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Book Review: The Big Ratchet

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One of the best books I have read in the last few years is *The Big Ratchet: How Humanity Thrives in the Face of Natural Crisis – a biography of an ingenious species* by Ruth DeFries. You can find it here. http://www.amazon.com/Big-Ratchet-Humanity-Thrives-Natural/dp/0465044972/ref=sr_1_1?s=books&ie=UTF8&qid=1444158074&sr=1-1

Ever since I was asked to participate in an SOA sustainability group, books like this one have attracted me. The big ratchet concept is very descriptive of humanity's ability to put off the limits to growth first described by Thomas Malthus over 200 years ago. His basic argument, if we continually increase the population at some point there won't be enough food for all of us and famine will result. The big ratchet describes a process where humans overdo one thing until it becomes a problem, then adjust (ratchet) to find a solution. Then they do that until it becomes a problem…

As I read the book there is hope things will work out and there is fear that it will not. It is still uncertain what the outcome will be. At times it seems like all we do is put off the foregone conclusion. A dominant species that puts itself above natural predators will continue to expand its reach until hitting a tipping point. Humanity continues to assume that science and human ingenuity continue to "fix" things. Some extend this to an infinite conclusion, which makes no sense to me. Resources are finite, whether minerals in the ground or clean air above it, and eventually they are used up. In the other extreme view, nature has the last say. The earth will survive (if we don't blow it up first) and continue to evolve in any case, whether we are here or not. Another book I enjoyed that talked about this possibility is Alan Wiseman's *The World Without Us*.

Jared Diamond's *Guns, Germs and Steel* remains the book that every person should read early in their adult life. *The Big Ratchet*, among others, are much more thought provoking when read with the Pulitzer Award winning book as a base.

The premise of this book is that all energy comes from plants, and humans either eat plants or eat things that eat plants as part of a complex food chain. As energy is extracted by plants from the soil there becomes a need to replace those nutrients. Each ratchet the author describes is an updated version of this process, increasing yields and allowing greater population growth. Humanity extends a cycle settling new areas and increasing population until, just in time before the hatchet falls, there is a new pivot to a method that works better and avoids the pitfalls of the prior method. This cycle has repeated multiple times.

The human species grew its brain, has opposable thumbs, and figured out how to control fire. We developed tools and language. We build on our knowledge (for the most part – there have been periods where past learnings were repressed and lost), learning to grow more food with fewer farmers. Much of this improvement has been built on experimentation. Often breakthroughs come from accidental occurrences, but they would not be possible if experiments weren't being done. To say it is random is often an overstatement.

The earth works because of its recycling features. Especially water and carbon circulates between land, ocean, deep beneath the surface and in the atmosphere. Most amazingly it is a self-correcting cycle that regulates the climate over long periods of time. DeFries states it is the "foundation for human civilization."

The oil that exists deep in the ground was originally leafy plants, but like today converted energy originally received from the sun. Many millions of years of growth resulted in carbon being taken out of the air and captured underground. As we pull the carbon back up we release the carbon back into the atmosphere, impacting weather and climate.

Early pivots: 3.5 billion years ago single celled organisms appeared, followed 2 billion years later by those utilizing photosynthesis. This built up oxygen in the atmosphere, replacing early bacteria with air breathing animal forms (and creating the ozone layer).

Next pivot: 1.5 billion years ago, sexual reproduction allowed quicker evolution and easier adaptation. Several hatchets fell as the environment rapidly changed, for various reasons. Up to 96% of species went extinct at least five times. Another good book I have read is *The Sixth Extinction: An Unnatural History*, by Elizabeth Kolbert. It analyzes whether we are currently in one of these periods, having created it ourselves.

Farming pivot: humans (not uniquely) pass on their genes and this allows a base for learning to occur. Man started out as a forager, but the (then) rich abundance of the Fertile Crescent led to farming and cities. As an aside, this area of the world is worth studying as man's influence has taken the "garden of Eden" to a desert state.

Settled life pivot: more than 6,000 years ago animal power was added to supplement human labor. In China about 3,000 years ago crop rotation was developed to return nutrients to the soil. They also collected "night-soil" from city dwellers to use as fertilizer. When a farmer went to town they returned carrying human waste. This picture in my mind is very powerful, and makes me wonder if there aren't some methods that could be incorporated with today's wastewater treatment plants to efficiently return nitrogen to the soil.

14th century: changing climate and wars led to famines and plague in Europe. During the agricultural revolution (followed shortly by the industrial revolution) crop rotation, enhanced tools, better seeds and livestock improvements led to a food surplus.

Columbus pivot: Using the sun driven trade winds to cross the Atlantic, a general homogenization between species began. Ships traveling west carried animals and seeds, those east carried crops (including potatoes) and gold. Disease mostly traveled west, as the domestication of animals that led to jumps between species and eventually immunity was much further along in the Old World. Populations were decimated by diseases such as smallpox. Africans had built up greater resistance to these diseases, encouraging the slave trade.

Late 18th century: drought, war and inflation led to Malthus' warning in 1798 that "the power of population is indefinitely greater than the power in the earth to produce subsistence for man." Cities had built up so much, with flush toilets and sewers improving sanitation, yet the phosphorus and nitrogen cycles were breaking down and soils were degrading.

Guano pivot: bird droppings in South America provided rich nitrogen and phosphorus to the Incas, and by the mid 1800s mining techniques were harvesting and shipping guano to North America and Europe.

Chemical reaction pivot: in the 1900s a process was developed to extract nitrogen from the air in the form of ammonia using heat derived from coal. The Germans improved the process during WWI as part of the war effort to make explosives. Sources of phosphorus were also discovered and developed during this time. Over time the runoff into lakes created algal blooms that destroyed everything else as it blocked sunlight and sucked up oxygen. It also created a powerful greenhouse gas. Over time the heat source switched to oil.

Monoculture pivot: hybrid seeds using the double-cross method increased yields while decreasing the diversity of crops and leading to the next hatchet, with unintended consequences allowing pests to defeat the defenses of a focused species. Failed solutions like DDT pesticides followed.

Green Revolution pivot: led by Norman Borlaug, breeders devised ways to defeat pests and bacteria using increasingly complex techniques to manipulate genes as the science advanced. First wheat rust was (temporarily) defeated, then other crops were added. Large scale monoculture farming that depletes aquifers, with Iowa as the model, became widespread. This left local crops to die out, with their broad defense structures eradicated. Over time a seed bank was developed but much has been lost. This is important because pests and bacteria continue to evolve, and solutions are always short-term. Efforts are currently underway to cross breed back in some of the traits lost from these efforts. DNA driven techniques allow pesticides to go after bugs or bacteria while having no impact on

the crops themselves. Genetic engineering and biotechnology have pros and cons, with concerns about incentives for the private sector offset by large populations that need to eat.

Urbanite pivot: more than half the world's population now lives in cities. We have manipulated many facets of life that originally were naturally occurring. There are three things needed for the planet to remain habitable: stable climate, recycling apparatus and diversity of life. Each is threatened today. Greenhouse gases from agriculture come from fertilizer, manure, stomachs of cows, and forest clearing fires. The process to extract nitrogen from the air has no counter that returns it. Sewage systems do not return phosphorus to the soil.

The book guesses at some future pivots. In the past the sole problem was deemed to be too little food. Now many diets are unhealthy, and obesity threatens to unwind the mortality improvements made as sanitation improved and cigarette smoking decreased in the last century. We see signs that city dwellers want to participate in the solution, with rooftop gardens and human waste recovery efforts. Farmers are using technology to manage water use and fertilizer. Other suggestions include less wasteful habits in the developed world and improving storage in the developing world.

With each surge in population a new hatchet has led to a pivot that allowed population to continue its growth. At any time, if the new pivot does not become available this leaves us to ponder the alternatives to controlling population – war and disease. Let's hope the scientists can keep up.

Overall I found this book well worth the read and will influence future research and reading interests on my part. It is well written and provides multiple perspectives on these important issues.