Environmental Philosophy

These are lecture notes, not a formal monograph. As such, they are not footnoted. Information presented as facts, quotes, and opinions borrow heavily from the references at the end and also from some of the original sources listed on the bibliography handout for this course. This should not be cited for anything because you cannot tell from this when something is my idea and when I lifted it whole from another source.

Environmental Science at UD was first built from the concept of understanding the *working, natural environment*, a program built from geologic, atmospheric, and biological understanding of the world. This planet has come into a geological, climatic, chemical, biospheric *balance* over several billion years, such that changes are really, really slow. Balance and equilibrium happen because forces have had time to find balance. Humans create problems mostly because of *rates* that cannot be accommodated by geological processes: erosion does not take down our messes, evolution does not compensate for our destruction of species and environments, breakdown of chemicals does not keep up with the speed at which we put things into the environment.

Human activities lead to *imbalances*, we apply a value judgment and call these **environmental problems**. Equating imbalances with problems contains a value judgment—decried by some academic theoreticians (post modern) and by some political or religious thinkers who regard human need as paramount. Fortunately for what is left of the environment, a sense that the imbalance and instability is a problem is a common attitude that informs most scientists.

We cannot define, understand, or cure a problem unless we understand how things would work in the absence of human-induced change. Study of the natural environment leads (we hope) to an appreciation of *subtlety* and *connectivity* of natural processes.

More of this has become politicized over the last four decades. It can be very difficult to explain different attitudes without bringing in "liberal" versus "conservative" or other political distinctions. However, there are differences of attitude, and the current American political mindset that associates concern for the environment with the Democratic party and liberalism is strictly a mindset, not a requirement. It is possible to be a conservative with a strong respect for conservation and the environment and it is possible to be a liberal who puts all human needs and raising the standard of living of everyone ahead of environmental concerns (and these attitudes were more common in the past).

Optimistic

Technological optimism. The world is vast; opportunity is unlimited. The history of humanity of one of *progress*, and for every problem there is a solution, so progress will never cease. Problems are solved by people. Many problems are solved by technology. Those problems that are not solved by technology will be solved in the social world of politics, economics. Whenever problems get really serious, we will apply ourselves and solve our problems before it is too late.

No limits to human growth, human progress, and the application of technology and such to a great future. This view accepts that the environmental degradation we have already seen is a reasonable cost of the progress we have had so far. To a certain extent, this is based on an *anthropomorphic principle*, which is that we haven't destroyed the earth so far, so we

never will. (An intelligent species that has driven itself extinct by environmental degradation does not sit around contemplating what went wrong. Old punchline about falling off a tall building, while falling past the 2nd floor: "so far so good.")

Technological utopian is an extreme version of this. Machines and technology will solve all problems, but it is also a vision that is less dependent on nature. Massive use of (clean, affordable, renewable) energy to feed, clothe, entertain, and sustain life, while leaving planets alone. (Star Trek, Bruce Sterling.)

Religious optimism. From *Genesis,* Earth given to humans as a dominion by an all-powerful deity who won't let it be destroyed. (Religious interpretations of that section varies. No scientific meaning, but it affects the political argument. This is often the motivation for human-centered – see below.)

Pessimistic

Malthusians, in limits to growth. Strongly driven by the visibility of negative change—continued species loss, continued loss of habitat. Doomsayers. (Cassandra suffered by being right but not believed. Doomsayers have not been right so far, hence not believed. Ignoring them requires a faith that they will *always* be wrong, *every time*.)

Apocalyptic pessimism. Built into pessimism is an opposite read of the Star Trek future: that leaving behind nature and becoming reliant on machines is an evil future, regardless of whether it leads to environmental collapse. The Roman Empire was followed with a dark age, and we are going to have a dark age. Dark age did not roll back technology of war, it rolled back control, created feudalism.

Good for art: *dystopian future.* Early movie, Fritz Lang's *Metropolis* (1927, set in 2026). More recently, *Blade Runner* (1982, set in 2019). Implicit environmental catastrophe: ordinary people cannot have real nature. Literature: *1984* (1949), recent cypherpunk literature (*Neuromancer, Snow Crash*).

Human centered

Resource conservation and development. Resources are preserved only because we need them in the future. Resources that won't be there in the future can and should be used.

Gifford Pinchot (1865–1946): "There are only people and natural resources." First director of the United States Forest Service, first scientific forester. Forestry was and is within the Department of Agriculture, and treating it purely from the point of view of a resource to be managed still is a major element of environmental policy. Pinchot promoted the idea of *conservation* as a resource stewardship idea, and also came up with the concept of "wise use" that has little to do with the extreme right-wing usage of that term in recent decades.

Pinchot's philosophy in three parts is made clear in the reader:

1) People here *now* have first rights to resources and first considerations

2) First principle of conservation is to prevent *waste,* forest fires, soil erosion

3) work for benefit of many, not the few

Most of the "wise use" followers only know about the first one.

Shading into this: *sustainable development.* Puts welfare of people as a first priority, but demands that we promote human welfare and dignity in ways that are compatible with environmental preservation. Not well defined. Tends to be an economist's idea, not an environmentalist's idea, because it puts human needs in front as usual.

Biocentric

Deep Ecology. Arne Naess (1912–2009) defined it, Aldo Leopold (1887–1948) and Rachel Carson (1907–1964) popularized it early. Characterized by openness to nonhuman life. Provides a value to nonhuman aspects of the biosphere that absolutely horrifies some. Aldo Leopold's *requires* acceptance of limitations on human activity; acceptance that all other life has a sufficient right to exist.

Naess (reader does not have a death date – passed away in January 2009 at age of 96) is the philosophical leader of the *ecocentric* or *biocentric* view. Works from a technical philosophical point of view, not very easy to read. Short extract in our reader is good for first few sections. Devall & Sessions book is an attempt to flesh it all out.

There is something fundamentally sound about a healthy biosphere that contains a complex wilderness and a lot of species. Humanity is durable and prolific, nature is fragile

Animal Rights, Animal Liberation, Radical vegetarianism, create a "pecking order in the moral barnyard." Extends rights to a limited other set of creatures, but doesn't remove the anthropocentrism and does not pay attention to ecology and interconnections. Contains practical ideas: limiting meat consumption is healthy and industrial meat production is environmentally harmful. Often turns it into inflexible dogma.

Gaian, New-Age versions, build a pseudo-religious or paganistic belief system around deep ecology. Neo-pagan worship usually builds something around the traditional seasonal calendar – solstices and equinoxes, harvest festivals, spring rebirth festivals – often explicitly trying to reclaim awareness of human dependence on nature. Can be fun in small doses, but can create a difficult image for some to accept.

The Dominant World View

Devall & Sessions (*Deep Ecology*) propose the "dominant world view." This is a world view that is not espoused by anyone in particular, but an alien anthropologist looking at the actions of the majority governments of the world should conclude something like this.

- People differ fundamentally from all other creatures, and people dominate all other creatures. All politics, most laws, and a majority of actions are human-centric. We maintain other creatures and their environments out of a sense of resource preservation and ecological entertainment. Even species extinctions must be weighed against human utility.
- People believe that they are masters of their own destiny, choosing goals and learning what is needed to achieve them. The world is vast, opportunity is unlimited, and perceived limits of resources and space are temporary limitations that will be overcome as our understanding increases.

- The history of humanity of one of *progress*, and for every problem there is a solution, so progress will never cease. Problems are solved by people and their technology. Those problems that are not solved by technology will be solved in the social world of politics, economics.
- Whenever problems get really serious, we will apply ourselves and solve our problems before it is too late.

In other words, some mixture of an optimistic, human-centered view of environmental problems drives actual, political reality and actual large-scale human actions. Furthermore, if you do not follow this line of thinking, you will be labeled, spend the rest of your life being called an enviroweenie, environazi, or worse, read editorials that disparage your point of view as anti-growth doomsaying. Enter an environmental policy program and be prepared to have any point of view that does not accept this dominant world view be dismissed as impractical and unrealistic.

However, you are being trained in a way that allows you the freedom to find a niche without having to commit to a world view. I would regard this program and your training most successful if you leave here understanding and concurring with elements of all of this, while not being totally committed to any one (and that especially applies to the dominant world view).

Attitudes toward environment (extremes only).

Radical Left, Greenpeace, Greens. Change the current view for change's sake, often radical, sometimes born of neomarxist movements in the past. Dominant worldview is destructive, so anything that seeks to slow it down may have to be a little destructive as well. Action centered: may prefer ineffective action or incorrect action to waiting for answers. (Effect of Green party in 2000 USA election.)

Radical Right, Wise Use, environment is a resource that can be paid for, and anyone who stands in the way is a communist. Despite that, our air is cleaner now and we have more furry little animals available than ever before, because we have responded to 30 years of regulation.

Somewhere in the range between those cartoon attitudes, you will find a niche, and you will find a job making use of what you have learned. You have been trained to work in jobs that are created within the dominant world view, primarily resource monitoring and extraction. Water (availability and cleanliness) is the number one concern of this program, whether explicit or not; air (availability not an issue, but cleanliness is); land (availability and usage), energy (use, availability, pollution), and this program is actually weaker about life than some (ecology programs, wildlife conservation) because we are so much stronger on the environment that surrounds life.

Even biospheric preservation becomes a human-centered thing. Endangered Species Act hinges on the *irreversibility* of the genetic loss. We actually argue to preserve species because we do not know what use might be made of the genetic material we are losing; what drugs might be made from plants we have lost; how lost species fit into the ecological world of the species we actually need.

Much of the debate within environmental regulation and preservation for the last century (actually, since Thoreau) has hinged on that dichotomy of view: environment as a resource for humans, versus environment as a thing of intrinsic value. Whether it matters or not depends on whether you see things getting worse or better.

Modification by Humans

Hominini – a group that diverged from the common ancestor with chimpanzees roughly 7 million years ago. Probably 20 or so different species evolved along the way, but we are the only survivors. Most of this evolution happened in Africa. Mostly these were omnivorous gatherer/hunter/scavengers – teeth and digestive processes adapted to be flexible. For 90% of that time, no culture, minimal tool usage, no significant effect on the landscape, no thought about anything except basic survival processes: food, safety, shelter, reproduction.

Fire: half million years or so, *Homo erectus* – probably not making fire, but controlling it and using it. (Evidence is weak: fired clays in occupied caves.)

H. erectus left Africa and covered much of Eurasia. (Recent controversy: *H. floriensis* – "hobbits" might indicate more of the late evolution of hominids was in Asia, which is a reversion to old theory. Unresolved.) *H. erectus* covered the reasonably warm parts of Eurasia, became *H. heidelbergensis* in Europe, which split into *H. neanderthalis* and *H. sapiens*.

Fire is first use of energy — a truly important milestone in the history of human activity. Control of fire is necessary for

- moving out of tropical and subtropical regions,
- expansion of diet to items that are not edible (or palatable) without cooking,
- manufacturing, fired pottery first, (Neolithic 8–5 kBP), then metals.

Once controlled, enabled a lightly furred species to spread out over the rest of the land area of the planet. "Home is where the hearth is."

Fire is also magic. It consumes things, transforms things. Basic element of many religions: cremation, sacrifice, the Burning Bush. Aeschylus Prometheus Bound: other gods gave Prometheus an eternal punishment for giving humans fire, a prerogative of the gods. (Raymond Dart, 1948, anthropologist, named an earlier fossil Australopithecus prometheus on assumption, now disproved, that it was a fire user.) Fire is a tool of frightening power that can bite back. We name the Holocaust (historical WWII events) via analogy: an all consuming fire.

In recent unconsolidated sediments where we can find charcoal layers, we see fires are not widespread from the late Pliocene through the early Pleistocene, but they become common within pollen cores during the late Pleistocene. Lightning has a hard time causing fires because lightning comes with rain. We now have pyrophytes in areas that do not have enough natural fires to support them, and have pyrophytes all over the world (long-leaf pine, lodgepole pine, Burmese teak forests, cheer pine in the Himalayas, Douglas fir.) (Internet search "pyrophytes" and you will find many discussions of how *not* to landscape in fire-prone areas.)

No evidence (I am aware of) of large-scale environmental change brought about by very early use of fire. Much controversy in anthropology covers rates, methods, routes, and

timing of the peopling of the planet. Total earth population probably a few million before any agriculture was developed.

In conjunction with growing population: swidden agriculture, pasture maintenance, control of hunted animals — begin to see that human modification of environment was widespread. Fire was a necessary tool for the next important changes, which was agriculture.

The Great Hunt. Paleolithic hunters in North American — date of entry also controversial — 17k to 12k years ago for entry, but this is the first notable rapid extinction event in human history that is attributed to human activity. Giant mammals gotten rid of.

This was near the end of the Great Hunt, probably 200k years of hunter-forager culture. Some of it survives into modern era, in North America it survived long enough that the older members of Indian tribes were interviewed by ethnologists, photographed by Edward Curtis, allowed to believe that aspects of their culture were worth preserving even as we were wiping out their ability to practice it.

Oelschlaeger tabulates the probable beliefs of the Paleolithic hunter-forager cultures, as deduced from their art and from leftovers of their culture into modern times:

- believed that irrespective of place, nature was home
- regarded nature as intrinsically feminine
- thought of nature as alive
- assumed that the entire world of plants and animals, even the land itself, was sacred
- surmised that divinity could take many natural forms and that metaphor was the mode of divine access
- believed that time was synchronous, folded into an eternal mythical present
- ritual was essential to maintaining the natural order of life and death.

Those are all technical ways of indicating what we think of as being "one with nature," which is really a way of saying we do not distinguish between nature and human actions. Less distinction between ourselves and creatures we need. *Totemism* – association with a particular creature (blue and yellow chickens?). Nevertheless, the idea of environmental awareness among stone-age people is overblown.

Agriculture

Origin of agriculture, also about 12k years ago. Before that, had become modern humans, populated the entire planet down to the tip of Tierra del Fuego, and developed language, culture, religion, but not yet society or civilization beyond the tribal level.

Usually talk about emmer and einkorn in the middle east (Iran, Turkey) as the ancestors of modern grains. Carl Sauer (*Seeds, Spades, Hearth, and Herds*) talked about the fishing cultures of southeast Asia developing clone based agriculture independently, maybe

earlier. Middle East grain gets most of the attention because we can trace the spread from there to all over Europe.

Problem of origin of agriculture: requires settlement to maintain crops, requires crops to maintain settlement. Fishing cultures had that because they could be supported in one location at a river. Some transhumance cultures could do that by passing near to a low-maintenance crop at various times of year. Probably invented independently at various times. Accidental conversions of trash heaps into gardens? Humans were smart. Once invented, *idea* of agriculture spread along with the particular plants, such that other plants were experimented with, found.

Implications of crop agriculture: modification of landscape, human interference in evolution, potential for major population growth, need for control of land, government, war at a huge scale.

Eisenberg (*Ecology of Eden*) (see also David Pollen: *The Omnivore's Dilemma*) stresses the coëvolution of grasses and humans. Grasses had much earlier developed coëvolution strategies. They survive trimming (lawn mowing, cattle grazing), can develop deep roots that don't require much seeding, develop seeds in very short periods of time if left alone. Accommodating grazing is a survival strategy: all the other species of taller herbs, trees, shrubs that would starve them for sunlight would be killed by grazing. Grazing animals in large herds need to be able to drift around over grasslands that will grow back if left alone.

These grasses, like your lawn, are *perennials* that will grow back each year without seeding. They are also weak nutritionally – whole ruminant stomach design evolved to process huge bulk of material, teeth to handle the wear of the opal phytoliths.

The second coëvolution is more dramatic. Wild grasses have seeds on loose threads, fall off easily, can colonize new areas as annuals. Annuals are colonizers. How do you get to a wheat head, which cannot disperse and plant itself? Selective use by humans? The most successful grasses on the planet have made a deal with their human users: propagate me, and I will feed you.

Domestication of animals: similar effects on evolution, lesser effects on the landscape for a while at least — grazing takes a long time to get out of hand in human history, but it does, of course, eventually. True domestication for food purposes probably took awhile — begin with following the migrations of herd animals, as still done today with reindeer.

Once again, rates matter. If swidden agriculture has a long enough down time between recutting trees (30 to 100 years, depending on environment), if grazing animals move enough to prevent overgrazing and erosion, if a small fraction of the land is cultivated, if a small fraction of the trees are cut for wood so that whole forests do not have to be removed, then we do not really have an environmental problem, we just have a different, modified, but potentially stable equilibrium.

Eisenberg stresses the sustainability of early agriculture. Seque into civilization which began unsustainability.

Implications of agriculture:

- more food can be gotten from a given piece of land
- allows (requires) settling down

From agriculture, in a tight mesh, comes a whole sequence of interrelated effects.

- Population took off, maybe half a billion people sometime in the middle ages, allowed for specialization of a tiny fraction of the people in nonsubsistence activities: beginning of specialists: kings/war leaders, wise men/witch doctors/shamans, craftspeople; great majority of people were just working at feeding themselves and their families.
- Technology could be created because it could be kept. Nomads have no tools that they cannot carry on a daily basis. Much technology was for improvement of agriculture: sickles, plows, mills, wheel.
- Expansion of control of energy: domestic stock, eat the young cattle, have the older ones pull the plough, turn the wheel. (Water and wind would come along – requires settled existence to maintain.
- Better tools required better materials. search for metals, experiments with metals, mining, further technology. At least for quite a while, this was all about farming.

EE p.96, "Wheat and the fall of Man":

> If grains meant knowledge, they also meant hard work, and it was work man had not previously evolved to do. For five million years we had forage, scavenged, hunted, gardened a little, which was hard work at times, but desultory, even leisurely. Adam's punishment, like Eve's, was a wrenching departure from the path o f primate evolution. Eve was sentenced to pain in childbirth—outrageous pain by any reasonable mammalian standard—because infants were being selected for bigger brains than the pelvis of a bipedal female could accommodate. To be sure, Eve's penance began long before Adam's, millions of years before the start of farming. But farming, by raising the birthrate, made it necessary for her to bear that penance more often. Farming meant more children; children meant more farming. Adam's and Eve's punishments fed each other.

Modifying the landscape. Almost any planted cropland is more susceptible to soil erosion than the natural landscape it replaces. Primitive agriculturalists with very little tilling technology were not bad with this. However, modifications could be large: paddy irrigation, terraces.

Modifying the species via selection for desirable characteristics.

What changes is carrying capacity. Highly speculative, but if there were a million people worldwide before the invention of agriculture, there were probably 10 million after.

Between agriculture and civilization comes substantial improvement in use of metals.

- Bronze age, 5500 BP to 3000 BP. (copper and tin, two soft metals that become hard if mixed in a reasonable proportion — tin serves as an impurity that prevents the copper

atoms from sliding over each other, similar to how carbon stabilizes iron atoms to form steel)

- Iron age, beginning 3000 BP, required hotter furnaces.
- Development of substantial trade networks over water, relatively large boats, still all coast huggers.

Civilization refers to the large scale organization of the population, not necessarily very civil, not necessarily very good. Most of the early big ones were called **hydraulic civilizations** because they were organized around and because of the need to irrigate land. China, India, Mexico, Egypt, Babylon, some lived for several thousand years. From the hydraulic civilizations of Egypt, Babylon, we get the roots of western civilization

- Exploitation of annual floods from the snowmelt in the mountains, particularly in the Nile.
- Annual flooding required annual resurvey of land: geometry = earth measurement.
- Predicting the annual flood required some astronomy to count days of the season. 360° circle comes from Mesopotamia as a conveniently divisible approximation of the 365d year.

Following the rise of the first civilizations, change towards the modern era proceeds rapidly. History: 3.5 billion years of life, 200 kyr of human-like creatures hunting, 7000 years of small-scale agriculture followed by 5000 years of agriculture-based civilizations, 300 years of industrialization within which the change is too rapid to summarize, but within which the ability of humans to modify the environment has become extraordinary.

EE. "The Tower of Babel" p.80–81:

> These people—the Sumerians and their predecessors in the region, the Ubaidians—gave us wheeled vehicles, yokes and harnesses so that animals could pull them, animal-drawn plows, sailboats, metalworking (casting, riveting, brazing, soldering, inlay, and engraving in copper and bronze), the potter's wheel, the arch, the vault, the dome, surveying, mapping, and a rough-and-read- mathematics. Above all they gave us the process in which you and I are now engaged, even if we no longer use wedge-shaped marks on soft clay. On the debit side of the ledger (another Sumerian invention) we might place large professional armies, siege engines, war chariots, a rigid division of labor and status, imperialism, and bureaucracy.

Environmental Science for a Young Earth

Now that we have the history of the earth and human modification of the earth, time to ask about the history of environmental science.

Preliterate. Hunters and farmers understand their environments, and they understand change. Paleo study of the environment was survival oriented: study plants to find food, study animals for the same reasons, totems to get power. Assume one simple thing about invention of agriculture: humans were paying attention to plants, seasons, water needs, soil needs. They were learning by observation, changing their ways to improve their use of resources, and passing information on generation to generation.

Awareness of change: story of Cain (farmer) and Abel (shepherd) and the ambivalence of the early Hebrew (rebels, outlaws) culture to settling down.

Story of Gilgamesh taming Enkedil, even earlier. Enkedil was tamed by the simple presence of civilization in his life (sex with temple priestess?) and then became less part of nature: gained and lost from the experience.

Mention those because they are rare: stories from the beginning of civilization that have survived to the present. Writing about the environment, about science, really begins with the Greeks, partly because they had a successful, wealthy civilization with a thin veneer of a thinking class and a slightly more open-minded government, so they did more enquiry, were not bound totally by tradition. Second part was that their work was considered important enough that it survived. (Much is owed to Strabo, librarian at the great library of Alexandria, Egypt, wrote textbooks for Roman administrators. Many of or references to Greek philosophers and scientists are totally based on Strabo's discussions and not on the original works.)

Greek thinkers began writing about science and our understanding of early science is often filtered through them. No other civilization that wrote things down has surviving writings that "think higher thoughts" on philosophy and science. Sumerians and Egyptians did a lot of accounting, Chinese ran their bureaucracy.

Miletus (Mediterranean coast of modern Turkey) seems to be the beginning of understanding the earth, environmental systems, and writing it down.

- **Thales of Miletus**, 624–547 BC, successful olive oil dealer with a hobby in geometry reputedly did a successful solar eclipse prediction. First known Greek natural philosopher, although everything he wrote is lost and his work is known only be references from others.
- **Anaximander** invented the sundial (611–545 BC, reputed to be a student of Thales), implies some understanding of solar geometry.
- **Hecateus** (550–480 BC), made world maps. Limited amount of understanding, nothing at a great distance. (Authors who ought to know better look at these and assume the earth was thought be flat. Unlikely they were doing this much astronomy and still thought so.)

Elsewhere

- **Pythagoras** (569–475 BC) asserted that the earth was round based on principles, not really from measurement. (Pythagorean theorem, P. solids, etc.: extraordinary geometer.)
- **Eratosthenes** (276–194 BC, born in Libya, moved to Alexandria). Estimated the circumference of the earth by parallax of insolation. May have been very accurate or as much as 10% off: scholars argue over the actual length of the unit (*stadia*) he used. Implication: knew the world was spherical, knew the sun was at a great distance (far enough that the rays coming in were parallel everywhere on earth), therefore knew that the *earth was of limited size*. (Eratosthenes also did math and geometry—one means of calculating tables of prime numbers is called the "sieve of Eratosthenes.")

Writers began to get the concept of a golden age. They saw degeneration. Glacken, p. 118:

> In the ancient world, there was a lively interest in natural resources and how man could exploit them: in mining, in ways of obtaining food, in agricultural methods, in canals, in maintaining soil fertility, in drainage and grazing and many other economic activities which—even if they produced only a partial philosophy of man as a part of nature which he was engaged in changing—are eloquent proof of his busyness, his incessant restlessness in changing the earth about him. ... The golden age of the past was often an age of simplicity and one in which the soil required no cultivation, but supported life spontaneously rather than by tillage and ordered plantings; if there had been a moral decline to the hard realities of the contemporary iron age, it wowed much to the advances of the arts and sciences and to applied technology.

Glacken, p. 132, paraphrasing **Hesiod** (Hesiod was 8th century BC, near time of Homer, wrote first (surviving) Greek mythology.):

> The people living in the golden age experienced no sorrow, remote and free from toil and grief, never suffered old age, and had all good things of life, for the fruitful earth unforced bore them fruit abundantly and without stint. They dwelt in ease and peace upon their land with many good things, rich in flocks, and loved by the blessed gods."

These began *nomothetic* work: naming things, gathering data, describing the world around them, often the sort of things that start science. (Birders are not necessarily ornithologists, map fiends are not necessarily geographers, rock collectors are not necessarily geologists.) The next phase was *idiographic*, rule making, philosophizing, making laws of nature, if possible. That is the beginning of the classic Greek philosophers.

Aristotle (384–322 BC) wrote about everything, became the first scientific law maker (often wrong). Absorbed all facts he could obtain into his philosophizing (data were beneath Plato and Socrates's dignity) What we call logic is Aristotelian logic.

Aristotle was still teleological: things have a purpose, or they would not exist.

Began to understand materials and substances: **Empedocles**: (490–430 BC) earth, air, fire, & water as elements.

Aristotle wrote about *meteorology*, climate zones (κλιμα), 5 zones from equator to pole became a model for self-centered understanding of climate: here is ok, south of here is unpleasantly hot, way south of here is uninhabitably hot, north of here is unpleasantly cold, way north of here is uninhabitably cold.

They were right about the uninhabitably cold, but missed out on understanding the tropics because they only knew of the world south into the Sahara. Highest surface temperature ever recorded was in Libya, and they knew about Libya, and they knew about the round earth and the linearized and assumed that it just kept getting hotter. Idea that there was an uninhabitably hot zone at the equator that humans could not pass through was common into the Age of Discovery.

Partly, they had traveled very little and had no historical records of any depth, so their idea of trends had to be *linear.*

Glacken's discussion of Greek thought gives an idea for how new the world was in terms of human thought about their place in the cosmos. The world was not new, but time for humans to sit back and think about it was new.

- Saw declines in forests and depletion of soil, were aware of problems of soil erosion. Were aware that soil had a limited ability to grow crops over and over, but obviously did not have any modern sense of what nutrients were.
- Took ideas of decline, had not seen reforestation of abandoned croplands, had not seen that rotation of crops and having natural vegetation would eventually reinvigorate the soil: all trends linear, not cyclical.
- Therefore, idea of a *Golden Age*, goes into the Greek philosophy: if all we see is that everything is always getting worse, then if we go back far enough, food must be falling from the trees and people doing no work at all. Garden of Eden concept widely spread in the middle east of the time.
- Influence of humans and landscape went both ways: humans modified the landscape and landscapes affected human activity.
    - Hippocrates (may have been name for a group or school, not a single individual): "father of medicine" but medicine was climate. Health is a function of balanced climate, tropical people are indolent, northerners are violent.
    - Comes into the modern era: influence of climate on economic and agricultural activity is obvious – Delaware is a major port of entry for bananas into the United States, but we do not grow them here. Well into 20th century, assumed to go beyond that into the *character* and personality of indigenous people: Ellsworth Huntingon *Civilization and Climate*, Ellen Churchill Semple and "environmental determinism." These were overblown and over deterministic versions of theories put forward by the Greeks.
- Judaeo-Christian effect on modern environmental philosophy.
    - Earth is dominion of humans, with a right to make use of it all, and a duty to use it well. Duty to use it is often source of philosophical differences: stewardship of

resources simultaneously implies a duty to make good use of "providence" and a duty to make sure that the future has that providence as well. Apocalyptic thinking (the world won't last much longer and we're all going to be better off for that) defers the need for preservation.

Parable of the three stewards: beginnings of "wise use" thinking.

- Design in nature: a creation story borrowed from the ancient Sumerians, who also had the flood story. Implication that the earth was at one point perfect.

  Again: golden age, a perfection in the past that was lost

- Mix up Roman and Greek ideas with some Judaeo-Christian philosophy and we come to the ideas of the middle ages and Dark ages. Characterized by lack of centralized control, a break down of large-scale civilization, and also characterized by
  - Struggle for survival: life was nasty, brutish, and short.
  - Dominance of the Church in all aspects of thought, philosophy, and education, led to the rise of universities. One good feature: educated class knew church Latin regardless of their individual origins, and even in pre-Gutenberg times communication of some ideas spread throughout Europe.
  - An odd perversion of the Golden Age concept led to the idealization of ancient Greek thought, the "pagan philosophers" were assumed to have known more than could be found by modern inquiry, so many that would have studied science actually studied what Aristotle and others had said about science, rather than looking for themselves.
  - Dark age for Europe and the Roman church was more of a Golden Age for Muslim cultures, Arabs, Turks, and North Africans. Huge moves towards modern mathematics were invented by Muslims and Indians, but that is another story.

From the Dark Ages to Humboldt

We come out of the Dark Ages to the **Renaissance, Reformation, Age of Discovery** in the 15th to 17th centuries. Secularized knowledge, discovered the rest of the world, discovered the sea, broke up the hegemony of the church on knowledge, developed a modern sense of science, developed modern means of how to circulate science.

A modern view of a global environment could not have existed without three major elements that came together in a roughly 400-year period. You get taught this stuff in world history courses from a different point of view because it creates the modern political and economic world in which European and European-derived (American) institutions are at the top of the ladder. This course, we look at some of the same events from the fact that they made the concept of global environment and its interconnectedness possible.

1. **Age of Discovery** lasted into the 20th century (highest mountains, south pole) but the basic layout of the earth had a huge amount accomplished in one century, 1424–1522.

2. **Reformation, Renaissance, and Age of Enlightenment** were related, in that the scientific achievements of 16th and 17th centuries that gave us the basis for modern science would not have happened easily without areas free from the inqusition of the church.

3. **Deep Time** needed the biological and scientific data from the entire world, enabled by the Age of Discovery, the basic principles of science from Enlightenment, and a willingness to shed young-earth doctrines. Between 1795 and 1859, everything about humans and their relationship to their environment, and why the environment fits together, changed more completely than in all of preceding human history.

The world in 1400

The world in 1400 was occupied by humans. Before the middle 15th century, the world consisted of three major land masses, completely independent of each other in terms of human occupation and interaction, but fairly well connected within a landmass: Europe-Asia-Africa, the Americas, and Australia.

Primitive trading networks spread goods farther than an individual would travel. Europe was indirectly connected to farthest reaches of Asia and Africa, but they may not have known that. Trade proceeded up the Nile to sub-Saharan Africa at a time when some Europeans did not believe this was possible. Europeans did know that they got spices from the east, that these went through Arab middlemen at huge price markups, and that a huge amount of money could be made by finding a direct way to the spices of south Asia, silks of China.

Japan had been occupied on and off for 30000 years, but modern Japanese came from China and Korea only 2000-2300 years ago. During ice ages, Japan and Korea were connected.

Australia, dated remains at least 40000 years old, could be much older. Diverse languages and cultures. Semi-nomadic hunter gatherers. Probably a few hundred thousand people only – a difficult landscape.

North and South America, absolutely uncontroversial here for 12000 years, older dates often put forward. Civilizations had arisen: Maya (broke up about 900), Inca, Aztecs in place at European contact. Mississippi Valley mound builders. Corn, beans. Ancestral Puebloans broke about 1300 and moved to the Rio Grande because of drought. Most of the rest were stone-age hunter-gatherers. Perhaps 50 million people in the America.

Subsaharan Africa, some small kingdoms had developed occasionally to provide larger scale organization than tribal. Kongo, Benin, Ghana, and Mali are all names associated with kingdoms or empires that developed in the last 1200 years.

Of course, all of Eurasia and North Africa was a populated, connected entity, and centers of population and learning were generally aware of each other even if information was poor.

Age of Discovery – European contact

Age of Discovery gets a bad name from those who were "discovered," because most of the rest of the world knew exactly where it was already, was surviving quite nicely, and had no particular need to be discovered by Europeans. "Discovery" implies a lesser value to the people being discovered. Other cultures may have been ahead of Europe in some areas of civilized behavior, food, and some kind of technology at the time. However, in 15th century Europe, the combination of technology, political will, and economic motivation allowed a set of voyages that created a more complete sense of the world than had ever been had before. The maintenance of that hegemony by Europe and the European-descended culture of America has not yet ended. So, the shape of the modern world was created in just 90 years, 500 years ago.

1424–1522.

1424, Prince Henry of Portugal "Henry the Navigator" started sending out ships south along the coast of Africa intending to see if there were a way around it. Spent a decade and 15 expeditions just trying to get around Cape Boujdour, just south of the Canary Islands. Sailors had an unreasonable fear of some very minor shoals around this very minor cape.

1434, Gil Eannes passed Cape Boujdour, landed on the coast south of it, found that he was not at the gates of Hell, and went home safely. Further exploration south proceeded swiftly.

Year by year, more southern explorations, a few major milestones:

1445, Dinis Dias rounded Cape Verde, westernmost tip of Africa. Began to have trade relations, south of the barren coast of the continent, so there were people.

1484, Diogo Cão discovered the mouth of the Congo. Did not have a reasonable sense of hydrology, so the implications of a huge amount of muddy water being poured into the ocean were not understood: it was draining an area that was more vast and wet than Europeans could yet imagine. By this point, they had to figure out how to navigate without the North Star, and knew that the Greeks had been wrong about linear climates: that it got cooler and wetter south of the Sahara.

1488, Bartholomeu Dias crossed the Cape of Good Hope, rounded the corner, entered the Indian Ocean.

[1492, Christopher Columbus, working for Spain, not Portugal, discovered continents that would be eventually called the Americas, but never publicly admitted that he had not found the outlying islands of Asia.]

1497, Vasco da Gama reached India and set up trade relations. At the time, this was far more important than Columbus.

This at least set up a Spain versus Portugal rivalry, Spain in the Americas, Portugal working around Africa to Asia.

Columbus got funding for his voyages by using bad estimates of the size of the earth and bad estimates of the longitudinal extent of Asia. No one would have given him ships to go to Asia in that direction if they had known how far it really was. He had convinced himself and his backers that Asia would be found only a few thousand miles from Europe. He refused to believe that the Caribbean Islands he was seeing were not outliers of Japan, even though there was no reasonable correlation between what he was seeing in the new world and what he had heard from traveler's tales about the Orient. Columbus did not prove that the world was round, everybody already knew that, he just used bad information to try to plan a voyage based on going the back way around.

Ferdinand Magellan became a sea captain by voyages around Cape of Good Hope to Asia and the islands of Indonesia, he pushed for completing Columbus's dream by going west to reach the east, and eventually, starting September, 1519, he led an expedition whose aim was to sail around the world. They already knew that the Americas were not Asia, that there was an ocean on the other side. Vasco Nuñez de Balboa had found the Pacific on the other side of Panama in 1513 – he called it the Southern Ocean because it was south of Panama. Magellan died in Phillipines, but at that point he had sailed over the unknown portions of the voyage, going around the tip of South America and crossing the Pacific to a place that Portuguese had visited from the other direction, so it is fitting that his name is honored, as he closed the circle for Portugal. However, it was Juan Sebastián del Cano who brought home 18 men in one ship in 1522, twelve days short of three years after setting out with five ships carrying 250 men. Their calendars were a day off; they had unrolled a day. (International Date Line was invented to remove that problem once long Pacific voyages became common.)

Perhaps, no greater accomplishment of 'going where none had gone before' was made until men walked on the moon – the size of the world and the general structure of its continent-ocean pattern were known. Much remained: Australia was unknown, and Antarctica would not be actually seen until 1840, the Northwest Passage around the north side of North America would be sought even later. The South Pole in 1912; the highest mountains and the deepest oceans in the 1950s.

And in the end ...

Columbus's voyage was paid for by the Queen of Spain as a political maneuver against Portugal, and it was only one voyage – relatively cheap. Prince Henry's Portuguese voyages were much more expensive and there were many of them. Once the Indian trade was established, nobody questioned the cost of the voyages that had made it possible, and Portugal spent some time as a very rich nation. However, the Indian trade was only

established 60 years and dozens of voyages after Gil Eannes had passed Cape Boujdour, so trade had to be established along the west coast of Africa to make the voyages seem worthwhile – to keep the funding for those voyages coming.

In the 1440s, Portuguese vessels started bringing back black Africans to be sold as slaves. August 8, 1444, 235 slaves were landed at Algarve in Portugal Gomes Eannes du Zurara, wrote (translated):

> What heart could be so hard as not to be pierced with pitious feeling to see that company? For some kept their heads low, and their faces bathed in tears, looking one upon another. Others stood groaning very dolorously, looking up to the height of heaven, fixing heir eyes upon it, crying out loudly, as if asking help from the Father of nature; others struck their faces with the palms of their hands, throwing themselves at full length upon the ground; while others made lamentations in the manner of a dirge, after the custom of their country....
>
> There now arrived those who had charge of the division of the captives, and ... then was it needful to part fathers from sons, husbands from wives, brothers from brothers. No respect was shown to either friends or relations, but each fell where his lot took him. ... Mothers would clasp their infants in their arms, and throw themselves on the ground to cover them with their bodies, disregarding any injury to their own persons, so that they could prevent their children from being separated from them. [Quotes taken from Boorstin and from Hugh Thomas, *The History of the Atlantic Slave Trade 1440-1870* on Google Books. I don't know who did the translations.]

Boorstin: "Zurara's eyewitness account of this first European episode in the African slave trade was a painful glimpse of the miseries to come. ... The arrival of this human merchandise from Africa, we are told, caused a change in the public attitude toward Prince Henry. Many had criticized the Prince for wasting the public substance in his frolics of exploration."

The profits from the slave trade quieted the complaints. Prince Henry took 46 slaves for himself, the royal fifth. Nothing written at the time recognized the enormous, and still unresolved, effects of what had just begun.

Reformation and Enlightenment

For Environmental Science, all of the component fields started to have major breakthroughs in the 18th century after most of the map was finally filled in.

Reformation

Martin Luther (1483–1546) from 1517 onward tried to reform the Roman Catholic church (which did not see a need to be reformed). Unlike many previous reformers, his religious ambitions correlated well with the political ambitions of some German princes, so he became the most-remembered figure of the reformation instead of another roasted heretic.

Religious implications were huge, but not part of this course. Scientific implications were that the Roman Catholic church had become wary of scientific inquiry that led to questioning of its authority. Eventually, we have Germany, Holland, and Britain as bastions

of free inquiry. Plenty of wars ensued, finally ending in 1650s with treaties that countries could choose their own religion. Main thing from our point of view is to break a reliance on ancient, dogmatic authority.

Scientific Renaissance – Biology

Dioscorides (Greek surgeon who traveled about the Mediterranean region with Nero's army) wrote *de Materia Medica* about 77 AD. Catalogued all known plants primarily on the basis of their medicinal uses. 1500 years later was *still being used* as a reference book in areas far north of the Mediterranean. "In the late sixteenth century the holder of the chair in botany at the University of Bologna was still described as 'Reader of Dioscorides' " (Boorstin, p.422) (Consider how often your textbooks are revised.)

Academic tendency of the times was to ignore the plants in the woods outside your door, but look in the books written centuries before by Greeks. Some kind of continental inferiority complex said the evidence of one's own eyes could not be trusted if it conflicted with the wisdom of the ancients.

Leonhart Fuchs (1501–1566, German) (Fuchsia flowers and their deep pinkish purple color are named for him) published in 1542 the first herbal based entirely on drawings and observations from nature. Woodcuts of 500 plants all based on artist's drawings that he commissioned from life – none taken from older books. (Inspired by Luther, was a German and could not have done this work outside of Protestant areas at the time.)

John Ray (1627–1705, British) also wrote botanies, but came up with the concept of *species* based on *reproduction*. Also arranged plants by form, based on idea that there should be ranges of plants that were similar.

Species: deceptively simple concept to a modern person because it seems obvious. 17th century people were burdened by:

- no understanding of genetics
- concept of spontaneous generation – life not necessarily a product only of like life reproducing itself.
- mythical creatures formed by "unnatural" couplings (e.g., Gryphon or griffon: an eagle crossed with a lion.)
- not yet even set on essential equivalence of all humans; races were more different to them.

Carl von Linné (Carolus Linnaeus, 1707–1778, Swede) extended Ray's concept and created modern taxonomy.

- Used sexual organs of plants extensively to categorize them and determine differences, at a time when the sexuality of plants was considered a perverse and obscene concept.
- Invented "botanical Latin," which is not so much Latin as a coded short description, using Latin elements.

- With the botanical Latin, recognized the importance that every species had a single unique name, regardless of common names which were variable locally and repeated among plants (how many 'stinkweed' species are there?).
- Specimen hunters: sent specimen hunters out for the sole purpose of finding new species to add to the catalogue. By the time Charles Darwin was sent out on the Beagle, having a specimen collector (Naturalist) on board survey ships to new areas was standard practice.

Scientific Renaissance – Physics

Rebirth of designing instrumentation, observational science, in the 16th century. Not clear why it died out. Romans had geometric measurements, lots of understanding of weight, strength of materials. Navigation by sun and star elevations had survived, but the rest of *repeatable* instrumental observations were underdeveloped.

- Galileo, 1564–1642. Kinematic description of gravity and motion, with basic relativity. Invented telescopes and thermometers. First major figure to point out that Aristotle was wrong, based on his own observations. Suppressed and threatened with torture in his own Italy, but his ideas were published in northern Protestant Europe and spread around.
- Evangelista Torricelli (1608–1647) mercury barometer 1643, measurements that led to what we now call the hydrostatic equation – understood how pressure decreases with height.
- Blaise Pascal (1635–1662) air exists, air is something
- Robert Hooke (1635–1703) elasticity and pressure
- Isaac Newton 1642–1727. By most accounts, not a nice person.

  Hard life growing up as son of a yeoman farmer, but managed to get some basic education, worked his way through college at Trinity College (Cambridge). College was closed for an outbreak of plague, 1665–1667. At the end of it, he returned to Cambridge and became a professor of mathematics at 26. During the time he was out of school on the farm hiding from the plague, came up with concepts of gravity, mechanics, and optics. Invented the calculus, found the binomial theorem.

  Newton changed the world. We refer to almost everything we understand intuitively as 'Newtonian physics' because it is based on the paradigms he started

  - *Universal laws* that worked in all places and all times (universal gravitation and the laws of motion were the first sense that the same physics worked in the heavens that worked on earth).
  - *Mathematical laws* that were not completely expressed until they could be written down in the form of equations. Resulting almost uncanny knowledge that the language that describes the universe is primarily mathematical.

> Physics that you learn in 201/207 is still primarily Newtonian, not because Newton invented it but because nearly everything in it could be derived from the basic principles of physics that Newton wrote down. That includes all of your forces, motions, optics and wave motion, and even thermodynamics.

Scientific Renaissance – The General Circulation

Edmund Halley (1656–1742) noted for Halley's Comet, but also noted for absorbing what was known about trade winds, pressure variations with latitude, and turning it into an incorrect single-cell theory of the general circulation. 1686 identified the concept of the ITCZ and that the general circulation was driven by solar heating, not just a direct temperature effect driven by solar heating that the Greeks had theorized 2000 years earlier.

By the time he was working, travel between the Americas and Europe as well as to the southern hemisphere was commonplace – no reasonable way to come up with this kind of theory without travel data that included instrumental measurements

George Hadley (1685–1786) added rotation of the earth, came up with the three cell model that gives a rough beginning to what we really understand now, and thus explained the trade winds.

Matthew Fontaine Maury (1806–1873) (much later than the rest) wrote *Physical Geography of the Sea* (1855) based on years of analyzing ships logs for the US Navy. Between Hadley and Maury there is a continuum of improving charts. The improvement of climate knowledge, of course, has continued unabated. Point here is to show how it ties to beginnings of navigation.

Scientific Renaissance – Geology

Geology before the renaissance had entirely been about mineral exploration, and it was pretty much random looking. No sense of time, no sense of depth.

Geology that made any sense was going to take a little while longer because of the pervasive ideas of young earth and the idea that all the sedimentary layers we see must result from a biblical Noachian flood. 17th century was still pretty much about finding proof in the layers of rock that the Flood story was true.

In the middle of the 18th century, correlation of layers between locations was understood to help find minerals, and fossils as a way of correlating layers was pretty well understood. Idea that the earth was much older than 6000 years and that explaining all geologic layering via a single flood was widely expressed within scientific circles, but not much outside them yet. More to come about that.

Scientific Renaissance – the lesson

Combination of reformation and a scientific renaissance enabled us to develop a modern understanding of the environment that was not encumbered by a predisposition to accept ancient authority. Also had the basics in place for the foundations of modern science.

Progress in environmental science had to wait until the explosion of data from places outside of Europe. It also required openness to new ideas, freedom from dogma, and a sense of how to measure things.

Alexander von Humboldt

1769–1859, German. The greatest, and nearly the last, of the collectors and organizers of data. He is the last hero of our discipline – the last person who knew everything.

Studied botany, physics, chemistry, philology. Needed to earn a living, so went to mining school, where he learned physics, chemistry, geology, and mining. Worked as a mine administrator, and studied magnetism. Then, inherited some land, the land had an income associated with it, so he stopped working to earn money and started working on his scientific interests.

1797, quit his job, bought some scientific instrumentation, recruited a fellow-traveler Aíme Bonpland. 1798 set off for Egypt to do archeological work there. Shipwrecked before Marseille, went to Madrid instead where he made some elevation measurements. In Spain, got permission to go to South America. With Bonpland, went to Venezuela, Central America, Cuba, Philadelphia, Ecuador, Columbia, Peru.

1806, after 8 years of travel, returned to Europe, wrote 30 volumes of species description and maps, with a few volumes of narrative, published 1808–1825. 1827, took another government job and went to Siberia.

Kosmos, a geography of everything, 5 volumes published 1845–1862.

Contributions by Humboldt:

- thousands of locational observations, 60000 plant specimens collected and described, many new species, new rocks, new minerals.
- concept of vertical zonation: relationships among altitude, air temperature, and vegetation zones in the mountains, and how those relations vary with latitude.
- climbed volcanoes all over Ecuador, going into the cones to determine composition of the gases coming out.
- climbed Mt. Chimborazo, 19286', an altitude record for its time. (1802)
- described and accurately diagnosed mountain sickness
- investigated chemical properties of guano and started its export as a fertilizer
- discovered upwelling off the west coast of South America, measured ocean temperatures and currents, described velocity of Peru Current, which was called Humboldt Current until recently.
- invented isotherms as a way of mapping temperature, constructed first world temperature map.
- discovered and named permafrost

- noted that large parts of Siberia had *not* been glaciated.
- wrote some surprisingly modern human geography, noting the common origin and equal quality of races
- recognized old lake beds as indicators of environmental change.

Humboldt was the last great generalist. In his day, he was enormously famous, so many towns, rivers, and physical features are named for him. Nobody after that matched his range – we begin to separate the fields.

Cataloguing the creation (Boorstin's phrase)

The Age of Discovery followed by the age of exploration, cataloguing species, inventing scientific instruments, developing theories based on confirmed observations: began to replace myths with facts. Problem was that the myths had been built around facts also (many fewer facts) and had arisen from preconceived ways of organizing things. Needed a new way to organize all the facts, and that led to modern components of environmental science.

Deep Time, a Trilogy

Deep Time refers to a concept that could not be understood before the 18th century: the earth was very old and constantly changing. Two competing views held before: the earth had a finite age that was quite young, or the earth was infinitely old but either changing cyclically or not at all. Modern view that the earth is 4.6 billion years old and constantly changing. Our concept of "environment" really depends on the idea that biological responses have a long time adapt to the climatic and geologic conditions in which they live. (If things just happen to be together, what's the point in worrying about disrupting one part of a system. If an ecosystem represents millions of years of balancing, short-term disruption can be catastrophic.)

I. Uniformitarianism

Geology had its ancient Greek roots, but did not have much deep-rock geology, mostly about geomorphology, landforms.

- Herodotus (485?–425 bc) recognized effects of the silt and sediment moved by the Nile in its annual floods. Saw shells in higher hills and concluded that sea level could change in long term.
- Aristotle wrote a little about karst, erosion, earthquakes, and volcanoes

Also Arab contributions, understanding of erosion and deposition involving streams and winds. However, on in to the 1700s, *catastrophism* ruled geologic thinking: huge earthquakes, floods, and volcanoes must have created the landscape – an inevitable conclusion from the young earth.

Some saw geological change by slow processes as a possibility. As early as Leonardo da Vinci (1452–1519) came recognition that valleys were cut by the streams that carried them. De Saussere (1740–1799, Swiss) was an advocate of the power of streams to erode valleys, and he is given credit for inventing the terms 'geology' and 'geologist' in their modern senses.

French School of thinking: Buffon (1707–1788) may have been the first to indicate that 6 days of creation was an allegory, not a literal idea, and that erosion of the current landscape may have taken thousands of years. Forced to recant by the church. Guétthard (1715–1786) saw that streams not only cut valleys, they deposited floodplains. Desmarest (1725–1815) saw that valleys of central France were cut by the streams occupying them and came up with ideas of landscape evolution.

All of these were still restricted by the idea of a very young earth – some believed as little as 6000 years based on interpretations of biblical chronologies. We have a 4.6 billion year old earth, and plenty of time to remake and destroy the landscape many times over. Breaking the young-earth prejudice required serious proof.

James Hutton (1726–1797, Scot) read all of that previous work. Educated in medicine, but interested more in chemistry and geology. Published a paper on **uniformitarianism** in 1785, 1795 published a two-volume *Theory of the Earth with Proofs and Illustrations.* Limited circulation, expensive, boring, and read by few.

Hutton might be forgotten, but for John Playfair (1748–1819), who published a popular version of the theory after Hutton's death. *Illustrations of the Huttonian Theory of the Earth.* (1802), smaller, cheaper, better written, presented the idea that the present was key to the past, that the modern landscape was best explained by slow processes acting over very long times. From Playfair:

> Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size, and all of them together forming a system of valleys, communicating with one another, and having such a nice adjustment of their declivities, that none of them join the principal valley, either on too high or too low a level, a circumstance which would be infinitely improbable if each of these valleys were not the work of the stream which flows in it.
>
> If, indeed, a river consisted of a single stream without branches, running in a straight valley, it might be supposed that some great concussion, or some powerful torrent, had opened at once the channel, by which its waters are conducted to the ocean; but, when the usual form of a river is considered, the trunk divided into many branches, which rise at great distance from one another, and these again subdivided into an infinity of smaller ramifications, it becomes strongly impressed upon the mind that all these channels have been cut by the water themselves; that they have been slowly dug out by the washing and erosion of the land; and that it is by the repeated touches of the same instrument that this curious assemblage of lines has been engraved so deeply on the surface of the globe.

(Each paragraph was one sentence!) Hutton in detail, and Playfair in better presentation, made it difficult to *not* believe that the streams and valleys we see were created over a long period of time by erosion. The idea could not be easily argued against, but the assumption of the time it would take was often unmentioned, being too controversial.

Hutton's ideas were presented again Charles Lyell's textbook *Principles of Geology* (11 editions, 1830–1872), which became a mainstay of geological education for a large part of the 19th century. It included general knowledge about geology, but geology was placed in the context of **deep time** for the first time. Geologists could not put numbers on how many years the process took, and they may have been afraid to state their guesses out loud, but they knew it was a long time.

(Optional idea to bring up: Lord Kelvin's estimate of the age of the earth, 20 to 400 million years, based purely on cooling rate leading to modern geothermal gradients. Old enough for the uniformitarianist ideas anyway. Didn't know about radioactivity.)

II. Climate Change, Ice Ages

Greeks (Aristotle especially) had the 5 κλιμα zones and a few ideas of prevailing winds. From understanding sun angles without understanding circulation, they got the myth of boiling seas near the equator. Following the Age of Discovery when exploration turned into world trade, ship's reports provided basic data about winds, ocean currents.

Modern (post-Greek) climatology starts with George Hadley, 1735, proposed a three-cell model of circulation. At that point, rising air→precipitation was an empirical observation

that could not be proved with theoretical physics, but Hadley had rising air in the tropics, sinking in subtropics, and rising air in the midlatitudes, and he had enough observations to know that these corresponded with the prevailing winds and the precipitation patterns in these latitudes. By the time Matthew Fontaine Maury (American naval observatory) reorganized these in the 1850s, it was possible to make a wind and current chart for the world ocean.

However, climate did not change. Just as the hills were "ageless as the sun" for predecessors of Hutton, the sun and its effect on earth were ageless.

Louis Agassiz (1807–1873, Swiss).

The story of Agassiz and the ice ages is the story of the difficulty of making a bunch of academic scientists believe something that every mountain peasant thought was obvious.

One problem in geology: **erratics**, boulders out of place. Various people, including Hutton, had seen erratics as remnants of larger glaciers that had retreated, but this was good for erratics that were not too far from their bedrock sources. Some that were very far from sources were still considered to be iceberg-rafted boulders from the great flood.

Perraudin: Mountaineer and chamois hunter, started trying in 1815 to sell the idea that glaciers in his valley had once filled the valley. Besides erratics and boulders that could not be moved by much else, he had seen scratches (we now call striations).

Venetz: Highway and bridge engineer working in the mountains had his ear turned by Perraudin and made a few tentative studies of evidence of larger glaciers in the past. 1829, annual meeting of Swiss Society of Natural Sciences at the Hospice of the Great St. Bernard (love the image) stated that immense glaciers had more than just filled the valleys, that they had spread out of the mountains and covered large parts of Europe.

He was ignored, mostly.

Jean de Charpentier heard Venetz and gave it some credibility, did 5 years of research in the mountains and presented a paper in 1834. Quote (translated):

> Traveling through the valley of Hasli and Lungern, I met on the Brunig road a woodcutter from Meiringen. We talked and walked together for a while. As I was examining a large boulder of Grimsel granite, lying next to the path, he said: "There are many stones of that kind around here, but they come from far way, from the Grimsel, because they consist of Geisberger [granite] and the mountains of this vicinity are not made of it."
>
> When I asked him how he thought that these stones had reached their location, he answered without hesitation: "The Grimsel glacier transported and deposited them on both sides of the valley, because that glacier extended in the past as far as the town of Bern, indeed water could not have deposited them at such an elevation above the valley bottom, without filling the lakes."
>
> This good old man would never have dreamed that I was carrying in my pocket a manuscript in favor of his hypothesis. He was greatly astonished when he saw how pleased I was by his geological explanation, and when I gave him some money

> to drink to the memory of the ancient Grimsel glacier and to the preservation of the Brunig boulders.

Charpentier spoke to Louis Agassiz about this paper, and in 1836 got Agassiz to come into the mountains for a field trip. Agassiz went expecting a good holiday in the mountains and nothing more, but he came away convinced.

Everybody that actually went into the mountains and looked at erratics, glaciers, and glacial valleys could see almost immediately that glaciers had at times in the past been much larger than at present and that glaciers had carved huge valleys that currently were not occupied with ice. However, not many people went into the mountains back then. Railroads that would take the urban upper classes to the mountains for sightseeing and to get away from summer heat were just being built. Mountain climbing as recreation not yet common.

Agassiz was young (30) and considered brilliant in 1837 when he had been elected president of the Swiss Academy of Sciences, primarily on the basis of his work classifying and describing fossil fishes.

At this point, Agassiz got lucky. Against and beyond all evidence that had yet been accumulated, he extrapolated beyond the observation that glaciers clearly had been larger in the Swiss Alps in the past, and he proposed a period of a global Ice Age during which ice sheets had covered most of the Northern Hemisphere land masses.

He also came up with a ridiculous theory: more complicated organisms give off more heat (i.e., endothermic organisms give off heat, snails don't), and the history of life on earth (remember, this was before Darwin) consisted of greater numbers of complex organisms with time, so the heat given off by complicated biological life had melted the ice and warmed the earth. He really published that.

The luck: he turned out to be right about the ice age, even though he didn't really have the evidence for it yet, and everyone forgot about the biological explanation.

By the late 19th century, evidence of past ice ages had been found all over the Northern Hemisphere and we had a widely accepted glacial history, although reasonable timing ideas did not come about until the ocean core isotope records of the 1970s.

Much not understood until recently, but astronomical cycles were proposed in the 19th century – they simply could not be proved until isotopes were understood.

III. Evolution

Jacob Bronowski, mathematician and philosopher of science, points out two competing traditions of explanation:

- Physical structure of the universe, from basic physics, working up through the things that physics explains (→chemistry, →geology, →meteorology, etc., all can be thought of as forms of applied physics, as we trace our underlying principles back to physical laws and try to deduce things as much as possible from the basic physics.)
- Life, biology, working from the complexity of observed life on down to figure out how it works and how it arose.

Another way of looking at this is that life science is in the details, physical science is in the rules. Biology is long on details, short on rules.

Consider turbulence. In fluid flow, apply Newton's laws, deal with the nonlinearity, recognize that turbulence will happen. We already saw turbulence in nature, but going backwards, trying to deduce Newton's laws from turbulence, would be very difficult.

In life sciences, what we see is the turbulence, the complexity of life, myriad of chemicals and interactions, myriad of ecological interactions, organism to organism, organism to environment, and making rules from that is hard. Thus the accomplishments of Charles Darwin and Alfred Russell Wallace, two gentlemen of Victorian England.

A sidelight to the Age of Discovery: ships at sea had a hard time determining longitude. Before chronometers, longitude measurements required setting up a telescope in a location and making some nighttime observations, waiting as many days as needed to get the clear skies – often observing transit times of moons of Jupiter. Got longitude relative to an astronomical observatory, England used the observatory in Greenwich, America used the Naval Observatory that is currently the Vice President's home in Washington, French had a location in Paris, Spain used Cadiz. Reason for 0° longitude set in Greenwich, England, universally now is that at the International Meridian Conference in Washington (1884) it was agreed to by all nations, primarily because everybody on the planet was already totally reliant on sea charts bought from the British Admiralty and was used to 0° in Greenwich. (Lucky: 180° used for International Date Line goes through nearly no land when 0° is Greenwich.)

Important technological improvement: John Harrison was awarded an Admiralty prize for an accurate chronometer in 1765, needed for determination of longitude. It did not go into wide use for a few decades, but was a revolution in mapmaking and navigation.

British Admiralty began sending out survey ships in the 18th century for the primary purpose of getting better sea charts, knowing where the good lands and islands were, and generally part of the aggressive naval strategy that would give them an empire. By the early 19th century, Britain truly "ruled the waves" as the dominant naval power of the world, on route to making a world empire that would last another century. The Admiralty, under command of Admiral Beaufort (invented the wind scale used in meteorology) sent out survey ships all over the world to improve their maps. They surveyed coastlines, improved latitude/longitude positions.

The survey ship, HMS *Beagle*, with Capt. Robert FitzRoy, was sent around the world starting with South America as part of the program to maintain and improve Admiralty charts. Capt. FitzRoy wanted a naturalist on board to collect specimens, and wanted it bad enough to give up part of his cabin (survey ships were small, *Beagle* was 90' long). FitzRoy had a strong interest in science, became a meteorologist and very good weather forecaster later on.

Charles Darwin (1809–1882, Brit)

Darwin born 12 Feb 1809 (same day as Abraham Lincoln) as a well-off country doctor's son with two famous grandfathers. Erasmus Darwin was well known in his day as an author who wrote popular works about biology, and was personal physician to King George III. Josiah Wedgwood founded the pottery company that still exists.

Charles was expected to do something respectable: doctor preferably (family tradition), clergyman acceptable. Sent to Edinburgh University for medical training and dropped/ flunked out – not really interested. Went to Cambridge, became a beetle collector. Brits at that time had an obsession with insect collections, and beetles and butterflies were most interesting. Became a student of botany under John Henslow (professor of mineralogy at Cambridge, but more interested in botany), became a naturalist, which was the best term in the day for what we might now call environmental scientist: knew something of all branches of biology, some geology and meteorology, but was still mostly interested in collecting things, filling out the knowledge of the planet's creatures.

When FitzRoy wanted a naturalist on the Beagle, he approached Henslow for suggestions, and Henslow suggested Charles Darwin. FitzRoy accepted him, despite some reservations about the shape of Darwin's nose – primitive phrenology.

1831, Beagle set sail: FitzRoy was 23, Darwin was 22. Darwin had two books along: Humboldt's *Personal Narrative* of his journeys in South America, and Charles Lyell's *Principles of Geology, Vol I.*, the latter a gift from FitzRoy.

Beagle traveled nearly 5 years. Coast of South America, Tierra del Fuego, back up west side of South America, Galapagos, across the Pacific island hopping to New Zealand, Australia, a little more island hopping and then back home.

Darwin wrote 4 books after return, *Voyage of the Beagle* was the popular traveler's account of the voyage (and still a good read), three books primarily on geology, with coastal processes, volcanoes, coral reefs. Recognized cycle of transitions from undersea volcano to reef-surrounded island, to coral reef atoll. Recognized that earthquakes and volcanoes probably resulted from interior liquid motions of the earth. If Darwin had done nothing more, he would still be mentioned today in the history of geology for the volcano-to-atoll theory.

1839, married his cousin, moved to the country, and set out on the important business of having 10 children, tending the garden, and being a hypochondriac country gentleman. Wrote a series of short versions of an idea about evolution of species. 35 page pencil abstract expanded to 200 pages, showed to various professors including Charles Lyell and was encouraged, but he was too reclusive to publish something that he knew would be controversial.

Did research on barnacles, worms, hybrids – things he could study in his garden. Wrote many short papers to gardening journals, letters to professors that were published, and such. Learned a lot about the mutability of species from studies of hybrids and gardening, that a considerable amount of variation was possible, although he did not know why (no genetics yet). Probably would have spent the rest of his life thinking about evolution and writing little, except that someone with similar experiences came up with the same idea.

Alfred Russel Wallace (1823–1919, Brit) an unlucky person. Not from a rich background, worked as a land surveyor (lucrative because England was being surveyed all over for potential rail lines at the time).

Trained as naturalist by Henry Bates, who is still well known for his work on mimicry in insects. At age 25, set out with Bates intent on being a professional collecting naturalist, earning a living by selling specimens to museums. Sailed up the Amazon, then Rio Negro, to Manaus, befriended some Indians and set them to helping him collect. As he collected, began to notice geographical variations, species nearby would be similar but have interesting changes in details.

Spent 4 years in South America, packed up his collection and sailed home. Ship burned down, crew saved in lifeboats but collection lost. This was typical for Wallace.

Went to Malaysia, developed biogeography. Drew a line in the Malay Archipelago, still known as the Wallace line, between area where species derived from Asian ancestors and where species derived from Australian ancestors.

February, 1858, Wallace was riding out a bad fever on a small island between Borneo and New Guinea, wrote a paper explaining that new species could derive from natural selection within the natural variability of existing species. Wallace sent his paper to an English scientist asking to have this new concept of evolution published. He sent it to Charles Darwin.

Darwin acted properly: had papers by himself and Wallace presented at the same meeting and gave Wallace credit for coming up with the idea independently, but also had his friends publicly attest that Darwin had been circulating drafts for many years.

Real public notice came with *The Origin of Species*, 1859. Talked about variation and modification of species, with very little about the original origin of original life, and without discussing human evolution. 12 years later, *The Descent of Man* talked specifically about the fact that humans had arisen by the same process.

Origin of Species presented long chapters of the basic data about hybrids, breeds, competition in the wild variations within species, and so on. Some of it is a fairly boring catalog of evidence to a modern reader already familiar with evolution.

> With the giraffe, the continued preservation of the individuals of some extinct high-reaching ruminant, which had the longest necks, legs, &c., and could browse a little above the average height, and the continued destruction of those which could not browse so high, would have sufficed for the production of this remarkable quadruped; but the prolonged use of all the parts together with inheritance will have aided in an important manner in their co-ordination.

That was one sentence – don't write like that.

Origin was a best seller, and everybody understood that this was incompatible with a literal interpretation of *Genesis*. 1860s America was occupied with Civil War, but Britain had a vigorous debate on science versus religion. Reconciled by putting limits on both. Science should not speculate on first causes. When we work our way back with "why" questions, we hit limits on what science can accomplish, and we accept those limits. Religion has no business denying the evidence of the senses and the validity of measurable facts and repeatable experiments.

Scientific debate on the fact of evolution was over within a couple of decades of Darwin within scientific circles. The mass of evidence for it was undeniable. Debate on mechanisms and history is still ongoing, but that is refinement of the basic structure.

First Closer

Deep time is the central theme from Hutton, Agassiz, and Darwin. (Do not give Hutton, Agassiz, and Darwin too much individual credit – they were products of their times, many of the ideas they espoused were already in the air. In all three cases, the ideas we associate with these names would have been around no more than a decade later without them. That proviso probably applies to every modern scientific figure except Newton.)

In 1800, the "normal" belief in Europe and America was that the earth was a few thousand years old, all the species in existence had been created as they currently were in an amazingly intertwined ecology that was taken as proof of the wisdom of the god who created them, the landscape had been created more-or-less as currently shaped, and then modified in a few cases by catastrophic events, and the climate, driven by the sun and the unchanging perfect orbit of the earth around the sun, was also unchanging.

In 1880, the normal belief was that the earth was very old – no dating methods yet but at least that millions of years was required – and that everything on the earth, including its biology, landscapes, and climates, were susceptible to change. That is the modern worldview of environmental science, all developed in a relatively short time.

In the last half of the 19th century, we knew that the earth could change, had changed, and there had been no Golden Age, just a long, slow, convoluted path to the present. Humans were a part of the earth – part of a continuum of life based on our evolution from other forms, and with a future inextricably linked to other life and to modifications of the earth. Within that context, modern environmental thought can begin.

Second Closer

Louis Agassiz had made his early reputation describing and categorizing fossil fishes in a scientific context that did not have evolution. He did not find evolution a necessary explanation for anything he saw in the geological record. He believed in special creation – that species arose fully formed at more than one time, but that they did not evolve from each other. Agassiz remained unconvinced of evolution to the time of his death in 1873.

Charles Darwin thought that the idea of a global ice age was poorly proved and was too disruptive for the evolution of species. He probably had hard time separating the time scales since he could not know that the ice ages were brief and recent compared to the time over which evolution had operated. Also, by the the time Agassiz's ideas were in circulation, Darwin was pretty well set in his ways at Down House in Kent and never

traveled to high mountains. His last known opinions on the ice age were skeptical, and that he preferred fluvial and iceberg-rafting explanations for erratics.

(Hutton died shortly after the publication of his book without knowing that his idea would be accepted or remembered, let alone become a foundation principle of geology, so we have no such ironic twist for him.)

Third Closer

Capt. Robert FitzRoy of the *Beagle* was conservative, narrow-minded, and autocratic. He was very competent as a captain and surveyor – remember that he was assigned captaincy of a naval vessel that would go around the world at age 23. He was also a religious zealot. Concepts of species change and an old earth were in the air, such as Lamarck's concept of acquired characteristics, Erasmus Darwin's ideas of species change, and Hutton's theory of uniformitarianism, and he did not like them.

Although having a naturalist on board survey ships was common, FitzRoy's motivation for inviting Darwin was that he wanted someone to gather geological evidence that would refute the old-earth ideas and help prove the literal truth of the Biblical creation story. FitzRoy committed suicide in 1865.

Walden Pond to Sand County

Humboldt published on everything. Darwin published on biology, ecology, agriculture, and soil science. Neither held a job, taught for tuition, received grants or otherwise got reimbursed for their science – their professional income was royalties from their books, and they lived on family money. Science became *professionalized* in the 19th century – done by people with PhDs working for universities or large corporate research departments – end of the gentleman scientist, beginning of the professional scientist. Big science and grant getting came more around WWII, but the modern structure of science was in place more than 100 years ago.

In the late 19th century, we also get the compartmentalization and professionalization of science. "Natural philosophy" or "naturalist" covered everything for Humboldt and Darwin. Biologists split from geographers, and then geology split off from geography, later meteorology did as well. Biologists stopped looking at families of organisms, then stop looking at whole organisms, became focused on ever smaller aspects of their field. Not much different from other fields, but may have been faster in biology because of the need to deal with the complexity. The term "scientist" was not formed until the early 19th century.

Environmental awareness begins in ancient times, as already discussed, but in the 19th century, they had learned much about how the world works. Had a range of empirically-based science fields, a realistic sense of time, freedom from religious dogma (at least from physical persecution about religious doctrine), and knowledge of all the different environments of the planet.

Age of discovery had segued into the age of colonial exploitation. "Tropical paradise" could be turned into wasteland by deforestation, erosion, silting harbors, extinction of species. Most problems were related to import of diseases, predators, and alien agricultural systems.

Europeans developed some forest preserves, dating back centuries. Preserved trees for masts for the Royal Navy, preserved hunting ground for royalty. Also had the idea of *rain preserves*, based on the idea that deforestation reduced rainfall. (May have had basis in fact, that soil storage is reduced after deforestation, so rivers that ran all year may become seasonal.) The French put forest reserves on some their islands in the Caribbean and the Indian Ocean. However, all this preservation was practical, resource preservation.

What begins in the middle 19th century is the less practical, more philosophical or ethical side of environmental understanding, a view of the environment as something to be preserved for its own sake.

Much of our discussion will become distinctly American, because it was the last great, useful "commons" on the planet. Unlike any other large land mass that Europeans were exerting hegemony over, it was underpopulated relative to its resources. American Indian populations at the time of Columbus may have been 50 million (most heavily in the Aztec and Inca empires, but spread around) – highly contentious field but that is the careful estimate of William Denevan and is a middle figure. Within a century of first contact, that population decreased by 80% because of exposure to European diseases that the population had no natural immunity to – smallpox usually highest on the list. In other words, while Europeans were finishing out discovery and preparing to make the first

colonies, an inadvertent Holocaust of disease was wiping out the indigenous population. It was an open continent, and the Europeans didn't know why. Some prejudices about the lack of industry and ambition of the American Indians came from noticing how underutilized the continent was, without understanding the cause. (Argument among historians and anthropologists continues over the size of the pre-Columbian population and the effects of disease. Also affected was amount of importation of Africans as slaves.)

From the time of Jefferson and the Louisiana Purchase until Frederick Jackson Turner declared the frontier to be closed in 1893 was precisely 90 years. During most of that time, the American ethos was to expand and conquer against a limitless resource of land. By the 20th century, the need was more to use the land efficiently, and this led to the resource conservation ethos of Gifford Pinchot. When Lewis & Clark traveled west (1804–1806) they brought back information about a vast continent, much of which would be difficult for European-descended cultures to use, but which was still an enormous source of wealth and lightly populated. By the end of that century, it would be mostly in use.

Lewis & Clark had less immediate fame that they did a century later. It was the first of a number of military-led explorations trying to figure out what we owned, for purposes of using it. The followed the Missouri to its source, with the purpose of crossing over the other side, in the course of which they also mapped the Columbia/Snake system. Zebulon Pike led expeditions to Minnesota (1805) looking for the headwaters of the Mississippi and to Colorado (1806) looking for the headwaters of the Red and Arkansas Rivers. All the great explorers of the American West – Kit Carson, John C Fremont, Jedediah Smith – were mostly route finders for people who came later, to get to the west coast, to trap beaver in the mountains, to look for mineral wealth, to look for other places that could be farmed. (Beaver felt was, and still is, a very high quality hat-making felt and had been valued for centuries.) Lewis & Clark did a huge amount of description of tribes, animals, plants, fish, and whatever in addition to topographical and geographical knowledge. Remarkably little of that got into print early on, mostly because Meriwether Lewis was a depressive alcoholic who committed suicide in 1809 without having rewritten his field notes. William Clark was busy as an administrator in Missouri territory and not as much of a writer.

First professional images of the west probably come from George Catlin (1796–1872) about whom we'll get a presentation. Most of the artists who went west were actually sympathetic to the Indians; saw themselves as documenting something that was going away. We wouldn't have pictures of many of the Indian tribes if not for the work of Edward S. Curtis, for example. Also see the bronzes of Frederic Remington.

From Catlin we may get the first assertions of how the Plains Indians used every part of the buffalo they killed, and relied on it totally. We know they were capable of wasting buffalo if they had a chance to kill a lot at once, but we also know that they relied on them.

We can talk about these early documents about what the North American continent included because some of them knew that the continent was going to be used. Catlin, in 1841, knew that the Indians would be removed. Part of this is the difference between American views of the environment as a resource and European views.

Consider **William Blackstone** (1723–1780) of England. Purpose of that reading is to get an idea of what Americans came away from, and still react to. European landownership was in the hands of the crown – nominally in the hands of the king. The Norman conquerors of England had put the *sole* right to hunt for game and seek forest resources *anywhere* in the hands of the crown. This was contrary to very old traditions, many of which persisted on the continent. The Romans had laws that restricted how one could hunt on public lands, but there was a lot of common land reserved for common use. British rule was more restrictive, and this was not for environmental reasons but for military and civil control of the activities of the population. All European countries had a sense of commons land in the past – land used for grazing, hunting, fuel gathering. As long as the population is low enough, no problems ensue. England had a multi-century tradition of putting more and more control of the commons into the hands of nobility, particularly the king.

p.8 (reader) list of reasons for restricting use of land

1) encouragement of agriculture

2) preservation of species

3) prevention of idleness and dissipation in … others of lower rank, which would be an unavoidable consequence of universal license

4) prevention of popular insurrections and resistance to the government by disarming the bulk of the people.

Last part is dealt with at length later: that restrictions on land use were as much for preventing the people from being armed and practiced in those arms (via hunting) as for preservation of species. Also, idea that farmers would be lazy if they were allowed to hunt instead of raising crops is a little hard to swallow.

Although the language is hard to follow, the meat is that common lands were very important, still in the 18th century in England, and we had brought concerns about that to North America. Other commentaries by William Penn and Benjamin Franklin are mostly about the problems of wood usage. We will see this affect most of American history, recognized by Hardin (to be discussed later.)

The Americans who made this country had in mind that we should use this free country freely, as a huge commons (once we had taken it away from the aboriginals). This commons approach is still part of the American mind set about environmental protection – that resources should be used. **Peter Kalm** (1717–1779, Swede) traveled in America in the 1740s to 1750s and published a discussion of the American continent with particular respect to its use of resources. It is particular interesting in its contempt for our conservation ethic. It was clear that the conservation ethic of colonial America was nonexistent.

In the modern era, we get haughty about the poor resource control of modern slash-and-burn in the tropics. (Failure to recognize that indigenous swidden systems are reasonably conservationist, even though what's going on in Brazil is not sustainable.) Kalm reams our predecessors for an attitude towards our landscape that is every bit as cavalier as what we

think of as the worst exploitation of the rainforest. We (our predecessors in America, not the modern "us") could not conceive of running out of resources.

Kalm is also traveling in the mid-Atlantic, and as a Swede he finds our summers unliveable. (As a Minnesotan with Scandinavian background, I completely agree.) There is a little argument that the Americas are not as resource rich as Europe – an assertion that Jefferson will attack in another reading. He recognizes that what we are doing here is not an adaptation of what we learned from Europe but is an aberration of the free availability of new land in America.

From the early 19th century until the present, some Americans have been trying to get us over the idea that we have an unlimited resource. Along the way, what Americans will do is actually change the rest of the world. We will invent concepts like wilderness preservation, resource conservation, national parks, land ethics. Remarkably, we will turn ourselves around before it's all destroyed.

Henry David Thoreau (1817–1862, American). *Walden* (1854), wrote other books, essays, and journals. Essay called "Walking" appeared in 1862. Much not published in his lifetime, *Wild Fruits* appeared in 2000.

Thoreau lived most of his life in Massachusetts except for travels (west to Minnesota, north to Canada, and all over New England). Harvard education, did a little teaching, worked in the family pencil business, but most of his life relied on economic support from an understanding family. Poet, philosopher, naturalist:

Thoreau developed a sense of wilderness in his natural philosophy. First to *de-emphasize the dominion* of humans over nature. In a very short time after Darwin, he was putting the concept of evolution into how humans should interact with the planet. He had read *Voyage of the Beagle* when it came out, and when *Origin of Species* came out, he copied major extracts from it into his natural history notebooks, with comments. One of his last manuscripts, finally published in 1993 as *Faith in a Seed*, was a naturalistic exploration of the ways in which seed dispersion and plant adaptation fit together, with sections on interactions with animals and birds.

Thoreau understood Darwin, but more than Darwin he understood the meaning of this for the human place in nature – that nature had an age, subtlety and *worth* that was independent of human values. Some more inspired writing on this topic came from a trip to Mt. Ktaadn (now Katahdin) in Maine. (*The Maine Woods*, published posthumously 1864 based on trips in 1846, 1853, and 1857.) The "Chesuncook" excerpt in the reader is from that group. Much of what he is doing is realizing that there is a tangible difference between the wilderness of Maine and the woodlands of Massachusetts. An excerpt a little more "out there" that is not in the reader.

> Nature was here something savage and awful though beautiful I looked with awe at the ground I trod on, to see what the Powers had made there, the form and fashion and material of their work. This was that Earth of which we have heard, made out of Chaos and Old Nights. Here was no man's garden, but the unhandseled* globe. It was not lawn, nor pasture, nor mead, nor woodland, nor lea, nor arable, nor waste-land. It was the fresh and natural surface of the planet Earth, as it was made forever and ever,—to be the dwelling of man, we say,—so nature made it and many may use if he can. Man was not to be associated with it. It was Matter, vast, terrific,—not his Mother Earth that we have heard of, not for him to tread on, or be buried in,—no it were begin too familiar even to let his bones lie there,—the home, this, of Necessity and Fate. ... Think of our life in nature,—daily to be shown matter, to come in contact with it,—rocks, trees, wind on our cheeks! the *solid* earth! the *common sense! Contact! Contact! Who* are we? *where* are we?

*__handsel__, var. of hansel, first down payment to seal a promise. Implication of "unhandseled globe" is that we have not paid for it, we have not promised to pay for it, we do not own it, we do not control it.

Before this, Nature had been mechanized, most particularly through Newton's laws and their application. Thoreau argued the possibility of an organismic Nature, that we were part of.

From the introduction of "Walking"

> I wish to speak a word for Nature, for absolute freedom and wildness, as contrasted with a freedom and culture merely civil — to regard man as an inhabitant, as a part and parcel of Nature, rather than a member of society.

Thoreau was wide-ranging and is often remembered for *Civil Disobedience*, which talked of protesting government as not just a right, but a duty when it was doing immoral things – inspired Gandhi, who in turn inspired M. L. King Jr. during the civil rights movement. During the protests movements of the 1960s, *Civil Disobedience* was almost required reading, and it may have associated Thoreau with the radical, uncompromising sides of environmentalism.

Even from *Walden,* most public understanding is of the "simplify your life" aspects. This has become one of the core values of modern environmental thinking in a resource-rich America – trying to end the concept of measuring worth in economic terms. Any current arguments over car size, house size, and the way we live can be put in terms of Thoreau's values. Good life, living in harmony with nature, which requires a holistic understanding of nature. However, that interpretation is more recent.

The *Journals*, not published until 1906, show Thoreau's holistic understanding of nature: naturalist observer, botanist, meteorologist. He previewed the concept of our modern national parks and influenced many later writers. From *Wild Fruits* (written 1859 and unfinished at Thoreau's death, published 2000):

> I find that the rising generation in this town do not know what an oak or a pine is, having seen only inferior specimens. Shall we hire a man to lecture on botany—on oaks, for instance, our noblest plants—while we permit others to cut down the few best specimens of these trees that are left? It is like teaching children Latin and Greek while we burn the books printed in those languages.
>
> ...
>
> I think that each town should have a park, or rather a primitive forest, of five hundred or a thousand acres, either in one body or several, where a stick should never be cut for fuel, nor for the navy, nor to make wags, but stand and decay for higher uses—a common possession forever, for instruction and recreation.
>
> ...
>
> We boast of our system of education, but why stop at schoolmasters and schoolhouses? We are all schoolmasters, and our schoolhouse is the universe. To attend chiefly to the desk or schoolhouse while we neglected the scenery in which it is placed is absurd. If we do not look out we shall find our fine schoolhouse standing in a cow-yard at last.

Thoreau died of tuberculosis in 1862. He was 44 years old. During his life he was not nearly as well known as he is now.

George Perkins Marsh (1801–1882, American), *Man and Nature*, 1864, with later editions.

Marsh was a Vermont polymath – a man of many interests who did not excel at any of his chosen careers. Dartmouth trained lawyer, not very successful – tended to piss off judges at a time when judges were not necessarily as well trained or respectable as we hope for now. Spent some time in U.S. Congress in 1840s, and then followed a common route for politicians out of office: sought an ambassadorship. Got Turkey first, then Italy.

Master of 20 languages, wrote such diverse things as an Icelandic grammar and a treatise on the habits and uses of camels.

Ambassador to Turkey while that country was the main seat of the Ottoman Empire, so had excuse and business to travel through much of the Mediterranean area. Developed an interest in human action on the landscape – uniquely able to read what ancient writers had said about some of these areas and look at them after 2000 or more years of human action. Wrote *Man & Nature* as a catalog of changes – not easy to read nowadays. From the preface to the first edition:

> The object of the present volume is: to indicate the character, and approximately, the extent of the changes produced by human action in the physical conditions of the globe we inhabit; to point out the dangers of imprudence and necessity of caution in all operations which, on a large scale, interfere with the spontaneous arrangements of the organic or the inorganic world; to suggest the possibility and the importance of the restoration of disturbed harmonies and the material improvement of waste and exhausted regions; and, incidentally, to illustrate the doctrine that man is, in both kind and degree, a power of a higher order than any of the other forms of animated life, which, like him, are nourished at the table of bounteous nature.

From the first chapter

> The decay of these once flourishing countries is partly due, no doubt to that class of geological causes whose action we can neither resist nor guide, and partly also to the direct violence of hostile human force; bit it is, in a far greater proportion, either the result of man's ignorant disregard of the laws of nature, or an incidental consequence of war and of civil and ecclesiastical tyranny and misrule.

Much the early part of the book is a survey of what was known about natural environmental change to put the *rate* problem visible. After introductory material, Marsh addressed environmental change in a disciplinary style:

- Extinction and modification of species, as well as transport of species to new locations (often to the detriment of previous species there).

- Forests, he brings up the old ideas about habitable earth is generally wooded.

- "Great American Desert" at that time referred to the high plains, which were called a desert because they did not have trees – still an assumption of infertility rather than dryness.
- It was generally believed that removal of trees led to climate change.
- Greatly influenced by Mediterranean scenes of bare, eroded hills for which he had ancient sources describing forests.

- Waters: emphasized on swamp draining, remarkable efforts in the Netherlands, aqueducts, canals, diversions, and irrigation. Control of water had a long history.
- Sands: talked about beach modifications and coastal processes.

Marsh was fact-oriented, not polemical. This book was a serious academic study of ways in which humans had modified the landscape and its biota. Marsh did have a few rants: he had lost money at the hands of railroad speculators, and could blame most of the problems of New England on railroad companies and land speculators.

Marsh had a remarkable effect on academic study and policy in his day. The book went through several editions, was read by nearly every geologist, geographer, resource planner in its day. *Man and Nature* influenced everyone important in its day, and had more effect on creating the resource control and planning agencies of the government than Thoreau's much more poetic work or Muir's polemics.

Much of what Marsh wrote could be adapted to the resource conservation point of view, and that is a useful starting point for environmental awareness. What it does not lead to is specific, quotable, readable literature after the problems of the day that one is writing about are passé.

Now, Marsh has been forgotten outside of academia. Some geographers remember and revere his name, historians of environmental thought must know about him, but the well-read public, a public that has heard of Thoreau, Muir, and Leopold, has not heard of George Perkins Marsh.

John Muir (1838–1914, American, immigrant from Scotland at age 11)

John Muir was raised in a strict Scottish-Calvinist family, and a biblical upbringing shows in his writing. He was not as much a scientist as a popularizer. Raised in Wisconsin, attended University of Wisconsin.

Turned to the "book of nature" to "read" its secrets in the way of many 19th century naturalists, and had a falling out with his father: fundamentalists often regarded uncontrolled nature as evil – humans must control nature to be proper stewards. Muir never became an atheist, but redirected his religious feelings towards wilderness, and wilderness became a sacred concept.

Raised as a farmer, became a gadget builder and inventor by talent. But in 1867, not yet 30, set off from Indiana to walk to the Gulf of Mexico.

> Crossing the Ohio at Louisville, I steered through the big city by compass without speaking a word to any one. Beyond the city I found a road running southward, and after passing a scatterment of suburban cabins and cottages I reached the green woods and spread out my pocket map to rough-hew a plan for my journey.
>
> My plan was simply to push on in a general southwest direction by the wildest, leafiest, and least trodden way I could find, promising the greatest extent of virgin forests.

The next year, he spent the summer in the Sierra Nevada and saw Yosemite Valley for the first time. From then on, he spent as much time as he could in the mountains of California, and is most closely associated with them.

Muir is notable for three things, but only for one of them is he widely remembered, and that often incorrectly.

- Muir strongly espoused a biocentric point of view that would be recognizable today as deep ecology. (The word ecology was invented after Muir had done much of his writing, so he did not use the word.) Starting with a pantheistic "god in nature" view, he tried to erase or minimize the line between humans and nature. "We seek to establish a narrow line between ourselves and the … angels but ask a partition barrier of infinite width to show the rest of creation its proper place." Muir felt that ecological crises and environmental degradation all resulted from humanity's failure to recognize its interdependence. This was similar to Thoreau, perhaps derivable from Thoreau, but Thoreau still recognized the dominion of humanity, even if he cautioned its limitations. Muir would have argued against the dominion of humanity (at least to make a point).

  > Now, it never seems to occur to these farseeing teachers that Nature's object in making animals and plants might possibly be first of all the happiness of each one of them, not the creation of all for the happiness of one. Why should man value himself as more than a small part of the one great unit of creation? And what creature of all that the Lord has taken the

> pains to make is not essential to the completeness of that unit—the cosmos? The universe would be incomplete without man; but it would also be incomplete without the smallest transmicroscopic creature that dwells beyond our conceitful eyes and knowledge.

Philosophically Muir has been taken less seriously than Thoreau, probably because he was less careful and consistent and was writing for a common audience – next point:

- Muir was a popularizer of nature. He wrote books, started clubs, led outings, advocated parks, and generally advertised the importance of getting into nature for ordinary people. He felt that people needed nature, and that the more people recognized this, the more they would support his other goals of preserving and taking care of wilderness. From *Our National Parks* (1901), recognize that within this boosterism for parks is a plea to go visit, recognition that people need to go visit, and mention that preserving land for resources alone is not good enough.

> The tendency nowadays to wander in wildernesses is delightful to see. Thousands of tired, nerve-shaken, over-civilized people are beginning to find out that going to the mountains is going home; that wildness is a necessity; and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life. Awaking form the stupefying effects of the vice of over-industry and the deadly apathy of luxury, they are trying as best they can to mix and enrich their own little ongoings with those of Nature, and to get rid of rust and disease. Briskly venturing and roaming, some are washing off sins and cobweb cares of the devil's spinning in all-day storms on mountains; sauntering in rosiny pinewoods or in gentian meadows, brushing though chaparral, bending down and parting sweet, flowery sprays; tracing rivers to their sources, getting in touch with the nerves of Mother Earth; jumping from rock to rock, feeling the life of them, learning the songs of them, panting in whole-souled exercise, and rejoicing in deep long-drawn breaths of pure wildness. This is fine and natural and full of promise. So also, is the growing interest in the care and preservation of forests and wild places in general, and in the half wild parks and gardens of towns.

From that quote, one can see that he has become hard to read – the fine flowery language that sold in 1901 does not sit well today. Other books: *The Story of my Boyhood and Youth, A Thousand Mile Walk to the Gulf, My First Summer in the Sierra, The Mountains of California, Our National Parks, The Yosemite, Travels in Alaska, Steep Trails.* Published starting in 1894, and continuing after his death as his publisher edited his journals.

- Muir was an advocate for preservation of wilderness for its intrinsic, not necessarily for its resource preservation. Humans needed to get into it, but to some extent they just needed to know it was there. He brought politicians into the woods and mountains to lobby them for park status and was instrumental in creating several national parks, including Yosemite.

Some associate this aspect of his accomplishment with his role as founder of the Sierra Club, which today is one of the major environmental advocacy organizations. However, Muir founded the Sierra Club as an outings club, and it remained that for 50 years. The move to advocacy was shepherded by David Brower in the 1950s and 1960s.

Muir's final battle was to protect the Hetch-Hetchy valley from being dammed to provide a reservoir for San Francisco. He lost, but caused enough political damage that such a project has never been tried again in a National Park. The excerpt from the reader is late writing, and based on a place that did not need exaggeration. It is perhaps his finest essay.

Aldo Leopold (1887–1948, American). *A Sand County Almanac*, 1949.

Leopold was a professional wilderness manager, worked as a wildlife research and professor the University of Wisconsin. Developed the concept of a *land ethic.* From the forward:

> There are some who can live without wild things, and some who cannot. These essays are the delights and dilemmas of one who cannot.
>
> Like winds and sunsets, wild things were taken for granted until progress began to do away with them. Now we face the question whether a still higher 'standard of living' is worth its cost in things natural, wild, and free. For us of the minority, the opportunity to see geese is more important than television, and the chance to find a pasque-flower is a right as inalienable as free speech.
>
> These wild things, I admit, had little human value until mechanization assured us of a good breakfast, and until science disclosed the drama of where they come from and how they live. The whole conflict thus boils down to a question of degree. We of the minority see a law of diminishing returns in progress; our opponents do not.
>
> ...
>
> Conservation is getting nowhere because it is incompatible with our Abrahamic concept of land. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science of contribute to culture.
>
> That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics. That land yields a cultural harvest is a fact long know, but latterly often forgotten.

Leopold tried to meld three concepts into his land ethic: ecological value, ethical necessity, and esthetic values. What he specifically did not include was economic value, the relevance of economics is *not* a primary concern, perhaps not a concern at all. Leopold recognized the necessity of deriving an economic benefit from the land, but he did not feel that humans had a right to material overabundance at the expense of the land.

Leopold graduate Yale in 1909 with a degree in forestry and started to work for the U.S. Forest Service in New Mexico. In the Southwest, he gained a perspective different from Marsh and Muir. The Puebloans (Anasazi) had maintained a culture in a hard landscape without degradation for centuries, whereas European-descended people had caused major damage in 1 1/2 centuries. Human occupance was not intrinsically bad, so there had to be more than one way of dealing with the land, and if you could find the right way, dealing with the land in a sustainable, undamaging way was not just a matter of resource preservation, it was an ethical and moral requirement.

Leopold was making the jump between resource management and ethics, that resource management drove an ethical point of view. Muir and Thoreau had come to ethics for their own sake – Muir derived his from a religious background and Thoreau derived his directly

out of philosophy. Marsh puts in the resource preservation without an ethical background; perhaps that explains why he is forgotten.

Leopold was trying to do the tricky bit: demand that land management and wilderness preservation were necessary while maintaining his credibility as a resource manage. Much of his early writing uses the theme of sustainability. Arguments against overgrazing, overcutting, and wilderness destruction could be made within a resource management point of view if sustainability was a requirement.

All his life, Leopold walked this line between what he thought about land and resources and what he was expected to do for a living. After leaving the southwest and moving to Wisconsin (1924) he became a game manager – note the emphasis on *game*, not *wildlife*, which drove resource-oriented bureaucracies. Leopold became one of the founders of game management *science*.

Traveled to Germany (1930s) and say that centuries of intensive management had produced a hopelessly humanized landscape, and that intensive management was part of the problem. Traveled to the Sierra Madre and saw that huge areas of totally unmanaged wilderness had great species diversity and stable ecosystems. One could no more have a managed wilderness than one could have a wilderness in Central Park.

Leopold got a concept that Thoreau and Muir would appreciate of *wilderness*, but the scientist in him required him to have definitions. In 1935, with others, he founded The Wilderness Society, which helped promote our modern designated wilderness areas. Defined wilderness in terms of species diversity because it was something measurable that he thought would make a good index.

Eventually, he came up with a succinct statement of the land ethic: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Hopelessly vague and ambiguous, it fails for many academic writers and philosophers, but seems to work for people who actually have spent time in the wilderness.

> Ability to see the cultural value of wilderness boils down, in the last analysis to a question of intellectual humility. The shallow-minded modern who has lost his rootage in the land assumes that he has already discovered what is important; it is such who prate of empires, political or economic, that will last a thousand years. It is only the scholar who appreciates that all history consists of successive excursions from a single starting-point, to which man return again and again to organize yet another search for a durable scale of values. It is only the scholar who understands why the raw wilderness gives definition and meaning to the human enterprise.

Oelschlaeger points out that Leopold was one of the few 20th century thinkers to understand that science is "inextricably entangled with the culture that sustains it." Einstein was one, Leopold was another.

The Wilderness Act (1964) is a descendent of Leopold's work. The reader has a one-page excerpt, and the last paragraph, "Definition of Wilderness," is what you might get if a lawyer edited Thoreau – an emphasis on lightly used, perhaps no visible signs of being used.

National Park Service does not totally get this concept. I have backpacked in wilderness of the east. Within Shenandoah National Park is some lovely designated wilderness, gorgeous places to spend a day down by the streams with the rushing water. At night, I moved up the hill a ways to sleep, and could hear jake-braking trucks in the Great Valley all night. That diminishes the concept of wilderness – it should be a five senses thing.

Where are we going?

Starting in the 1950s, change accelerated in environmental thinking, and often turned into environmental action. We get a shift from land-based environmental thinking to an overemphasis on health-based environmental thinking: toxic pollution instead of wilderness preservation. We get a strong regulatory landscape, with pollution controls, wetlands regulation, wilderness preservation, and environmental limitations built into law. With that comes the professionalization of lobbying both for and against such regulations, and the radicalization of some elements of the movement on both sides. *Silent Spring* was published in 1962, the Glen Canyon was dammed in 1963. In the 40 years since those events, no act of pollution has been unnoticed, uncommented upon, unprotected; every dam has been challenged, and our whole definition of how we use land, water, and air has been turned around.

Changing ideas of the Commons. Much is written about this that is mistaken or short-term thinking. Europeans did not come to North America and bring in an idea of ownership and private property to an indigenous population that had no such concept. They brought in a view that "our tribe" should be able to control our commons in a way useful to us, and the tribes from which they took the land were already using it as a commons, just in a much less intensive way, and those tribes were used to fighting each other over control.

Garret Hardin (1915–2003, American) *The Tragedy of the Commons* 1968. Tragedy is not used in modern sense, but a throwback to old language: a situation that must inevitably get worse. The later subtitle is refers to the tragedy of *freedom* in a commons, which basically means that use of a commons must always fall apart unless restricted.

Consider a common pasture, being used for the grazing of cows by a village. Each individual, looking at the situation, sees that his or her *personal* well being improves by putting another cow on the commons. If everyone does that, acting in their personal interests alone, a lot of cows go into the commons. If everyone repeats the step a few times, the commons will deteriorate, and everyone will be worse off. Therefore, the only solution to maintaining a commons is if there is some authority that looks after the quality of the commons, reducing the freedom of individuals to act to their own personal benefit.

This was obvious long before 1968 (although expressed quite nicely here) if we are talking about cattle pastures. Hardin brought it to a wider understanding of commons, including shared air and water and the privilege to pollute. Also, the extension to the idea that the world is our commons and people are the "cows" brought this into population discussions of the time.

Fundamentally, we changed attitudes about responsibility from this article. Pollution of the air and water were seen as a societal cost of doing business, extinction of species from land-use as an unfortunate side effect of progress, but during the subsequent few years, under the Nixon administration, we had acts for Clean Water, Clean Air, Endangered Species, and the formation of the EPA. Hardin didn't create the consensus, but he summarized it at a critical time. Familiarity with this article is a necessity for intelligent conversation about the history of environmental thought.

Change from wilderness ethics to a pollution concern is often tied to **Rachel Carson** (American, 1907–1964). Had a career as a marine biologist and wrote two popular books, *The Sea Around Us* and *The Edge of the Sea*, in the early 1950s. These were very popular with the general public that was flocking to the shore for recreation in the postwar boom. These had no particular advocacy stance, they simply taught ordinary people the biology of the sea and of the shore. They provided Ms. Carson enough income to retire from the US Fish and Wildlife service and turn to writing full time.

After becoming concerned about DDT in particular, she wrote a magazine article that magazines rejected out of deference to their advertisers. She published a book about pesticides in general, DDT and dioxin-based compounds in particular, and proceeded to endure a harsh personal campaign of attacks from the chemical industry. Quoting from Paul Brooks's introduction: "Hundreds of thousands of dollars were spent by the chemical industry in an attempt to discredit the book and malign the author—she was described as an ignorant and hysterical woman who wanted to turn the earth over to the insects."

Silent Spring — title came from the idea of all the birds and insects being dead.

In the spirit of Hollywood, where it is said that any publicity is good publicity, attacks by the chemical industry backfired, primarily because she was sufficiently right about enough different things, and because birds have a remarkable constituency.

Widely understood: pesticides could be dangerous in large quantities. Not widely understood by the general public at that time was that they could be *cumulative* in two ways: each exposure you get to some of them builds up in your fatty tissues, and food chains concentrate the chemicals at higher levels of the food chain in creatures which must eat large numbers of smaller creatures to survive.

Attention shifted from land preservation and wilderness preservation and became rather obsessed with pollution control for a while. This was not a bad thing, but it did create a misapprehension that picking up litter is saving the planet, and some of that dreck is still in elementary and preschool curricula.

We now regulate pollution where it is put into the environment. There is a lot already there, some of which predates environmental regulation, or even predates understanding that some substance was particularly harmful. Mercury in South River, PCBs in the Hudson. A turning point that we need to hold companies responsible for their past behavior came after the Love Canal disaster in New York. This is one of the readings for which the introductory part of the story is almost as important as the reading. Suffice it to say, Love Canal forced all corporations to start taking responsibility for everything they had ever done, and Superfund was created to take care of problems left behind for which the responsible party may no longer exist. This is a source of many Environmental Science jobs – still cleaning up after the past.

Luella Kenny lived near Love Canal for ten years, and during that time she lost a son to an obscure disease call nephrosis. Following up, she determined that excessive deaths from

various things were being reported for more than ten years and ignored. She became one of the activists whose work led to Love Canal cleanup and eventually to SuperFund.

> … why worry about an enemy who will destroy us when we are self-destructing. We don't need sophisticated nuclear weapons; all we need are the multitude of dumps strategically placed all over the country that will insidiously destroy everything and everyone in its path.

And finally, Environmental Justice. (Read the bullet points on 261–262, problem becomes utterly obvious.

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