The Sixth Extinction Study Guide

The Sixth Extinction by Elizabeth Kolbert

BOOKRAGS

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Summary

“The Sixth Extinction – An Unnatural History” by Elizabeth Kolbert is the story of the investigative journalist’s quest to discover if the Earth is undergoing the sixth time that the majority of species on earth are at risk or indeed headed for extinction. When Kolbert, who is a journalist and author who has an interest in man’s relationship with nature, read an article about the possibility that the Earth was headed for mass extinction, she got very interested and decided to see if she could answer that question.

Kolbert travels around the globe to seek resolution and to learn what signs of extinction there are, what species are endangered, what the possible causes are for the crisis, when did it start and what naturalists and scientist are doing to try to prevent as much loss and damage as possible. Her travels not only take her to spots around the globe where species are vanishing and scientists are working day and night to understand the phenomenon and diminish its impact, she travels back in time to learn about early scientists who first proclaimed that the extinction process existed. She describes the theories and explanations for extinction from these long-ago scientific researchers and naturalists.

In her information-gathering endeavor, she learns some basic things about extinctions. There is a natural extinction process that goes on virtually at all times. This type of extinction is called a “background extinction,” and like background noise no one other than scientists knows that it’s even occurring. The extinction of one species takes hundreds of years in this process which is why it is an unremarkable and invisible attrition of animals and plants. The background extinction is based on the theory of natural selection in which weaker species are ultimately pushed out by predation and loss of habitat and other natural occurrences including disease.

Although the weeding out of species in a “mass extinction” has occurred only a few times throughout the history of the Earth, the losses are swift and devastating. The extinction that is most familiar to everyone is the one that occurred at the end of the Cretaceous period when the dinosaurs were literally wiped out. Not many species from that time survived to the next geological period.

Another major difference between the two types of extinction processes is the “why” element of the event. While background extinctions are natural and on-going and do not cause a disturbance, mass extinctions are caused by cataclysmic events. Most scientists believe that the Cretaceous extinction was caused by the impact of a massive meteor that impacted the earth. There are unusually high traces of iridium around the globe which is one of the main elements of meteors. It is speculated that the meteor caused years of darkness and debris filled air that disallowed plant growth and killed off most species especially the largest of them which were the dinosaurs.

As Kolbert wades her way through eons of historical data, conflicting theories and today’s jungles and islands where extinction is at work, she begins to get a sense of the cause for the current mass extinction and learns that that same cause was behind mass

extinctions in the past. Man is wired to explore and advance. In doing so, he has since the beginning of his existence disturbed the natural lives of other species. Global warming which is largely a result of man's activity has caused the oceans to become acidified which presents a grave threat to the coral reefs of the world. The reefs are the apex species of the ocean's ecosystem. If the reefs fail, so does the entire marine ecosystem. That failure – if it is not stopped or diminished – will lead to the destruction of other species that live on land and fly through the air.

Chapters I - II

Summary

El Valle de Anton in Central Panama is a small town that sits atop a four-mile side volcanic crater. It is known for selling golden-frog figurines in shops geared for tourists. The Panamanian Golden Frog is bright yellow with brown splotches and is indigenous to the region. The frog is considered a lucky symbol in Panama. The frogs were so plentiful that the forest floor and river banks were coated with them. Then they began to disappear. They disappeared from one region to the next and by 2002 they were wiped out. There were signs that the frog was in danger so a plan was devised to take a number of them and raise them indoors. But before the research team could act, the frogs were nearly gone. They were able to save a small number and were given space at a local bed and breakfast. It was referred to as the “frog hotel.”

Herpetologists David Wake and Vance Vredenburg wrote an article entitled, “Are We in the Midst of the Sixth Mass Extinction?” In the article, they refer to what is considered five foregoing mass extinctions. As a journalist, author Elizabeth Kolbert felt that there was a big story to tell. Elizabeth quickly made plans to visit Panama.

The El Valle Amphibian Conservation Center is dedicated to research on the Panamanian Golden Frog and other at risk amphibians of the region. Elizabeth met with its director, Edgardo Griffith. He was one of the first to notice the many golden frog corpses found lying about. The first speculation about the decline of amphibians in the region was met with general skepticism among researchers since amphibians are known to be great survivors. They have been around 400 million years which predates mammals.

The frogs were disappearing from pristine wooded areas as well as areas impacted by man’s expansion. At the same time, it surfaced that frogs were also disappearing from Costa Rica, California, Ecuador and Australia. Frogs raised indoors in control climates in the Washington, D.C. Zoo began to die off. A zoo veterinarian discovered that the frogs had contracted a chytrid fungi. Healthy frogs exposed to the fungi, also known as Bd, were dead within weeks. It caused heart attacks in the amphibians. It was learned that the fungi existed after killing off amphibians which prevented the team in Panama from returning the frogs to the forest. The fungi spread throughout South America, the U.S., Europe and Australia. Amphibians are currently considered to be the most ask-risk class of animals. There are other at-risk animals that rival this number one position: sharks, coral reefs, mollusks and rays and large number of mammals and birds.

Bd spores spread through the water. However, how it jumps from continent to continent is not fully understood. Some believe that it is spread through the shipments of the African clawed frogs which are not affected by Bd. North American bullfrogs have been exposed by Bd but do not seem to be affected. Scientists are certain that there is no way the fungi could have spread unless it was transported across the oceans.

Elizabeth accompanied Griffith and his team of researchers on a mission to collect new species from the Chagres National Park. Griffith found a San Jose Cochran frog, also known as the glass frog because of its translucent skin that reveals their internal organs. He only brought back the specimens that first night: two blue-bellied poison frogs and a white salamander.

Through the ages not much attention was paid to extinct animals. For centuries there was no record keeping of animals that had gone extinct. It wasn't until the time of revolution in France that the concept of extinction got attention when naturalist Jean-Leopold Cuvier of the Museum of Natural History in Paris began to study the American mastodon. The first mastodon molar was found in upstate New York in 1705 and sent off to London for study. The bones of a mastodon were discovered in 1739 by Charles le Moyne who was traveling down the Ohio River leading four hundred troops. He instructed his troops to pack up the bones which were later shipped to France.

The bones confounded the experts. The animal resembled an elephant but its teeth were not elephantine but rather carnivorous. Many naturalists thought the bones were from two or more animals. Fifty years after the bones were sent to France, Curvier began conducting research on them. He concluded that they were different species from elephants. He wondered what happened to the enormous animals and referred to them as lost species. He took note of other animals that had disappeared, leaving only bones behind. Curvier did not make a connection between the extinct animals and the concept of evolution, something he vehemently opposed. He did establish characteristics that distinguished herbivores from carnivores.

Jean-Baptiste Lamarck, a colleague of Cuvier, advocated the "power of life" which compelled an organism to become increasingly complex. He opposed Cuvier's extinction concept believing that there was no force that could wipe out a species. Curvier did not believe in evolution; for example, he did not accept that birds grew longer legs so they could wade in the water. However, Curvier did not have an explanation for the appearance of new species but that wasn't his focus.

Curvier initially believed that the mammoth and mastodon had been wiped out by a single catastrophe. Later, he decided that multiple calamities were to blame. He believed that animals that were functioning successfully would not die out from a minor catastrophe; therefore, he felt their extinction was caused by a great, unknown event. He looked to the Bible as well as to the Hindu religion for evidence of these event. Some took a published paper on his theory as proof of the Great Flood. Cuvier's theory has ultimately been proven wrong. However, his claims that there are life-changing events on earth that change the projector of species had credence. He was also accurate in his claim that the American mastodon had disappeared 13,000 years before.

Analysis

Author Elizabeth Kolbert wanted to convey to the reader what got her interested in the subject of extinction – especially an impending mass extinction. As a reporter and

author and someone interested in the topic of nature and mankind, Kolbert felt compelled to find out as much as she could about the sixth extinction that some naturalists and biologists feel the Earth is currently undergoing.

The importance of this section is that it lays out the premise for the rest of the book. She describes how the first bones of what would come to be called the mastodon were found and how that discovery fostered many theories including a new one called “extinction” and changed science forever. It also describes the devastation of one formerly robust species – the Panamanian golden frog – and how its extinction is taking place literally before our eyes.

Kolbert wants the reader to be aware of what is taking place on his planet and the threat that it presents to all species including man. Everyone should be aware of such a profound event.

Vocabulary

haunches, endemic, herpetologist, ubiquitous, disparate, etiology, nomenclature, temerity, lampooned, cataclysms, mutability, empirical

Chapters III - IV

Summary

In 1832 William Whewell, an early presidents of the Geological Society of London, coined the phrase, “catastrophist” a category which he claimed most scientists fell under. There as an exception in Charles Lyell, a friend and associate of Curvier, who Whewell termed a “uniformitarian.” In his research, Lyell found no evidence of a cataclysmic event. He believed that everything had developed at a slow pace over time. He included the process of extinction in these gradual changes. He felt that all species had existed in all times and that a species that was thought to be extinct could reappear. He was at odds with catastrophists who belittled his theory.

Lyell published three volumes on his research including “Principles of Geology” which was read with great interest by Charles Darwin. At 22 Darwin embarked on a journey to South America and parts beyond that lasted five years. Many scholars believed that upon seeing the wide variety of species in his travels Darwin developed his theory of natural selection. Darwin advocated Lyell’s theory that there was a balanced raising and lowering of terrain to maintain the globe’s balance. He believed that a series of earthquakes over time could create mountains. Lyell’s impact on Darwin was profound. Once biographer wrote that there would have been no Darwin without Lyell.

Lyell did not believe that one species gave rise to a new one. He did not have a cogent theory for the appearance of new life. In Darwin’s theory of natural selection, the organic world was subject to constant change that included human beings. His theory eliminated the need for divine intervention which Lyell eluded to in his work. Darwin’s departure from Lyell’s claims caused a split in their relationship. Darwin made a direct connection between evolution and extinction. His theory of natural selection was based on the extinction of species that lose advantage over other species. Extinction was driven by only natural selection. The processes proceeded in tandem with extinction occurring slightly more gradually.

At the same time naturalist Alfred Newton and John Wolley concluded that the great auk was extinct, Darwin issued his first paper on natural selection. Darwin had personally observed in the Galapagos Islands. The governor of the islands told Darwin that the tortoises on each of the islands had different shapes. Darwin also learned that seamen who landed there, carried off large volumes of tortoises to strengthen their provisions. One ship took 200 tortoises on one stop.

Darwin noted the decline in the number of tortoises. One of the species of the tortoises disappeared in fewer than 20 years after Darwin’s initial visit. Darwin wrote of animals becoming extinct “through man’s agency,” something which Darwin, oddly, did not seem to place much importance on. Darwin believed in the evolution of all species including man and that extinction was a natural consequence of evolution. But if man were

responsible for the extinction of some species, was that not a cataclysmic event against the species? If so, Cuvier was proved to be right.

Just beyond the small town of Gubbio, Italy, there is a gorge called Gola del Bottaccione. The walls of the gorge contain limestone evidence that the gorge had at one time been under the sea. There are millions of the remains of tiny sea creatures. Geologist Walter Alvarez wound up rewriting the history of life after visiting the Gola. He found evidence of the great asteroid that put a period on the end of the Cretaceous period. The asteroid wiped out 75%t of all species. Until that discovery, Alvarez had been a uniformitarian and believed in the theories of both Lyell and Darwin.

Alvarez saw a disturbance in the patterns of forams, tiny marine creatures, in the Gola. Large forams seemed to vanish around the time of the disappearance of the dinosaurs. Alvarez told his father Luis who was a Nobel Prize winner in the study of plate tectonics. Luis had samples of the Gola limestone tested and learned that the amount of iridium in the samples was off the charts. Iridium is a common element of meteorites. Tests run on samples collected from other locations around the globe had the same results.

Their conclusion was that 65 million years before, an asteroid six-miles wide had impacted the earth with a payload more powerful than a million H-bombs. Day turned to night, temperatures declined and the majority of species were wiped out. Walter's paper on the finding was published in 1980. His paper was met with everything from curiosity to complete contempt from scientists and paleontologists. Lyell had found time gaps between plants and animals in his research. But Lyell would not ascribe the intervals to a calamitous event. Darwin was aware of the lapses especially after the Cretaceous period. He noted the disappearance of ammonites but dismissed it as an imperfect record.

It was difficult for many scientists to accept that tens of millions of years were just missing and some began to consider the possibility of a mass extinction due to a calamity. But others, including renowned paleontologist George Simpson, were certain that Alvarezes were writing about an event that didn't happen and couldn't happen. Scientists were surveyed and few made a connection between a cataclysmic event that could have happened and extinction.

But evidence began to build for the Alvarez theory. Tiny grains of rock known as "shocked quartz" showed signs of high pressure that deformed the crystal structure. Post-Cretaceous sandstone in Texas showed evidence of a huge tsunami. A hundred-mile wide crater was discovered beneath the Yucatan Peninsula. The crater was the evidence that moved many other scientists into the Alvarez-impact column. Since the first discoveries, traces of iridium from the meteorite's impact have been found around the world.

Neil Landman, a paleontologist who specializes in the study of ammonites, had originally been taught in pre-Alvarez days that the sea creatures had declined throughout the Cretaceous period so the fact that they vanished was just a natural progression. It is thought that ammonites died out while other similar sea animals like

nautiluses survived the crisis because the ammonite eggs were extremely small and because newly hatched ammonites floated near the toxic surface of the water.

In his paper, Alvarez wrote that the cause of the extinctions was not the impact of the meteorite but, rather, the resultant heat and the dust and debris that lingered in the air. On land every animal the size of a cat or larger died. The casualty rate among the dinosaurs was 100 percent. Lizards, birds and birds were also hard hit. Sea creatures large and small were all decimated.

Analysis

In this section, Kolbert gets into the “why” of extinction. She describes the two theories that existed about. She describes the two fundamental theories about extinction. Conservative scientists in the early days in the study of extinction believed that extinction was an ongoing process with change so slow and subtle that most people didn’t even notice it. The other school of thought was more radical and touted the theory that mass extinction was due to a cataclysmic event.

An important element of this section is the introduction of two naturalists who were pioneers in their fields and belief systems. Charles Lyell believed that the earth changed gradually and was referred to as a uniformitarian – Earth changed only to right itself, to stay balanced. Young Charles Darwin was initially a devotee of the older Lyell and advocated his theory of background extinction that was nearly invisible. The two became friends and colleagues - however, that abruptly ended when Darwin developed his theory of evolution, which Lyell was adamantly opposed to.

Flashing forward to the 1970s, Kolbert describes a discovery by geologist Walter Alvarez that put an end to debate about extinction. He found extremely large levels of iridium where there should be none. In the end, this iridium and many deposits across the globe proved to be traced of the meteor that impacted Earth at the end of the Cretaceous period and wiped out all the dinosaurs. It was a cataclysmic event that caused the instantaneous extinction of thousands of species. It was not background noise – it was a catastrophe. This extinction was one of the five mass extinctions the preceded the current one. The author is conveying the importance of Alvarez’s discovery and how it changed life as science knew it.

Vocabulary

pejorative, catastrophist, neologism, uniformitarian, myopically, transmutation, archipelago, vehemence, manifestation

Chapters V - VI

Summary

In an experiment in 1948 conducted by two Harvard psychologists, student subjects were asked to identify abnormal playing cards among normal cards. Among the doctored cards were ones with “red spades” and “black diamonds.” When the cards were displayed rapidly, these doctored cards went unnoticed. When the cards were revealed more slowly, they students tried to explain what they were seeing but were largely confounded. Science historian Thomas Kuhn found that the study confirmed his belief that people try to justify misinformation when first confronted with it. In the world of science, accepted theories are defended when contrary evidence is initially presented. A paradigm shift takes place when someone is bold enough to accept the new data.

The history of the science of extinction went through a series of such paradigm shifts. “Extinction” didn’t exist until the end of the 18th century. When unknown fossils were discovered scientists tried hard to place them with an existing species. What the Alvarez-impact theory did was prove Lyell and Darwin wrong. The slow and lonely process of extinction that they described was debunked. Catastrophes did happen and they caused extinctions.

In the Southern Uplands of Scotland, Elizabeth heads to Dob’s Linn with geologists to look at layers of rock, some of which date back 445 million years to the end of the Ordovician period. During this period, Africa, South America, Australia and Antartica were all joined together to form one giant land mass called Gondwana. This period followed the Cambrian period in which there was an “explosion of new life forms.” During the Ordovician period, sea life flourished but it was followed by a period that saw 85% of sea life vanish. It became known as the first of the Big Five extinctions. The animals that survived the Ordovician extinction made it to the modern world.

One of the geologists accompanying Elizabeth is an expert in graptolite fossils. They were a diverse class of marine animals that were nearly disappeared during the Ordovician extinction. Graptolite fossils are plentiful in Dob’s Linn. Many marine species were wiped out and only a relative few graptolites made it through the extinction. Research and study revealed that a mass extinction occurs approximately every 26 million years. A group of astrophysicists put forth the possibility that a companion star to the Sun was producing comet showers every 26 million years as it passed through the Oort cloud. The Nemesis Affair gained the most interest as a reason for the extinctions. The idea of this mysterious death star was exciting but groundless.

Alvarez continued his search for iridium and discovered rock samples from southern China that fell between the Permian and Triassic periods. The extinction that took place during this time span was the most devastating and came close to obliterating all multi-cell animals. The iridium found in these layers of rocks was negligible. Something else had caused the extinction.

It is believed that the Ordovician extinction was caused by glaciation possibly caused by land mosses that sucked the carbon dioxide from the air. If that is the case, the first of the Big Extinctions was, therefore, caused by plants. The end-Permian extinction was caused by climate change. There was a huge release of carbon into the air which caused an imbalance in the seas and soaring temperatures. After the extinction period ended, ninety percent of all species on earth had been eliminated. One geologist believes that giant rats may take over the world after the next extinction. Rats follow man and, therefore, rats have been embedded into every area of the world.

Scientists have made suggestions about what to call the age ushered in by humans. One biologist suggested the “Catastrophozoic” era; another suggested “Homogenocene.” The suggestion of The “Anthropocene” era was suggested by Nobel Prize winning chemist Paul Crutzen who chose that name because of the damage that man is doing to the earth and atmosphere. Other scientists agreed that the “Antropocene” was an apt name for the era. The name will be voted on by the full body of the International Commission on Stratigraphy in 2016.

Analysis

In this section, Kolbert summaries the science of extinction to date. She describes her travels to far reaches of the earth to learn about the process of fossil research and how it is important for the tracing of extinction events in the past. She describes how paleontologists are able to determine the date of fossils and why it’s an essential element of their work.

The Ordovician period event was another mass extinction which was caused by glaciation which was possibly caused by a battle between animals and plants. Some scientists believe that man will eventually cede the planet to other species – like giant rats perhaps – an event which man himself will have caused.

Scientists have temporarily named Earth’s current time as the Anthropocene era. By definition an Anthropocene era is any period in which man’s activities have had an impact on the ecosystems of Earth. The name is going to be voted on in 2016 by the International Commission on Stratigraphy. Many feel it’s an appropriate name for the time since man is the major cause of this, the sixth big extinction.

Vocabulary

paradigm, evocative, vanguard, promontory, physiology, myriad, sequestered, obdurate, gelatinous, seminal

Chapters VII - VIII

Summary

Ulf Riebesell, a biological oceanographer, believes that one result of the acidification of the ocean is that there will be less diversity – fewer animals will survive. Ocean acidification played a role in at least two of the Big Extinctions. Ocean acidification damages the nutrients of marine animals and it impacts the bodily functions and systems. It will also change the way light is filtered through the water and they way sound is reproduced. The marine animals most affected by acidification are calcifiers which include star fish, sea urchins and animals that build a shell or external skeleton. Geologists believe that the vents have been spewing gas bubbles for several hundred years.

One-third of the CO2 that has been pumped into the air has been absorbed by the ocean which is 150 billion metric tons. The speed at which carbon is being absorbed by the ocean is extremely fast which makes it more dangerous. The speed in which the ocean is taking on the carbon is unprecedented. Continuing this trajectory, the resultant catastrophe will also be unprecedented.

One Tree Island is located south of the Great Barrier Reef, fifty miles from Australia. The only sign of humans there is a small group of researchers from the University of Sydney. Lyell had been fascinated by coral reefs. Darwin had visited Tahiti and was also enamored by them, calling them “amongst the wonderful objects of the world.” (129) Coral reefs are part animal, part vegetable and part mineral – both alive and dead. The expansive coral reefs have been building upon themselves for eons. Many researchers believe the reefs will be one of the first victims of the next extinction.

There are over a thousand species of trees in the Andes in Peru. Elizabeth joined Miles Stillman, a forest ecologist, and his students on a trek through the forests of Peru. Stillman established a few plots of trees to conduct research on the impact of climate change on the trees. It’s common knowledge that climate change will have a devastating impact on the polar caps. Stillman believes the threat to the tropics is just as great if not greater. The fundamental reason is that there are more animals and plants in the tropics. Organisms can produce more offspring in the tropics. The chances of producing mutants and thus new species are also more possible. The tropics are old and have had more time to produce diverse species.

As they walked through the forest, they came across numerous new species of plants and trees. Each of Stillman’s tree plots are two and a half acres and are arranged along a ridge at different elevations. Every tree over four inches in diameter is tagged and catalogued. Due to the different elevations, each plot has a different mean temperature. Different species are found in every plot. Climate change can cause tree migration. Trees don’t actually move but due to the change in temperature can disperse their trees at higher elevations.

Temperatures change all over the globe and organisms have learned to cope with normal fluctuations. The first 40 million years that earth existed was a cooling stage. Once global temperatures had declined sufficiently, ice began to form on the polar caps. Then the earth entered into periods of glaciations with large ice sheets moving across the Northern Hemisphere and then melting away 100,000 years later. Even by the late 19th century, scientists didn't know what caused the ice ages. By well into the 20th century experts concluded that the ice ages were caused in slight deviations of the earth's orbit. Darwin believed that animals survived the Pleistocene in which the freeze-thaw process repeated twenty times because they migrated to more temperate areas. The temperature swings in the coming century are expected to be similar to those of the ice age. However, the difference is the pace of change is ten times faster. Animals will not be afforded as much time to cope with the changes.

The group looked for a small black toad, the Rhinella manu which was an indigenous species in Peru. After looking for it all day, they team hadn't found one. Elizabeth had heard that the chytrid fungus had spread to Peru. While looking for the frog, Sillman discovered a whole new mustard plant species. They collected seeds from a new genus of tree on one of his plots to send back to the lab for analysis.

A group of scientists used the SAR formula to estimate the extinction risk that global warming presented. On the conservative side, the results was if the current trend continued, between 22 and 31 percent of species would perish by 2050. Reaching the likely maximum temperature, the range would be between 38 and 52 percent. Another research group arrived at lower numbers Taking the average of both, 24 percent of all species would be extinct by mid-century 2000. The maximum figure looks too low now. A second scenario in which species were more mobile was more optimistic. There is great controversy over these findings. Many believe that climate change will lead to an extinction that is slightly less than the Big Extinctions.

Stillman's research suggests that global warming will restructure ecological communities because different trees will respond differently to temperature changes. Trees are like coral reef in that they structure the ecosystem. Some plants may thrive but others will die off. There is evidence of the migration of animals due to climate change. Some species that are now found just in the tropics had in the past lived in other regions. Animals have learned to cope with the cold but they have not learned to cope with heat because temperatures have never risen to extremes. Whether animals possess the internal ability to cope with excessive heat is not known.

Analysis

The author describes the huge threat to the coral reef systems of the world due to the CO2 that has inundated the air and fallen into the oceans which causes harmful acidification. The coral reefs around the world are living creatures that provide nutrients to thousands of other species.

There are signs that the acidification is beginning to deteriorate some of the reefs. The reef is the apex species in the marine ecosystem. If that disappears, so does the ecosystem and so do many marine species. Once this occurs, devastation would also follow onto land.

The calculation that scientists use to predict the extinction risk due to global warming is also described. There are estimates that between 22% and 52% of all species will be extinct by 2050 due to the effects of global warming.

The author explains that global warming has only have to rise seven degrees to cause the thawing of the glaciers, the drowning of islands and coastal cities, wildfires in some regions and the melting of the ice caps.

The author provides this dire information because it may well happen in the lifetime of many readers according to experts.

Vocabulary

incongruity, flotsam, conquistadors, verdant, luxuriant, salient, asymmetry, estivate, arcane, taxonomic

Chapters IX - X

Summary

Reserve 1202 in Brazil could be compared to an island in the center of the Amazon. The foliage there is so dense that it can seem like night in the day time. The reserve is 25 acres of pristine rain forest. Reserve 1202 is part of an archipelago of Amazonian islands which together are the longest running experiment in the world which is named the Biological Dynamics of Forest Fragments Project or BDFFP. Researchers from all over the world come to the reserves.

There are fifty million miles of land on the planet that are ice free. Man has transformed half of this land by converting it to farmland and building cities. Wildlands are those areas that are largely untouched by man which represents eleven million square miles. Still, there are things like pipelines and hydroelectric plants that intrude on these lands. Reserve 1202 represents the state of the world.

Elizabeth visited the reserve with Mario Cohn-Haft an ornithologist. There are said to be 1,300 different species of birds in the Amazon but Cohn-Haft thinks there are more that just haven't been identified. Through his research, he learned that higher temperatures would not create a new equilibrium with fewer species; it would just be a steady devastation in diversity.

Cohn-Haft explained that that there are mega-diverse ecosystems where every species is extremely specialized. On a trek in the woods, they came upon a column of army ants. These ants stay on the move and eat constantly. A number of species of birds follow the ants and eat off them. Research indicates that as many as 300 species benefit from the army ants. There are about 50,000 species of beetles in the Amazon and as many as 30 million species of arthropods – insects, spiders and centipedes. Some believe that number is too high but all agree that there are millions of insect species in the Amazon. By comparison there are only 5,500 species of mammals and 10,000 species of birds in the entire world. This means that the number of extinctions in the Amazon would be astronomical.

While some experts claim that tropical deforestation is responsible for destroying one species each hour, others ascribe to the theory of extinction debt which means there is a lag in the extinction process. The forests of the Amazon have an amazing resiliency; after deforestation, it can return to flourish. Since the majority of species are insects, it is difficult or even impossible to notice when one or 10,000 have been devastated.

Tom Lovejoy, a scholar in biological diversity, provided some conclusions that can be taken from the Amazon reserves. Changes in land can impact the atmosphere. Could the disappearance of the rain forest make the rain stop? Species that are sensitive to change in heat and light have decreased markedly. Migrating birds are not likely to survive global warming because the destinations of their migration have also undergone

change. The profound impact of climate change on species is the domino effect – when one species is threatened the others that in some fashion depend on it also are weakened and vulnerable to extinction.

The study of bat populations is best done in the winter when they are hibernating. A group of biologists conducted a bat census in a cave near Albany, New York. There were dead bats everywhere that looked like they'd been dusted with talcum powder. The scientists were confounded and hoped that it was an anomaly. But the next winter, it was worse – more bats and caves were impacted with the mysterious malady which had also spread to surrounding states. The white powder was discovered to a fungus known as psychrophile that originates in Europe.

Without man's help, long-distance migration of species is not possible. Different species evolved on each of the continents. This isolation created global diversity. Darwin, after noticing the great diversity on the Galapagos, was mystified as to how their ancestors got to the island. He did experiments with seeds crossing waterways but couldn't account for the migration of animals across 500 miles of ocean. Perhaps there had been ocean-spanning land bridges in the distant past. The present-day continents had formed one supercontinent called Pangaea. The modern world has been made small by the ability to travel quickly and easily and accounts for the migration of many species.

White-nose syndrome spread and killed a million bats. The fungus eats at the bats' skin which causes them to burn their fat storage for winter. The bats also lose moisture through their skin because of the fungus. The migration of species is not always successful. Sometimes the new climate is not right. The second result is that the species succeeds in his new environment and established the species into the new location. A third outcome is after establishing itself, the species spreads. Why some transplanted species flourish is not clear. For one thing, the species left behind its enemies and perhaps found new sources of prey. Some scientists compare this behavior to that of humans.

When a new pathogen is introduced into an area, the species who inhabit it have no natural defenses against it. Chestnut trees were practically wiped out by a fungus that had been imported into America. There are efforts to hunt down and isolate species that have been transplanted into regions where they are disrupting animal or plant life. The floor of Aeolus Cave in Vermont was coated with dead bats. It was a cave that a variety of bats had hibernated in year after year.

Infected bats transfer the fungus to healthy bats that then disperse it to other caves. In 2010, there were only a thirtieth of live bats compare to other years. The fungus was traced to Europe where it is widespread. It is not lethal to some bats which indicates they and the fungus evolved at the same time. By 2013 white-nose had spread to 22 states and five Canadian provinces and killed more than six million bats. The brown bat that was not long ago abundant is now on the endangered species list.

Analysis

This section focuses on how the overuse of land by man is forcing species out of their natural habitats. When they flee to other areas, they face disease for which they have no immunity and are vulnerable to predation for which they have no knowledge or built up defenses. It is another way that man is causing the extinction of other species. Some experts believe that man's current deforestation of the Amazon is causing the extinction of one species per hour. Changes in the land can also impact the atmosphere which then has a debilitating effect on the oceans.

The author underscores how man's hand is in the extinction of many other species. Many has also been largely responsible for the transference of species from their natural habitat to new territories. When this occurs, the species are not equipped to handle their new surroundings and their fragile lives become at risk.

The author describes the thousands of dead bats she personally observed in a cave in New England. The bats were dying off from a fungi called white nose syndrome which was a pathogen that originated in Europe. Man was the intermediary that somehow transferred the disease to the U.S. Bats down fly across the Atlantic. In the end, millions of bats were killed and many bat species are now on the endangered list.

Vocabulary

depauperate, corollary, extrapolate, baroque, lethargic, sepulchral, torpor, innocuous, proliferate

Chapters XI - XIII

Summary

Suci, a Sumatran rhino, lives at the Cincinnati Zoo where she was born in 2004. The Sumatran rhino is the smallest and oldest of the five existing rhinoceros species. It is the closest descendent of the wooly rhino. Suci is often described as a living fossil. The zoo had been trying but failed to artificially inseminate Suci. The Sumatran rhino became endangered when its natural habitat in parts of Asia and India began to shrink. Sumatrans were captured for a breeding program in an effort to avoid the animal's extinction. Of the forty captured, many died from disease or injury but none produced offspring.

The Bronx and Los Angeles Zoos sent their Sumatrans to the Cincinnati Zoo which had the only bull in hopes of breeding success. After many disappointments and miscarriages, Emi, the female from Los Angeles, and Ipuh, the bull had two males and one female, Suci. It appears these captive-bred Sumantrans were the only ones to be born anywhere in the past30 years. There are fewer than 100 left in the world. Humans caused its decline and now humans are trying to save it. All the other species of rhinos are in decline. Most bears and elephants are on vulnerable or endangered lists. Most large cats are also in decline.

Each era had its share of large animals that thrived on every continent and even on islands. Scholars were faced with a question they could not readily answer: why did so many large beasts die off? Large animals in today's world are endangered for extinction. In the late 18th and early 19th century there were literally tons of big bones taken from a region near the Cincinnati Zoo called Big Bone Lick. It was the region that Longueuil found the mastodon tooth that was to inspire Cuvier's theory of extinction. A sign displayed at the Big Bone Lick display placed the blame for the disappearance of large mammals on climate change and/or their slaughter by paleo-Indians. Lyell supported the first cause while Darwin thought man's agency was involved. If the latter is right, the current extinction event started in the ice age and man was a killer of the species of that period.

The Neander Valley is north of Cologne. In German, its name is Das Neanderthal. Bones of the Neanderthal man were found in a cave in the valley in 1856. Since then, many Neanderthal bones have been found all around Europe and the Middle East. Also found are tools and implements used by this early man. The Neanderthals populated Europe for 100,000 years. They vanished 30,000 years ago. Climate change and disease have been blamed. Modern man made his appearance 40,000 years ago, and there is speculation that the Neanderthals were pushed out by this superior species. Modern man had sex with Neanderthals and many people today have a Neanderthal heritage.

Svante Pääbo is the head of the Max Planck Institute for Evolutionary Anthropology near Neander Valley. He is known as the father of paleogenetics. He undertook his latest project to sequence the entire Neanderthal genome in 2006. Although skeptics insisted that the bones found in the Neander Valley cave were those of modern man, more and more bones found displayed thicker skeletons and odd-shaped skulls.

Pääbo obtained 21 Neanderthal bones for his study, three of which had Neanderthal DNA which began to yield results. The DNA sequences were similar to human sequences but shares more similarities with Asians and Europeans than Africans. This finding questions the long-held belief that man came “out of Africa.” There are indications that instead of overkill the Neanderthals were replaced through “leaky replacement.” This theory holds that the Neanderthal faded out natural but had sex with modern man and help population Europe and the Middle East.

One big difference between archaic and modern man is that the former did not cross water to inhabit other lands. Pääbo would like to find the mutation in modern man’s DNA that made him a risk taker, an explorer who did not stop at the water’s edge but rather explored and, therefore, inhabited other lands. He referred to it as the “madness” gene. A finger bone was discovered that belonged to an unknown group of hominid which Pääbo called the Denisovans after the Denisova Cave where it had been found in Siberia. There is no evidence as to what wiped out the Denisovans or the Hobbits bones of which were discovered in 2004 in Indonesia. Some experts hold the belief that if modern man had not showed up there would still be Neanderthals, wild horses and wooly rhinos.

Human beings can cause destruction of the earth and its species but they can also take steps to save them. Alfred Newton described the devastation along the British Coast resulting in the Act for the Preservation of Sea Birds. John Muir shed light on the damage being down to the mountains of California which resulted in Yosemite National Park. Several years after DDT was banned, the U.S. Congress passed the Endangered Species Act. Great lengths were made by humans to save the U.S. condor.

The San Diego Zoo keeps a Hawaiian crow named Kinohi. He is one of about 100 Hawaiian crows that still exist in captivity – none are found in the wild. It probably became extinct because of predation, loss of habitat and disease. The zoo wants to use his sperm to artificially inseminate one of the captive females.

Elizabeth Kolbert has tried to capture not only the individual stories of extinction and human efforts to save them but also to place this possible sixth extinction within the framework of history. She has learned that life is resilient but within limits. There have been specific reasons for extinctions – glaciations, global warming or the impact of an asteroid. The current event can be attributed to mankind. What each extinction has in common is that there is change that is too rapid for certain species to adapt to in time to save themselves. People do care about other species and extinction. However, the human is wired to explore, discover and advance its own kind.

A plaque on the wall of the American Museum of Natural History's Hall of Biodiversity notes that Earth is in the midst of the sixth mass extinction the cause of which is man's "transformation of the ecological landscape." Experts hint at man's ultimate undoing at his own hand through the disturbance of nature – cutting down rainforests, polluting the atmosphere and acidifying the oceans. Man might ultimately be a victim of the on-going extinction event. If global warming is not dealt with, the atmosphere could be re-engineered or man could resettle on another planet. Exploration could lead to the survival of man even if giant rats take over the planet known as Earth.

Analysis

In this section, Kolbert describes the heroic efforts that scientists are making to save the Sumatran rhino. There are only a relative handful of these beasts left in the entire world. The animals were abused and slaughtered by man in their natural environments. She points out the irony of how man often causes the endangerment of animals and it is man who tries to save them – different men but still man.

There is focus on the Neanderthal and his relationship to modern man. One scientists is attempting to develop a full sequencing of Neanderthal DNA. Their extinction may well have been at the hands of modern man who were more advanced and wily and eventually pushed them out of their natural habitat only to become weakened and ultimately perish.

Modern man has the "mad gene." He is not happy with where he is; he wants to know where he's going. He is the species that crossed oceans to see what was on the other side. He climbs mountains, as someone once said, because it's there. These are admirable qualities but it is this behavior of modern man that has helped caused the extinction of other species. Man is a paradox. He kills tigers and then tries to save them. He inundates the oceans with CO2 and then tries to rectify it. Perhaps man can find a way to reengineer the atmosphere and make it livable in spite of global warming effects. Or maybe he can find a new planet and leave the old one in his dust… and debris and heat.

Vocabulary

prodigious, formidable, euphemistically, lugubrious, coniferous, Paleolithic, genome, capacious, futurology, caveat, altruistic

Important People

Jean-Leopold Curvier

It wasn't until the time of revolution in France that the concept of extinction got attention when naturalist Jean-Leopold Cuvier of the Museum of Natural History in Paris began to study the American mastodon. Curvier was a visionary and saw the tragedy that lay ahead for Earth and all its species including man.

Bones of a mastodon were first discovered in what is now the Ohio Valley in the United States. Through a sequence of events, the bones wound up in Paris, France and 50 years after being discovered Curvier began conducting research on the fossils. Although some scientists were certain that the subject of much controversy, it was Cuvier who first concluded that the fossil bones did not belong to elephants as was widely believed. He wondered what happened to the enormous animals and referred to them as a lost species. He took note of other animals that had disappeared, leaving only bones behind. His curiosity led to the theory of extinction.

Cuvier had concluded that a whole world existed of lost animals. He dedicated himself to finding evidence of these animals. Bones were sent to him and he solicited them from other naturalists and from all over the word. Some of the bones he had possession of have never been identified to this day. Cuvier traveled to other museums and research labs to study other fossils. In most cases he determined that the fossil bones had links to living animals. He identified one set of fossil bones as a flying reptile and called it the ptero-dactyle or Pterodactyl in today's parlance. In 1806, Cuvier finally named the mysterious animal found in the Ohio Valley the mastodonte. In 1812, Cuvier published a book on his findings on extinct animals, listing species that had proof of having lived on earth but were lost. Although Cuvier did not ascribe to the theory of evolution, he was more advanced than many of his contemporaries in his acknowledgment and understanding of the extinction process.

Charles Lyell

Charles Lyell was a naturalist and a uniformitarian who believed in the gradual change of the Earth and all its species. He did not ascribe to the more popular catastrophist philosophy with held the belief that change, especially mass extinction, was due to a cataclysmic event. He sloughed off evidence to the contrary by commenting that the records were unreliable. He felt that species thought to be extinct could one day appear. He wrote his ideas and beliefs in a three-volume work that was entitled "Principles of Geology: Being an Attempt to explain the Former Changes of the Earth's Surface by Reference to Causes Now in Operation."

The volumes were written in layman terms and became very popular among the general public. Young Charles Darwin was also quite inspired by Lyell's work, and the two later

became colleagues, but their relationship ended when Darwin developed her own theory of evolution, which Lyell did not agree with.

Charles Darwin

Darwin was just 22 and a recent graduate of Cambridge, when he was invited to tag along on the HMS Beagle by Robert FitzRoy.The ship was heading to South America for survey and remapping work. One of the goals of the voyage was to map out a map that allowed easy access to the Falkland Islands which had recently become a British possession.

The voyage lasted seven years and traveled far beyond South America. The Beagle traveled through the Strait of Magellan to the Galapagos Islands and across the South Pacific to Tahiti, Australia, New Zealand and through the Cape of Good Hope winding up in South American again. It was on this voyage that Darwin became familiar with the work of Charles Lyell. The Captain gifted Darwin with a copy of Principles which Darwin soaked up like a sponge. On the trip Darwin saw hundreds of different animals and species and experience which would later impact his theory of evolution by natural selection. Darwin became an advocate of Lyell's theories that the earth and its species underwent slow change. The two men became friends and colleagues.

However, as Darwin studied and conducted more research he developed the theory of evolution which was called transmutation in England at the time and it was something that Lyell was vehemently against. Although their relationship virtually ended over this disagreement, one Darwin biographer wrote that there wouldn't have been a Darwin without Lyell.

David Raup

David Raup is a paleontologist who believes that for the most part the large majority of species are not at risk for endangerment or extinction. But there are rare periods of devastation that place these same species at higher risk.

Pascal Tassy

Pascal Tassy is the modern-day director of the Museum of Natural History and specializes in the study of proboscideans an animal group that includes elephants, mastodons and mammoths. Elizabeth visited the museum and was shown the mastodon bones were found in Ohio. The largest tooth was eight inches high and four inches wide. Tassy praised the early work of Curvier who was a pioneer in the study of the extinct animals.

Charles Willson Peale

Charles Willson Peale established the first natural history museum in America in Philadelphia. He gained possession of the complete skeleton of a mastodon and presented it for viewing in 1801. It was referred to as a “mammoth” and became the rage of America and Europe.

Mary Anning

Fossilist Mary Anning discovered the first dinosaur fossil which was first thought to be a large bird. Another dinosaur fossil was called the “plesiosaur” or “almost lizard.”

Thomas Jefferson

Thomas Jefferson weighed in on the mastodon controversy. He wrote in his “Notes on the State of Virginia,” in 1781, that the animal was larger than beasts in Europe and was probably roaming around somewhere in Virginia. When he was president, he sent Lewis and Clark off to the Northwest with the hope that they would find a living example of the beast.

Jean-Baptiste Lamarck

Jean-Baptiste Lamarck was a colleague of Jean-Leopold Cuvier’s and a proponent of “transformisme” which was the French word for what later became known as “evolution” a theory which Cuvier was adamantly against. Lamarck believed that there was a “power of life” force that compelled species to become increasingly complex and therefore resilient to environmental change. Lamarck, however, did not agree with Cuvier that there was an extinction process. He could not fathom an event that was capable of wiping out entire species.

Charles Lyell

Charles Lyell was a young geologist in the early 19th century. He did not believe that cataclysmic events caused disruptions or extinctions in animals and plants. He was what was termed a “uniformitarian,” a scientist who believes in the slow and natural progress of life on earth. He was diametrically opposed to Cuvier’s theory of cataclysmic extinction. He believed that the earth and its inhabitants were the result of very gradual processes that took place over eons. His belief in extinction did not go beyond what is referred to in modernity as background extinction.

William Whewell

The word “catastrophist” was coined by William Whewell in 1832. He was one of the first presidents of the Geological Society of London. He also gifted the English language with such words as “anode,” “cathode,” “ion,” and even “scientist.” Whewell considered himself to be a catastrophist – a scientist who believe that change including extinction is the result of a cataclysmic event that has profound and far reaching impacts on Earth and its inhabitants. Most scientists tended to agree with Whewell and also considered themselves to be catastrophists.

Walter Alvarez

Walter Alvarez is the first scientist to offer the theory that the Cretaceous extinction was due to the impact of a massive asteroid. Alvarez was a geologist who in the late 1970s came to Italy to study the Apennine Mountains but wound up making an earth-shattering discovery that changed life as science viewed it from that point on. In conducting his geological research on samples taken the Gold del Bottacione gorge in Gubbio a few hours from Rome, he found unusually high traces of iridium which is the main element of meteors. He took the matter to his father, Luis, who was a Nobel Prize winning scientist who confirmed that the level of iridium found in the gorge had to have come from a meteorite. Ultimately, Alvarez issued these findings and, not surprisingly, they were met with much skepticism. However, as scientists pursued the theory, unusual levels of iridium was found around the earth forcing them to believe that the earth had been struck by an asteroid that destroyed the dinosaurs and many other species at the end of the Cretaceous period.

Charles Elton

Charles Elton was a British biologist and the author of “The Ecology of Invasions by Animals and Plants” in 1958. He wrote about the often disturbing impact of moving species from their natural habitat. He was concerned that indigenous species would be forced out by new species and that ultimately the biological world would become simpler and poorer. He worried about losing the variety and richness of diverse species that the earth was home to.

Svante Pääbo

Svante Pääbo heads the evolutionary genetics department of the Max Planck Institute for Evolutionary Anthropology in the city of Leipzig, Germany. He is often called the father of paleo-genetics. He was one of the pioneers in the study of ancient DNA. In 2006, Pääbo took on the challenging project of sequencing the entire Neanderthal genome. Once completed, the strand can be compared by laying it next to the DNA sequencing of human DNA and point-by-point be able to analyze and ultimately understand the similarities and differences between the two species.

David Jablonski

David Jablonski is an expert in the field of biology and he views mass extinctions as “substantial biodiversity losses” that occur rapidly and have global reach.

Dr. Terri Ross

Dr. Terri Ross is the director of the Cincinnati Zoo’s Center for Conservation and Research of Endangered Wildlife. Ross was dedicated to saving the Sumatran rhino and oversaw the artificial insemination of Suci who was a resident of the zoo. Suci is one of only a handful of Sumantrans that still remain all of which are in captivity.

Objects/Places

El Valle de Anton

The town of El Valle de Anton in Central Panama is the site of a four-mile wide volcanic crater that was formed some one million years ago. The frogs are highly toxic and it is believed that the venom of just one frog could kill a thousand mice. It is the home to the El Valle Amphibian Conservation Center that is dedicated to the study and research of the Panamanian Golden Frog and other amphibians of the region.

The Panamanian Golden Frog

The Panamanian Golden Frog is endemic to Central Panama and is considered a symbol of good fortune. It is referred to as taxi-cab yellow with brown splotches. Figures of the frogs in a variety of poses can be found in all the tourist shops. Although it was abundant in the not too distant past, they began disappearing and by 2002 they were gone.

Background Extinction

There are two basic kind of extinctions – background extinctions and mass extinctions. During a background extinction, the disappearance of species takes place rarely, even more rarely than speciation, and occurs at a background extinction rate. There is a complex calculation that determines a background rate of extinction for an animal. Currently there are about 5,500 species of mammals. The background extinction rate is at .25 per million species per year. At that rate, one mammal will go extinct every seven hundred years.

Panamanian Ants

When author Elizabeth Kolbert was traipsing through the jungle in Panama she noticed small paths that crossed the main path every few hundred yards. The paths were made by leaf-cutter ants that make millions, even billions, of trips to fetch greenery for their colonies. Some of these colonies which look like sawdust can ultimately be the same size as a city park. She was warned to stay away from soldier ants. They would leave their jaws in her shin even after they die.

Fossil Dating

Scientists knew that fossils could be dated by the layer of rocks in which they were discovered. For example, dinosaur bones were placed in the Mesozoic era by virtue of the rock layers they were found in while the fossils of mastodons and similar creatures

were found closer to the surface of the earth than were dinosaurs. Those animals closer to the surface lived fewer eons ago than did those buried in deeper layers.

Catastrophist v. Uniformitarian

In the early days when the process of extinction was largely just a theory, scientists came down on two sides of the issue as for as its cause. William Whewell was a British geologist in the early 19th century. He coined the phrase “catastrophist” which described a scientist who believe that catastrophes were behind extinctions. On the other side of the issue, there was the “uniformitarian” who believed that the state of the Earth and all its inhabitants were the result of a slow process that brought about change in a gradual almost imperceptible manner. They, in fact, believed that change was so rare and slight that much of changes that occurred were virtually invisible and unnoticed by the common man.

SAR

One concept that is universally accepted in the field of ecology is species-area-relationship or SAR which basically means the larger the area the more species there are. The formula is S =cAz and it holds true no matter what the territory or terrain from rain forest to island. Humans are destroying the world because they are changing the value of “A” which is area. When man builds modern buildings or highways in grassland, a great number of species are displaced.

Global Warming

The island of Castello Aragonese in the Tyrrhenian Sea west of Naples, Italy, is being pushed by the African plate toward Eurasia, moving an inch or so closer to Rome each year. Streams of gas bubbles up from vents on the sea floor. Humans have burned through fossil fuels – coal, oil and natural gas – which have added 365 billion metric tons of carbon into the air. The average global temperature is expected to rise seven degrees F higher which will trigger global events including the melting of the glaciers, the drowning of islands and coastal cities and the melting of the Arctic cap. Additionally, the oceans will be inundated with carbon, some of which will be retained making for toxic conditions. The acid reduces the pH balance. The biologists believed that this area represented what the future of the ocean would be like. In the waters far from the vents, the assemblage of fish was normal. The scientists found that certain fish failed to assemble closer to the vents. The ecosystem completed crashed at pH 7.8 which is where scientists expect the ocean to be in 2100. Much research has been on acidification subsequently confirming these findings.

Relaxation of Species

Actual islands, surrounded by the ocean, are generally species-poor. This is true no matter how distant or remote an island is from a land mass. It is believed that the relative small size of an island inhibits diversity. The relaxation of species, a term for their disappearance, happens over time. Relaxation is explained by the experts as the result of smaller areas and smaller populations making species vulnerable to happenstance. The re-colonization of a species on an island is nearly impossible.

Transplanted Species

There are a variety of ways that species move across oceans to other lands. Sometimes the results are disastrous. Settlers that crossed the Bering land bridge into the U.S. brought domesticated dogs with them. The Polynesians who settled Hawaii brought rats, lice and fleas with them. Members of an acclimatization society advocate the release of species into new areas. Garden catalogs are filled with non-native plants and pet shops sell non-native fish. Exotic animals are brought into new regions as pets. Pythons have been released into the Florida everglades and have become a huge threat to the swamp's ecosystem. New species have a better chance of weeding out indigenous species because they left their enemies behind and initially are not vulnerable to predation. The number of Hawaii's indigenous species has decreased. The total number of species worldwide is also on the decline.

Mass Extinctions

Mass extinctions are the polar opposite of background extinctions. They occur from an event and the extinction rate of species is rapid and spectacular. Such an extinction has been described by British paleontologists Anthony Hallam and Paul Wignall as a "significant proportion of the world's biota in a geologically insignificant amount of time." The losses are global, profound and at a rate that is fast relative to the framework of geological time.

Themes

The Five Extinctions

“The Sixth Extinction” is based on the possibility of a new mass extinction that follows five preceding extinctions. If the species of the world are going through a new extinction process, it probably started in the Ice Age. Therefore, although in the context of Earth’s age the Ice Age isn’t that long ago, it can readily seen that the process of extinction is a very slow one in terms of modern man’s view of it.

The authors of an article in the Proceedings of the National Academy of Sciences by herpetologists David Wake of the University of California-Berkley, and Vance Vredenburg, of San Francisco State, caught author and reporter Elizabeth Kolbert’s attention. The article entitled, “Are We in the Midst of the Sixth Mass Extinction?” intimated that the Earth and many of its species may be in the process of the next mass extinction.

The previous mass extinctions have been a debilitating force that led to a “profound loss of biodiversity.” The first mass extinction took place late in the Ordovician period, 450 million years ago. At the time most life was limited to the water. The most devastating extinction event that scientists have been able to isolate is one the one that occurred during the Permian period which was 250 million years ago. This extinction is sometimes referred to as the “mother of mass extinctions” and “the great dying.” During the years that this extinction had a grip on the Earth and its species, it nearly wiped out all forms of life.

The most receipt extinction prior to what some feel is the sixth extinction that is currently occurring was in the Cretaceous period which is one that is probably most familiar to students and the general public. During this extinction the dinosaurs vanished – the plesiosaurs, mosasaurs, ammonites and pterosaurs all disappeared forever.

Wake and Vredenburg based their theory on the dramatic decline in amphibians which are hardy animals that usually make it through harsh conditions. Frog and toad populations are particularly hardy. Once flourishing in numerous areas around the globe, their populations are declining and scads of frog and toad corpses are being found where the animals once thrived.

Amphibians

Amphibians are in the dubious position of spearheading the current mass extinction if, indeed, it is actually occurring. With the rapid devastation of the Panamanian golden frog, it is difficult for naturalists or biologists to deny the existence of a far-reaching and on-going process that is destroying a once robust species which is now considered endangered and vanishing. A fungi has been identified as the cause behind the massive losses of the golden frog as well as other frogs around the world. Scientists do agree

that it is unusual for an amphibian to be at the lead in this current leg of the extinction event. The cataclysmic nature of the devastation that amphibians are currently undergoing points to the sixth mass extinction event known to have occurred on Earth.

Several decades back when the devastation of frog populations came to the forefront, there was initially general skepticism. Amphibians were hardy creatures that made it through mass extinctions in the past. They were small and resilient creatures unlike giant herbivores or humongous dinosaurs that were vulnerable to cataclysmic events that led to mass extinctions. The distance ancestors of the modern frog crawled out of the seas over 400 million years ago. From that earliest amphibian the modern frog, toad, salamander and other species have evolved. Amphibians were around when dinosaurs roamed the Earth.

The name itself portends survival – “amphibian” is Greek for “double-life.” Frogs produce offspring at a prolific rate being able to lay their eggs in streams, pools, underground and in nests and some species even carry their eggs on their bodies. In other words, frogs do not have a fragile or limited system of reproducing their young and therefore their populations have boomed. Worldwide more than 7,000 species have evolved from that first creature that dragged onto the shore from the ocean. Although concentrated in the tropics, these resilient creatures have survived in deserts and in North American winters. Some species have been frozen like popsicles in the cold only to thaw and hop away into the spring.

What was disturbing to scientists was that once pristine locales where frogs were abundant saw a rapid and dramatic drop off in populations. What has frightened naturalists and researchers about the future for all species is that amphibians, the old reliable survivor of eons and eons, are now listed as the most endangered class of animals. It does not bode well for the thousands and thousands of other species that live on Planet Earth.

Extinction

French naturalist Jean-Leopold Cuvier was the first scientist to put forth the theory of extinction in the late 18th century. He studied fossils that were discovered in what is now the Ohio Valley in the United States. These large bones confounded everyone. They appeared to be elephantine and many scientists wanted to pigeon-hole them into some early elephant species. But Cuvier saw too many dissimilarities. He went on to name this fossil the mastodon and therefore proclaimed the discovery of an entirely new species that once roamed the earth.

This discovery led Cuvier’s interest in what happened to this “lost” animal. As time passed, more and more fossils were found and sent to Cuvier that could not be identified with current animals of the time. There are some fossils that Cuvier had in his possession that have not been identified or categorized to this day. Cuvier was a charming and persuasive man and had success on a lecture tour on “the species of elephants, both living and fossil,” and was able to convince the scientific world of the

process of extinction as a fact. Cuvier rightly pictured an entire lost world of fossils representing animals that once lived but were no more. Cuvier dedicated his life to discovering as many of these fossilized animals as possible. Cuvier did not believe that extinction was caused by evolution, a theory that he adamantly did not adhere to.

There had been disagreement for many years about the cause of the lost animals. There were scientists who believed that extinction was a slow and gradual process that created such slight change that it often went by unnoticed. Others scientists were catastrophists who believed that mass extinction events occurred in the past and wiped out entire species in a rapid and devastating manner. In the 1970s, evidence was found by geologist Walter Alvarez whose accidental discovery led to what was the upheaval of life as it was known up to that point. He found high levels of iridium in places where the chemical shouldn't be at all. With this help of his Nobel Prize winning scientist father, Luis, it was confirmed that the iridium was the major element of meteors. Father and son presented the theory that a massive asteroid had impacted the earth and brought about the extinction of the dinosaurs of the Cretaceous period. They had proved that mass extinctions are brought about by cataclysmic events. While background extinction is an on-going process, the scientific world were forced to agree that mass extinctions occurred because of major catastrophes.

The Disappearance of the Great Auk

The process of extinction is more meaningful when an account of the disappearance of an actual animal is described. There were several such instances in the book but one of the more dramatic extinction episode centered on the Great Auk. Though it was said that this once great and plentiful bird is gone forever, his vanishing led to a law that protected other sea birds.

The Great Auk is one species that literally disappeared before man's eyes. Darwin's theory of natural selection was rocked by the disappearance of the great auk. While he holed up in his residence and worked on his theory of evolution no one could find even one auk. Elizabeth visited the Icelandic Institute of Natural to learn about the auk which was last known to live in Iceland. The institute's deputy director showed her the great auk's stuffed remains. This particular bird was killed in 1821 in an accident and was one of the last auks to exist. At its most populous, auks numbered in the millions worldwide.

They have sometimes been called the first penguin but auks are in a different species, the same one as puffins. Flightless auks were plentiful and were hunted and consumed by humans. Auks were abused by humans and used for bait and exploited for their feathers. Penguin Island, now known as Funk Island, was off the coast of Newfoundland and teeming with birds, particularly auks. At one point, 100,000 pairs of great auks were found and were tending to a 100,000 eggs. By the late 1700's the birds were in great decline due to the lucrative market for the auk feathers. It is unknown if the feather merchants killed off the great auk of Funk Island which is noted as occurring in 1800.

The only remaining great auks were on Eldey Island off of Iceland. The last known pair of auks on the island were killed in1844. The last humans to see them alive were a dozen Icelanders who rowed out to the island who found one pair of birds and a nest with one egg. The men broke the egg and strangled the birds. Naturalists Alfred Newton and John Wolley visited Iceland in an attempt to find an auk but failed to find one auk and concluded that the species had died out. Naturalist Alfred Newton was successful in lobbying for one of the first laws in England that protected wildlife: the Act for the Preservation of Sea Birds.

Endangered Coral Reefs

On One Tree Island near the Great Barrier Reef research on corals and the impact of ocean acidification was an on-going project. Atmospheric scientist Ken Caldeira was in charge of the research team. Coral reefs grow in large expanses around the world, from thirty degrees north to thirty degrees south latitude. The Great Barrier Reef is the largest reef and the reef off the coast of Belize is the second largest. Strangely, the threat to the reefs was discovered in Arizona in a biosphere. The biosphere was built to prove that life could exist on another planet. It contained a rainforest, a desert, an agricultural zone and an “ocean.”

The experiment was largely a failure with CO2 levels out of control. Most of the fish in the ocean – an Olympic size pool – were dead and corals were deteriorating. The building was handed over to Columbia University to try to salvage something of value from the experiment. Chris Langdon, a marine biologist, was given the task of figuring out if there was something of educational value to be gleaned from the ocean. The pH readings were low due to the calcification. He also measured the saturation state of calcium carbonate or aragonite which is measured by the concentration of calcium and carbonate ions floating about. His research found that as saturation levels fell, the energy for calcification would increase which would result in a decline in calcification which is what drives the growing and expansion of the reefs. In order to survive, reefs must keep growing. Members of the One Tree research team published a paper that within the next 50 years all coral reefs will stop growing and begin to dissolve.

The volume and diversity of marine life around a coral reef is amazing. Reefs have gone extinct before as evidenced by ruins that have been observed from past events. In addition to ocean acidification, coral reefs are also threatened by among other perils overfishing, agricultural run-off and dynamite fishing. Under these threats, the reefs are weakened and vulnerable to contracting white band disease. Several major reefs are infected with the disease and are listed as endangered.

The biggest threat to the reefs is climate change. Reefs need to stay warm but when temperatures rise too high the reef and the individual animals that it is comprised of lose their symbiotic relationship. White or bleached colonies result and this damage can result in the death of the reef. Once a year at the start of the astral summer, the coral reefs of the Great Barrier Reef spawn. The acidification that has brought down saturation levels resulted in declines in fertilization.

The scientific world has consensus that coral reefs are crucial in building the ocean's ecosystem. If the reefs vanish, the whole marine ecosystem will fail.

Styles

Structure

“The Sixth Extinction” by Elizabeth Kolbert is broken up into 13 chapters. The chapters cover her travels to the far reaches of the planet in order to get her story. She was intrigued by an article about the earth possibly being in the midst of a sixth mass extinction. As a reporter and lover of the dynamics between man and nature, she felt compelled to gather as much information as she could about the extinction and share what she learned with her readership.

Kolbert goes back in time to the first discovery of mastodon bones. This finding led to the theory of extinction and made profound changes in the world of science, geology and paleontology. She discusses specific extinctions that appeared right before our eyes – the Great Auk of yesteryear and the Panamanian Golden Frog of today.

The cause and effect of the extinction is discussed and the early controversy about the manner of extinction. Some thought it was gradual and hardly noticeable while others thought that it came about because of catastrophes. Both are actually correct but the cataclysmic events that cause rapid extinction are the worrisome ones. Man is behind the current extinction through global warming that some scoff at and through his advancement and encroachment upon the natural habitat of other species. Man has the “madness gene” that makes him want to explore and push himself to new adventures and discoveries. Doing so he hurts other species. If the global warming and acidification of the oceans continue, up to 50% of all species could be extinct by 2050.

There are many illustrations and photos throughout the book that help tell the story. In the preface at the beginning of the book the writer explains her motivation in conducting her investigative research and in writing the book.

Perspective

“The Sixth Extinction” written by Elizabeth Kolbert is written from the perspective of her reporting. She is a writer for the New Yorker magazine and is the author of another book about the future of mankind entitled, “Field Notes from a Catastrophe: Man, Nature and Climate Change.” Kolbert became interested in the topic of extinction after reading an article by two accredited herpetologists entitled, “Are We in the Midst of the Sixth Mass Extinction?” In the article the scientists referred to five preceding mass extinctions and pointed at the disappearance of the golden frog in Panama as evidence of a sixth mass extinction.

As a reporter who is interested in the subject of the trajectory of mankind, Kolbert wanted to know more about what was taking place in Panama that could impact mankind and the entire globe. She immediately traveled to Panama to gather and report

what data should could about the frogs and the possibility that it pointed to a far ominous possibility.

Kolbert first traveled to Panama but her quest literally took her around the world. She sought information about endangered species and those at risk of becoming endangered in all reaches of the globe. Her point of view is not based on her own opinion and knowledge; rather, it is based on the myriad of scientists, researchers, experts and scholars that she sought out to tell her story.

Kolbert also relied on historical data about extinction issues in the past and the discoveries and conclusions that scientists and naturalists made about the state of the earth and all its species. She references the works of such diverse experts of yesterday as Curvier, Lyell and Darwin to modern scientists like Elton, Alvarez and Paabo, all detectives trying to find out where man came from, what good and harm he's done to the earth and its species and most importantly where the earth and mankind are heading.

Tone

"The Sixth Extinction" is written by Elizabeth Kolbert who is a journalist and author. Her interest in nature and the future of the earth and mankind is obvious from her relentless determination and dedication in learning all she was able to about the sixth mass extinction an event that many experts in the field believe the earth is currently in the midst of.

Extinction is a deep and complex topic and Kolbert presents facts, figures and historical, factual and anecdotal material in an appropriate manner. There are light moments and incidents that occur during her travels and she shares those with her readers as well. These breaks from the heft of the subject are a welcome relief to the reader who is led through eons of data about species and their fate and the causes for cataclysmic events that caused the five, now six, mass extinctions.

Kolbert presents data and complicated descriptions of the pathway that scientists through the ages have taken in first acknowledging extinction and then coming to grips with it. However, the author does not bog the reader down with too much technical data or technical and unfamiliar terms but conveys what is a complex subject in a clear and concise manner that the average person can understand. By doing so, the impact of the phenomenon known as extinction will be better understood by those beyond the research lab and biological think tanks.

Quotes

The frogs are toxic – it's been calculated that the poison contained in the skin of just one animal could kill a thousand average-sized mice – hence the vivid color, which makes them stand out against the forest floor.
-- Author (Chapter 1 paragraph Page 5)

Importance: The golden frog of Central Panama is bright yellow with brown splotches and highly toxic. The bright color gives its prey fair warning that the frog is nearby.

But what was this primitive earth? And what revolution was able to wipe it out?
-- Jean-Leopold Cuvier (Chapter 2 paragraph Page 30)

Importance: Naturalist Jean-Leopold Cuvier was the first scientist to entertain the concept of animal extinction. He concluded that the bones of the mastodon and other species represented animals that had lived on earth but no longer did. He was the first to be curious about what happened to extinct animals.

The present is the key to the past.
-- Charles Lyell (Chapter 3 paragraph Page 48)

Importance: Charles was an English naturalist who didn't believe in cataclysm; rather, he believed that everything developed gradually over time.

The appearance of new forms and the disappearance of old forms were bound together.
-- Charles Darwin (Chapter 3 paragraph Page 55)

Importance: Charles Darwin was the first naturalist to draw a connection between evolution and extinction. In this statement he claims that there is an undeniable and ongoing link.

Though the world does not change with a change of paradigm, the scientist afterward works in a different world.
-- Thomas Kuhn (Chapter 5 paragraph Page 94)

Importance: Science historian Thomas Kuhn succinctly describes the difference between scientist and ordinary man. Scientists are confronted with challenges when paradigm shifts are discovered in the story of life. But such discoveries have no impact on the ordinary person.

We're seeing right now that a mass extinction can be caused by human beings. So it's clear that we do not have a general theory of mass extinction.
-- Walter Alvarez (Chapter 5 paragraph Page 104)

Importance: Mass extinctions have involved climate change. Alvarez is pointing to the

possibility that man's involvement in the current change in climate may lead to a mass extinction. There seems to have been no one cause for the extinctions.

Under business as usual, by mid-century things are looking rather grim. I mean, they're looking grim already.
-- Ken Caldeira (Chapter 7 paragraph Page 132)

Importance: Atmospheric scientist Ken Caldeira made this grim prediction about the impact of CO2 absorption on the oceans and the resultant acidification that will destroy marine life.

Broadly speaking, all our results have been negative so far. If we continue the way we are, without making dramatic changes to our carbon emissions immediately, I think we're looking at a situation where, in the future, what we've got at best is remnant patches of corals.
-- Selina Ward (Chapter 7 paragraph Page 147)

Importance: Selina Ward, a research scientist at the University of Queensland commented on the threat to the coral reefs as a result of high CO2 emissions. Coral reefs are the apex animals of the marine ecosystem and if they fail, the entire ecosystem will be at risk.

Look around you. Kill half of what you see. Of if you're feeling generous, just kill about a quarter of what you see. That's what we could be talking about.
-- Anthony Barnosky (Chapter 8 paragraph Page 167)

Importance: Paleontologist Anthony Barnosky put scope of the next extinction in simple terms that anyone could understand.

In the face of climatic change, even natural climatic change, human activity has created an obstacle course for the dispersal of biodiversity, one of the greatest biotic crises of all time.
-- Tom Lovejoy (Chapter 9 paragraph Page 189)

Importance: Tom Lovejoy who is a biological diversity expert stresses that climate change caused by humans has harmed the diversity of species. The lack of diversity is a threat to the ecosystems within specific regions.

I want to know what changed in fully modern humans, compared with Neanderthals, that made a difference. What made it possible for us to build up these enormous societies and spread around the globe, and develop the technology that I think no one can doubt is unique to humans?
-- Svante Paabo (Chapter 12 paragraph Page 240)

Importance: Svante Paabo is called the father of paleogenetics and began a study in 2006 to determine the link between Neanderthals and modern man that it made it possible the advancements that man has achieved.

There is every reason to believe that if humans had not arrived on the scene, the Neanderthals would be there still, along with the wild horses and the woolly rhinos. With the capacity to represent the world in signs and symbols comes the capacity to change it, which, as it happens, is also the capacity to destroy it.
-- Author (Chapter 12 paragraph Page 259)

Importance: The author captures the belief by many scientists and researchers that man has caused the extinction of many species and that human activity is bringing on another extinction.

Topics for Discussion

Topic 1

What was found to be the cause of the devastation of the Panamanian golden frog? How is the disease spread from continent to continent?

Topic 2

Where were the first bones of a mastodon discovered and by whom? What were some of the initial theories about the animal that the bones belonged to?

Topic 3

What book did Charles Darwin read with great interest? What probably compelled Darwin in the development of his theory of natural selection?

Topic 4

What did Walter Alvarez find in the gorge called Gola del Bottaccioine? How did his findings change his belief as a uniformitarian and how did they change life as seen in the rear view mirror?

Topic 5

What occurrence in the Cambrian period was of great interest to scientists and biologists? Describe what Gondwana was and how it has evolved.

Topic 6

What is the Anthropocene era and why do many scientists feel it is an apt name? What were the causes of the extinctions at the end of the Ordovician period and at the end of the Permian period?

Topic 7

What do some experts claim the cost of tropical deforestation is to indigenous species? Describe the theory of extinction debt.

Topic 8

What is “white-nose” syndrome” and what species has it impacted? Why is the introduction of a new pathogen into an area devastating for the species that inhabit the region?

Topic 9

Describe the efforts that are being made to save the Sumatran rhino. Why are large species more at risk for endangerment or extinction? What are some examples of these animals?

Topic 10

What is the madness gene? What are some fundamental differences between modern and archaic man?