Ecological Economics 70 (2011) 721–728

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Can domestication of wildlife lead to conservation? The economics of tiger farming in China☆

Brant Abbott [a], G. Cornelis van Kooten [b,*]

[a] University of British Columbia, Department of Economics, 997-1873 East Mall, Vancouver, BC, Canada V6T 1Z1
[b] University of Victoria, Department of Economics, P.O BOX 1700, STN CSC, Victoria, BC, Canada V8W 2Y2

ARTICLE INFO

Article history:
Received 4 June 2010
Received in revised form 2 October 2010
Accepted 10 November 2010
Available online 22 December 2010

Keywords:
Endangered species
Extirpation
Wildlife farming
Bioeconomics

ABSTRACT

Tigers are a threatened species that might soon disappear in the wild. Not only are tigers threatened by deteriorating and declining habitat, but poachers continue to kill tigers for traditional medicine, decoration pieces and so on. Although international trade in tiger products has been banned since 1987 and domestic trade within China since 1993, tigers continue to be poached and Chinese entrepreneurs have established tiger farms in anticipation of their demise. While China desires to permit sale of tiger products from captive-bred tigers, this is opposed on the grounds that it likely encourages illegal killing. Instead, wildlife conservationists lobby for more spending on anti-poaching and trade-ban enforcement. In this study, a mathematical bioeconomic model is used to investigate the issue. Simulation results indicate that, unless range states are characterized by institutions (rule of law and low corruption) similar to those found in the richest countries, reliance on enforcement alone is insufficient to guarantee survival of wild tigers. Likewise, even though conservation payments could protect wild tigers, the inability to enforce contracts militates against this. Our model indicates that wild tigers can be protected by permitting sale of products from tiger farms, although this likely requires the granting of an exclusive license to sellers. Finally, it is possible to tradeoff enforcement effort and sale of products from captive-bred animals, but such tradeoffs are worsened by deteriorating tiger habitat.

1. Introduction

Wild tiger (*Panthera tigris*) populations have declined from about 100,000 in 1900 to perhaps as few as 5000 today. The Bali tiger became extinct during the 1930s, the Caspian tiger during the 1970s, and the Javan tiger disappeared a decade later. Six species of tiger (Bengal, Indochinese, Amur, South China, Malaysian and Sumatran) remain, scattered throughout eastern Russia, Indochina, the Indian subcontinent and Southeast Asia (Table 1). Along with tiger poaching and depletion of prey, habitat degradation and destruction caused primarily by illegal logging contribute greatly to the demise of the tiger. Ninety-three percent of the tiger's historic range has disappeared, while the area known to have been inhabited most recently by tigers has declined by 41% over the past decade (Dinerstein et al., 2007).

International trade in tigers has been prohibited since 1975 when the species was listed under Appendix I of CITES, although the Amur tiger was listed only in 1987 and China imposed a domestic ban on trade in tiger bones and medicine from tiger bone in 1993. Nonetheless, evidence indicates that illegal trade in wild tigers continues with tiger bone still used in some traditional medicines (Bhalla, 2006). Within China, the domestic ban coincided with the establishment of tiger farms that now house some 4000–5000 animals (Kirkpatrick & Emerton, 2010; Gratwicke et al., 2008; CATT, 2007), with some evidence indicating there are two tiger breeding facilities in Vietnam and one in Thailand (Conrad, 2010). Wildlife groups are concerned that (seemingly inevitable) sales of products from tiger farms will increase the demand for tigers and facilitate marketing of poached animals.

The government of China has considered partially lifting its domestic ban on trade in tiger products to allow products from captive breeding farms to be sold legally. The carcasses of tigers that have died in captivity are currently frozen and stored as owners speculate that the domestic trade ban will be relaxed, although there is concern that tiger farms are already a significant source of illegally traded products that contain tiger bone (Nowell & Ling, 2007; EIA, 2007). Opponents to the sale of captive tigers argue that any weakening of the trade ban will legitimize consumption and increase the demand for tiger parts; this, in turn, will increase poaching because detection of products from poached tigers would be more difficult (Gratwicke et al., 2008). Researchers have surveyed tiger populations and the extent of their habitat, the availability of tiger products in Chinese and international markets, the state of captive tiger breeding

* Corresponding author. Tel.: +1 250 721 8539; fax: +1 250 721 6214.
E-mail addresses: abbottb@shaw.ca (B. Abbott), kooten@uvic.ca (G.C. van Kooten).

0921-8009/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2010.11.006

Table 1
Remaining tiger species, location and estimated populations, 2008.
Source: http://www.savethetigerfund.org/AM/Template.cfm?Section=Community (as viewed 14 April 2009).

Tiger species	Location[a]	Estimated population	Estimated habitat (km^2)
Amur tiger *Panthera tigris altaica*	Russia (Siberia), China	431–529	156,000
Bengal tiger *Panthera tigris tigris*	India, Nepal, Bangladesh, Bhutan, Myanmar, China	3500–4700	210,000[c]
South China tiger *Panthera tigris amoyensis*	China	20–30[b]	10,000[c]
Indochinese tiger *Panthera tigris corbetti*	Cambodia, Laos, Burma, Thailand, Myanmar, Vietnam, China	750–1300	300,000[c]
Malayan tiger *Panthera tigris jacksoni*	Malaysia (Malayan peninsula)	>500	45,000
Sumatran tiger *Panthera tigris sumatrae*	Indonesia (Sumatra)	400–500	130,000[c]

[a] Although four species of tiger were historically found in China, evidence suggests that numbers of any species would now be extremely small (Walston et al. 2010).
[b] Some sources indicate that the South China tiger may even be extinct (Walston et al. 2010).
[c] Own calculations based on data from www.savethetigerfund.org. Sanderson et al. (Sanderson et al., 2006) provide information by region for effective potential habitat (land cover with low human influence), although this is potential and not current habitat. For Sumatran tiger, information is from Shepherd and Magnus (Shepherd & Magnus, 2004).

in China, and confiscations of poached tigers, concluding that wild tigers will likely become extinct if the status quo is maintained (Gratwicke et al., 2008; Nowell & Ling, 2007; Dinerstein et al., 2007; Sanderson et al., 2006; Shepherd & Magnus, 2004; Bolze et al., 1998).

The most common recommendation for preventing extirpation of wild tigers is to increase enforcement of the trade bans, while opposing tiger farming on the grounds that farmed output removes the stigma of using tiger-based products and facilitates the laundering of illegal tiger parts. The so-called 'stigma effect' (Fischer, 2004) postulates that the demand for illegal wildlife products falls when trade is banned. Proponents of tiger farming and trade in tiger parts, on the other hand, favor a supply-side approach to conservation, arguing that a captive breeding industry could meet all demand for tiger products, thereby eliminating illegal killing of wild tigers and preventing their extinction.

Damania and Bulte (Damania & Bulte, 2007; Bulte & Damania, 2005) assume imperfect competition to demonstrate theoretically that multiple equilibria are possible in a game between organized purveyors of illegal wildlife products (criminal poaching gangs) and domestic wildlife farms. In their model, it is not possible to determine unambiguously whether products from captive-bred wildlife will increase or decrease harvests of wild animals. If poachers and farmers compete on the basis of quantity (Cournot competition), the solution to the game leads to higher populations of wild tigers; but, if competition is on the basis of price (Bertrand competition), wild stocks are reduced. However, as Singh and Vives (Singh & Vives, 1984) demonstrate, the poacher and farmer are unlikely to compete on the basis of price because they can both do better if they compete on the basis of quantity when the goods they market are substitutes (which they must necessarily be). That is, the Cournot outcome (with higher wild stocks) dominates the Bertrand outcome (reduced wild stock) if wild and farmed products are substitutes, and especially if demand is linear (as assumed by Damania and Bulte).

Damania and Bulte also argue that, since the costs of raising tigers are considerable (some $4000–$5000 annually for four years), farmers are unable to undercut suppliers of illegal wildlife products. However, they underestimate the costs of processing and marketing wild animals. As a consultant from Singapore notes: while it is cheaper to kill a tiger in the wild than raise one on a farm, the "wild tiger must be transported across numerous borders …. As an illicit good, bribes and payoffs would be required; the rule of thumb is a doubling of price each time the cargo is handed off from one dealer to another. China has imposed the death penalty for trafficking tiger parts, and this strong deterrent further raises the price" (Conrad, 2010). Tiger farms need a retail price of $20,000 per tiger to break even, but current prices are higher (Conrad, 2010). But clearly the existence of tiger farms despite a trade ban suggests that costs may not be onerous, that there might be benefits specific to tiger farming (e.g., paid public viewing), that farmed products are somehow circumventing the current trade ban, or some combination of these factors.

Similar arguments have been raised concerning the ivory trade ban. There is fear that CITES-sanctioned intermittent sales of stockpiled raw ivory from southern African states with large elephant herds promote illegal killing of elephants. Given the extent and scope of poaching, van Kooten (van Kooten, 2008) found that the elephant could go extinct in some African states despite a trade ban and high levels of enforcement. The stigma effect appears to have had little effect in reducing the rate of decline in elephant populations in west and central Africa, although Blanc et al. (Blanc et al., 2007) find elephants in east and southern Africa to be increasing by 4% annually. Van Kooten argued that the elephant is best protected by effectively protecting its habitat through actual on-the-ground payments tied to elephant numbers. While conservation of tiger habitat is an important policy in range states, as are captive breeding programs designed to ensure survival of various tiger subspecies, economic incentives to prevent poaching and promote tiger protection have seemingly been ignored.

The present study contributes to the debate about tiger farming by using a bioeconomic model of wild tiger population dynamics, trade and habitat to analyze the potential of heightened anti-poaching enforcement and/or liberalization of the captive tiger breeding industry to prevent extirpation of wild tigers. A major conclusion is that anti-poaching and trade-ban enforcement must be increased to seemingly unattainable rates if extirpation of wild tigers is to be prevented, but that a captive breeding industry and/or effective transfer payments from rich countries to poor ones for protecting the habitat could potentially prevent the extirpation of wild tigers.

The fate of the wild tiger population is modeled by a tiger survivability function that is derived from economic principles. The survivability function is a differential equation that maps the tiger population, the rate of poacher detection, the output of tiger farms, the stigma effect, available habitat, and other relevant variables to the rate of change in the wild tiger population. Using the survivability function, we determine for any combination of parameters whether the tiger population will reach a stable positive equilibrium or go extinct. The model makes no distinction between poachers and farmers, except that the ability to sell farmed animals increases the supply of tigers while also shifting out the demand function, which is taken to be downward sloping. We estimate the current levels of all of the parameters and then calculate how much each must change, ceteris paribus, to prevent wild tigers from becoming extinct.

2. Model of Tiger Trade

An economic model of the interplay between killing of wild tigers and culling of farmed animals is provided in Fig. 1 (van Kooten, 2008; Heltberg, 2001). When there is no ban on farmed tigers, equilibrium occurs at point z, with the number of wild plus farmed tigers harvested equal to q^* and corresponding price of p^*; q_1 wild tigers are poached and $q^* - q_1 = q^{legal}$ farm-produced tigers are killed. When there is a ban on products from tiger farms, the demand curve shifts inwards as indicated — it is assumed for simplicity that the slope of the demand function remains constant while the intercept shifts from k to s to account for the stigma effect. With a trade ban and demand function D_{Stigma}, the market equilibrium shifts from z to w, with price p^{**} and