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Can Prescribed Fire Save the Endangered Coastal Prairie Ecosystem from Chinese Tallow Invasion?

James B. Grace

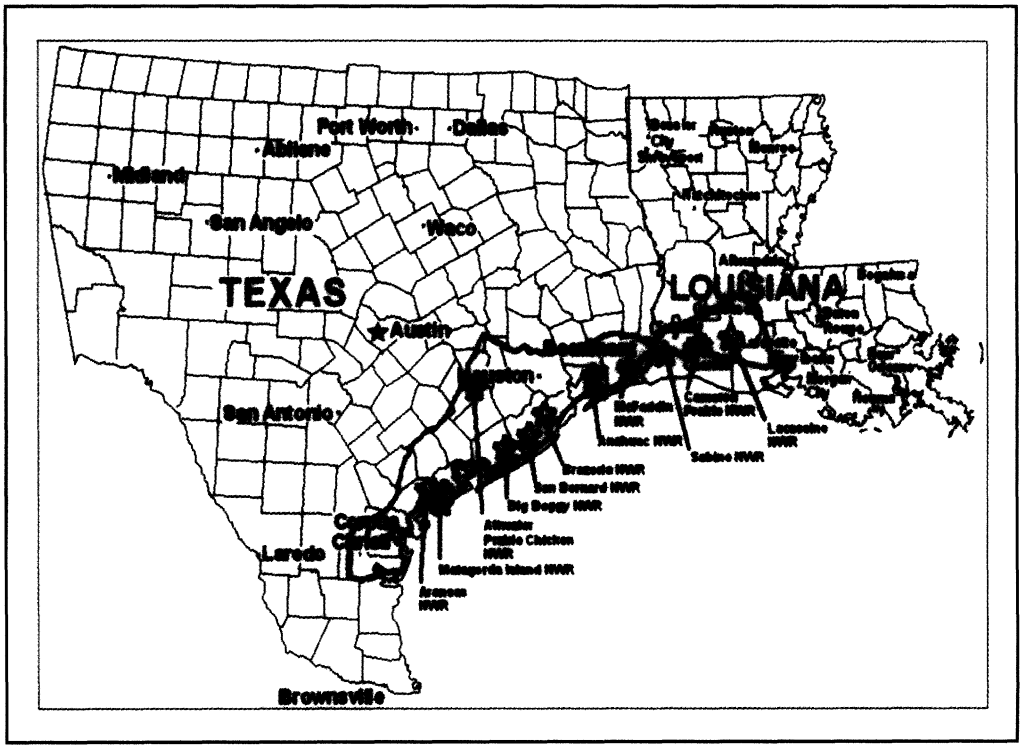
Abstract

The remaining fragments of the coastal prairie ecosystem and efforts to restore it are currently threatened by Chinese tallow (Sapium sebiferum *(L.) Roxb.), an invading exotic tree. With its capacity for rapid growth and prolific reproduction, tallow is capable of converting native prairie into a near monoculture forest in only a few years. Although tallow possesses several adaptations to fire, evidence is mounting that prescribed burning may be an effective management tool for limiting its invasion into coastal prairie.*

Stretching along the coastal plain from central Louisiana to southern Texas lies a poorly described and badly degraded natural grassland that has long escaped the attention of ecologists and conservationists alike. Prior to European settlement, the coastal prairie ecosystem was a band of grasses and forbs nearly 500 miles long, bordered to the south by marsh and to the north by forest. At that time, herds of bison roamed the region, pronghorn antelope were abundant, and wolves hunted from the riverine strand forests that dissected the plains. In the spring, the drumming of the prairie chicken was commonplace, and wildflowers, butterflies, and grassland birds were abundant throughout the prairie region.

Once railways into this region were completed in the late 1800s, the prairie was opened up to widespread cultivation, and farming began in earnest. Conversion of much of the land to agriculture, particularly in the eastern coastal prairie, was so rapid and complete that biological descriptions of the native communities at that time are rare. Today, it is estimated that less than one percent of the original prairie remains (Smeins et al. 1991). In Louisiana, less than 200 of the original 900,000 hectares (2.2 million acres) still exist, while in Texas, as much as 100,000 of the historic 2.8 million hectares persist due primarily to the tradition of livestock ranching instead of cultivation. Today, remaining coastal prairie is threatened by urban sprawl and invasion by exotic species such as the Chinese tallow tree (*Sapium sebiferum* (L.) Roxb.).

From a geographic perspective, the coastal prairie comprises the southeastern component of the vast prairie region that extends southward from Saskatchewan and Alberta, Canada to Corpus Christi, Texas (Diamond and Smeins 1984). Certainly the dominant grasses and forbs of the central and northern



Location of coastal prairie showing management and restoration sites within the Department of Interior.

prairies are characteristic components of coastal prairie. The bluestems (*Andropogon* spp., *Schizachyrium* spp.), coneflowers (*Echinacea* spp., *Ratibida* spp.) and blazing stars (*Liatris* spp.) are all there in abundance. However, on closer inspection, one realizes there is much more to this prairie ecosystem. Mingled throughout the typical prairie flora are numerous coastal wetland species such as gulf cordgrass (*Spartina* spp.) and saltmarsh morningglory (*Ipomoea* spp.), as well as species characteristic of the sandy pine savannas, such as pine lilies (*Eustylis* spp.) and even sundews (*Drosera* spp.). Sprinkled within the prairie are small mounds (known as "mima mounds") a few meters across that number in the millions and whose geologic origins are still contested. Coastal prairie also stands out from other prairie types based on climatic and edaphic features. While most natural grasslands are found in regions with less than 700 mm (28 inches) of rain annually, coastal prairie extends into areas with more than 1400 mm (56 inches) of precipitation in its eastern range. Instead of deep loamy soils known to support root systems several meters deep, much of the coastal prairie possesses a shallow soil underlain by a clay hardpan.

In its current condition, the coastal prairie ecosystem has lost the wild populations of many of its distinctive animal species such as bison (*Bison bison*), antelope (*Antilocapra americana*), red wolves (*Canis rufus*), and prairie voles (*Microtus ochrogaster*). How much has been lost of the other mammals, reptiles, amphibians, and invertebrates is unknown. Despite this, much biodiversity persists in the remaining remnants and is at risk in what The Nature Conservancy calls a "globally imperiled ecosystem" (Grossman et al. 1994) and what the Texas Organization for Endangered Species calls an "endangered community" (Diamond et al. 1992). Coastal prairie is the sole habitat of the federally endangered Attwater's prairie chicken (*Tympanuchus cupido attwateri*), the exclusive wintering ground of the federally endangered whooping crane (*Grus americana*), and important habitat for several other critically imperiled grassland birds. In addition, one federally endangered and 12 critically imperiled (category II) plant species occur in the remaining fragments of this once vast system.

Aside from the threats due to habitat loss, degradation, and fragmentation, the remaining pieces of coastal prairie and efforts to restore them are now facing a somewhat different enemy, the exotic tree Chinese tallow. Cultivated in China for about 14 centuries (Bruce et al. 1997), tallow is believed to have been first introduced to North America by Benjamin Franklin in 1772. In the coastal prairie region of Texas and Louisiana, tallow has been introduced numerous times since the early 1900s and has often escaped cultivation. By the 1940s it was a common feature of the landscape and since that time has been spreading and increasing in abundance. During the 1980s and 1990s, tallow abundance reached dramatic levels that have caused it to be recognized as one of the exotic plants of greatest threat to native habitat in the southern United States.

A number of characteristics of tallow contribute to its reputation as a threat to native species, both in prairie as well as in other community types within its range. Because it has been bred as a seed crop, primarily for the oils and waxes in its seeds and fruits, it has rapid growth, early reproduction, and prolific seed production. Seeds are released from pods from September

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Cover: J.J, a California gray whale, in a holding tank at SeaWorld San Diego.

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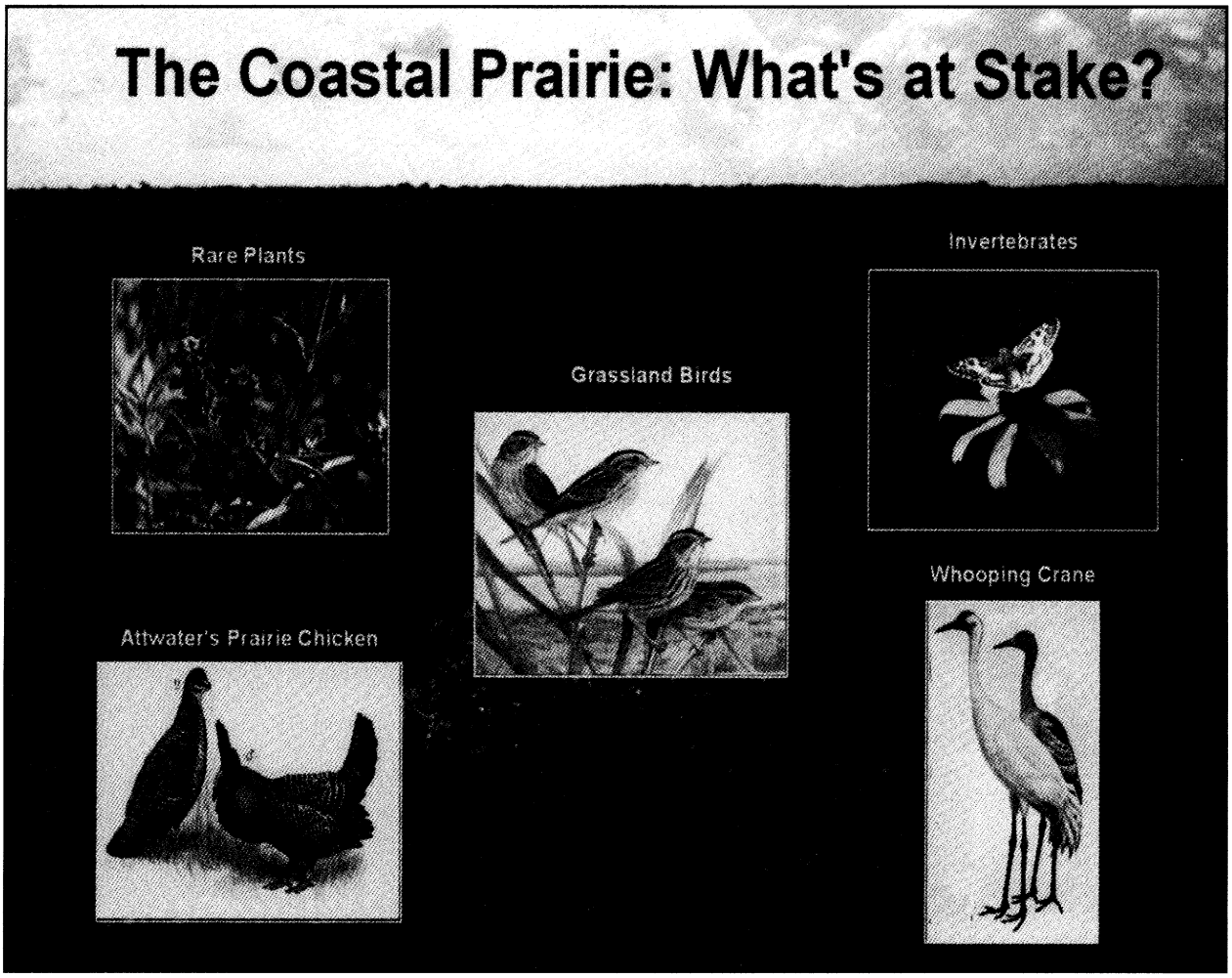


through November (though the seed may remain on the twigs for many months after dehiscence) and dispersal is primarily by birds and water. There is some indication that unlike most native trees, tallow seeds may survive for several years, permitting the development of a seed bank and enhancing its colonization capacity. Because of its rather large seed and shade tolerant seedlings, tallow has been observed to invade undisturbed habitat, though, like most invasive species, its entry into a system is enhanced by disturbance. Once it establishes, tallow grows rapidly and resists both flooding and drought, an uncommon feature for most species. Through both rapid growth and reproduction, this invader can effectively suppress native woody and herbaceous species alike, creating near monoculture forests devoid of prairie species, either plant or animal. It has been reported that tallow is capable of invading and dominating an open habitat in as few as 10 years (Bruce et al. 1995).

Recently, our studies of tallow have focused on the question of whether prescribed fire might be an effective control. As for most prairie types, as well as for many other kinds of ecosystems, wildfire is believed to have played a critical role in the formation and maintenance of the coastal prairie (Smeins et al. 1991). Before the widespread conversion to agriculture and the subdivision of the landscape by roadways, wildfires swept through the prairie on what is presumed to have been a regular basis. During periods of hotter and drier weather, fires would have been more frequent, while in periods of cooler or wetter weather, substantial intervals between fires would have allowed the encroachment of shrubs until the next period of hot fires (Archer et al. 1988).

It is unlikely that fire was the sole determining factor for the prairie's persistence in the wet climate of the coastal prairie region. Much evidence exists to suggest that this prairie was also edaphic or soil regulated, especially in the eastern portion where rainfall is most plentiful. Here the soils are hard, cracking clays or fine, silty loams underlain by a hardpan inimical to the ready establishment and growth of trees. The increase in woody plant cover in the recent decades since wildfire has become uncommon suggests that these edaphic features alone are not sufficient to restrict tree growth. Rather, it is likely that a combination of soil properties, periodic droughts made more severe by the soils, and frequent fires maintained the ecosystem in a state of "disclimax" where trees and shrubs were frequently disfavored. To some degree, natural grazers such as bi-

son, antelope, and deer may have also contributed to the restriction of trees and shrubs, but the common occurrence of all these species in forests suggests that their role in prairie maintenance was not a dominant one.

When fire moves through the prairie, the native woody plants are typically killed or severely damaged, resulting in a maintenance of fire-tolerant and sometimes even fire-promoting grasses and forbs (Scifres and Hamilton 1993). Through the process of repeated burning, it is believed that these communities become strongly selected for fire-tolerant species over those less able to withstand the many effects that fire can have on growth, survival, and reproduction. For some other fire-dependent ecosystems, it has been suggested that species may even be selected for their flammability as a way of disadvantaging their less fire-tolerant neighbors (Williamson and Black 1981). While this feature of prairie vegetation has not been established, it is clear that typical prairie species must be adapted to frequent fire.

A number of human activities have reduced the incidence of fire in the coastal prairie. Historically, lightning strike fires would have moved across vast areas until they encountered streams or other natural barriers, or were put out by rain (Anderson 1990). Fragmentation of the landscape is a key feature that greatly reduces the probability that a remnant prairie will burn naturally. Fire suppression activities, as well as grazing and mowing (which reduce available fuel) lower the odds of wildfire occurrence. As a result, human-set fires have come to be the cause of a great percentage of the fires, though certainly wildfires (including escaped human-set fires) are still common. For the people responsible for managing native prairie habitat, prescribed fire is currently viewed as one of the primary tools of choice for controlling tallow. Alternative methods such as mowing and herbicides, while useful, are expensive, labor intensive, and sometimes counter to management objectives.

A consequence of the low frequency of fires in the coastal prairie has been the increased development of woody vegetation. In most cases, however, these overgrown systems are still vulnerable to fire when it finally occurs. For example, in areas where eastern baccharis, a native coastal shrub, grows unmolested for many years, one hot, growing-season burn can completely kill the tops of the shrubs, reducing the plants to basal sprouts and stimulating a resurgence of native grasses and forbs, usually with a profusion of flowering. Thus, even with fire suppression, it seems that the community remains "pyrogenic", capable of supporting a strong fire that resets succession.

When the exotic Chinese tallow tree enters the picture, this normal pattern of fire-induced succession can be dramatically altered. Tallow has a number of adaptations to fire. First, as trees get larger, thickening of the bark provides protection for the cambium layer where secondary growth takes place. Above some minimum size, tallow appears to become resistant to being killed or "top-killed" (death of the above-ground portion of the plant) by fire. Second, for smaller trees or large trees subject to a very hot fire, the response to being top-killed is a vigorous resprouting that can produce 2 meters of regrowth in only a single season. Thus, the plants can recover from fire quickly. Third, when damaged by fire or mechanical cutting, tallow typically responds by root sprouting at some distance from the original stem, resulting in clonal spread for distances greater than 5 meters. Fourth, only the hottest fires ignite tallow and it does not typically propagate the fire as a crown fire, unlike many trees and shrubs. Finally, and perhaps most importantly, stands of tallow are excellent

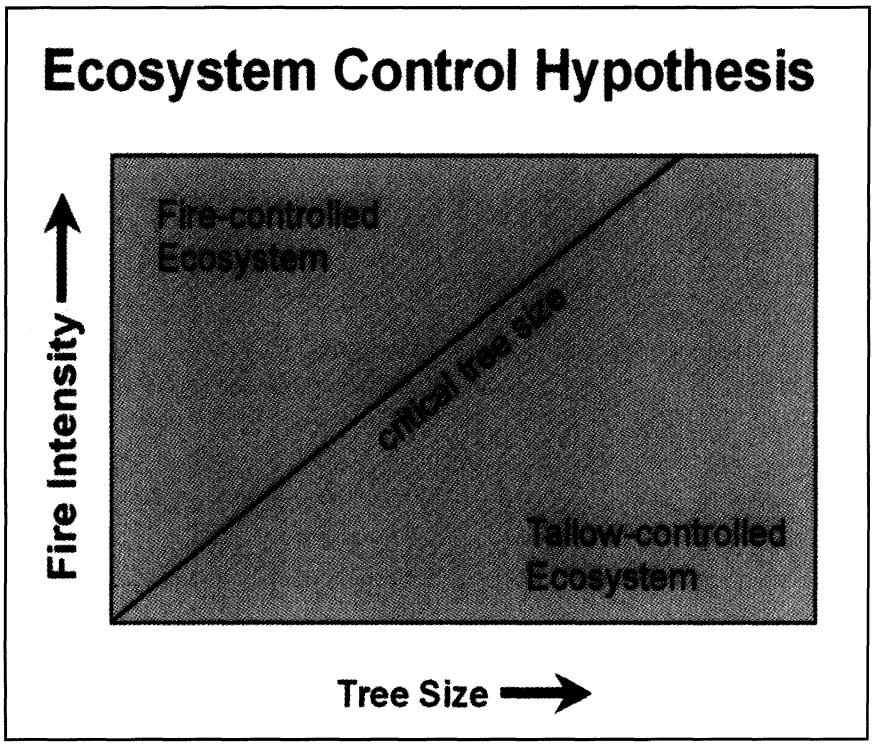
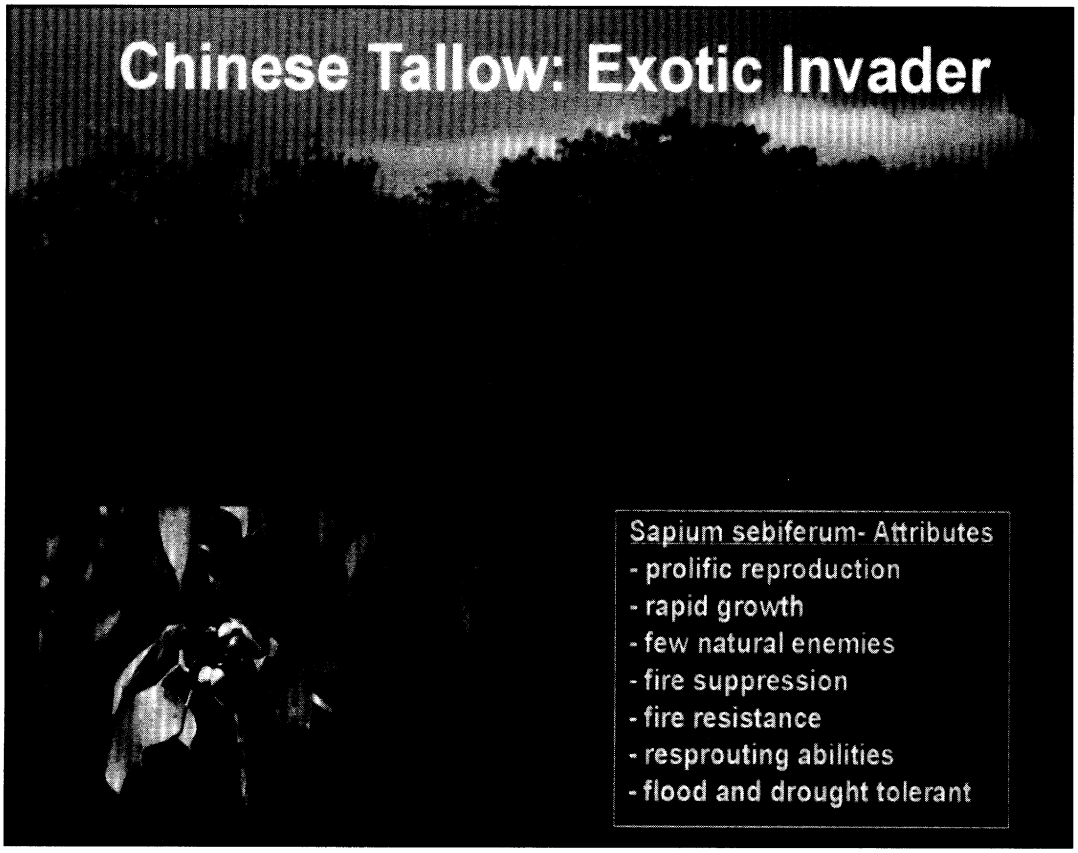


Figure 1. Hypothesized relationship between tree size and the capacity for fire to control tallow.



at competitively excluding the fuel species that drive fire. It is common to watch a prescribed fire burn right up to the edge of a tallow stand and simply go out because of a lack of fuel. Because of these last two features, low flammability and strong ability to suppress fire, it is possible for tallow to render the ecosystem nonflammable.

The conversion of prairie from pyrogenic to nonflammable has potentially severe consequences for both the fate and management of prairie. In essence, the system changes from being fire regulated to being tallow regulated. There is some evidence that once tallow stands are well developed, soil properties may become altered (Cameron and Spencer 1989), having consequences for the plant and soil invertebrate communities that are, as yet, unknown (Harcombe et al. 1993). Certainly, stands of tallow greatly reduce available light and can be expected to alter soil moisture profiles, microclimate, and, therefore, a wide range of habitat characteristics. Once a site has become tallow regulated, the only means of recovering the ecosystem is through applications of herbicides in combination with mechanical activities. Such approaches, while necessary in certain cases, should be viewed as the last line of defense because of the potential for undesirable effects on the native community as well as the expense and effort.

Recently, our studies of tallow have focused on the question of whether prescribed fire might be able to provide effective control if used early in the process of invasion or as a preventative to successful invasion. The essence of the hypothesis is shown in Figure 1. The basic idea is that below some critical size, tallow is vulnerable to fire and that the critical size will depend on the intensity of the fire. In areas with poor fuels or subjected to a low intensity fire, only the smallest trees will be killed or top-killed. In areas with high fuel loads and intense fires, however, much larger trees will be heavily impacted. To a certain extent the critical factor determining whether a fire is effective is whether the trees are shorter in stature following the fire than before the fire. As an example, if a tallow tree is 2 meters tall before being subjected to fire, a reasonably hot fire may damage the canopy of the tree considerably. Shortly after the burn the tree will begin resprouting, which may occur from basal shoots or along the main axis at some distance above the ground. It is also possible that some of the tallest branches may not be damaged at all if they escaped the upward influence of the flames and the main axis was not girdled by damage to the cambium. Assuming that the below-ground parts of the tree are not completely killed, which is typically the case for trees of even modest size, the recovery process continues until the next fire. If at the time for the next burn the tree is smaller than it was before the first burn, we can see that the tree is getting smaller over time and we are moving toward increasing damage to the tree, resulting in control. If, on the other hand, the tree is larger than it was before the first burn, the tree is moving increasingly toward invulnerability, both because of its increasing size and because of its increasing effect on fuel species.

Since 1996 our research group has been examining the question of whether a minimum critical tree size exists for control of tallow using fire, and if so, what factors deter-

mine that size. Our study is being conducted at the Brazoria National Wildlife Refuge, a unit of the U.S. Fish and Wildlife Service. In 1990, the refuge acquired an approximately 12,150-hectare (30,000-acre) tract of coastal prairie and wetlands for conserving and restoring this land for wildlife habitat. Since that time, refuge staff have been using various management practices, including the extensive use of prescribed fire, in order to bring this habitat back into a relatively natural state.

In 1996, studies were initiated at the Brazoria Refuge to determine the effectiveness of fire on tallow populations in areas previously subjected to grazing (virgin prairie, that is, never plowed) or rice farming (abandoned field). Special attention has been paid in these studies to determine the relationship between tree size and fire effects, and to factors that might influence the effectiveness of fire. Because of the heterogeneous nature of fire in woodlands, measurements of both fuel conditions and effects on woody plants are being made by using a tree-centered approach. Fires were conducted in both growing season and dormant season conditions, and the fate and subsequent recovery of trees were examined during the following year.

Initial results seemed to confirm the worst fears of conservationists. Investigations immediately after the fire indicated that nearly all trees were resprouting or only slightly damaged. Of the 400 trees being studied, the only trees that appeared dead were 10-cm-tall seedlings transplanted into the site as part of the experiment. Not a single tree of the natural population was killed. In the abandoned field sites, one clear problem was inadequate fuel conditions and a very incomplete fire, with only 24-37% of the trees actually being burned. At the prairie site, however, fires directly affected 73-100% of all trees. Regardless, even trees exposed to the most extreme flames showed vigorous resprouting shortly after the fire.

Under good fuel conditions, fire causes severe damage to tallow trees.

When trees were reexamined at the end of the growing season in 1997, we were surprised to find that rather than showing continuous recovery, many trees showed evidence of much greater damage than initially apparent. Of those trees subjected to fire, all new seedlings had died, and 70% of trees 2 m or less in height, as well as more than 30 trees in the range of 2-5 meters, were either killed or top-killed. While the tallow populations were not decimated, it was clear that this single burn event had an impact. Further, other variables measured revealed that for many surviving trees, leaf area was dramatically reduced and final heights were less than those before the fire.

Detailed examination of the results indicates that there is considerable variation in the effects of fire. While analyses are still preliminary, it appears that the long-term effects of the growing season burn were substantially greater than those from the dormant season burn, particularly on the survival and growth of basal resprouts. Also, total stand fuel loads, the species composition of the fuels, and fuel continuity appear to have contributed to generally hotter and more complete fires at the virgin prairie sites compared to the abandoned field sites. These hotter fires not only burned more trees but were more likely to kill trees outright.

Much is yet to be determined concerning the potential for fire to reduce tallow populations. Subsequent burns have been conducted to ascertain the effects of repeated fires so as to better judge long-term fire

management programs. How quickly will the fuel recover? How does the interval between burns influence fire's impact? Are tallow resprouts more susceptible to damage by fire? How does the season of burn affect the total community? Does burning ever enhance the potential for tallow to invade? What has been established is that hot fires can kill or top-kill even large tallow trees and have long-term residual impacts. When we consider how few success stories there are with exotic plants in natural ecosystems, we are encouraged. The long-term viability of the coastal prairie ecosystem, as well as the persistence and recovery of endangered species such as the Attwater's prairie chicken, depend on the prairie not becoming a tallow controlled system.

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Estimating and Questioning Economic Values for Endangered Species: An Application and Discussion[1]

Matthew J. Kotchen
and Stephen D. Reiling

Abstract

*The economic costs of Endangered Species Act provisions receive substantial attention, but the economic benefits of species protection are often overlooked. This paper presents an overview of the theory and methods necessary to estimate public values for threatened and endangered species. Results are presented from a contingent valuation study that estimates economic values for the peregrine falcon (*Falco peregrinus*) and shortnose sturgeon (*Acipenser brevirostrum*) in Maine. Using empirical evidence about what motivates economic values for threatened and endangered species, questions about what the numbers truly represent are pursued. The intention is to provide a perspective that highlights potential advantages and limitations of estimating economic values for threatened and endangered species.*

Introduction

The federal Endangered Species Act (ESA) is frequently accused of prioritizing the well-being of fish and wildlife over people. ESA provisions designed to protect threatened and endangered (T&E) species are rarely free of criticisms for adverse economic impacts. As critical habitats are protected, these impacts may be associated with short-run effects such as decreased employment. Long-run effects may be associated with opportunity costs from foregone resource uses and higher production costs. Thus, ESA provisions frequently spark controversies pitting species protection against economic concerns.

While substantial attention is given to the economic costs of protecting T&E species, there is less recognition of the economic benefits of ensuring species survival. Protection of T&E species is typically justified on the basis of ecological importance, yet studies in the economics literature demonstrate how people value a wide variety of species, ranging from the bald eagle (*Haliaeetus leucocephalus*), to the gray whale (*Eschrichtius robustus*), and the obscure striped shiner (*Luxilus chrysocephalus*) (Boyle and Bishop 1987; Loomis and Larson 1994). A benefit-cost analysis of northern spotted owl (*Strix occidentalis caurina*) protection in the Pacific Northwest, for example, found the economic benefits of protection to exceed the highly publicized costs (Rubin et al. 1991).

As species protection efforts continue to conflict with economic development, measuring public values for T&E species becomes more important. Documentation of the real and positive benefits resulting from species recovery helps avoid the false implication that things not readily measurable in dollars are without value. Estimation of these values, however, must be approached with caution. Economic techniques for estimating public values for T&E species have been advancing, but disagreement remains about theoretical underpinnings and applied methods. Questions are also raised as to the appropriateness of these values for influencing public policy.

The intent of this paper is to highlight some of the advantages and disadvantages of placing monetary values on seemingly priceless resources. There is initial discussion of why estimating economic values for T&E species is important, followed by an overview of possible economic values for T&E species. Results are presented from an application to the peregrine falcon (*Falco peregrinus*) and shortnose sturgeon (*Acipenser brevirostrum*) in Maine. Using empirical evidence, these results are analyzed from the perspective of what the numbers truly represent.

Why estimate economic values?

Why is it important to estimate economic values for T&E species? There are those who cite the difficulties of eliciting such values, and those who believe that ascribing values is actually devaluing. While this perspective is undoubtedly valid in various circumstances, many, if not most, environmental advocates and

economists approach the question differently. Estimating economic values is perceived as necessary, rather than something to pursue in its own right. As described by Costanza et al. (1997), whether we acknowledge it or not, we implicitly or explicitly value environmental or ecological resources every day. Every decision with potential impacts on the environment is directly or indirectly based on the relative weights we give to aspects of the decision problem. The choice is whether or not we decide to make these weights explicit, taking into account the best available science and recognition of uncertainty. Since we are in effect doing valuation while making societal decisions, the prudent course is to be as informed as possible.

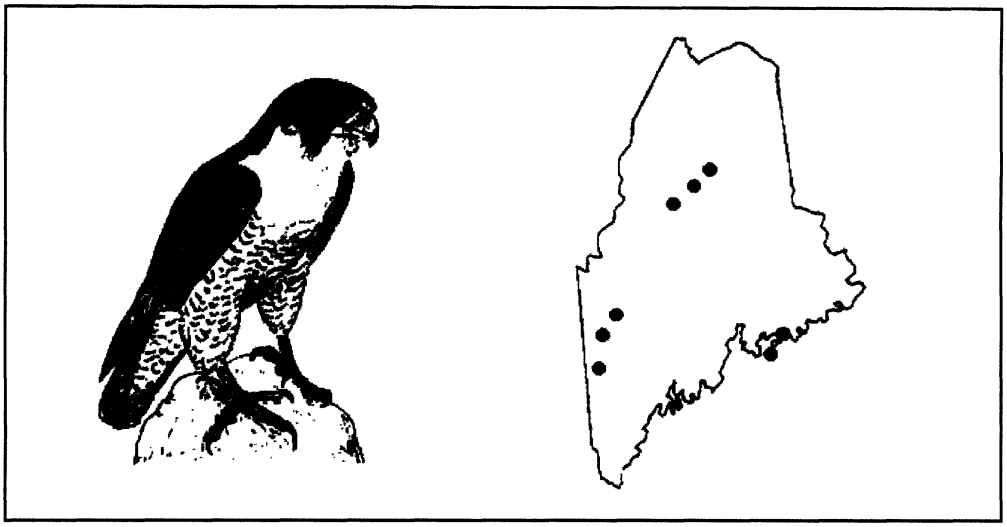

Figure 1. Peregrine falcon (*Falco peregrinus*) and locations of pairs in Maine.

Considering wildlife or T&E species specifically, less virtuous reasons for estimating economic values also exist. First, Congress has not only considered lifting prohibitions on using economic analyses in ESA listing decisions; recommendations have been made to require benefit-cost analysis (U.S. Congress 1996). Although these recommendations violate the original intent of ESA legislation, they underscore the importance of refining valuation techniques and communicating information about benefits associated with species protection. Second, whether involving T&E species or not, natural resource damage assessments have become increasingly important to mitigating adverse environmental effects of human activities. The Valdez oil spill in Prince William Sound, Alaska, provides a well-known example, in which Exxon was forced to pay compensation for their damages. While the justness of the final outcome is debated, one thing is certain: without research into the economic value of afflicted wildlife species, there would have been no compensation for such damages.

Economic values for endangered species

People value endangered species for different reasons and therefore benefit from their protection in different ways. The total benefits of protection are generally partitioned between those arising from "use" or "nonuse" values, which together comprise a species' "total" value. Use values may arise from consumptive, non-consumptive and indirect activities (Boyle and Bishop 1987). Consumptive activities involving wildlife may include hunting and fishing, but these activities are prohibited for species officially listed as threatened or endangered. Therefore, use values for T&E species and not their habitat are limited to non-consumptive and indirect uses, which include activities such as observation (e.g., bird watching) and photography. While both observation and photography require on-site, active use, individuals may also benefit from indirect use activities, such as enjoyment gained by reading about or viewing photographs and motion pictures of the species.

Temporal and intergenerational dimensions of use values are captured by two additional sub-value categories: option and bequest values. Option values arise from uncertainty about the future and the desire to preserve options for either direct or indirect uses. Someone who has never seen a particular endangered species, for example, may want to maintain options to do so in the future. Bequest values arise from concern about future generations. Someone holds a bequest value if they gain satisfaction from knowing protection of an endangered species today ensures the species continued existence for the benefit of future generations.

Nonuse values are different from use values because they arise in the absence of any past, present, or intended future use. In other words, nonuse values are derived from the satisfaction of *simply knowing* that an endangered species has a sustainable population in its native habitat. John Krutilla (1967) is credited with first introducing this economic concept by explaining that "there are many persons who obtain satisfaction from the mere knowledge that part of the wilderness of North America remains even though they would be appalled by the prospect of

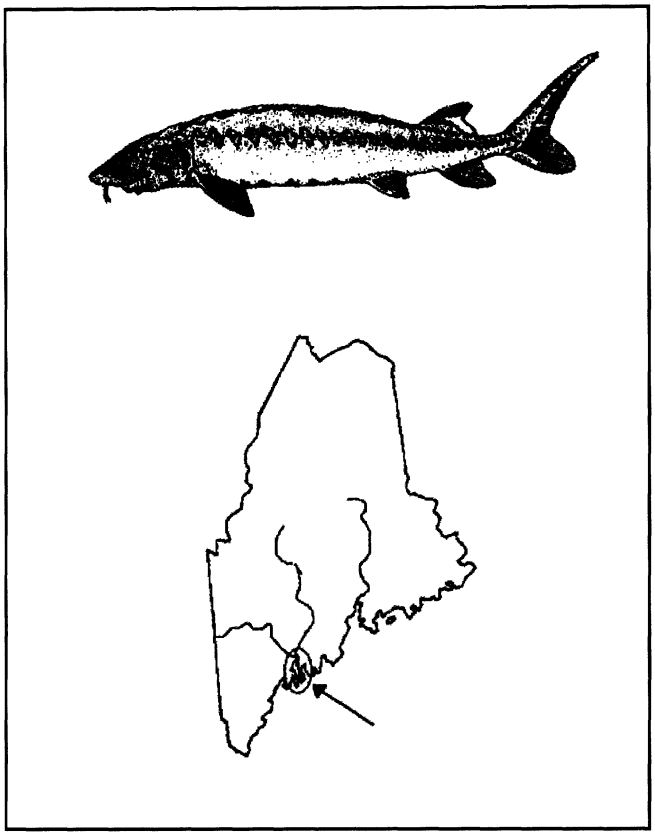

Figure 2. Shortnose sturgeon (*Acipenser brevirostrum*) and location of population in Maine.

being exposed to it." Subsequently, numerous studies have demonstrated that many people are willing to pay a certain amount to ensure the continued existence of unique environmental resources, regardless of the fact that they may never personally use them. Loomis and White (1996) provide a review of studies investigating T&E species in particular.

Given this theoretical outline of potential economic values for a T&E species, how feasible is it to derive estimates? Considering direct and indirect use values, one might look at actual economic transactions. While this is not an easy task, methods have been derived to estimate direct values (see Freeman 1993). The travel cost method, for example, estimates the cost people incur to travel for specific purposes related to a threatened or endangered species. These costs are then used to infer values. Estimating indirect values, which are inherently more diffuse, is more difficult. Nevertheless, there are market transactions involving indirect uses of many endangered species that could be accounted for one way or another. The more controversial values to estimate are option, bequest, and nonuse values. Such values are difficult to estimate because they are not observable through economic activity and are not measurable through market transactions. Therefore, estimation requires the use of hypothetical markets by a method known as contingent valuation (CV). CV uses surveys to directly question people about their economic values (see Mitchell and Carson 1989). This technique is described in the next section for an application to the peregrine falcon and shortnose sturgeon in Maine.

Economic values for peregrine falcon and shortnose sturgeon in Maine

The peregrine falcon and shortnose sturgeon are both endangered species in Maine. Their total economic value to Maine residents was estimated from a mail survey administered during the Spring of 1997 to a general population sample of 1,200 Maine residents over the age of 18 (Kotchen 1997). Mailing procedures were conducted in accordance with the Total Design Method (Dillman 1978). A total of 194 surveys could not be delivered due to incorrect or incomplete addresses, and 635 were returned for a response rate of 63.1 percent.[2] In addition to questions about economic values, the survey contained a variety of questions about environmental attitudes, prior knowledge of the species, outdoor activity participation, and socioeconomic characteristics.[3] Bias that may have resulted from asking respondents to value more than one species was avoided by stratifying the sample such that one-half received questions about peregrines and the other half received questions about sturgeons.

The CV section was constructed according to guidelines established by a panel of economists assembled by the National Oceanic and Atmospheric Administration (Arrow et al. 1993). Background information and a proposed recovery plan based on consultations with the Maine Department of Inland Fisheries and Wildlife and the Department of Marine Resources was provided in each survey for either the peregrine falcon or the shortnose sturgeon. Recovery for both species involved restoring a self-sustaining, breeding population. For the peregrine falcon, this involved increasing the State's current population of 8 resident pairs to 15 resident pairs. For the shortnose sturgeon, this involved protecting a population at the mouth of the Kennebec River from future dredging and water pollution. A technical drawing of the species and map indicating its present range in Maine was also included (Figures 1 and 2). The question format was a voter referendum to approve establishment of a statewide species protection fund. After reading background information, respondents were asked to:

> *Suppose this proposed fund to increase Maine's [species name] population*

*was on the next State ballot. If it would cost you $____ **in a onetime payment** through increased taxes, would you vote to approve the proposal? (CIRCLE ONE NUMBER)*

1 YES
2 NO

Specified dollar amounts were randomly assigned to respondents and correspondingly printed in survey booklets. These ranged from $2 to $50 for the peregrine falcon and $1 to $35 for the shortnose sturgeon. The ranges of specified dollar amounts were based on focus group results and a review of studies having valued similar species.

Several variables were hypothesized to influence the probability of a respondent answering "yes" to this question. Consistent with economic theory, one would expect higher prices (or specified dollar amounts) to result in lower probabilities of responding "yes." Based on established relationships between attitudes and behavior, respondents with stronger pro-environmental attitudes were expected to have higher probabilities of responding "yes" (Kotchen and Reiling in review). Moreover, those with prior knowledge of the species in Maine were expected to have higher probabilities of responding "yes." Using this framework and multivariate logistic regression, an econometric model was estimated to determine the effect of each variable on respondents' actual decisions. The approach enables evaluation of each variable for its partial effect on the probability of "yes" responses while holding other variables constant.

Results from this model for the peregrine falcon and shortnose sturgeon are presented in Table 1.[4] All coefficients are significant at the 95% level and have signs in the expected direction. The specified amount respondents were asked to pay (*BID*) is negative, indicating that higher prices decrease the probability of a "yes" response. The coefficient on environmental attitudes (*ATTITUDE*), as measured with the New Ecological Paradigm (NEP) Scale (Dunlap and Van Liere 1978; Dunlap et al. 1992) is positive, confirming the notion that stronger environmental attitudes increase the probability of "yes" responses. Prior knowledge of the species in Maine (*KNOWLEDGE*) also has a positive and significant influence on the probability of respondents answering "yes." The overall percentage of variation in responses explained by the independent variables is captured by the pseudo R squares of .18 for the peregrine and .237 for the sturgeon. The percentages of correct predictions are 66.1% and 66.5%, respectively.

Estimates of mean willingness to pay (WTP) for species protection are derived from these equations. The technique is explained by Hanemann (1989) and assumes no negative values. Mean WTP for the peregrine is approximately $29, and mean WTP for the sturgeon is approximately $23. Note that these values represent a onetime payment to increase populations to a level that ensures continued survival of the species in Maine. Confidence intervals around these means are also estimated to account for uncertainty (Park et al. 1991). These indicate that with 90% certainty the mean WTP is between $17 and $93 for the peregrine and between $17 and $39 for the sturgeon.

An estimate of the total economic value of the peregrine falcon and shortnose sturgeon to Maine residents is readily estimated from these ranges. Multiplying the high and low bounds of mean WTP by Maine's population of roughly 1.2 million yields values somewhere between $20 million and $111 million for the peregrine and $20 million and $47 million for

Table 1. Logistic regression results and mean willingness to pay for responses to a dichotomous-choice, contingent valuation question for the peregrine falcon and shortnose sturgeon.

	Peregrine falcon		Shortnose sturgeon	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Constant	-3.207*	1.012	-3.976*	1.081
BID	-0.040*	0.013	-0.064*	0.020
ATTITUDE	0.067*	0.018	0.091*	0.019
***KNOWLEDGE* (1=yes, 0=no)**	0.598*	0.288	0.762*	0.377
Pseudo *R* squared	.180		.237	
Percent correct predictions	66.1		66.5	
Log-likelihood	-142.11		-122.29	
Number of observations	230		212	
Mean WTP	$29.15		$23.32	
90 percent WTP interval	$16.99-$92.85		$17.48-$39.48	

* indicates significance at the 95 percent level.

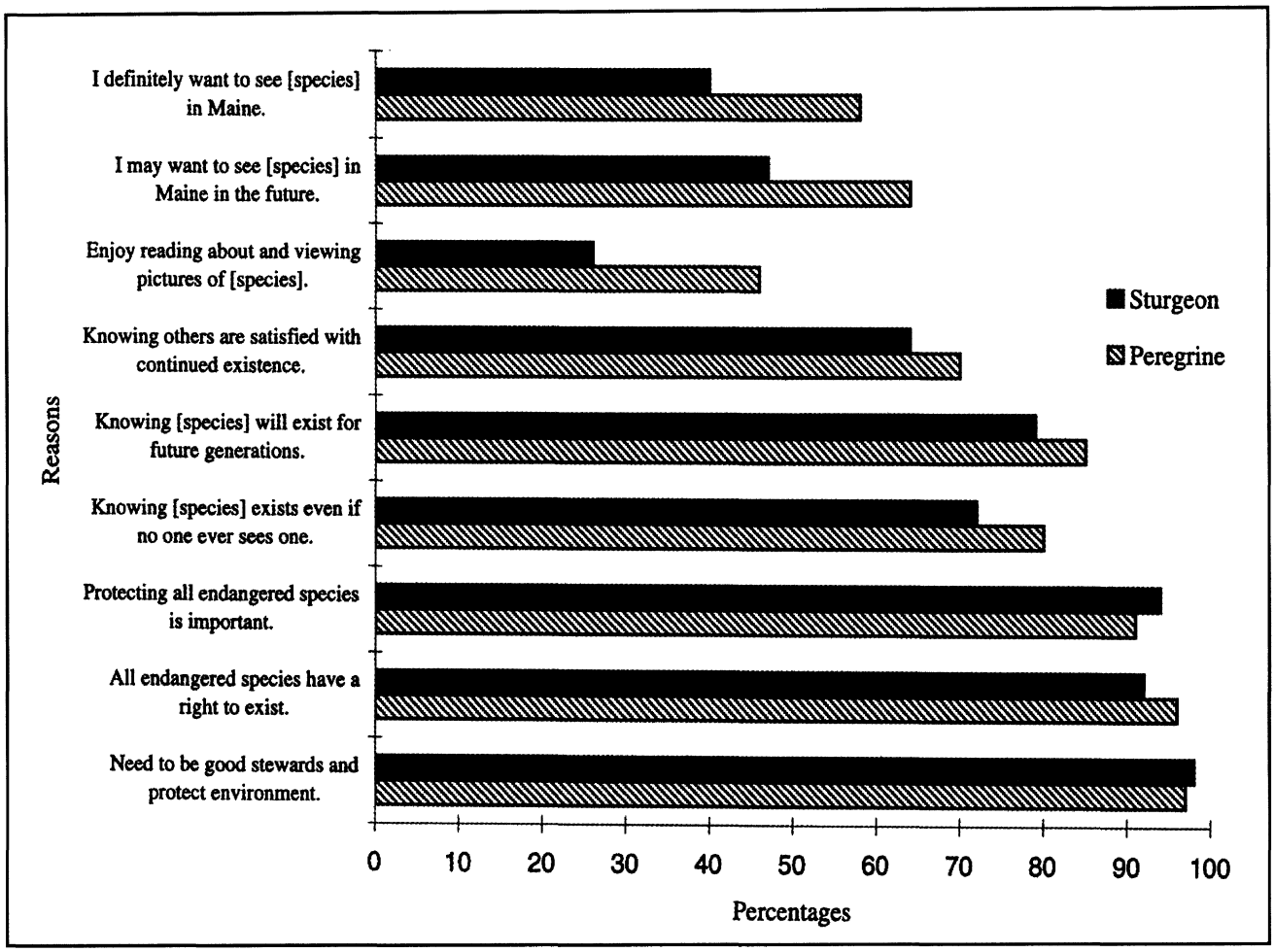

Figure 3. "Very important" and "important" percentage responses for species protection willingness to pay reasons.

the sturgeon. Thus, protection of these species is associated with substantial economic benefits. Moreover, failure to protect these species would be associated with substantial economic losses. The values presented here should, however, be recognized as underestimates because only Maine residents are included. Non-residents may also value the continued existence of these species in Maine, but capturing their values would require broader samples to account for potential distance-decay factors.

What's behind the numbers?

Most valuation studies for an endangered species stop after presenting the final numbers. The additional question of what the numbers truly represent is pursued in this paper. The intention is to provide a somewhat different perspective that highlights potential limitations of estimating economic values for endangered species and that leads to a discussion of policy implications.

Economists have repeatedly shown that obtaining reliable estimates of economic values for resources such as endangered species requires an examination of underlying motivations (e.g., Bergstrom and Reiling 1997; Johansson-Stenman 1998). Nevertheless, there has been surprisingly little applied research on what motivates people to hold resource and environmental values. This lack of information is most likely due, in part, to the difficulty of accurately measuring motivations. Such difficulties, however, should not limit common sense approaches. In this application to the peregrine falcon and shortnose sturgeon, respondents were asked to directly rate the importance of potential motivating reasons for reporting a WTP.

Abbreviated versions of these reasons are shown in Figure 3, along with the percentage of responses that were either "very important" or "important." Lengths of the bars, therefore, are a heuristic measure of the relative importance placed on each reason. Many of these reasons correspond to the resource and environmental values previously described.[5] "I *definitely* want to see the species in Maine" and "I *may* want to see the species in Maine" are statements with different probabilities for future option values. Note how these two statements are more important for the peregrine falcon than for the shortnose sturgeon. Indirect use values are one of the least important reasons, as shown by the relatively small importance of enjoyment gained from reading about and viewing pictures of the species. Moving to the somewhat more abstract motivations,

altruistic concern for others of the current generation are more important, although less important than concern for future generations. Motivations for nonuse values are relatively important. Between 70% and 80% of the respondents felt that protecting the species even if *no one* ever sees it was either "very important" or "important." Together, these motivations for use and nonuse values cover the topology of general resource and environmental values previously described, and the results provide empirical evidence that each comprises a meaningful component of the total economic value for these particular endangered species.

The remaining reasons for reporting a WTP in Figure 3, however, warrant further consideration. Unlike the motivations discussed above, the last three listed in Figure 3 are somewhat problematic for the theoretical economic framework, yet these motivations appear most important. The first reason, "Protecting all endangered species is important," reveals what economists identify as an embedding effect (Mitchell and Carson 1989). Embedding occurs when hypothetical responses represent something larger than the resource actually being valued. In this case, respondents think all endangered species should be protected, and the fact that the two species are being valued is only incidental. Thus, difficulties arise when trying to attribute reported values exclusively to the subject species. Moreover, questions arise as to whether respondents can accurately think in terms of valuing a single species. The reason that "We need to be good stewards and protect the environment" reveals a similar effect. Protection of peregrine falcons or shortnose sturgeons is embedded in larger opinions about what is important, thereby making it difficult to interpret what WTP responses truly represent.

This task is complicated further with evidence of a biocentric, or nonanthropocentric, perspective in the statement that "All endangered species have a right to exist." This motivation demonstrates how many respondents made their decision on moral and ethical grounds. Such rights-based approaches to decision-making are distinguished from utilitarian, or economic, approaches (Spash and Hanley 1995). The fundamental difference between the two approaches is the degree to which tradeoffs are possible. Because rights-based decisions are based on moral and ethical beliefs, tradeoffs jeopardizing a species survival are unlikely to occur. A utilitarian perspective, on the other hand, may acknowledge benefits and costs of protecting a particular species and be willing to accept tradeoffs in order to maximize personal or social utility. Economic analysis, however, is based on the latter approach, and many economists recognize the limitation of applying analytic techniques, such as valuation, to decisions with substantial moral and ethical components (e.g., Brookshire et al. 1986; Rosenthal and Nelson 1992; Nelson 1996; Spash 1997).

So what does the motivational analysis of this application to the peregrine falcon and shortnose sturgeon imply? Consistent with the framework of resource and environmental values, people value protection of these species for many reasons compatible with economic analysis. Nevertheless, there are difficulties in assessing the accuracy of WTP estimates, and many people hold values for moral and ethical reasons. That is, people believe T&E species are priceless and should be protected at any cost. Unfortunately, the problem in reality is not so simple. Environmental managers recognize that other people make opposing arguments, and trying to balance opposing moral and ethical arguments leaves little room for compromise. Such positions leave environmental managers with polarized decision spaces of "jobs" or "environment." Nevertheless, there is a middle ground, and this is reflected in the way most people recognize the need to make tradeoffs on some level. Economists may argue that estimating economic values is the way to determine such middle ground, but the analysis presented here demonstrates limitations of this technique. Attempts to measure economic values for T&E species inherently become tangled in moral and ethical positions, and problems with methods still exist. Economic research may find ways to resolve empirical problems, but resolving policy differences based on ecological uncertainties and moral and ethical positions requires more than economic analysis.

Conclusion

Estimating economic values for T&E species is important to better understand the ramifications of decisions. There are several types of economic values, and this application to the peregrine falcon and shortnose sturgeon in Maine provides evidence of the existence of such values. At the same time, the economics framework has empirical limitations and cannot incorporate all potential values for T&E species, as shown by the importance of moral and ethical considerations. Therefore, societal decisions affecting T&E species must be worked out as part of a dynamic political process, be informed by the best available science, and take advantage of economic analysis as a *policy tool* and not a *decision rule*. This, of course, is not a revolutionary conclusion, but this paper attempts to provide structure to the subject of estimating economic values for T&E species. The problem is not as simple as saying economic valuation is inappropriate and should be abandoned. Moreover, economic analysis does not have all the answers. In the end, economic analysis is a

powerful tool for promoting the conservation of T&E species, and just as diverse ecosystems are more stable and persistent, taking advantage of the full range of tools to promote conservation may lead to more stable and persistent solutions.

Acknowledgements

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Notes

[1]This paper is based on a presentation given to the University of Michigan Chapter of the Society of Conservation Biology, March 26, 1998, Ann Arbor, Michigan.

[2]The sample was obtained from the Maine Bureau of Motor Vehicles in Augusta, Maine, and this rate of undeliverable surveys is expected when sampling from Maine State drivers' licenses and registration cards, which only require renewal every seven years.

[3]Copies of the survey instrument are available upon request from the authors.

[4]Note should be taken that not all respondents are included in this analysis. As is customary in CV studies, respondents identified as providing "protest" no responses are excluded. These responses are those thought to arise from rejection of the hypothetical scenario, rather than from the absence of value (for details see Mitchell and Carson 1989).

[5]One category not included is direct use values. Information about direct use motivations was obtained elsewhere in the survey. Forty-four respondents had seen a peregrine falcon in the wild, and ten had made a special trip to view the species. Only sixteen respondents had seen a shortnose sturgeon in the wild, and due to limitations imposed by the species' habitat, a question about special trips was not asked.

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Rehabilitation and Release of a Gray Whale Calf: J.J.'s Story

Jim Antrim, J.F. McBain and Donna Parham

Abstract

*SeaWorld's Animal Rescue and Rehabilitation Program affords wildlife experts the opportunity to learn about the kinds of environmental problems that impact wild animals. The information gathered from wildlife rescues is a valuable source of knowledge that can be used in making wildlife management decisions. The SeaWorld animal departments rescue, rehabilitate, and release stranded animals. In early 1997, a neonatal gray whale (*Eschrichtius robustus*) was brought to SeaWorld San Diego for rehabilitation after stranding on the coast of Southern California near Marina Del Rey. An initial physical examination revealed severe infestation with whale lice, multiple skin wounds, dehydration, hypoglycemia, malnutrition, and infection. The whale was successfully rehabilitated and released. The calf's rescue and rehabilitation prompted a flood of public interest. During her 14-plus months at SeaWorld, the whale gave scientists, educators, and the public an unprecedented learning opportunity.*

Introduction

On January 11, 1997, a newborn gray whale (*Eschrichtius robustus*) that had become separated from its mother stranded on the beach of Marina Del Rey, near Los Angeles. One of the only places on the west coast of North America with the resources to care for and rehabilitate the undernourished, dehydrated, days-old gray whale was SeaWorld San Diego.

While it was clear to all involved that rehabilitating a gray whale calf would require a huge investment of time, money and effort, SeaWorld and its parent company, Busch Entertainment Corporation, immediately gave park animal care experts the go-ahead. The SeaWorld San Diego Marine Mammal Rescue and Rehabilitation Team was activated and began preparations to treat the newborn gray whale. Authorized by the National Marine Fisheries Service (NMFS), volunteers transported the gray whale calf to SeaWorld. The whale arrived at about 4 p.m.—dehydrated, hypoglycemic, and semi-comatose. Park veterinarians immediately administered fluids, glucose, and antibiotics. Just 24 hours later, the calf was alert, negotiating its 12 by 12-meter holding pool and being fed—via stomach tube—six liters of whale milk substitute every three hours.

Exactly one month after her arrival at SeaWorld, the female calf known as J.J. had grown 51 centimeters and gained 408 kilograms at the rate of 0.5 kilograms per hour. About 14 months later, a healthy J.J.—by then 8,700 kilograms and 9.4 meters long—was released into the Pacific Ocean off San Diego's Point Loma. What transpired during those 14 months is a story of hard work, adaptive veterinary care, scientific study, and public policy.

SeaWorld's Animal Rescue and Rehabilitation Program

When marine mammals strand, death is usually imminent without intervention. SeaWorld's Animal Rescue and Rehabilitation Program, the goal of which is to return rehabilitated animals to the wild, is an important part of the park's commitment to conservation, research, and education. The program affords wildlife experts the opportunity to learn—in an intimate, hands-on way—about the kinds of environmental problems that impact wild animals. The information gathered from wildlife rescues is a valuable source of knowledge that can be used in making wildlife management decisions.

After arrival at SeaWorld, a rescued animal is assessed by staff veterinarians. Medical technologists analyze blood, stool and urine samples in an effort to help pinpoint specific trouble areas. Most stranded animals are grossly undernourished and severely dehydrated—often 30% to 40% below normal weight. The first step in treating a stranded animal is usually to overcome dehydration and restore normal body weight. Orphaned calves that are still nursing are fed formula. Rehabilitation program staff use a powdered artificial milk replacer as the base for most marine mammal formulas. The powder is blended with water to produce milk with a 13% fat and 7% protein content that supplies nutrition comparable to milk produced by many marine mammal species. To meet the nutritional needs of individual animals, animal care staff may

add balanced electrolyte solutions, dextrose, salmon oil, heavy whipping cream, fish, taurine (an amino acid found in cetacean milk but not known to be common in most other species), and/or other supplemental ingredients.

All marine mammals, including stranded animals, are protected by the Marine Mammal Protection Act (MMPA) of 1972. The MMPA is administered by the NMFS with regard to whales (order *Cetacea*), dolphins (family *Delphinidae*), porpoises (family *Phocoenidae*), seals (family *Phocidae*), and sea lions (family *Otariidae*). The NMFS, through the U.S. Secretary of Commerce, has issued letters of authorization to SeaWorld parks in California, Florida, and Texas that allow these parks to rescue and rehabilitate stranded marine mammals.

The California park typically rescues 100 to 200 stranded animals each year—more than 400 in a particularly severe winter such as the 1997-1998 El Niño season. J.J., the largest animal SeaWorld had ever attempted to rehabilitate, was far from typical.

California Gray Whales

California gray whales inhabit the eastern North Pacific Ocean. They spend summers in the icy waters of the Bering and Chukchi Seas, off Alaska. As the pack ice advances in the fall, the animals embark on one of the longest known migrations of any mammal species. Hugging the North American coastline, the whales swim south more than 9,000 kilometers to Baja California, Mexico. Females give birth to 4.9-meter calves in the warm, shallow lagoons of Baja.

During the 19th and early 20th centuries, whalers twice hunted gray whales to the brink of extinction. Beginning in 1946, gray whales were legally protected from further hunting and began a long and rather remarkable comeback. The current population is more than 22,000 individuals, a figure believed to match pre-whaling numbers (Hobbs et al. 1997). In June 1994 the California gray whale was removed from the list of species designated as endangered and threatened under the U.S. Endangered Species Act (U.S. Department of Commerce 1996). Global conservation of gray whales is still governed, however, by the International Convention for the Regulation of Whaling. Further, conservation and protection of gray whales in U.S. waters remains governed by the MMPA, which prohibits the taking of all marine mammals within U.S. jurisdiction unless specifically allowed by government permit.

J.J.'s diagnosis and treatment

J.J.'s first examination revealed an infestation with whale lice (an external parasite typical of gray whales) and multiple non-healing skin wounds, which indicated she lacked the resources to support normal healing. She showed no response to touch and did not have a blink response. She was thin, and her initial blood work confirmed dehydration, hypoglycemia, malnutrition, and infection. Veterinarians immediately administered glucose along with corticosteroids and a broad-spectrum antibiotic. Upon arrival, J.J. had to be supported by a team of animal rescue specialists so she didn't sink to the bottom of her medical pool. Within 15 minutes of initial treatment, J.J. began swimming, and shortly opened her eyes. Within 30 minutes of initial treatment, she began navigating on her own. Two hours later, animal care specialists began feeding J.J. milk replacement formula via stomach tube.

SeaWorld veterinarians were encouraged by indications that J.J. likely had spent enough time with her mother before separation to have nursed. If so, she would have ingested antibody-rich colostrum that would help prepare her immune system to fight infection. There were two indications that J.J. may have nursed before separating from her mother. First, laboratory technologists detected gamma globulin as a component of the infant whale's blood. J.J.'s blood profile was compared with the blood work of another newborn whale that stranded in northern California the same day. Blood from the second whale (which did not survive) had no gamma globulin, confirming that the protein isn't a component of newborn whale blood, but that whales probably acquire it by nursing. Another indication that J.J. spent enough time with her mother to have nursed was her infestation of whale lice, which are passed on via contact with other gray whales. The second stranded calf lacked this gray whale parasite.

Just six and a half weeks after her arrival, analyses of J.J.'s blood indicated that her infection had subsided, so antibiotics were discontinued. Once this critical milestone passed, the remaining challenges were to administer proper nutrition and to prepare the whale for eventual release.

Nutrition

Though the composition of gray whale milk is unknown, data on the milk of other large baleen whales have been documented (Jenness and Sloan 1970). Based on this information, SeaWorld whale experts predicted gray whale milk to be about 52% moisture, 35% fat, 12% protein, and 1% carbohydrate, yielding 3.67 kcal/ml. A formula for J.J. was developed by park veterinarians who had been able to closely monitor the needs of newborn whales and dolphins through the Animal Rescue and Rehabilitation Program's dolphin and killer whale breeding programs. Her formula consisted of the

following components (amounts listed are per 1 liter of formula):

- 230 g ground herring (heads removed)
- 45 g Zoologic®[1] 33/40 Milk Matrix Powder (artificial milk replacer powder)
- 25 g Zoologic® 30/55 Milk Matrix • Powder (artificial milk replacer powder)
- 50 ml heavy whipping cream
- 7.5 g dextrose
- 4.5 g NaCl
- 3.5 g lecithin
- 125 mg taurine
- 18.75 g dicalcium phosphate.

The resulting formula was 82.4% moisture, 8.4% fat, 6.4% protein, and 1.7% carbohydrate, yielding 1.08 kcal/ml. The formula was considerably less calorically dense than gray whale milk, but efforts to increase the caloric density resulted in a mixture that was too thick to pass through a feeding tube. Veterinarians had to estimate the gray whale calf's caloric requirements, based on what they knew of other cetacean species. The initial estimate, which proved successful, was 60 to 65 kcals/kg of body weight.

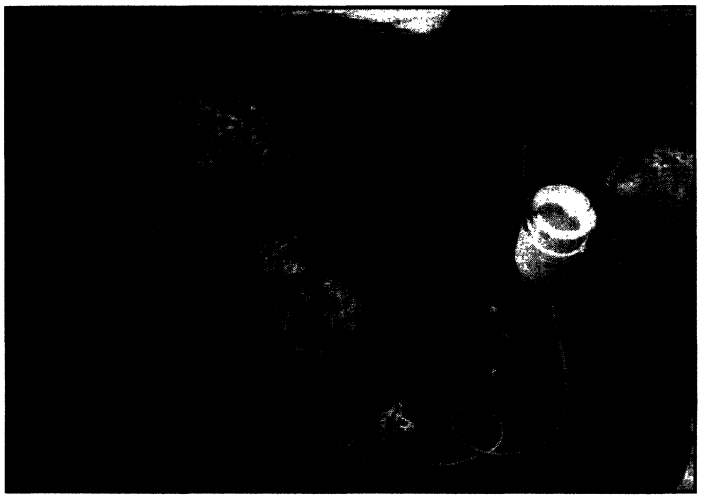
J.J. was fed every three hours, around the clock. While one group of animal care specialists created the blend of heavy cream, pureed fish and special powdered milk formula critical for the calf's nutritional needs, another group donned wet suits and climbed into the pool with the whale. Coordinating their efforts, animal care specialists surrounded the calf and gently supported her. At first, they used a 3-centimeter diameter stomach tube to feed the whale. They placed a feeding tube through her mouth, down her esophagus, and into her stomach. With a large funnel in place at the end of the tube, the formula (warmed to body temperature) was slowly poured down the tube into the whale's stomach. When the calf had been fed the entire 7.6 liters, the feeding tube was removed.

By January 15, J.J. had already gained about 41 kilograms and was becoming increasingly active. The calf quickly realized that when she was held by people, she got fed. She learned to swim directly to an animal care specialist for food. Soon J.J. learned to accept a nursing device devised by the animal care specialists—an important first step toward nursing on her own. The nursing device consisted of a "nipple" made from a short length of flexible, thick-walled natural rubber tubing. This was connected by a length of clear, thin-walled plastic tubing to an insulated 7.6-liter container that held the formula.

Just eight days after her rescue, J.J. could nurse on her own with the help of just one person. Animal care specialists soon transitioned from feeding her in the water to feeding her at the edge of the pool, and J.J. soon responded to a "feeding call"—a tap on the surface of the water. Where once five people had to help feed her, J.J. now took the feeding tube on her own. At first, J.J. consumed 7.6 liters of formula, seven times per day. Over time, her food intake increased. For the last few months before she was weaned, J.J.'s daily food intake consisted of six 20-liter feedings. On day 95, J.J. took her first solid food, and by day 130, she was actively soliciting solids.

Gray whales differ from other baleen whales in their feeding behavior. Bottom feeders, gray whales forage along the ocean floor. Turning on its side, a gray whale gulps great mouthfuls of silt, strains water and mud through its baleen, and swallows bottom-dwelling invertebrates. So, twice each day, squid, krill, and small fish were distributed on the floor of J.J.'s pool. Animal care specialists were encouraged by her apparent understanding of the location of the solid food and the mechanics of bottom feeding. J.J. scooped the food into her mouth and used her baleen to filter out the water.

J.J's weaning was a meticulous process that involved precise weighing of the solid food. To determine J.J.'s solid food intake, animal care specialists dove 9 meters to the bottom of the pool and collected uneaten food. The leftovers were weighed and results recorded and compared against the original portion. At first a small part of her diet, the solid food gave J.J. the opportunity to scoop food off the bottom as she would eventually have to do in the ocean. At day 213, about 7 months old, J.J. was still interested in formula. SeaWorld animal care specialists assumed they had a small window of time to complete the weaning process. They reduced the powdered milk content of her formula gradually over the next 10 days. As the caloric content of the formula decreased, J.J. began to satisfy more of her hunger by eating solids. Within three weeks she was completely



J.J. learned to accept a nursing device devised by SeaWorld animal care specialists, and eventually to nurse on her own.

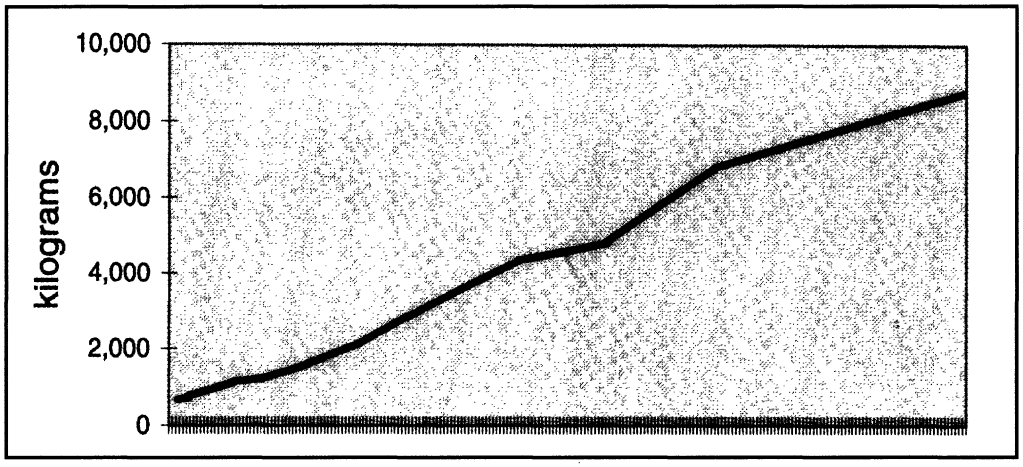


Figure 1. J.J.'s weight gain (kg) between January 11, 1997 and March 31, 1998.

weaned onto solid food—180 to 230 kilograms of krill and small fish per day. At this point she weighed 4,800 kilograms and measured about 8 meters in length.

Growth and morphometrics

Most of the previous data of gray whale weights and measurements have been gathered from beached and stranded animals, which are typically grossly underweight. J.J. was weighed and measured regularly, and the results may one day be combined with data from other healthy gray whales to form a more accurate picture of wild gray whale growth and morphometrics. J.J.'s growth chart for her first year appears in Figure 1.

By mid-February 1997, J.J.—at that point nearly 1,220 kilograms and more than 4.6 meters long—had outgrown her 12- by 12-meter medical pool. With the approval of NMFS, J.J. was moved to a 6.4-million-liter pool inside the park. SeaWorld became the first facility in the world where researchers could study an infant baleen whale in such detail. Previously accepted data regarding the development and nutritional needs of young gray whales became outdated as J.J. continued to amaze researchers and guests alike with her rapid growth.

Public interest and attention

J.J.'s rescue and rehabilitation prompted a flood of public interest. Throughout J.J.'s stay at SeaWorld—and well after she had gone—SeaWorld San Diego remained firm in its commitment to share what park experts were learning about J.J. with the educational, scientific, and general public communities.

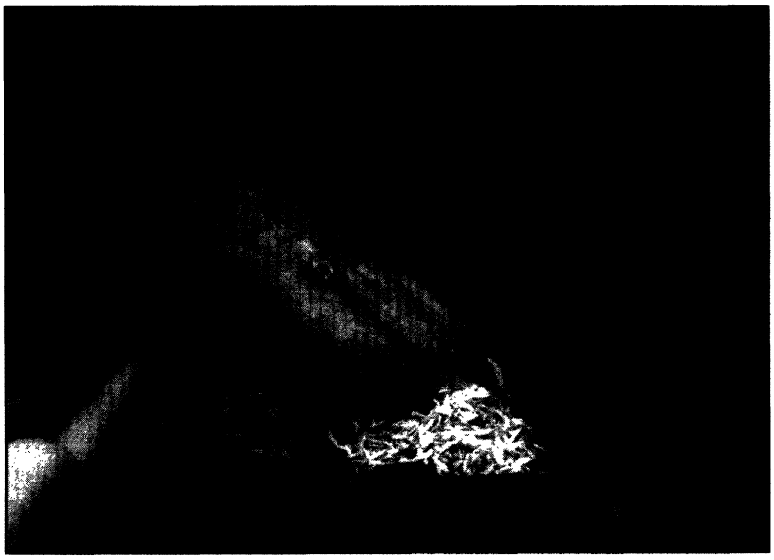
The park's education department answered massive amounts of J.J.-related mail, phone calls, and e-mail. In response to the vast number of inquiring phone calls for the latest information on the newborn gray whale's condition, SeaWorld provided a toll-free J.J. hotline seven days a week. In addition, park educators created a gray whale teacher's guide with information and activities for students, and SeaWorld San Diego featured J.J.'s progress at the park's annual Whale Symposium.

Once J.J. was moved from her off-exhibit medical pool to a larger pool in the park, SeaWorld visitors got a unique perspective of the calf through a 21-meter long viewing window. SeaWorld educators were on duty at J.J.'s pool to answer questions and provide information about California gray whales. A status board, updated daily, provided information about J.J.'s vital statistics. Educational graphics gave information about the park's animal rescue program, J.J.'s progress at SeaWorld, and facts about California gray whales. On June 11, 1997, Internet users had the unprecedented opportunity to go underwater with J.J. as SeaWorld initiated a live "J.J. cam" for day and night viewing of the orphaned calf. The park positioned two cameras in her 6.4-million-liter habitat, providing views of several angles of the rapidly growing whale. Throughout the day, SeaWorld educators periodically used the camera's pan, tilt, and zoom capabilities, giving both online participants and SeaWorld guests excellent views of the whale. More than 179,000 Internet users, from Antigua and Botswana to Venezuela and Yugoslavia, logged onto the J.J. Web site.

The media were particularly interested in J.J., and her eventual March 31 release was broadcast live to television stations all over the world.

A unique opportunity for gray whale research

Bioacoustician Dr. Ann Bowles of the Hubbs-Sea World Research Institute (HSWRI) studied J.J.'s vocalizations and behavior. With the help of interns from San Diego State University and University of California at San Diego, more than 500 hours of J.J.'s behavior and vocalizations were collected using five underwater cameras, one overhead camera, and nine hydrophones mounted in her pool. Dr. Bowles made recordings of J.J. several times per week, creating spectrograms ("voice prints") using signal analysis software. Based on the spectograms, J.J.'s vocalizations could be compared to sounds made by wild gray whales. Previous researchers have described a repertoire for wild whales that consists mainly of moans, grunts, and trains of pulses. Early in



Like her counterparts in the wild, J.J. rolled on her side to gulp great mouthfuls of food from the bottom.

her SeaWorld stay, J.J. began making calls, clicks and gray-whale sounds, but her calls were not as varied as expected. She didn't seem to be making the pulse trains that were so familiar in recordings of wild gray whales. HSWRI bioacousticians played recordings of gray whale pulse trains for the calf for several hours each day from July 1997 to October 1997. Bowles played the pulse trains at feeding time. It was hoped that by associating these sounds with food, J.J. would follow the sounds when she heard them in the open ocean, discover other gray whales feeding, and feed along with them. In late 1997, J.J. began to make some of the sounds.

Other scientists also took advantage of the unique circumstances to further their research on gray whales. Dr. Jim Sumich, a biology professor at Grossmont College in San Diego, conducted research on J.J. to determine gray whale growth, respiration, metabolic rates and nutritional demands placed on a gray whale nursing mother. Using J.J.'s oxygen consumption rate and other data, Sumich is working on developing a formula for predicting growth rates and energy budgets in young gray whales. In addition, Dr. Sam Ridgway, Navy Marine Mammal veterinarian and scientist, conducted studies of J.J.'s hearing abilities.

In January 1998, California sea lions (*Zalophus californianus*) from Moss Landing Marine Lab were fitted with video cameras and introduced into J.J.'s pool in an effort to begin to desensitize J.J. to other marine life before she returned to the Pacific. The sea lions had been trained by Dr. Jennifer Hurley over the preceding two years to videotape and tag a free-swimming baleen whale.

Based on studies of the structure of vascular tissue in the tongue of other gray whales, Dr. John Heyning of the Los Angeles County Museum of Natural History had hypothesized that a countercurrent heat exchange system in the tongues of gray whales minimized heat loss to the environment. Dr. Heyning was able to test those ideas on thermoregulation by measuring the temperature of J.J.'s tongue as she was feeding (Heyning and Mead 1997).

Dr. Lev Mukhametov of Moscow, Russia, along with several colleagues, did a round-the-clock study of J.J.'s circadian rhythm—the first such research ever conducted.

The final step: J.J.'s release

By early 1998, J.J. measured 8.4 meters, weighed 6,800 kilograms, and was eating on her own. Rehabilitation efforts were a success: J.J. was deemed ready for release.

J.J. was the largest animal ever to be returned to the wild, and getting the immense mammal to the ocean required the teamwork of SeaWorld, the NMFS, Hubbs-Sea World Research Institute, the U.S. Navy, Navy Public Works, the U.S. Coast Guard, and the San Diego Police Department. SeaWorld began working with these community partners on plans to release J.J. in late March. The release was timed to coincide with the northward migration of gray whales, which pass San Diego on their way from the lagoons of Baja California to feeding grounds in Alaska. The U.S. Coast Guard vessel *Conifer*, a 55-meter buoy tender used to lift large navigation buoys and anchors, was selected as J.J.'s transport vessel. In early March, SeaWorld and the Coast Guard conducted release drills that included releasing 8,100-kilogram weighted buoys into the ocean. They tested a 10-m, custom-designed and-fabricated stretcher, made from ballistic nylon and webbing and supported by two 10-meter steel pipes.

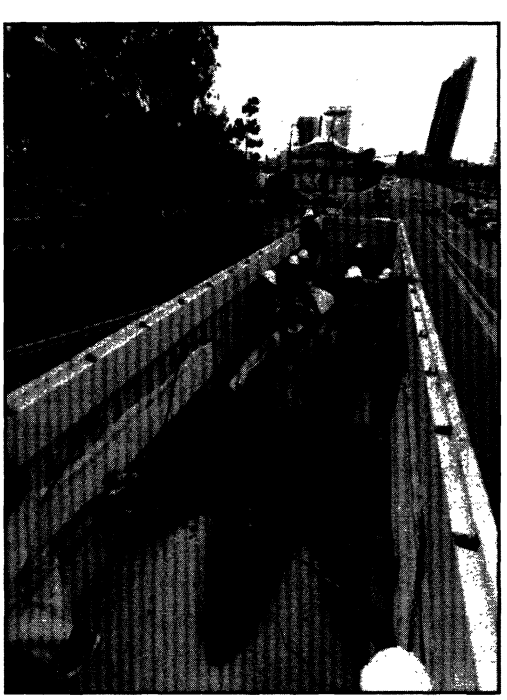
At her release on March 31, 1998, J.J. weighed 8,700 kilograms and measured 9.4 meters. The transport effort began before dawn. At SeaWorld, the animal care team guided J.J. into her stretcher. A crane slowly lifted the whale out of the pool and placed her carefully inside a 12-m, foam-lined steel transport unit aboard a flatbed truck. At 7 a.m., escorted by San Diego Police, the truck transporting J.J. departed SeaWorld for the Naval Station San Diego at 32nd Street. Along the way J.J. was kept wet and comfortable. At the Naval Station, a calm J.J. was again lifted out of her transport unit and placed on thick foam pads on the deck of the ship. With J.J. aboard, the *Conifer* departed the Naval Station at 8:32 a.m. and headed for San Diego's Pt. Loma and open ocean. At 10:17 a.m., about 3.2 km off Pt. Loma, the *Conifer's* 180-kilogram cargo boom

lifted J.J.'s sling over the water and released the whale into the Pacific Ocean. J.J. was now officially a free-ranging marine mammal, under the jurisdiction of the NMFS.

Tracking and observation

A few days before her release, two sets of VHF radio and satellite transmitters were attached to J.J. to allow HSWRI scientists to follow J.J.'s movements upon release. The transmitter packages were placed on the whale's back, anchored through her 2.5-centimeter skin layer. While scientists hoped that the transmitters would stay attached for life of the batteries—approximately 18 months—they were designed to detach easily upon impact or entanglement.

Within the first 15 minutes of J.J.'s release, scientists Dr. Brent Stewart and Dr. Pamela Yochem from HSWRI and Dr. Jim Harvey from Moss Landing Marine Lab aboard the vessel *Megalodon* received three signals from J.J.'s radio transmitters. Using locations communicated by the radio and satellite transmitters, the researchers tracked J.J. for the first critical hours and days of her release. Immediately following her release, J.J. demonstrated typical gray whale behavior and seemed to be exploring and learning about her environment. J.J. exhibited spyhopping behavior, aligning herself vertically in the water and lifting her head and eyes clear of the water—behavior typically exhibited by migrating gray whales. In cooperation with Orincon, Inc. in San Diego, the *Megalodon* researchers laid out a trail of listening devices called sonobuoys along J.J.'s path. The buoys relayed J.J.'s vocalizations—moans and pulses normally associated with migrating gray whales.



Animal care specialists kept J.J. wet and comfortable as she was transported through downtown San Diego on her way to Naval Station San Diego.

In the first 48 hours post-release, J.J. swam steadily at 3.7 to 5.6 kilometers per hour, taking several breaths at the surface between 1- to 6-minute dives, a pattern typical for young gray whales. She swam strongly and cumulatively covered about 150 kilometers during the three days she was tracked. J.J. remained in relatively shallow water, probably less than 9 meters deep, and successfully avoided obstacles such as boats and piers.

To the disappointment of researchers, both of J.J.'s transmitter packages became dislodged and were recovered within a few days of her release, curtailing further electronic tracking efforts. The detached transmitter packages likely broke free from J.J. while she was foraging for food on the ocean bottom. Both were retrieved from beaches near San Diego.

Conclusion

Rescued animals provide insight into their species' biology and ecology. This information adds to the pool of knowledge necessary to conserve threatened and endangered species. Data gathered through animal rescue and rehabilitation programs can help scientists more accurately assess population management programs in the wild. In addition, public policy ultimately benefits by the added public awareness of how human actions, both good and bad, affect animals. This awareness is the first step toward educating the community about ways to conserve and protect wildlife.

Although J.J. was only at SeaWorld for about 14 months, the information gained will be an important addition to marine mammal research. She gave scientists, educators, and the public an unprecedented learning opportunity. J.J. can still be identified by a small red, white, and blue streamer identification tag embedded in her skin about 1 meter behind her blowholes. Her distinctive color patterns and markings, as individual as fingerprints, also will allow researchers to identify her in future years.

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Notes

[1]Zoologic® is a product of Pet-Ag, Inc., 201 Keyes Ave., Hampshire, IL, 60140

Jim Antrim is the General Curator, Jim McBain D.V.M a veterinarian, and Donna Parham a Science Writer at SeaWorld. Jim Antrim, Jim McBain, and Donna Parham can be contacted at SeaWorld San Diego, 500 Sea World Drive, San Diego, California 92109.

NEWS FROM ZOOS

AZA CEF Awardees

AZA is pleased to announce the recipients of the 1998 Conservation Endowment Fund. The AZA Conservation and Science Office received a total of 56 proposals, representing $1,045,500 in requests, by the May 15th deadline. Many excellent proposals were submitted, and they competed for $290,000 available from AZA Endowment and Disney Funds. Below are some of the 19 proposals that were selected for awards:

"Population Assessment and Propagation of the Barrens Topminnow (*Fundulus julisia*) and Imperiled Freshwater Fish of the Eastern Highland Rim, Tennessee." Christopher Coco—Tennessee Aquarium: $19,992

"Determining the Migratory Routes of a Restored Population of Trumpeter Swans (*Cygnus cygnus buccinator*) Using Satellite/Radio Telemetry." Sumner Matteson—Wisconsin Department of Natural Resources (WDNR); Edward Diebold —Riverbanks Zoological Park and Botanical Garden; Fred Koontz, Ph.D.—Wildlife Conservation Society/ Bronx Zoo: $9,615

"Antigenic Heterogeneity of Ophidian Paramyxovirus." Edward Ramsay, D.V.M., Stephen Kania, Ph.D., Melissa Kennedy, D.V.M.—University of Tennessee, College of Veterinary Medicine: $16,900

"Noninvasive Study of the Ecology of Wild Bush Dogs in Paraguay." Robert Klemm, Ph.D.— Sunset Zoo: $8,480

"Mexican Wolf SSP Keeper Training Workshop." Susan Lyndaker Lindsey—Wild Canid Survival and Research Center: $6,000

"Characterization and Hormonal Control and Aggression in Gerenuk (*Litocranius walleri walleri*) Bachelor Groups." Linda Penfold, Ph.D., Steven Monfort, D.V.M., Ph.D—Conservation and Research Center: $16,070

"Sperm Cryopreservation and Controlled Gamete Release for Enhancing Toad Propagation." Terri Roth, Ph.D.— Cincinnati Zoo & Botanical Garden: $8,150

"Western Pond Turtle Project." Frank Slavens—Woodland Park Zoological Gardens: $18,500

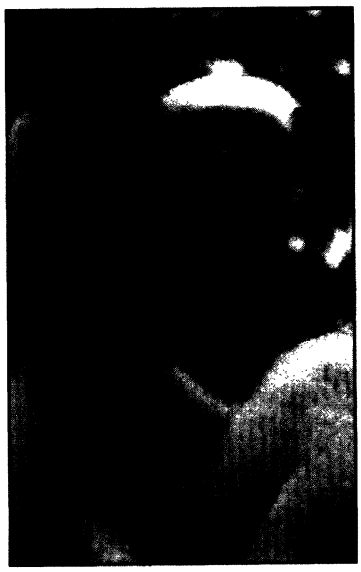
"Diagnosis and Prevention of Tragopan Herpesvirus Disease." Don Bruning, Christine Sheppard—Dept. of Ornithology, Wildlife Conservation Society: $16,500

"Wildlife Conservation Society Papua New Guinea Education Project." Annette Berkovits—Wildlife Conservation Society-Education Department: $20,000

Information on applying for next year's awards and applications will be available on the AZA web page (http://www.aza.org/programs/cef/) and from the C&S Office beginning in November.

New, Rare Polka-Dotted Stingray At The San Antonio Zoo

Five rare young fish from the Amazon basin are making the San Antonio Zoo's Friedrich Aquarium their new home. Leopold's stingray (*Potamotrygon leopoldi*) is one of several species of freshwater stingray that inhabits the rivers and streams of tropical South America. The indigenous peoples of this region fear the ray more than the infamous piranha. Closely related to their marine relatives, these fishes have a barbed tail capable of delivering a venomous sting. Leopold's stingray is considered among the most beautiful of the rays with a coloration of velvety black covered with yellow spots.



Coquerel's Sifaka (*Propithecus verreauxi coquereli*). Photo courtesy of the St. Louis Zoo.

Endangered Coquerel's Sifaka at St. Louis' Zoo Primate House

Two young sifaka (shee-fahk) (*Propithecus verreauxi coquereli*) brothers have been sent to the St. Louis Zoo from the Duke Primate Research Center. The Zoo was selected because of its extensive experience with numerous other lemur species. Sifakas are among the most endangered of the 33 lemur species found in Madagascar, and are rare in captivity. The Saint Louis Zoo is only the second North American zoo to exhibit sifaka, and one of only four worldwide. Duke's researchers have recently learned to increase longevity and reproductive success, enabling them to transfer offspring to qualified zoos. When more females are born into the captive population, these two males will be paired and allowed to reproduce.

Information for News From Zoos *is provided by the American Zoo and Aquarium Association.*

You do interesting work!
Share it with the *UPDATE.*

The *Endangered Species UPDATE* is designed and published as a forum for information exchange on endangered species issues. The *UPDATE* welcomes articles related to species protection in a wide range of areas including, but not limited to, research and management for specific endangered or threatened species, theoretical approaches to species conservation, policy and legislation related to species conservation, and strategies for habitat protection and preserve design. In addition, book reviews, editorial comments, and announcements of current events and publications are welcome.

The *Endangered Species UPDATE* accepts several kinds of manuscripts. These include:

1. Feature Article—on research, management activities and policy analyses for endangered species, theoretical approaches to species conservation, and habitat protection. Manuscripts should be approximately 3000-4000 words with abstract.
2. Opinion Article—a concise and focused argument on a specific endangered species issue; can be more speculative and less documented than the feature article. These are approximately 600-800 words with abstract.

Manuscript Submissions and Specifications

The manuscript should be submitted on a disk or by e-mail. Regardless of how you submit the manuscript, please send us a hard copy, a short author's byline, a daytime phone and fax number and an e-mail address. If you are using Microsoft Word for Macintosh or WordPerfect, please save as version 5.1. For other programs, save the the document in a rich text format (RTF). Send disks and hard copies of the manuscript to Editor, Endangered Species UPDATE, School of Natural Resources, University of Michigan, Ann Arbor, MI 48109-1115. If submitting by e-mail, please send as an attachment to esupdate@umich.edu.

Photographs, Illustrations, and Other Visuals

Photographs, line drawings, and other graphics are encouraged. The issue is printed in black and white so black and white prints are preferred. Any color prints should be chosen with the final black and white print in mind (i.e., no photos that rely on color for contrast). We can also accept slides. Copyrighted material must include written permission for use in the *UPDATE*, signed by the copyright holder. The author's and photographer's name should be written on the back of all photos. Computer-generated illustrations should be produced on a 600 dpi laser printer. In the case of all photographs and illustrations, a caption should be included, and they should be clear enough to be reduced 50 percent.

Citations, Acronyms, etc.

Literature citations in the text should be as follows: (Buckley & Buckley 1980b; Pacey 1983). The Literature Cited section must be typed and follow the format used in the journal Conservation Biology. For example:

Balmford, A., N. Leader-Williams, and M. J. B. Green. 1995. Parks or arks: where to conserve large threatened mammals? Biodiversity and Conservation **4**:595-607.

For other abbreviations and details consult the Editor.

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Authors will receive by fax a final version of their article, before it goes to press, for their review and proofing. The Endangered Species UPDATE and University of Michigan typically hold copyright for articles published, and authors will be asked to sign a contributors agreement when the article is accepted. The vast majority of copyright requests are from educational institutions and non-profit organizations. The copyright agreement allows the author to reprint the article as long as credit is given to the *UPDATE*.

Bulletin Board

New Wildland Road Removal Guide and Updated Bibliographic Database

Wildlands Center for Preventing Roads (Wildlands CPR) has published a new guide as part of the ***The Road-Ripper's Handbook***. *The Road-Ripper's Guide to Wildland Road Removal* will help you understand how roads are built, where and why they fail, and how to influence road removal projects. The guide is $7 for non-members, and $4 for members of Wildlands CPR (Standard membership is $30).

Wildlands CPR recently updated its bibliographic database titled, *The Ecological Impacts of Roads*. Originally supervised and edited by Reed Noss, the bibliography contains over 6,000 citations (750 new as of February 1998) regarding the ecological impacts or roads.

Contact: Wildlands CPR, P.O. Box 7516, Missoula, MT 59807. Tel. 406-543-9551, e-mail: WildlandsCPR@wildrockies.org, www.wildrockies.org/WildCPR.

Hope for Critically Endangered Puaiohi

In a rush against extinction, bioloists at The Peregrin Fund's Keauhou Bird Conservation Center on the Big Island of Hawai'i have successfully bred the Puaiohi (*Mydadestes palmeri*) in captivity. This first-ever event provides hope for the critically endangered Puaiohi whose population is estimated at about 150 individuals. The first hatch occurred in March of 1998 with 21 chicks hatching thus far this season. The young Puaiohi are expected to be released in early 1999 into managed areas of the 'Alaka'i Swamp where the species used to occur.

The work to save the Puaiohi is part of a larger program initiated in 1994 which focuses on all of the endangered forest birds in Hawai'i. The program involves The Peregrin Fund, U.S. Fish and Wildlife Service, State of Hawai'i's Division of Forestry and Wildlife, the Biological Resources Division of the USGS and private landowners. Restoration efforts include monitoring of the wild population, protection of nests, captive propogation and reintroduction.

For more information contact: The Peregrin Fund, Kaeuhou Bird Conservation Center, P.O. Box 39, Volcano, HI 96785. E-mail: htsu21a@prodigy.com.

Seal Hunt Campaign

The International Fund for Animal Welfare has launched a national effort to mobilize opposition to the commercial seal hunt in Canada. Targeted states include Michigan, Connecticut, New York, Massachuesetts, and Washington. Ten U.S. Senators recently signed on to a letter opposing the seal hunt to the Canadian Prime Minister. IFAW has also worked within Canada on significant nation-wide efforts to raise awareness and mobilize opposition. For more information, call Adam Wright at (517) 374-2703 or e-mail at wrightad@pilot.msu.edu.

Announcements for the Bulletin Board are welcomed.

Endangered Species UPDATE

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