Anthropogenic Causation and Prevention Relating to the Holocene Extinction

Jesse S. Browning
English 225

Introduction

The tumultuous state of the biosphere is largely attributable to anthropogenic input and several aspects of this complex situation are worthy of consideration. The aim of this paper is to further understand the loss of biodiversity that is currently taking place. Opinions tend to differ regarding the relative importance of issues of such magnitude. The current loss of biodiversity is evolutionarily important as it is currently impacting the trend of life on Earth.

In order to achieve a better understanding of said issue it is useful to examine the estimates regarding both current, and background, rates of extinction—as well as how *Homo sapiens* factor into the equation. First, we must account for the idea that human values shape our goals in regards to maintaining biodiversity. Then, explore how anthropogenic factors may be directly influencing this phenomenon by surveying some human causes of biodiversity loss. Subsequently it is possible to look at courses of action that will uphold human values regarding our relationships with other organisms and natural processes.

Importance of Biodiversity

Preservation of biodiversity is essentially the preservation of nature and is considered important based primarily on human values. Jepson and Canney (225-226) present a well-compiled list of the preeminent reasons for maintaining biodiversity or "nature," they state:

(1) aesthetic and intellectual contemplation of nature is integral to the biological and cultural inheritance of many peoples (Wilson, 1984);
(2) humans lack the right to cause knowingly the extinctions of another life form (Leopold, 1949);
(3) species are critical components of the healthy ecosystems necessary to support economic and social development (Ehrlich & Ehrlich, 1992); and
(4) it is prudent to maintain the Earth's genetic library from which society has derived the basis of its agriculture and medicine (Myers, 1979).

The first reason highlights the cultural importance of nature. The existence of organisms are an integral part of human cultures; many flora and fauna are essential to human livelihoods, traditions, art, and aesthetically pleasing *natural* environments. The idea that the "observation and contemplation" of the natural world has essentially shaped many aspects of human civilization implies that loss of nature will in turn have a detrimental impact on Humanity (Jepson and Canney, 2001). This establishes one reason why humans value conservation of nature.

Second, it is unethical for human beings to drive other species to extinction. This belief implies that the human capacity for compassion, and the propensity for people to be compassionate towards other organisms, is one of the "tools" that conservationists often use in the name of conservation. Conservationists focus efforts on what are considered "charismatic" creatures. Charismatic creatures are those species considered by many to be cute, cuddly or beautiful animals such as Pandas, Tigers, and Polar Bears, etc.

Third, is the importance of socioeconomic matters as they relate to the natural world. The relationship between the health and function of the natural world, ecosystems, and the health and function of societies and their economies is inextricable, and often overlooked. In order to continue to enjoy the benefits of functional societies and economies, humans must devote more energy towards maintaining healthful ecosystems. Biotic and abiotic natural resources are an integral part of human activities, and as these resources diminish, so will the condition of society. Some maintenance of the natural world that sustains humanity is unavoidable.

Lastly, agriculture and medicine are both highly derived from organisms, especially flora. As we decrease the numbers of plants and animals, we also decrease the possibilities of finding new ways in which these organisms can benefit humanity.

Extinction Rate Estimates

Presented extinction rates often compare current and background estimates. Extrapolations from available data tend to yield variable results due to limitations inherent to establishing both current and background rates of extinction. It is suggested that we may currently be experiencing a mass extinction, which is defined as a loss in greater than 60% of species within one million years. The definition itself is difficult to apply due to the large temporal scale and reliance on an estimated total number of species.

There is much uncertainty in establishing extinction rates because historical extinction rate estimates are dependent on the fossil record, and therefore subject to biases and gaps found within the fossil record. The current rate estimates also have limitations, mainly that we really do not know how many species existed. Estimates for currently extant species range widely "between 3 million and 30 million" (May 1990; Erwin 1991; Gaston 1991 [Regan 2001]). This illustrates the great amount of uncertainty in such estimates. Similarly the fossil record offers little insight into numbers of species that were present since life began on Earth—extinction rate estimates should therefore be considered critically. Extinction rate estimates which are often presented have the ability to grab the attention of people and raise concern over the state of biota. Critical observers should realize that such estimates are potentially inaccurate.

The authors of the article "The Currency and Tempo of Extinction," feel confident enough in their interpretation of available data to conclude: "There is little doubt that species are going extinct extremely rapidly and that we are in the midst of a major extinction interval" (Regan 8). Such a statement is supported by data suggesting "that there have been approximately 490 animal extinctions and 580 plant extinctions recorded globally since 1600" (May et al. 1995). The available data also suggest that the frequency of these extinctions has increased dramatically in the past 100 yrs (Regan 1). There is a consensus that we are in a period of rapid extinction, and that humans are partly responsible.

Anthropogenic Causation

Human activities have greatly impacted many of the other organisms on earth. Such processes include pollution, overexploitation, introduction of invasive species, habitat destruction, and disease. Introduced non-native, or "invasive" species have had a tremendous impact on native species that did not co-evolve with such competitors or predators—resulting in the introduction invasive species and habitat fragmentation. As a result, the native species exhibit naiveté and rarely out compete the recently introduced species. One profound example of this is birds on islands where predators were previously absent (Blackburn 2005).

European arrival on oceanic islands has resulted in the introduction of mammalian predators. There is a positive correlation between this phenomenon and bird species decline (Blackburn 2005). Introduced cat and rat species top the list of detrimental introduced predators, and these predator populations increase the extent of species decline. Non-mammalian predators have had a destructive effect on animal populations as well. The introduction of the brown tree snake *Boiga irregularis)* is a striking example of this. The arrival of this invasive species correlates to a dramatic decline in both appreciable habitat reduction and extinction among native bird species on the island of Guam (Savidge 1987). Habitat destruction, more specifically habitat fragmentation has had a similarly negative impact on numerous species. Habitat fragmentation increases extinction thresholds of selected species, and in the wake of habitat fragmentation, species subsequently require greater habitat areas to remain viable (Fahrig 2002).

Anthropogenic Prevention

There are numerous ways to approach the problem of conserving biodiversity. One of the more prominent global approaches is that of hotspot identification. Hotspots are areas that exhibit high levels of endemism, species richness and suffer from habitat degradation (Reid 1998). Twenty-five of these regions have been identified worldwide.

The general aim of the hotspot approach is to maintain the greatest number of species for the least cost. This objective is fine for a private organization such as Conservation International; governments and other agencies that implement conservation efforts, however, must consider the values of the people they represent. A narrow objective such as that of the hotspot approach might fail to account for many of these human values (Jepson 2001). Humans tend to place different values on different species due to biases based on cultural importance. The hotspot approach fails to differentiate between the relative values of individual species.

Another program aimed at maintaining biological diversity is the GAP analysis program. This program is not yet global, instead it functions primarily in the United States. Considerable headway has been made in mapping the biological resources of the country on a state-by-state basis (Jennings 1995). This proactive approach compiles data concerning extant species and their current levels of protection.

From this data, it is evident where the 'gaps' in conservation are. In an effort to achieve representativeness in conservation, underrepresented species and habitat types can thus be given additional attention. Through a better understanding of the biological inventory in the country the GAP program is then able to influence land management practices. An interesting element of this proactive approach is that it attempts to maintain viability of populations before they are reduced to the point of becoming endangered or federally listed. This approach is important, especially since many conservation efforts are reactive (trying to bring species back from the brink of extinction or merely working to slow down habitat loss).

Rewilding is another proactive conservation idea. It has been hypothesized and argued at length whether or not humans were responsible for the extinction of megafauna in Europe, Australia, the Americas, and on continental islands. In this ongoing debate, there appears to be a correlation between the arrival of humans and the disappearance of large animals as humans dispersed throughout the Americas approximately 10,000-12,000 years ago (Vernon 1975).

These large carnivores and herbivores played important roles in the pristine ecosystems were once present in North America and beyond. In addition to being reactive, conservation efforts are often limited by a small temporal scale. They typically aim to restore ecosystem processes to the way they were no more than several hundred years ago. This disparity in temporal scale poses a problem; if ecosystems in North America have been degraded for more than 10,000 years, and we aim to restore them to a state similar to that before the arrival of Columbus (~500 yrs ago), healthy ecosystem function is not likely to be achieved. The article, "Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation," addresses this issue among others, arguing for ecosystem restorations including the extinct megafauna, via taxon substitutions that once were important parts of landscape regimes.

Interestingly, two conservation efforts have already been implemented that may set a precedent for such a seemingly radical effort. First, the Giant Vulture or California Condor G*ymnogyps californianus* is a species has not only benefited greatly, and perhaps even been saved from extinction by conservation efforts, but has been re-introduced to parts of the historical range that it has not enjoyed due to human disturbance since megafaunal extinction. Second, the North American Peregrine Falcon (*Falco peregrinus*) was also brought back from the verge of extinction through conservation efforts. This time however the "species," or perhaps more importantly the ecological role that the species once filled, was maintained by the introduction of genetically similar sub-species whose origins spanned four continents. This success story shows that inter-continental taxon substitutions can be an effective means of conservation (Donlan et al. 2006).

Genetic diversity is defined as "any measure of the genetic variation at neutral or adaptive loci of a population or a species; in other words, how diverse are the populations" (Holderegger Kamm, and Gugerli 799). Genetic diversity is an important consideration in conservation of biodiversity. Populations and landscapes are dynamic in order for organisms to effectively *adapt* or change to match its changing environment: a certain level of genetic diversity must be maintained. Greater genetic diversity within a population results in greater ability to adapt to changes in the organisms environment. This definition introduces the neutral and adaptive nature of genetic diversity and alludes to the idea that we are concerned with varying, especially decreased, levels of diversity within species. Neutral as well as adaptive variation are important to maintenance of populations therefore it is necessary to understand both.

Neutral loci or genes are those that do not affect an organism's level of fitness, or ability to adapt to it's changing environment. These neutral genotypes are not expressed as phenotypes that are subject selective pressures, therefore these characters are considered selectively neutral. Neutral genetic markers do not offer insight into the "adaptive or evolutionary potential of populations or species." (Holderegger Kamm, and Gugerli 798). They do however provide information about other aspects of population dynamics such as gene flow that should not be discounted while considering the adaptive potential of populations.

Adaptive genetic variation is very important to maintaining viable populations in that it does have a direct impact on fitness. When environmental factors change, a greater range of genes provides for a greater possibility that organisms will be present that are fit for the newly emergent environment. When the population is small and genetic diversity is low, environmental change is more likely to have drastic consequences. Thus conservation efforts should strive to maintain maximum levels of genetic variation within species.

Conclusion

Though it is difficult to ascertain accurate background or present rates of extinction, it is widely accepted that we are experiencing a high extinction rate resulting in loss of biodiversity. It is also accepted that this alarming progression is due in part to human activity. This concept may be thrown around too liberally but must not be ignored (Jepson 2001).

As humans we have the ability to drive species extinct, and have been doing so for quite some time. Conversely, we have the ability to slow down, stop, or possibly even reverse this disturbing trend. And if we decide this is what we value, we should utilize available knowledge and resources in order to maximize conservations efforts—through hotspot approach, GAP Analysis, and others, species can possibly be saved (Mech 1996; Doerner et al. 2005).

It is important to diversify our efforts and refrain from relying too heavily on one approach and conservationists should broaden their efforts tremendously. It is prudent to examine how well such efforts support the values of people that are affected by their implementation, because once decisions are made, there may be no recourse (Kati et al. 2004).

When considering conservation methods, maximum effectiveness must be strived for as outlined by Kati et al. There are different approaches to conservation: the most effective means of achieving the desired outcome should be explored to the greatest extent that is feasible based on availability of time and resources. In many cases, time is the primary variable when establishing reserves or taking similar measures to maintain biodiversity.

The current methods employed in maintaining, preserving and restoring ecosystems fall short in many ways. They are often limited both spatially and temporally. While economic and political factors often limit spatial scale, bigger (yet well planned and managed) reserves are potentially more beneficial—this idea carries over into the temporal realm.

While conservation efforts often aim to restore ecosystems to the state they enjoyed 50-100 years ago (or more ambitiously to the way they were when Columbus *discovered* the Americas), this is often inadequate. Conservationists should strive to expand the geographic boundaries of conservation efforts, and temporal boundaries as well, if we wish to appreciate the benefits that healthy functioning ecosystems have to offer all species, including our own. Fortunately, precedents have been set that lead the way for recognition of much larger temporal and spatial scales that span epochs and continents respectively. This is no easy task, and will require outreach and education in order to appeal to the masses.

Through examination, humans may arrive at the conclusion that maintaining biodiversity does not fit into our values. All of the species that we now value, and exploit, are the result of evolutionary processes since the last great extinction. Perhaps we should cast aside this idea of slowing, preventing, or reversing a *mass extinction* and simply let nature run its course.

Works Cited

Blackburn, Tim M.; Petchey, Owen L.; Cassey, Phillip; Gaston, Kevin J. "Functional Diversity of Mammalian Predators and Extinction in Island Birds." *Ecology* 86 (2005): 2916-2923.

Doerner, Kinchel C.; Braden, Wes; Cork, Jennifer; Cunningham, Tom; Rice, Amanda; Furman, Bonnie J.; McElroy, Doug. "Population Genetics of Resurgence: White-Tailed Deer In Kentucky" *Journal of Wildlife Management* 69 (2005): 345-355.

Donlan, Josh C.; Berger, Joel; Bock, Carl E.; Bock, Jane H.; Burney, David A.; Estes, James A.; Foreman, Dave; Martin, Paul S.; Roemer, Gary W.; Smith, Felisa A.; Soule, Michael E.; Greene, Harry W. "Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation." *e American Naturalist* 168 (2006): 660-681.

Fahrig, Lenore. "Effect of Habitat Fragmentation on the Extinction Threshold: A Synthesis" *Ecological Applications* 12 (2002): 346-353

Fox, Gordon A. "Extinction Risk of Heterogeneous Populations" *Ecology* 86 (2005): 1191-1198

Holderegger, Rolf, Urs Kamm, and Felix Gugerli. "Adaptive vs. neutral genetic diversity: implications for landscape genetics." *Landscape Ecology* 21(2006): 797-807.

Jennings, Michael D. "Gap Analysis Today: A Confluence of Biology, Ecology, and Geography for Management of Biological Resources" *Wildlife Society Bulletin* 23, (1995): 658-662

Jepson, Paul.; Canney, Susan. "Biodiversity Hotspots: hot for what?" *Global Ecology & Biogeography* 10 (2001): 225-227.

Kati, Vassiliki; Devillers, Pierre; Dufrene, Marc; Legakis, Anastasios; Vokou, Despina; Lebrunf, Philippe. "Hotspots, complementarity or representativeness? Designing optimal small-scale reserves for biodiversity conservation." *Biological Conservation* 120 (2004): 471–480.

Mech, David L. "A New Era for Carnivore Conservation." *Wildlife Society Bulletin* 24 (1996): 397-401

Pearman, P.B. " Conservation value of independently evolving units: sacred cow or testable hypothesis?" *Conservation Biology* 15: 780–783

Regan, Helen M.; Lupia, Richard; Drinnan, Andrew N.; Burgman, Mark A. "The Currency and Tempo of Extinction." *e American Naturalist* 157 (2001): 1-10.

Reid, Walter V. "Biodiversity hotspots." *Trends in Ecology & Evolution* 13 (1998):275-280

Savidge, Julie A. "Extinction of an Island Forest Avifauna by an Introduced Snake" *Ecology* 68 (1987): 660-668

Smith, Vernon L. "The Primitive Hunter Culture, Pleistocene Extinction, and the Rise of Agriculture" *e Journal of Political Economy* 83 (1975): 727-756

Turner, Monica G. "Landscape Ecology in North America: past, present, and future." *Ecology* 86 (2005): 1967-1974.