Raiders of the Last Auk:
What the nineteenth century extinction of a North Atlantic seabird tells us about some economic factors affecting endangered species

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INTRODUCTION:

Modern rates of extinction and the resultant loss of biodiversity concern scientists and the public alike. Both social scientists and biologists have conducted studies on the circumstances surrounding historic and prehistoric extinctions. These studies are intended to advance our knowledge of the causes of extinction, and to inform the development of policies to eliminate or ameliorate the conditions causing extinctions. Most scientists recognize that extinctions are complex events involving many factors. Still, it is often helpful to try to tease apart the causes of a population's decline and to determine which factors made the most significant contribution to the demise of a particular species. Batabyal and Beladi (2000:609) emphasize that understanding extinction necessitates understanding the affects of both economic activities and environmental factors on species existing within "ecological-economic systems (ecosystems) that are jointly determined."

Researchers in economics and political science have examined human overexploitation of animal and plant resources, as well as the ways in which human economic practices interact with other factors affecting a population's decline. Some of the questions these researchers ask are: 1) How does open access to a resource affect exploitation of that resource? 2) Does privatization of natural resources lead to

conservation? 3) How and why might overexploitation lead to species extinction? 4) What motivates overexploitation? and 5) How does the rarity (or perceived rarity) of a commodity lead to changes in its value?

In this paper, I discuss research providing some answers to these five questions. I then apply theories gained by this research to the case of the Great Auk, or Garefowl, a flightless North Atlantic seabird hunted to extinction in the mid-nineteenth century. This bird was at first exploited for its meat, fat, and feathers – commodities with relatively high bulk and low value. As the Auk became rarer, however, publicity from the scientific community led to the establishment of a market for stuffed auk skins and preserved eggs as "collectibles". This redefinition had striking affects on the price of commodities derived from the bird, and quickly drove the endangered bird to extinction. The Auk's extinction was pre- and post-dated by legislation intended to protect seabirds from overexploitation. I describe the incentive structures put in place by two pieces of formal legislation passed to protect North Atlantic seabirds, and discuss why the second was more effective than the first. I conclude with a brief discussion of the dangers that modern endangered species face from human overexploitation, including how a species' rarity may itself increase the value of products derived from that species, thereby providing economic incentives for extermination.

ECONOMIC THEORY REGARDING OVEREXPLOITATION OF RENEWABLE RESOURCES

Ludwig et al. (1993:17) summarize the history of human interaction with the environment in the following way. "Although there is considerable variation in detail,

there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction." Most early economic theories about the causes and results of overexploitation are based on the fishing industry, which exploits what is known as a "common-pool resource". One of the first questions economists ask is how common pool resource use differs from the use of privately owned resources, and whether common pool resources are more likely to be overexploited.

1) How does open access to a resource affect exploitation of that resource?

Gordon (1954) studied the economics of the fishing industry and determined that the industry faces a situation later termed the "tragedy of the commons" by Hardin (1968). Competition among fisherman allowed to fish wherever they like leads to suboptimal production in the fishing area. In addition, measures taken to limit over-harvesting of common-pool resources like fish are often unsuccessful. Placing quotas on the total number of fish caught in a season, or limiting fishing activity to a shorter season only leads to a rush for each fisherman to increase his own production capability so as to compete against other fishermen for the catch. Gordon (1954) notes that reducing the length of the lobster season in one region had no effect on the total number of lobsters caught in the region. Instead, it merely raised the cost to the individual fishermen of the gear and supplies necessary to catch all the available lobster. He summarizes the situation in this way: "There appears, then, to be some truth in the conservative dictum that everybody's property is nobody's property. Wealth that is free for all is valued by none

because he who is foolhardy enough to wait for its proper time of use will only find that it has been taken by another" (Gordon 1954: 135).

Common-pool resources for which property rights are ill-defined are subject to the tragedy of the commons, and privatization of these resources as a means for resource conservation is often debated (e.g. Rasker et al. 1992, Caughley 1993).

2) Does privatization of natural resources lead to conservation?

Although privatization of renewable resources is often proposed as a way to encourage sustainable harvesting of natural resources, Clark (1973a, 1973b) describes a model of resource exploitation in which private ownership is just as likely to lead to overexploitation. He has two main criticisms with previous studies done on overexploitation. First, the time variable is often ignored in fishery models. This means that resource managers are assumed to prefer strategies intended to maximize the yearly return on the resource (the rent) over those which maximize the present value of the resource. Private ownership in which one is not forced to compete with others for access to the resource is often seen as favoring resource conservation, since private owners are assumed to be most interested in sustainable harvests as the best way to maximize rent from their holdings. However, Clark (1973a: 951) disagrees with this.

> It has been noted that, if harvesting costs rise with decreasing population levels, a rent-maximizing policy will automatically lead to biological conservation, with an equilibrium population in excess of the population corresponding to maximum sustained yield. It is perhaps more reasonable to suppose, however, that the "sole owner" of a resource population would in fact choose to maximize the present value of his harvest sequence, discounting future revenues at some fixed rate."

If the discount rate is higher than the potential of the population to rebuild itself, and if an immediate profit can be made from harvesting the animals to the point where they cannot recover, private ownership can lead to overexploitation and eventual extinction. As Caughley (1993: 943) puts it, privatization creates an environment in which "… the highest return in both the short and long term comes from converting the population to cash and reinvesting that capital."

3) How and why might overexploitation lead to extinction of species?

The second problem Clark has with fishery models like that proposed by Gordon (1954) is that such models usually assume that total extinction of the resource is impossible. Two features of fisheries tend to prevent extinction. The first is that as the number of animals in a population drops, competition between the members of the population for resources relaxes, allowing more animals to survive and breed. Thus, harvesting at low levels can increase the fecundity of the animals left in the population and eventually increase the population. Of course, the rate at which a population of fish replenishes itself after over-harvesting is higher than the rate would be for slow-breeding populations like elephants, whales, primates, or Great Auks.

Second, the lower the stock of the resource, the more costly it is to find and harvest that resource. The model predicts that over-harvesting will become economically unproductive long before extinction of the resource occurs (Allen and Keay 2001: 449). As Clark (1973b: 632) explains, the idea that extinction is highly unlikely may be based on a misreading of the model used to explain the inverse relationship between harvesting costs and population:

> …we made the assumption that harvesting costs vary inversely with population x. It thus appears that costs become infinite as x approaches zero. The variable x, however, is in reality restricted to integral values (x =1,2,3…), and the cost of extinction is actually the cost of a unit harvest when x=1…The cost of extinction (B)…is the cost of a unit harvest which reduces the breeding population from one to zero. If B is less than the price p, then the cost curve C will lay below the revenue curve…for all values of x…In this case the zero rent population equals zero, and rent dissipation will lead to extinction.

It is also obvious from biological studies done on endangered species that it is not necessary to literally wipe out the last member of a species for the species to become extinct. Instead, there is what is known as a minimum viable population (MVP), below which a species is unlikely to survive. The MVP is different for each species, and had not always been well established for each individual taxon. Predictions can be made about the MVP based on features of the species' biology, such as the age at which the species begins to breed, how many offspring it has per year, the interbirth interval, and the extent to which members of the species are dependent on each other.

Clark does not dispute that open access to resources leads to overexploitation. He is more concerned with adding to this knowledge models showing how overexploitation can also be the strategy that maximizes profits to a private owner if the discount rate is high. The higher the economic value of the resource and the lower the reproductive capacity of the population, the more likely it is that private ownership will lead to extinction.

4) What incentive structures lead to overexploitation?

Unfortunately, renewable resources are difficult to manage efficiently. Often they are subject to what Ludwig et al. (1993) call a "ratchet effect". During stable periods,

harvesting rates stabilize at those positions predicted by bioeconomic theory. A series of good years may cause harvesters to over-invest in the materials necessary to increase harvesting or production capacity of the newly abundant resource. When things go back to normal, or when conditions deteriorate, the industry appeals to the government to help save their investments and jobs. Usually, the government responds with subsidies, which make over-harvesting economically viable again. “The ratchet effect is caused by the lack of inhibition on investments during good periods, but strong pressure not to disinvest during poor periods. The long-term outcome is a heavily subsidized industry that overharvests the resource" (Ludwig et al. 1993: 17).

Even when monopolies on resources have been created, overexploitation can occur, particularly if companies are granted monopolies from the government for only short periods of time. This was true in the case of the Alaskan seal fur industry in the late eighteenth and early nineteenth centuries. Paterson and Wilen (1977) describe the sequence of events whereby the Russian-American company, a Siberian organization, was given exclusive rights to harvest fur from seals on the Pribilof Islands and in Alaska for 20 years. From 1785 to 1803, 800,000 skins were accumulated by this company, and as storage facilities were not available to accommodate so many, 700,000 were reportedly cut or thrown away in 1803 (Paterson and Wilen 1977: 87).

5) How does the rarity of an endangered species lead to increases in its market value?

Both Gordon’s (1956) and Clark’s (1973a, 1973b) models feature an unchanging price of the exploited resource. The market price stays the same despite available supply in both models. It is only the cost of harvesting the resource that goes up in response to

the population's diminishing size. Swanson (1994: 803) writes optimistically that preventing extinction is as simple as varying the costs and benefits of the system. "Any act that would either decrease the price of the resulting products, or increase the costs of the production process, would shift the harvest function downward…creating the possibility of a stable bioeconomic equilibrium". Unfortunately, in some cases, including that of the Great Auk, increasing rarity of the resource can have the effect of transforming the resource from one valued as a "staple good" – used for food, fuel, or other utilitarian purposes – to one valued as a "collectible", a luxury good with some interesting economic properties. This has the effect of raising the worth of the animal or its products, sometimes dramatically, which makes continued or intensified harvesting of the resource profitable despite rising harvesting costs.

Collecting is an activity practiced by many people in the United States and Europe. Belk (1995) defines collecting as "the process of actively, selectively, and passionately acquiring and possessing things removed from ordinary use and perceived as part of a set of non-identical objects or experiences." It is a form of luxury consumption, because the goods included in a collection are essentially useless and removed from their original context (Long and Schiffman 1997). Collecting is "inquisitiveness legitimized as art or science that provides the collector with an expanded sense of self" (Belk 1995:480). Long and Schiffman characterize collectors as exhibiting a number of contradictions in their behavior. One tension is between what the two researchers term "rationality" and "passion."

> …rationality exists in the assessment collectors make about price in relation to quality and rarity; collectors make rational estimations of fair price and future value based on knowledge of the market. On the other hand, collectors also exhibit passion which may at times override rational

> considerations. They fall in love with objects, cannot resist buying them, and may spend a great deal of time hunting for them (Long and Schiffman 1997:498).

Other researchers have noticed that "behavioral anomalies" – those behaviors that deviate from those expected by rational actors – are more frequently observed in the art market than in the financial market (Frey 1997). Collecting is a competitive activity, and, as such, it is liked to prestige and feelings of adequacy. Often collectors find an object they perceive as just out of reach and infinitely desirable. This psychology is prevalent and encouraged by the auction system, and collectors often find themselves devising ways to afford the unaffordable by cutting back in other areas of their lives (Belk 1995).

It is possible to turn what many would consider to be just another commodity into a collectible if the commodity is managed correctly. For example, the Swatch collecting phenomenon was managed in such a way as to turn ordinary wristwatches into desired collectors items, which fetched higher prices than they otherwise might have, as well as encouraging the purchase of multiple watches of different types (Burton and Jacobsen 1999). Long and Schiffman (1997: 507) list some of the ways in which the Swatch company manipulated its products to encourage their entrance into the collectibles market.

> Activities such as purposefully holding back on supply to engage consumers in hunting and competitive activities; forming clubs and using marketing communications to encourage cooperative, social aspects of collecting, disseminating resale information to help consumers rationalize their collections, sponsoring activities such as seminars to educate individuals about collecting rules, and emphasizing aesthetic aspects to position an ordinary object as sacred, all fit into the consumer's paradoxical framework of collecting.

Collectible markets are always plagued by the introduction of forgeries. Forgers of art and other collectibles know that one of the key factors contributing to a collectible's value is rarity. Imperfections can significantly raise the price of a particular collectible if they are rare. Thus forgery attempts during the Swatch collecting phenomenon focused on manipulating products to create extremely rare variants that could be falsely marketed as "manufacturers' mistakes" (Long and Schiffman 1997: 500).

Some studies (e.g. Pommerehne and Feld 1997) have been done to examine the effects that the purchasing strategies of publicly funded museums have on the fine art market, a subdivision of the collectibles market. They found that these museums tend to pay extraordinarily high prices for the items they purchase, which can make it more profitable for dealers or individual sellers to sell to museums than to private collectors or to private museums. In addition, Pommerehne and Feld (1997) suggest that studies should be conducted to test whether the purchase of a specific painting by a museum increases the purchase price of other paintings by the same artist. This may occur because museum purchases lend legitimacy to an artist. In the same way, museum purchase may lend legitimacy to a particular collectible type.

THE HISTORY OF THE GREAT AUK

Extinctions are most often the result of synergistic effects between the interacting factors of biology, environment, and human exploitation. In the case of the Auk, aspects of the bird's biology and the geographical location of its major breeding grounds interacted with human exploitation in ways that led to extinction. We can separate these factors in order to discuss them, but any one of the factors leading to extinction in this

case is unlikely to have caused the extinction if it were to have occurred in isolation from the others.

Was the Great Auk doomed by its biology?

The auk had several features that made it sensitive to both human predation and environmental change. "It was larger than the other auks, enabling it to exploit larger fishes; to survive in the cold arctic waters it had evolved, like the penguins, a large subcutaneous layer of insulating fat. Together, these features made it an attractive source of food. In common with many large birds it probably did not breed for the first few years, and when it did it laid only a single egg" (Halliday 1980: 73). The fatty nature of the bird made it a pork substitute and a crucial resource to farming communities in the Northern Isles (Serjeantson 1988). The bones of the Great Auk are widely distributed prehistorically, and are found at many archaeological sites in the North Atlantic, both European (Serjeantson 1988) and Inuit (Gotfredsen 1997). The pattern of exploitation in the Northern Isles of Scotland shows restrictions in breeding grounds accompanying the spread of farming into the area. Thus even before the exploitations recorded historically, humans had driven the birds to use fewer and less accessible breeding grounds then they had used before human contact (Serjeantson 1988). In addition, "their habit of breeding in dense colonies made them a resource which, if not easy to exploit, was at least reliable (Serjeantson 1988: 214).

Serjeantson (2001) compares the exploitation of the Great Auk with that of the Gannet, another seabird heavily exploited for food and feathers. Because the Gannet can fly, and tends to have a higher rate of population replacement, it was able to survive

overexploitation during the historic period. The flightlessness of the Auk, combined with its tendency to breed in dense colonies, the fact that each female bird laid but one egg per year, and its apparent naivety in the face of predation may have been factors that led to its demise in the face of the double onslaught of overexploitation and environmental change. The low replacement rate of the population makes the Auk prone to extinction under Clark's (1973a, 1973b) model of overexploitation. The population would have been very slow at replenishing itself from harvesting episodes, and over-harvesting may have been the best means of maximizing the present value of the population to exploiters.

How did environment and geography lead to population reductions?

Because of its biology, the Great Auk had very specific needs for a breeding location. Breeding islands had to be low enough to allow the flightless bird to climb up onto them. Because of human predation, the islands most successful for breeding were either far from the mainland or surrounded by currents that made the island difficult to reach by boat. Two of the largest breeding areas used by the Great Auk in historic times were Funk Island (named for its bad smell due to all of the guano) in Newfoundland, and the Geirfuglasker (Garefowl island), a volcanic island off the coast of Iceland.

The problem with the first island that developed historically was its location at the end of the transatlantic passage from Europe to Newfoundland. Hungry sailors stumbled onto an island full of quick and easy prey that could be used to satiate immediate hunger and provide sustenance for the journey back to Europe. In 1534 Jacques Cartier described Funk Island and the uses to which its occupants were put:

> We…sailed…as far as the Isle of Birds…Some of these…are so large as geese…black and white with a beak like a crow's. They are always in the

> water, not being able to fly in the air inasmuch as they have only small wings…with which…they move as quickly along the water as the other birds fly through the air. And these birds are so fat it is marvelous. In less than half and hour we filled two boats full of them as if they had been stones, so that besides them which we did not eat fresh, every ship did powder and salt 5 or 6 barrels full of them (Fuller 1999: 64).

The second breeding island, Geirfuglasker, was ideal because it was surrounded by currents making it difficult for would-be bird exploiters to reach it. It also was gently sloping on one side, which allowed the flightless birds to come ashore. Unfortunately for the Auk, volcanic eruptions caused the island to disappear in 1830 (Fuller 1999), which forced already highly stressed and declining populations of Auk to use more human-accessible breeding grounds, where they were hunted to extinction. This is an example of how synergistic effects can lead to extinction. In the absence of human predation of the kind experienced in the eighteenth and early nineteenth centuries, the loss of Geirfuglasker would not have had such severe effects.

The Great Auk as a Source for Food, Fat, and Feathers

Initially the Auk was so plentiful at its breeding grounds that it seemed an inexhaustible source of food and feathers. The naivety of the auk seemed to make "hunting" the vulnerable bird on land extremely easy.

> So valuable did these Garefowl prove as an article of food, that the ships which frequented the Banks for fishing were principally provisioned with them, as they fell an easy prey to the mariners, and were so stupid when on land that they allowed themselves to be driven on board the vessels on planks or sails spread out from the sides of the ships to the shore. Another plan which was resorted to, but probably in later times when the bird became less plentiful, was to drive them into compounds, where they were slaughtered with a short stick or club (Grieve 1885: 5).

Use of the breeding islands to provision ships was supplanted by use of the islands as a source of bait and food for local colonial communities. Later, commercial outfits began to exploit the islands in order to supply cities in America and Europe with feathers, meat, and eggs. Those people who came to breeding sites to collect feathers or eggs discovered ways to maximize the return on their time, often through extremely wasteful and unsustainable harvesting practices. For example, this account of egg gathering is from the journal of Aaron Thomas, a crewmember of HMS Boston, who wrote about collection practices he learned from local eggers:

> If you go to the Funks for Eggs, to be certain of getting them fresh, you pursue the following rule – you drive, knock, and shove the poor Penguins in Heaps! You then scrape all the Eggs in Tumps in the same manner you would a Heap of Apples in an Orchard in Herefordshire. Numbers of these Eggs, from being dropped some time, are stale and useless, but you having cleared a space of ground the circumference of which is equal to the quantity of eggs you want, you retire for a day or two behind some Rock at the end of which time you will find plenty of Eggs – fresh for certain! – on the place where you had before cleared (Gaskell 2000:100).

Occasional exploitation by commercial outfits was soon replaced by seasonal occupation of the islands, so that production of Auk feathers and oil could be maintained throughout the breeding season. Thomas also records this description of the feather harvesting practices taking place on Funk Island:

> If you come for their feathers you do not give yourself the trouble of killing them, but lay hold of one and pluck off the best of the Feathers. Then you turn the poor Penguin adrift, with it skin half naked and torn off, to perish at his leasure [sic]. This is not a very humane method, but it is the common Practize…While you abide on this Island you are in the constant practize of horrid crueltys for you not only Skin them Alive, but you burn them Alive also, to cook their bodies with. You take a kettle with you into which you put a Penguin or two, you kindle a fire under it, and this fire is absolutely made of the unfortunate Penguins themselves. Their

> Bodys being oily soon produce a Flame; there is no wood on the island (Gaskell 2000: 113).

Eventually the Great Auk became so rare that the effort required to catch and kill it for food or feathers was not worth the money the bird would fetch on the market (Gaskell 2000). It is not known whether the population at this point was too low to recover from the overexploitation it had experienced. One of the reasons this is not known is that the species was not given the chance to recover. "The Auk's increasing rarity merely meant that one form of commercial exploitation gave way to another, for trophy hunters and collectors now went after the eggs and skins and sold them at higher and higher prices" (Halliday 1980:74).

The Great Auk as a "collectible"

The late publicity and support that the Great Auk received from the ornithological community popularized the "soon extinct" bird, and served to make it a sought-after commodity and status item for collectors and museums. The auk was featured in the popular literature as a sort of "icon of extinction" (Fuller 1999:88). In the nineteenth century all the major scientists studying the auk were also interested in collecting specimens of the rare bird. Ornithologists, oologists, amateur naturalists and private collectors interested in "natural curiosities" were all incited to learn about the auk, a goal which at that time meant pursuing remains of the bird. Professor Reinhardt of the Royal Museum, Copenhagen, was in the perfect position to manage the distribution of Auk remains. Copenhagen was the main port where imports from Iceland arrived in Europe, and it was via this supply that Reinhardt was able to sell the remains to many museums

and private collectors throughout Europe. It is possible that museum purchase of the eggs and skins added to their value in the collectibles market, as it may do in the art market (Pommerehne and Feld 1997). The fragility of eggs increased their rarity and made them highly collectible. Their fragility meant that collectors had to be vigilant in protecting their collections since a broken egg was worth nothing. Some collectors amassed large collections, and competed with each other to own the biggest collection of Auk eggs. The most eggs owned by any one collector at a time was 13 (Fuller 1999).

The last sighting of the Auk resulted in the death of the breeding pair, as Icelandic fisherman were willing to expend great energy in seeking out this increasingly rare bird for both the status of being the supplier of such a rare commodity, as well as the extreme prices that the skins and eggs could fetch on the market. Southwell writes "…these poor birds were prosecuted, their eggs plundered and their necks broken to supply the demand which museums were then creating. And so the number dwindled, until in 1844, the only two then to be seen were taken, their egg broken (the shell left on the rock) and their skins shipped to Europe…"(Gaskell 2000: 134).

Auks were in a few cases captured alive and sold at high prices to collectors as pets. They did not tend to live long in captivity. One was reportedly kept successfully for four months while being fed a diet consisting of mashed potatoes and milk (Grieve 1885). Lists were compiled in the nineteenth century containing the owners of skins and eggs, and these animal parts were traded at increasingly high prices long after the extinction of the Auk. Extinction seems to have, if nothing else, increased the value of the Auk's remains. In 1900, the going rate for a stuffed auk in good condition was £300-400. In 1936 a stuffed auk went for £700, which at the time would buy 3-4 moderately sized

houses. In 1971 the Icelandic government raised £9000 to buy a stuffed auk offered by Sotheby's auction house in London.

Legislation for the Protection of Seabirds

Auks were by any measure becoming endangered by exploitation for oil and feathers, and in 1786 legislation was put in place to protect breeding areas like Funk Island. Mariners used the sight of the birds to locate low islands, and the rarity of the birds was becoming a navigational hazard. Exploitation of birds on the islands was criminalized, and violators were subject to public flogging.

Unfortunately, the legislation was not well enforced. One reason for this was that the recent American and French revolutions created a hostile attitude by colonists toward the Newfoundland government. Colonists saw the punishment for the crime of egging to be overly cruel, and there was no incentive to report offenders. The islands were remote and it was hardly economical for the government to send patrols to the island, so the harvesting continued. Thomas relates that in more recent times the islands were "seldom visited, except by Pirates and Robbers to steal the Feathers and Eggs" (Gaskell 2000: 112).

Popular attention and sympathy for the Great Auk's extinction had the consequence of prompting further legislation. In April, 1845, *An Act for the Protection of the Breeding of Wild Fowl in this Colony* was passed to protect other seabirds from over-harvesting. One good feature of the new law was that the punishment for violation involved fines, half of which were given to the person reporting the offense. This made

violations much more likely to be reported, and decreased the cost to the government of enforcement (Gaskell 2000).

CONCLUSIONS

Modern endangered species with slow reproductive rates like that of the Auk include whales, elephants, and rhinoceros. These animals have been harvested for many products including meat, ivory, horn, skins, and oil. Some policy decisions regarding these species depend on determining the level at which populations can be sustainably harvested. Unfortunately, models that can be used to answer these questions are difficult to develop. First, it is hard to model ecosystem relationships without making simplifying assumptions that can drastically reduce the model's predictive power. Secondly, even when adequate models are created, they are nearly always complex, nonlinear, and dynamic.

Studies done by Moxnes (1998, 2000) show that humans are extraordinarily bad at using complicated models to interpret feedback. Of 47 subjects participating in experimental reindeer-herding game, not one was able to create a sustainable system. All participants overstocked reindeer and half drove the population to extinction by the end of the game, despite being instructed on the nature of the relationship between the reindeer and their grazing source, lichen (Moxnes 1998). Moxnes (2000:327) resists the idea that humans can correctly engineer ecosystems to produce the maximum sustainable harvest of resources. Instead he asserts that "there seems to be a general tendency that decision makers misperceive feedback in that they undervalue the importance of delays, misperceive the workings of stock and flow relationships, and are insensitive to

nonlinearities that may alter the strengths of different feedback loops as the system evolves."

One simplifying assumption often made in models of resource exploitation is that the price of a given commodity will not change in relation to the abundance of its source. In the case of the Great Auk, this was certainly not the case. It is also not the case for those modern endangered species that are being exploited for organs used in the manufacture of Asian pharmaceuticals. These products include tiger and seal penises, which are thought to increase male potency, and rhino horn, which is thought to treat a number of ailments. Just as in the collectibles market, rarity in the supply of these products makes the price of medicines containing them rise. It may be the case that the more expensive a given drug is, the more curative power it is thought to have. As with Auk eggs and Swatch watches, high prices can shape perceptions that the object has greater value. "Forgers" have entered the market in Asian medicines as well. Molecular biologists studying the DNA of a number of items from Asian apothecaries have found that items marketed as "seal penises" were actually derived from a number of animals including dog and cow. In one case, an item was shaped to look like a tiger penis, was marketed as a seal penis, and actually contained tissue from a cow (Malik et al. 1997). The problem with determining the content of Asian patented medications is that it is not always possible to tell how much of the product is actually made from the endangered specied. Often the desired effect is perceived to obtain from medicines containing miniscule amounts of the actual animal product. Unfortunately, this can lead to incentives for intentionally driving population sizes down, and if a particular group holds a stockpile of a storable good like rhino horn, it may make economic sense to drive the

species to extinction to reduce competition from other suppliers. Kremer and Morcom (2000: 231) speculate that

> … if the population if live animals were very small, poachers and storers might not take prices as given, and would instead take into account that killing animals could raise prices. This may help explain why rhinos in Zimbabwe which had been dehorned by game wardens to protect them from poachers were nonetheless killed by poachers. …'If Zimbabwe is to lose its entire rhino population, such news would increase the values of stockpiles internationally'.

It is possible that prices of storable commodities derived from endangered animals may rise significantly following the animal's extinction, a speculation that may lead to intentional overexploitation by poachers with incentives to drive prices up.

Caughley (1993:943) summarizes the debate over sustainable harvesting of natural resources by writing, "…the best biological strategy and the best economic strategy coincide only when a population's maximum rate of increase is relatively high." This was not the case for the Auk, nor is it the case for elephants, rhinoceros or whales. If private ownership is not the answer, what is? Who will pay for conservation efforts if not the animals themselves? What are the incentives shaping the behavior of the people involved in harvesting and protecting the animals? What is the best way to develop and implement policies that prevent extinction? There are many issues in the debate over natural resource conservation, including conservation of endangered species, that remain to be resolved.

The example of the extinction of the Great Auk presented in this paper brings to light some of the many factors that can act in synergy to cause extinctions. Human mismanagement, environmental change, and the Auk's biology were each partially responsible for the fate of the species. However, the death blow for the Auk was the

consequence of its redefinition as a "collectible item". In the history of the Auk, we see how a species' rarity may itself increase the value of products derived from it, thereby providing economic incentives for extermination. Conservation efforts are underway to ensure that modern endangered species do not end up like the Auk: as the ultimate "limited editions".

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