safe levels for other processes could also be under serious risk, they caution. Seven expert commentaries respond to this proposal in *Nature Reports Climate Change*. Join the debate and listen to the podcast.

- [FEATURE](#)
- [OPINION](#)
- [ELSEWHERE IN NATURE](#)

“This could see human activities push the Earth system outside the stable environmental state of the Holocene, with consequences that are detrimental or even catastrophic for large parts of the world.”

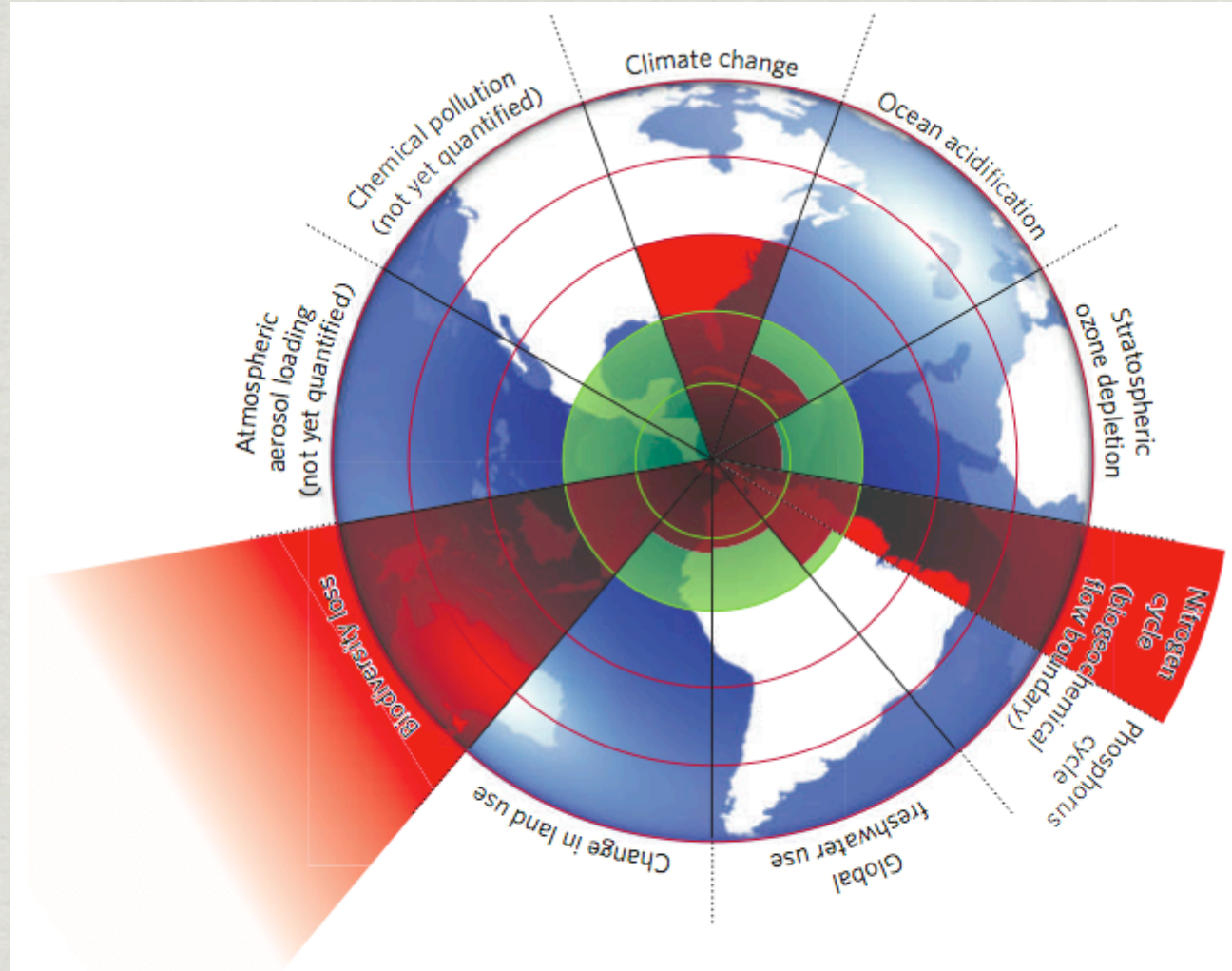
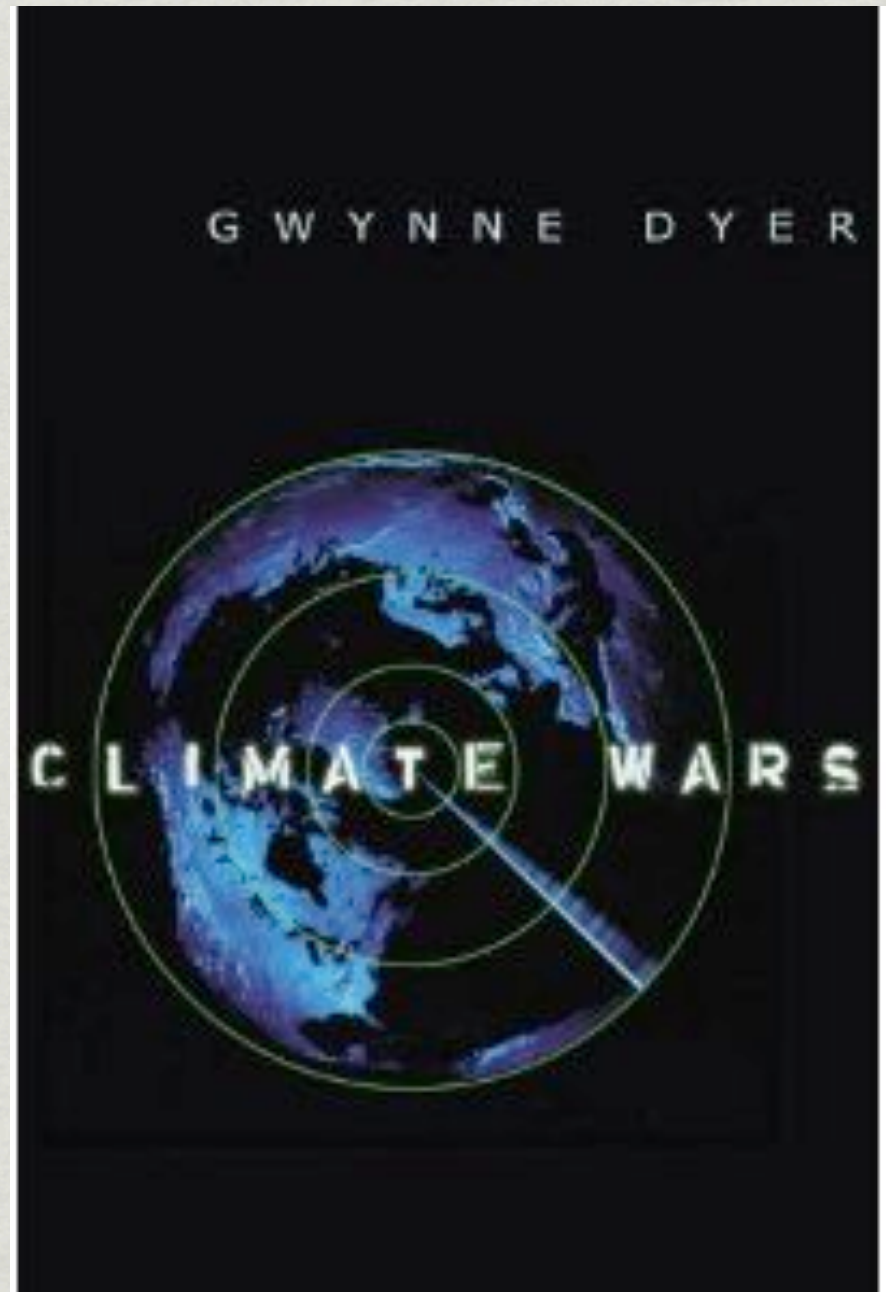


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

“Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables. If these thresholds are crossed, then important subsystems, such as a monsoon system, could shift into a new state, often with deleterious or potentially even disastrous consequences for humans.”

If this seems exaggerated,
I urge you to read this...



So, what are these tipping points?

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1-1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N ₂ removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5-9.5	-1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km ³ per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disruptors, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof	To be determined		

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

How could things be so bad,
when they look so average?



Many of the factors
that govern climate
have great momentum.

In the long run,
momentum loses out
to gravity.



The answer to specialization? Collaboration!

Authors

Johan Rockström^{1,2}, Will Steffen^{1,3}, Kevin Noone^{1,4}, Åsa Persson^{1,2}, F. Stuart Chapin, III⁵, Eric F. Lambin⁶, Timothy M. Lenton⁷, Marten Scheffer⁸, Carl Folke^{1,9}, Hans Joachim Schellnhuber^{10,11}, Björn Nykvist^{1,2}, Cynthia A. de Wit⁴, Terry Hughes¹², Sander van der Leeuw¹³, Henning Rodhe¹⁴, Sverker Sörlin^{1,15}, Peter K. Snyder¹⁶, Robert Costanza^{1,17}, Uno Svedin¹, Malin Falkenmark^{1,18}, Louise Karlberg^{1,2}, Robert W. Corell¹⁹, Victoria J. Fabry²⁰, James Hansen²¹, Brian Walker^{1,22}, Diana Liverman^{23,24}, Katherine Richardson²⁵, Paul Crutzen²⁶, Jonathan A. Foley²⁷

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These are the authors of the “Boundaries” study.

How to proceed...?

- ✱ As “the economy” holds the stage, we must cast our arguments in these terms:
 - ✱ Ecosystem services.
 - ✱ Sustainability \neq Growth because growth requires using more energy, not less. And we must use less.
- ✱ Crucially, we must recognize that “the economy” merely reflects how we use energy: **Energy is the key.**
- ✱ Because, if we don't reduce CO₂ to 350ppm soon, little of the economy will survive.
- ✱ All of the important variables are potentially chaotic.
- ✱ **In short, we must acknowledge that the problem is huge.**

Change paradigm: Science

- * Science isn't about certainty. It is about doubt.
- * Religion is about certainty.
- * While not perfect, science is the best we have and gets better over time.
- * Regarding climate: Science is very sure of 3 things:
 - * The planet's surface is getting warmer,
 - * Mostly because of changes caused by humans
 - * Even +2° C will be a major change. More will be a catastrophe.
- * As new factors arise, the prescription for the most effective response MUST change: be flexible.
- * **As the climate system the limiting variable** but is not represented in economics, "The Economy" must be driven by the best science.

I have found this paper very useful.

■ POLICY FORUM

Uncertainty, Resource Exploitation, and Conservation: Lessons from History

Donald Ludwig, Ray Hilborn, Carl Walters

There are currently many plans for sustainable use or sustainable development that are founded upon scientific information and consensus. Such ideas reflect ignorance of the history of resource exploitation and misunderstanding of the possibility of achieving scientific consensus concerning resources and the environment. Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point

amount of fishing effort. The consequence has been the elimination of some substocks, such as herring, cod, ocean perch, salmon, and lake trout. He concluded that an MSY based upon the analysis of the historic statistics of a fishery is not attainable on a sustained basis. Support for Larkin's view is provided by a number of reviews of the history of fisheries (2). Few fisheries exhibit steady abundance (3).

It is more appropriate to think of resources as managing humans than the con-

markets were developed and technology improved, but most stocks were eventually overexploited, and many were lost as a result of overharvesting, dams, and habitat loss. However, in the past 30 years more fish have been allowed to spawn and high seas interception has been reduced, allowing for better stock management. Oceanographic conditions appear to have been favorable: Alaska has produced record catches of salmon and British Columbia has had record returns of its most valuable species (5).

We propose that we shall never attain scientific consensus concerning the systems that are being exploited. There have been a number of spectacular failures to exploit resources sustainably, but to date there is no agreement about the causes of these failures. Radovitch (6) reviewed the case of the California sardine and pointed out that

SCIENCE, 2 APRIL 1993

[HTTP://WWW.SCIENCEMAG.ORG/FEATURE/DATA/SUST/PDF/260-5104-17.PDF](http://www.sciencemag.org/feature/data/sust/pdf/260-5104-17.pdf)

Decision making in the presence of uncertainty.

- * Be cautious. Include human motivation in analysis.
- * Act before complete scientific consensus.
- * Hedge (But don't trust your hedge too much!).
- * Distrust all claims of sustainability.
- * Confront uncertainty: consider many alternatives.
 - * Choose actions that are robust to uncertainty.
 - * Update assessment. Modify policy
 - * Favor actions producing data; monitor results.
 - * Favor reversible actions.
- * Distrust any who profess unwarranted certainty.

Economics and Climate Change.

- * The present economics has led to the pit we now face.
- * Something new is needed: the externalities are no longer external.
- * Regarding climate: we are very sure of 3 things:
 - * The overarching requirement: climate change $<2^{\circ}\text{C}$.
 - * Because even a simple cigarette lighter is now a WMD, massive inequalities in income distribution are can no longer be sustained: everyone now has a veto.
 - * The new metric for all economic activities and processes must become energy efficiency, even if this means that humans have to work more: Sewing machines- YES; Hummers No.
 - * Even $+2^{\circ}\text{C}$ will be a major change. More will be a catastrophe.
- * As new factors arise, the prescription MUST change over time.
- * “The economy” must conform to the best science.

Economist's roadmap

- ✱ Stop!
- ✱ Learn enough about climate, ecology and energy to convince yourself that rapid, massive change is essential.
- ✱ Close down and go back to school.
- ✱ Learn about energy: Easier than business--you can't cheat on the accounting!
- ✱ While developing new rules, impose substantial carbon tax (\$50-200/ton of carbon, \$150 to \$300 ton of CO₂, offset **only** for CO₂ captured/stored.)
- ✱ Trade with no country lacking such a tax.
- ✱ Use your advertising moxie to sell the necessity of above.
- ✱ Fund massive, worldwide education program.

Change paradigm: Economics

- * Economics is the study of a number of interacting, chaotic factors.
 - * Many of these have positive feedback.
 - * It is virtually impossible to obtain useful measurements of any parameters characterizing a system constrained by strong feedback because causes and effects become confused.
- * Consequently, accurate predictions in economics are impossible.
 - * At any time, a variety of analyses and predictions exist: after a period of time, some will appear to have predicted the current state more accurately than others.
 - * However, as this apparent success is as likely to be caused by some “random event” as by the perfection of the analysis. **Be very cautious about applying the seemingly successful “theory” to future problems.**
- * As practiced, “public economics” is more a religion than a science.

Change paradigm: Economics

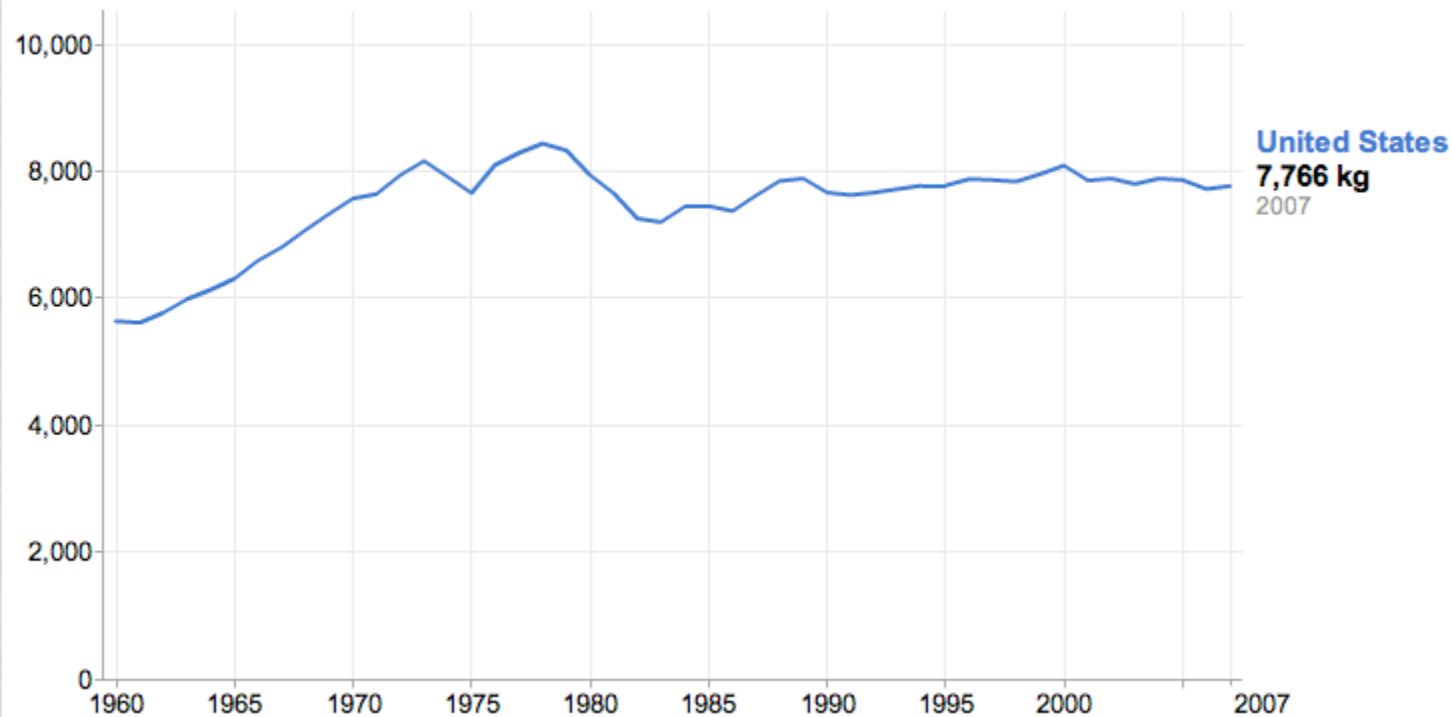
- ✱ The source of our current state of material well-being is not the perfection of the Western economic model but the availability of almost free energy.
- ✱ A human can produce about 200w of mechanical power.
- ✱ This ABSOLUTELY constrains what he/she can accomplish.
- ✱ The average American is the beneficiary of ~11.45 kW of power being utilized somewhere else in the economy. (~18 kW /working adult)
- ✱ i.e., Every American now benefits from the services of 50-100 “hydrocarbon slaves” working day and night, with no food, lodging or “fabrication” costs.*
- ✱ Almost all of this energy comes from burning fossil fuels.

* Wikipedia, 30PWh for all US in 2006,/(330,000000 • 24 • 365)

Per capita energy use.

Energy use per capita

Primary energy use (before transformation to other end-use fuels) in kilograms of oil equivalent, per capita. [More info »](#)

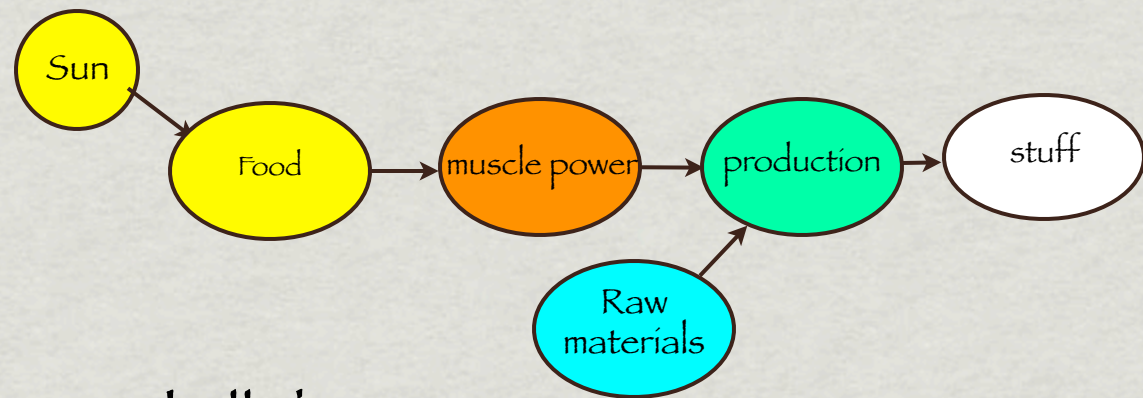


Data source: [World Bank, World Development Indicators](#) - Last updated October 1, 2010

- * This period of cheap energy is now coming to an end:
 - * Remaining supplies are limited.
 - * The sink for waste products is overflowing.
- * Because in practice, economics is just our way of apportioning access to this energy flow, **most present economic paradigms are *ipso facto* incorrect and probably misleading.**
- * Any economic framework not based on energy is irrelevant and dangerous.

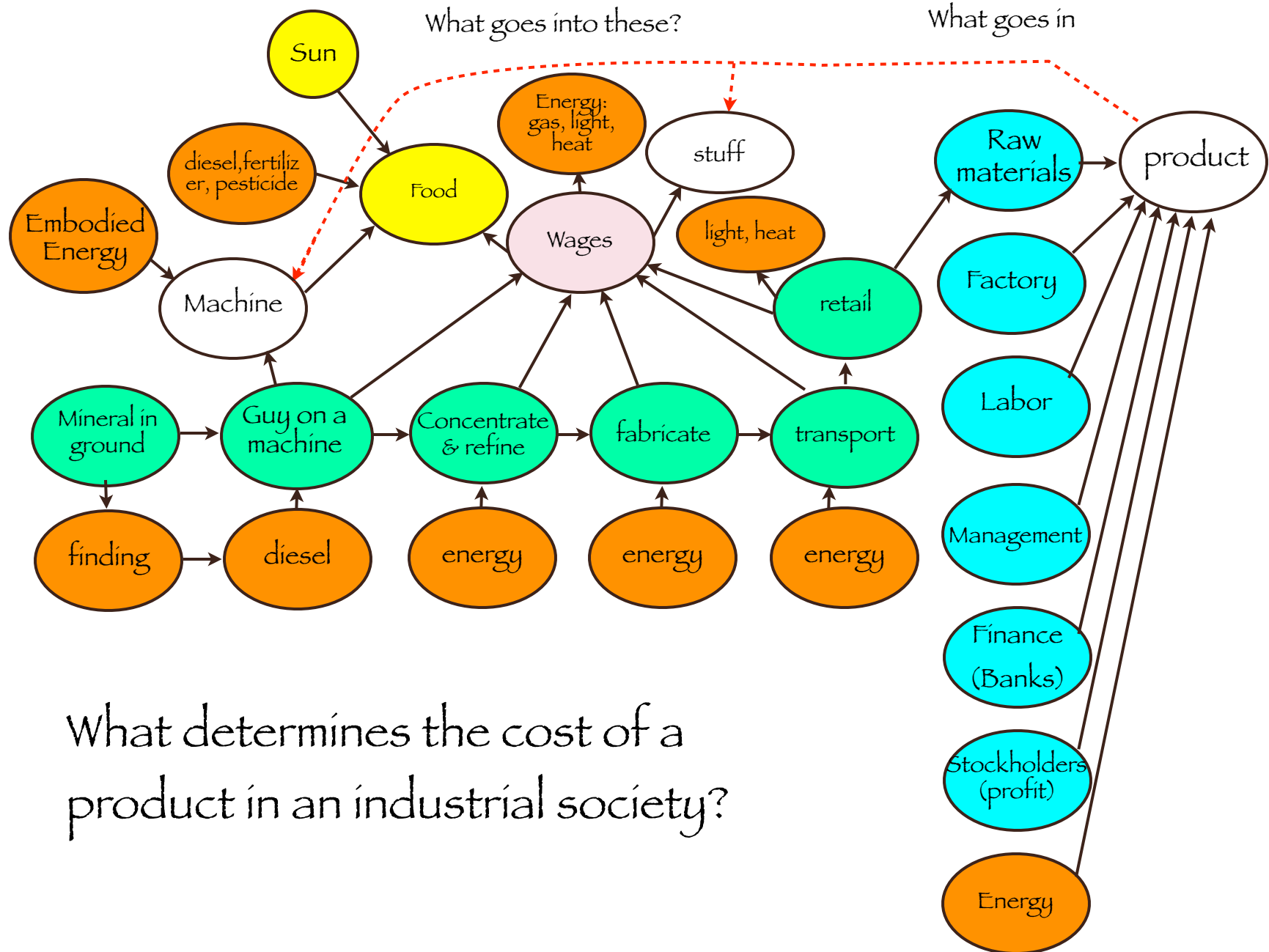
The point is that nothing changes unless energy is expended.

For a long time, the energy used to power the actions of human society was “recent solar” energy, and the process was fairly simple:



Industrial society changed all this.

The most important change is that muscle power now represents less than 1% of the energy utilized to make a modern society function. Virtually everything you buy exists only because vast amounts of energy were used to make it.



What determines the cost of a product in an industrial society?

Any change requires the consumption of energy and the production of heat.

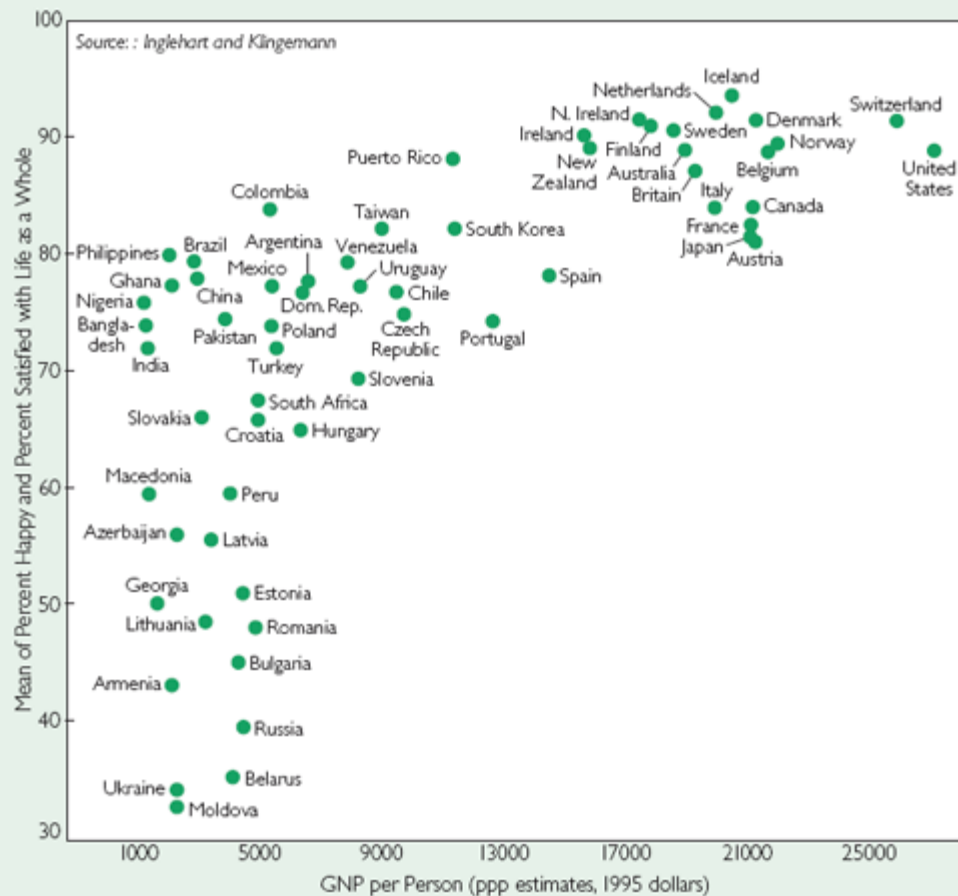
- * Fossil fuel “ Energy” doesn’t represent 8% of the economy but 98 or 99%.
- * Essentially all terrestrial energy flows and stores represent solar energy in one form or another.
- * Before the industrial revolution, we lived on solar income.
- * Now we live on stores.
- * The sink for these flows has been the atmosphere and it is now past full.

Won't the economy collapse?

- * Yes. “Over” means “over.” The garbage can is full to overflowing.
- * If we don't respond, collapse will still occur, but be “permanent.”
- * Good news:
 - * Only 7% of economy is needed for food, clothing, shelter etc.
 - * Only 15% if you include basic services, including medicine.
 - * The US produced no automobiles during WW II. They survived.
 - * Above a minimum: Energy use and well-being are not coupled.
 - * If the US reduced energy use by 80%, (but with today's energy efficiency), it would look like 1969.
 - * **And we still waste 80% of the energy we use. It is too cheap.**

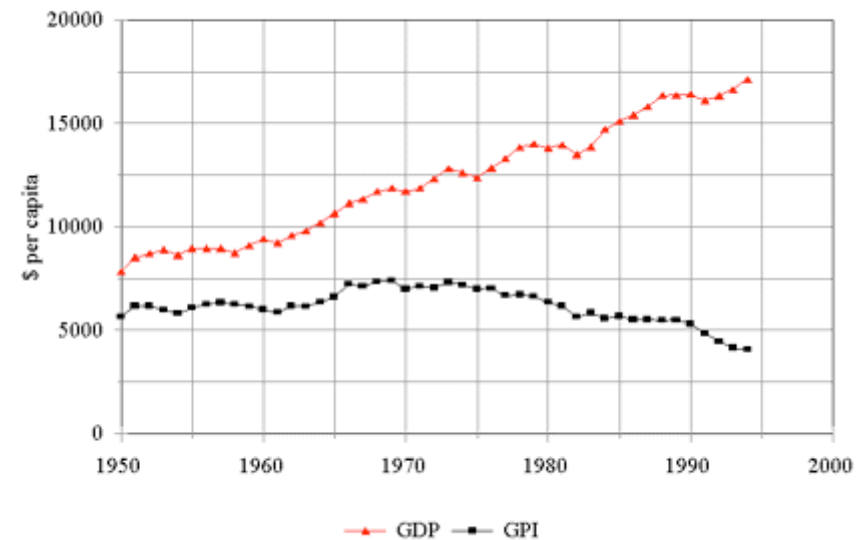
What do we need?

Figure 4-2. Subjective Well-being and Per Capita Income, 2000



Are we getting it?

USA Genuine Progress Indicator



One doesn't "need" 50 slaves to live a comfortable, productive life.

Maybe 10?

Maybe 5?

Let's grow up, stop complaining and make the best use of these!

Thank you for your attention.