The Ecological and Economic Impact of Siberian Marmots in the Eastern Steppe of Mongolia

CERC Independent Project

Erika Reuter
WCS Living Landscapes Program

December 2008

Summary

The market value of Mongolian wildlife is driving current levels of consumption which, for many species, are unsustainable. The Siberian marmot (Marmota sibirica) *is an ecologically and economically important species in the Eastern Steppe of Mongolia. This paper reviews available literature to determine the ecological functions of marmots on the steppe, their economic value, and an exploration of how changing marmot populations would be expected to affect ecosystem services and local livelihoods.*

Introduction

More than half of Mongolians today earn the majority of their income from the livestock trade (Havstad, Herrick and Tseelei 2008). However, since this is a resource which can be negatively impacted by factors such as poor weather, disease outbreaks, and predation, many people obtain supplemental income from wildlife and some families rely heavily (or entirely) on natural resources for their survival (Pratt *et al.* 2004). While many species of wildlife are economically important to Mongolians, including the Mongolian gazelle, wolves and foxes, the Siberian marmot (*Marmota sibirica*) may be the most crucial to the country's economy (Coonan 2007). Unfortunately, marmots, hunted primarily for meat and fur, have declined greatly as a result of this demand. Although there were approximately 40 million marmots in Mongolia in 1940, they experienced substantial declines between 1990 and 2005 (Townsend and Zahler 2006), declining at least 75% in the 60 years before 2000 (Adiya 2000, as cited in Townsend and Zahler 2007). Although the population in 1990 was still as high as 20 (Clark *et al.* 2006) to 23 million animals (Townsend and Zahler 2006), the population had declined to only about 5 million by 2001 (Clark *et al.* 2006). In Russia, too, there is evidence of mass poaching; their current population in the Russian Federation is estimated at only 92,000 individuals (Mashkin and Kolesnikov 2007).

The Eastern Steppe consists of the three Eastern aimags (provinces) of Mongolia: Dornod, Sukhbaatar and Khentii. The area is mostly sparsely populated open steppe grassland, inhabited mainly by nomadic herders. The population of these three aimags is around 202,000 people and approximately 14% of these Eastern Steppe residents are hunters (Wingard and Zahler 2006). The Eastern Steppe is estimated to have supported 6,230,772 marmots as recently as 1990 (Batbold *et al.* 2000 as cited in Townsend *et al.* 2008). The Dornod and Sukhbaatar aimags alone supported an estimated 4,169,145 marmots in 1990 (Batbold *et al.* 2000 as cited in Townsend and Zahler 2007 and Townsend *et al.* 2008). A 2005 study derived a population estimate based on the density of active burrow clusters within the study area (using colony proportion/number projections from Suntsov 1981; Townsend 2006 and Townsend *et al.* 2008 provide greater detail on how this population estimate was derived). This number was then extrapolated from the area of the study to the entire area of the Dornod and Sukhbaatar aimags (S. Townsend, *personal communication*) to provide an estimate of only about 462,130 marmots remaining in those two aimags in 2005 (Townsend and Zahler 2006, Townsend *et al.* 2008). While these two population estimates were derived using different methods, and are rough estimates that should be interpreted with caution, they do indicate a large decline (88.9%) in those two aimags in just 15 years. In 1990, 66.9% of Eastern Steppe marmots lived in Dornod and Sukhbaatar aimags (Batbold *et al.* 2000 as cited in Townsend *et al.* 2008); if we assume a similar distribution in 2005, we can speculate that the entire Eastern Steppe may have supported around 690,777 individuals at that time.

In 2005, around 95% of the burrows observed were inactive, with neither living individuals nor scat seen (Townsend and Zahler 2006), suggesting that marmots may have experienced a fairly precipitous recent decline. However, this situation appeared to improve the following two years with fewer observed burrows being inactive; in 2006, 81.33% of burrows were inactive, while in 2007, 79.73% were inactive (Townsend *et al.* 2008). In 2005, the population density of marmots was quite low; there were only 0.423 *active* burrow clusters per square kilometer (Townsend and Zahler 2006). A lower density of animals will likely lead to lower genetic diversity within the remaining populations and associated further declines. Luckily, the hunting ban initiated in 2005 may have had a positive effect; the number of active burrow clusters per square kilometer increased to 2.280 in 2006 and 7.914 in 2007 (Townsend *et al.* 2008). The density of active burrow clusters was measured because marmots spend a great deal of time underground, making them difficult to observe (S. Townsend, *pers. comm.*). Therefore, observed marmot densities are lower than active burrow cluster densities, even though an active cluster likely houses multiple marmots. Approximately 0.123 (+/- 0.044) marmots were observed per square kilometer in 2005; in 2006 there were 0.98/km^2 and in 2007 there were 1.038/km^2 (Townsend *et al.* 2008). These numbers indicate improvement during the hunting ban, but are lower than densities that have been found elsewhere on the Mongolian steppe. For example, one study found 1.16 marmots per *hectare* (Takhi Reintroduction Centre 1998, as cited in Van Staalduinen and Werger 2007) in Hustai National Park, this is the equivalent of 116 per square kilometer. As many as 3.85 per hectare have been observed in some areas of that park (Van

Staalduinen and Werger 2007), although such high densities are likely only found within a colony in a strictly protected area such as Hustai Nuru and are thus not representative of density on the open, unprotected, steppe (P. Zahler, *pers. comm.*).

One interview of Mongolian people found mixed viewpoints on marmot numbers; whereas some people felt that populations were declining slightly, others felt that their numbers remained constant (Pratt *et al.* 2004). A different 2004 interview of Eastern Steppe herders found that the vast majority felt that marmot numbers were declining (Townsend *et al.* 2008). This is likely due to the different locations of the interviews; the Eastern Steppe herders had likely noticed the large recent declines that the open steppe has experienced, while Pratt *et al.* interviewed people in Batshireet and Mongonmort, both northern mountain-steppe locations which may have experienced lower levels of marmot decline (A. Fine, *pers. comm*.). Recently calculated densities support this observation; observed marmot densities were much higher in the forest-steppes west of Ulaanbaatar (Van Staalduinen and Werger 2007) than they were in the Eastern Steppe (Townsend *et al.* 2008).

Pratt *et al.* (2004) interviewed local people in 2 Mongolian soums; this qualitative research revealed that in the current free-market system, it is the financial value of wildlife and natural resources that drives their harvest. Declining wildlife numbers are viewed as a regrettable necessity to many people, who recognize that unsustainable harvests are driven by the (relatively high) market value of wildlife products in combination with a changing lifestyle that has made making ends meet a more difficult objective to obtain. In other words, wildlife consumption in Mongolia is currently driven by market demand, the fact that those species being exploited have a market value (Pratt *et al.* 2004). Therefore, the timing of the recent rapid wildlife decline corresponds to Mongolia's shift to a market economy in 1990; marmots, for example, experienced substantial declines between 1990 and the institution of a 2005 hunting ban (Townsend and Zahler 2006). Two main factors come into play in the timing of this decline: increased rates of unemployment, especially through the loss of government jobs, so that people began to rely more heavily on natural resources; and the abandonment of the stricter hunting regulations that were in effect in Mongolia's Soviet-influenced system (Pratt *et al.* 2004). Unsustainable harvests are further facilitated by a combination of additional factors, such as: insufficient enforcement of those laws that do exist; availability of a ready market for wildlife, particularly in neighboring China (Pratt *et al.* 2004); and 'scramble competition' among local people who recognize that if they do not use a resource now someone else is likely to do so (P.Zahler, *pers. comm.*, Pratt *et al.* 2004).

Species Background

Marmots are rodents in the squirrel family (*Sciuridae*). The fourteen species within genus *Marmota* are divided into two subgenera: *Marmota* and

Petromarmota. Subgenus *Marmota* includes the Siberian marmot (*M. sibirica*), as well as the Altai marmot of Siberia (*M. baibacina*) and several other marmots of Asia, the Alpine marmot (*M. marmota*) of Europe, and the woodchuck (*M. monax*) and Alaska marmot (*M. broweri*) of North America. The other subgenus, *Petromarmota*, includes 4 species of Western North American marmots (Cardini *et al.* 2005).

The Siberian marmot, also known as the tarbagan marmot, Mongolian marmot, Transbaikal marmot, or, locally, Mongol tarvaga, is currently endangered in Mongolia even though globally they are considered a species of “least concern” (Clark *et al.* 2006). Although only 6% of their current range occurs within Mongolia’s protected areas, local governments are required to assess populations every four years and shut down hunting when the species is threatened (Clark *et al.* 2006); this happened with a two-year hunting ban instituted in 2005 which was later extended a further 2 years (Townsend *et al.* 2008). The tarbagan has a lower reproductive capacity and suffers from a higher rate of harvest than some other species; both factors contribute to its current rates of decline (Mashkin and Kolesnikov 2007). The species is composed of two sub-species, *M. sibirica sibiricus*, which lives in the grassland steppes, and the mountain-dwelling *M. sibirica caliginosus* (Clark *et al.* 2006).

In areas heavily impacted by human activities, marmot populations may adapt to changing habitat conditions by adjusting their habitat preferences. For example, Semikhatova and Karakul’ko (1994) found that bobac marmots (*M. bobac*) tended to concentrate in areas such as gullies that were unsuitable for agriculture, margins of currently cultivated lands, or abandoned agricultural zones. Suntsov *et al.* (1994) also found lower densities of marmots in cultivated crop or grass fields but they found the highest densities of marmots occurred in deserted villages (or the borders of inhabited areas) and the protective areas around industrial enterprises, which they speculated was due to the favorable food and shelter conditions that exist in such areas. While Ukolov and Rymalov (1994) found that *M. camtschatica* prefers areas with little human impact, they noted that both *M. baibacina* and *M. bobac* species will live in agricultural areas. Some species of Russian marmots can not only exist compatibly with grazing mammals but actually prefer areas of intensive grazing; for example, Suntsov *et al.* (1994) found higher densities of marmots in natural or pastured steppes, as opposed to cultivated crop or grass fields, and Kolesnikov (2007) found that bobac marmots released in areas of intensive cattle grazing (100 heads of cattle per square kilometer) fared better than those released in other areas. It is the action of grazing itself which provides optimal forage conditions for marmots; grazing encourages vegetative growth and marmots feed on the soft vegetation provided by plants as they grow. In Himalayan marmot territories, wild yak populations have largely been replaced by domestic yaks; whether domestic or wild, the positive effect of grazers on marmot populations was the same (Nikol'skii and Ulak 2007). Therefore it is possible to envision grazing livestock and marmots living compatibly on the Mongolian steppe as well; domestic livestock production, even if intensive, need not occur at the exclusion of marmots.

Marmots have traditionally been, and continue to be, valuable sources of food, fur and medicine. Marmots were hunted for game meat in Switzerland as far back as the year 1000 and marmot fat was noted in French medicinal recipes of the thirteenth century (Ramousse and Le Berre 2007). Siberian marmot meat is a traditional food source for the Tuvinian, Buryat and Mongol people (Mashkin and Kolesnikov 2007), although this may not have always been the case. Nassan-Bayer and Stuart (1992) describe one Mongolian creation story in which an archer, Erkei-Mergen, angry that he could only shoot down six of the seven suns that were drying up the earth, chopped off his own thumbs and became a marmot. For this reason, some people refused to eat marmots since they believed them to be descended from a man. However, their meat was traditionally used by the Buryats of Transbaikalian Siberia for summer food (Badmaev 1996); and even today, people in Mongolia often supplement their diets with wildlife such as marmot and roe deer, particularly in the spring when their livestock are too thin to justify slaughter (Pratt *et al.* 2004). The Buryats also used marmot fur for hats and coats, and their fat, gall, and internal organs for traditional medicinal applications (Badmaev 1996). In Mongolia, too, they are traditionally used for medicinal purposes as well as for food and fur (Wingard and Zahler 2006). More recently, marmot meat, organs, and oil were observed being openly traded at the Bayanzurkh and Narantuul food markets (Parkinson *et al.* 2008).

Marmot populations, like those of many wildlife species, are affected as the needs of humans and marmots intersect. While game and trade hunting have negatively impacted many species of marmot, reduced populations have also occurred when they are persecuted because they are viewed as agricultural pests (in crop-fields and pastures) and/or carriers of epizooses (Bibikov and Rumiantsev 1994) such as plague (*Yersinia pestis*) (Clark *et al.* 2006, McNeill 1998), of which Siberian marmots are a major carrier. Many human cases of plague are contracted through the hunting and skinning of marmots; in the Qinghai Province of China, for example, Himalayan marmots (*Marmota himalayana*) are the main host of plague and human cases are generally caused by hunting or butchering marmots (Li *et al.* 2005). Since sick marmots are slower and more easily caught, they pose a particular risk to those involved in indiscriminate hunting practices and many hunters in China take antimicrobial drugs on a prophylactic basis in order to avoid developing plague (Li *et al.* 2005).

The plague likely spread to the rodents of the steppes, perhaps in the mid-13th century, as a result of the increasing amounts of travel and trade begun under Mongol reign (McNeill 1998). As plague was carried from one city to another along the caravan routes, so too did it probably spread and establish itself among local rodent burrow clusters. In the microecosystems provided by burrows, plague was able to survive the harsh winters of Siberia; the animals and insects within these burrows thus became carriers of the infection (McNeill 1998). In China, Manchurian nomads had managed to effectively avoid plague infection due to their traditional methods of harvesting marmot. Fur trapping was culturally prohibited – marmots were only harvested by shooting – therefore sluggish animals or those that were obviously sick could be easily avoided. Furthermore, nomadic people would move away from sick colonies of marmots, which they believed to be bearers of bad luck. These local customs were likely very effective in protecting natives from plague infection. Nonetheless, the 1911 and 1921 plague outbreaks in Manchuria were linked to marmots because recent Chinese immigrants to the area, unaware of these practices, trapped marmots to obtain their valuable fur. This indiscriminate method of harvest infected the hunters, an infection that was quickly spread along the train lines which had recently been built in the area (McNeill 1998). Ukolov and Rymalov (1994) note that some populations of *M. sibirica* were exterminated in Russia during anti-plague campaigns; thereby reducing their numbers nationwide.

The traditional Mongolian tasseled hat ("daluur") worn by marmot hunters may have originally been adopted to help hunters avoid plague-infected populations (Formozov *et al.* 1994). The unique hunting costume was meant to elicit alarm calling behavior from their quarry and, because alarm-calling behavior declines greatly in plague-affected colonies, animals which were obviously sick were more easily avoided (Formozov *et al.* 1994). Marmots over the age of 4 were found to avoid hunters wearing the daluur, thus the use of such a costume may even contribute to sustainable rates of harvest (Formozov *et al.* 1994). Although juvenile bobac marmots (*Marmota bobac*) tend to respond more strongly and quickly to alarm calls than adults, adult calls tend to elicit more frequent responses and longer alert times than juvenile calls (Nesterova 1994). Therefore, the use of a traditional costume that elicits an avoidance response from older animals (like the daluur) may save not only those older animals who have learned to avoid the hunter but also young animals who react to the alarm calls of the adults within their colony.

Of Mongolia's human population of around 2.5 million, approximately 245,000 are believed to be hunters between the ages of 15 and 65; nearly 50% of hunters nationwide are from the countryside rather than from aimag centers or the capital (Wingard and Zahler 2006). There are most likely three main types of Mongolian marmot hunters: 1) people who hunt marmots for meat, and may or may not keep the skins to sell later if the opportunity arises; 2) occasional hunters who are interested in harvesting marmot skins, and who may also eat the marmots and/or sell the meat; and 3) "commercial" or large-scale skin harvesters, who may also sell the marmot meat (P. Zahler, *pers. comm.*). In 2004, the total estimated Mongolian harvest of marmots was between 3-4 million animals; the *M. sibirica* harvest was approximately 3.3 million animals while the overall harvest of *M. baibacina* nationwide was estimated to be 66,000 animals (Wingard and Zahler 2006).

Although the Ministry of Nature and Environment instituted a complete ban on marmot hunting in 2005 (Clark *et al.* 2006), marmots are still being hunted during the ban, as evidenced by seizures of skins (Wingard and Zahler 2006). The initial 2-year ban was later extended a further 2 years, through 2008 (Townsend *et al.* 2008). Recent *observable* trading in marmot skins at Ulaanbaatar markets is drastically reduced, although it is unclear if this is due to fewer animals being hunted under the ban, to the trade persisting at high rates but being driven underground due to its illegality, or to the fact that fewer wild marmots are able to be harvested because of declining population size (A. Fine, *pers. comm.*). Parkinson *et al.*'s (2008) observations suggest that many marmots are probably being transported directly to China and therefore never make it to the markets in Ulaanbaatar; and, furthermore, that many more skins have been harvested and are available domestically than are observed in open trading.

Economic Value

Today, the trade in marmots is primarily driven by: 1) export of fur to China; and 2) increasing domestic demand for traditional medicine derived from organs, meat, and oil (Parkinson *et al.* 2008). Although Mongolia was not one of the 12 countries represented at the Second International Conference on Marmots (held in Aussois, France in October 1994), one of the results of this conference was the recognition that economic studies of marmots, as well as more accurate measures of their current population size, are needed to help direct sustainable management of these species (Le Berre and Ramousse 1994). Additionally, the World Bank (2006) has noted the necessity of determining a clearer estimate of the contribution of natural resources to the Mongolian economy, in recognition of the importance of the local environment to the livelihoods of Mongolian people. The commercial value of marmots in Mongolia is mainly driven by the value of their skins (A. Fine, *pers. comm.*). However, Wingard and Zahler (2006) note that local traders often trade the meat and medicinal products obtained from marmots separately from the pelt; making this trade *additive* to the value of the skins. Parkinson *et al.* (2008) concur; they note that the growing demand for wildlife-based medicines is supported by some by-products – such as meat and other medicinal parts – of the Chinese fur trade in certain species (particularly wolves and marmots). Although not all of the animals hunted for fur are also traded for meat and other parts, and even though the market for meat and medicinal parts of marmots is mainly small-scale and local (A. Fine, *pers. comm.*), each animal should ideally be valued as the sum of all the marketable parts because there is the *potential* to gain monetarily by selling the whole animal.

Many Mongolian people, especially those living in poverty, rely on natural resources for their livelihoods but despite its importance to local livelihoods, the amount currently invested in the environment is insufficient for its protection. Current estimates of Mongolia's environmental spending equal only 0.5% of GDP, a vast underinvestment, given its immense contribution to the Mongolian economy in sectors such as tourism, mining and livestock farming (World Bank 2006). The World Bank, the Government of Mongolia, and their external partners suggested that proper management of natural resources in Mongolia is essential for economic growth and poverty reduction. They recognized the potential for Mongolians to benefit by the provision of the resources necessary at the local level for community investment in environmental services (World Bank 2006).

Mongolian wildlife trade, which was once quite open, has recently become increasingly clandestine; the majority of this trade is illegal and some even involves CITES-listed species (Parkinson *et al.* 2008). In years past, the majority of marmot furs were traded through Russia; now, although some Russian trade continues (Wingard and Zahler 2006) wildlife trade in Mongolia is driven by demand from China or Korea (Pratt *et al.* 2004). Generally, much of the wildlife harvested in Mongolia was believed to be sold to dealers, who sell it to middlemen in Ulaanbaatar, who then export it to China (Pratt *et al.* 2004). At the raw materials markets, only a small proportion of wildlife trade was domestic trade in parts (skins, meat, organs, oils, etc) while the rest was obviously destined for China; in fact, around 80% of the trade in wildlife at the market in Choibalsan (in Dornod Aimag) is thought to go directly to China, while only 20% is transported into Ulaanbaatar (Parkinson *et al.* 2008). This observation suggests that much of the trade at regional centers such as this one may go directly to China and never even make it to the markets in the capital; in other words, the observable trade in Ulaanbaatar markets may just be the proverbial tip of the iceberg when it comes to wildlife trade. The fact that fur-bearing species comprise a full 40% of the trade recorded suggests that demand for fur is driving the illegal wildlife trade (Parkinson *et al.* 2008).

Since the trade in marmot parts has been banned it, too, has become more organized and better hidden; for example marmot skins are smuggled across the border to China inside the tires of vehicles making the crossing (Parkinson *et al.* 2008). While the trade in marmot skins remains mainly hidden, it is by no means an insignificant contributor to the problem of illegal hunting; a survey of Ulaanbaatar's wildlife raw materials and food markets conducted during the winter of 2007-2008 found that marmots remained the fourth most commonly traded wildlife species (of the 51 species of wildlife seen), after fish (all species combined), wolves and red fox. And, although there were only 6 marmot observations made at the Tsaiz raw materials market, dealers there admitted to having over 2600 skins (Parkinson *et al.* 2008). The 51 direct observations of trade in *M. sibirica* and *M. baibacina* accounted for 7.5% of all wildlife trade observations made from December 2007 through February 2008 (Parkinson *et al.* 2008). Of the 51 total observations of marmot trade, 15.7% were made at the raw materials markets, 62.7% were at food markets and 21.6% consisted of newspaper advertisements for marmot meat, oil, or organs (Parkinson *et al.* 2008).

Although many rural people rely quite heavily on wildlife for their livelihoods, the income that a Mongolian trader is able to generate can be extremely unpredictable, fluctuating wildly due to changing demand within East Asian markets (Pratt *et al.* 2004). For example, prices of wildlife parts can be low while the border with China is closed, causing poachers to keep their catches out of the markets until the borders open up, demand and prices increase and wares can be exported (illegally) across the border (Parkinson *et al.* 2008).

Ecological Value of Marmots

Siberian marmots likely play a keystone role in the Eastern Steppe of Mongolia; that is, they provide many ecosystem services and have a greater impact on their ecosystem than suggested by their abundance alone (Townsend and Zahler 2006). Firstly, they are "ecosystem engineers" that bring soil to the surface during the course of burrow excavation, aerating the soil and adding buried nutrients to the surface layer (Clark *et al.* 2006). In fact, *Marmota* species create specific "zoogenic landscapes" that are highly stable (Zimina 1994). These burrows can later be used by a variety of other steppe species, from hedgehogs to foxes to birds (Townsend and Zahler 2006). Secondly, because they are selective in their feeding, they affect the composition of the local vegetation (Clark *et al.* 2006, Townsend and Zahler 2006), leading to a local landscape containing associations of plant species which are different from the native assemblage (Zimina 1994). And, finally, they are an important prey source for a variety of mammals and raptors; thereby playing a crucial role in local food webs.

Marmots are certainly the major "ecosystem architects" on the Eastern Steppe (A. Fine, *pers. comm.*). In fact, where marmot colonies are densely populated, they create stable landscapes consisting of specific vegetation, soil and microclimate that depend on the action of their burrowing (Zimina 1994). The specific plant communities that their soil disturbances encourage, such as *Artemisia adamsii* and *Leymus chinensis*, are found to contain higher levels of nitrogen despite having lower species richness; they therefore provide better forage quality than the surrounding, *Stipa*-dominated steppe (Van Staalduinen and Werger 2007). These burrows also provide refuge to a wide range of other species including the corsac fox, a small canine indigenous to the Eastern Steppe. Corsac foxes, including those with young, can often be observed near active marmot colonies (Townsend and Zahler 2006). Burrows likely provide resting mammals protection from weather and predation. A study by Murdoch *et al.* (in press) found that corsac foxes preferred to rest in burrows rather than choosing an exposed resting location and that 64% of the burrows that they chose belonged to marmots. Of their 207 total observations of resting foxes, a marmot burrow was chosen as a resting location 53% of the time (Murdoch *et al.*, in press). Additionally, active marmot colonies have been found to support higher numbers of non-marmot-sized burrows than inactive colonies, suggesting that smaller burrowing species will tend to co-exist with marmots in spite of the increased interspecific food competition which would be present in such an arrangement (Townsend 2006).

Although burrows may persist for a long time after marmots are extirpated from an area (Townsend 2006), an entire colony's burrows have been observed to fill in with sand within only a year and a half of their extinction (Murdoch *et al.* in press). Furthermore, inactive burrows are found to have more debris in the entrances than active burrows (Townsend 2006); burrows that fill in with sand and/or other debris will likely be unusable as refuges. Townsend's (2006) finding that inactive burrow clusters contained fewer burrows than active ones supports the idea that burrows may be gradually lost over time when marmots are no longer present to excavate and maintain them. Unfortunately, marmots are not well suited to traveling long distances to re-colonize abandoned areas; therefore when marmots are extirpated their former ranges are likely to remain empty for a long time (P. Zahler, *pers. comm.*). In at least one instance where a marmot colony was hunted to extinction, their burrows filled in and corsac foxes, losing an important protection, were no longer observed in the area (Murdoch *et al.* in press).

In China, both snow leopards (*Panthera uncia*) and wolves (*Canis lupus*) have been found to rely heavily on marmots in their diets. In one survey of wolf scat, Schaller *et al.* (1988a) found that *M. bobac* were found to comprise 21.6% of their diet in the mountains of Horendaban Shan and that *M. himalayana* comprised 80% of their diet in East Kunlun Shan. Wolves in the Qinghai and Gansu provinces, too, were found to rely heavily on marmots; their spoor was found to contain between 47.1 and 61.2% marmot remains (Schaller *et al*. 1988b). In the Qinghai and Gansu provinces, marmots are important to the diet of snow leopards as well; *M. himalayana* comprised between 36.5 and 65.3% of the cats' diet depending on region (Schaller *et al*. 1988b), while *M. caudata* made up 29.1% of snow leopards' diet in the Taxkorgan Reserve (Schaller *et al.* 1988a). The researchers concluded that marmots were at least as important as ungulates in the diet of snow leopards, particularly during the summer months when marmots emerge from hibernation and are available as prey.

In the Eastern Steppe, too, wolves are likely to be heavily dependent on marmots because gazelle are the only other large-sized prey and they are sporadically unavailable due to their nomadic nature (P. Zahler, *pers. comm.*). Other potential predators in the area are badger, Pallas' cat, red fox, corsac fox, steppe ferret, golden eagle, steppe eagle and upland buzzard (P. Zahler, *pers. comm.*). The presence of marmots and raptors may be correlated due to the fact that many species of raptors – such as golden eagles, steppe eagles and upland buzzards – feed on marmots and on other species that use marmot burrows (Townsend and Zahler 2007). Large predator species such as the wolf and lynx were noted in interviews with Mongolian people for their ecological, not just their economic, importance; they are valued for keeping disease levels down by preying on weak and diseased animals (Pratt *et al.* 2004). Since large predators are valuable to local people, marmots' role in maintaining their populations should likewise be considered to be of value.

Marmots can act as a “buffer” to ease hunting pressure on ungulates, both native and domestic, since large predators rely so heavily on marmots in their diets (Schaller *et al.* 1988b). This buffer effect may translate into fewer herders' animals lost to predation by wild predators. Each domestic animal killed by a predator because of lack of marmots would result in a monetary loss to the farmer. Each kilogram of meat from domestic sheep that is unavailable to farmers (due to predation) is valued between 1692-2553 MNT (2005 numbers from the National Statistics office; Maytsetseg and Riichiro 2006), or $1.50-2.28[1]. The loss of marmots as wild prey would be expected to directly affect the economic well-being of farmers due to the monetary loss experienced when sheep are killed by hungry predators. Furthermore, if predator populations crashed due to lack of prey, the potential value of predator pelts would be lost to local people as well. Those predators, such as wolves, could experience double/triple pressure if marmot populations are killed off: 1) lack of prey would be expected to lead directly to population declines; 2) predators may be increasingly killed for their fur as marmot fur is no longer available; and, potentially, 3) they could be killed by herders in retaliation for livestock killed when natural prey sources are no longer available.

Economic Value of Marmots

Fur

Mongolian trade in marmot fur exceeded 1.2 million skins annually since the end of the 19th century; averaging 1.4 million marmots hunted annually under permit between 1960 and 1989 (CBD 1996), to as many as 3-4 million animals killed during more recent harvests (Townsend and Zahler 2006). In fact, between 1906 and 1994, an estimated 104.2 million marmot skins passed through Mongolia on the way to market (Clark *et al.* 2006); the value of the pre-ban marmot fur trade is estimated at $340 million (Wingard and Zahler 2006). In 2006, Wingard and Zahler found that each Altai marmot (*M. baibacina*) fur was worth $13 and each Siberian marmot (*M. sibirica*) fur was valued at $10. More recently, dealers surveyed in the marketplace noted that the price of Marmot skins had declined to about $3 (Parkinson *et al.* 2008). The speculated reasons for this drop in price may involve: reductions in the Chinese demand for marmot fur; collapsing marmot populations; lessening trade due to successful law enforcement activities; or simply a normal “off-season” price reduction due to the timing of the surveys (Parkinson *et al.* 2008).

At $10 a skin, the 2004 hunting quota of 100,000 animals (Wingard and Zahler 2006) would bring in $1 million. Even if prices have truly declined to $3 per skin,

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[1] This dollar value was obtained using the currency converter at www.oanda.com. The exchange rate used was from 12/31/05 since Maytsetseg and Riichiro supply 2005 numbers.

the total value of legally collected furs would still be around $300,000. The true value (the combination of both official and illegal international shipments) is of course much higher. At the 2004 estimated national harvest of 3.3 million *M. sibirica* valued at $10 each and 66,000 *M. baibacina* valued at $13 each (Wingard and Zahler 2006), the total value of skins harvested from all marmot hunted in Mongolia was $33,858,000; 0.87% of the 2007 Mongolian GDP of $3.905 billion (CIA 2007). If the value dropped to $3 per skin, the value would nonetheless be over 10 million dollars ($10,098,000 or 0.26% of Mongolian GDP).

To see how the price of marmot skins compares to that of other fur-bearers, see Table 1.

Table 1: A comparison of prices for pelts reported at Mongolian markets in 2006 (from Wingard and Zahler 2006) and 2008 (from Parkinson *et al.* 2008).

Species	Price per Pelt 2006	Price per Pelt 2008 (1)
Ibex	$2	--
Red squirrel	$2-3	--
Pallas cat	$3	--
Marmot	$10-13	3,000-3,500 MNT ($2.56-2.98)
Roe deer	$6 (2)	--
Red fox	$18 (3)	25,000-80,000 MNT ($21.33-68.27)
Corsac fox	$28	25,000-80,000 MNT ($21.33-68.27)
Lynx	$25-200 (4)	180,000 MNT ($153.61)
Wolf	$50-250 (5)	20,000-200,000 MNT ($17.07-170.67)
Brown bear	$200-300	--
Snow leopard	$500 (6)	800,000-1,200,000 MNT ($682.70-$1024.05)

NOTES:
(1) 1 US Dollar = 1,171.82 MNT (www.oanda.com for 02/29/08)
(2) small amount of domestic trade
(3) traded almost exclusively with China
(4) $25-80 in domestic trade; $100-200 in China
(5) $50-150 domestically, up to $250 on Chinese border
(6) equivalent of $250 per meter

Meat

Marmots have historically been used as a food source for many Transbaikalian peoples, including the Buryats, a pastoralist people, who use marmots as a summer food (Badmaev 1994). Marmot meat is a prized protein source and has long been consumed in Mongolia; even when domestic sources of meat are available, modern Mongolians will often hunt marmots to supplement their diet (Wingard and Zahler 2006). Many Mongolians (27% of those surveyed) use marmots on a regular basis and approximately 370,000 people regularly consume their meat; most of these people either hunt the meat themselves or buy it at a local market (Wingard and Zahler 2006). In fact, of all domestic uses, meat is the primary use reported by 85% of marmot consumers (Wingard and Zahler 2006). To this day, in spite of the hunting ban, demand for marmots remains high since both the meat and organs are highly prized for food and medicine (Parkinson *et al.* 2008). In an environment where many people are struggling to get by, and where over 60% (Havstad, Herrick and Tseelei 2008) – and, in some areas, more than 90% (Pratt *et al.* 2004) – of herders do not own enough animals to supply them with necessary income, the importance of supplemental food sources cannot be overemphasized. A small family needs at least 200 sheep or 50 cattle to be able to subsist on livestock herding alone; few families own this much livestock (Pratt *et al.* 2004). Interviews of Mongolians from Batshireet and Mongonmort soums revealed that, although the value of marmot meat as a supplemental food source was noted, it was not quantified by interviewees since it generally did not represent a direct financial gain (Pratt *et al.* 2004).

Each Altai marmot (*M. baibacina*) provides $10 worth of meat; a Siberian marmot's (*M. sibirica*) meat value is $7 (Wingard and Zahler 2006). Although trade in marmot meat, fur, and oil may occur locally, nationally, and internationally (Clark *et al.* 2006), it is the international fur trade that is likely the main driver of illegal wildlife trade of fur-bearers such as marmots (Parkinson *et al.* 2008), while meat and medicinal use are mainly national trades (Wingard and Zahler 2006). One reason that marmot meat tends to be traded in-country may be the lack of available refrigerated transport during the summer and the fact that marmots are hibernating, and thus unavailable for harvest, during the winter (P. Zahler, *pers. comm.*).

Meat has traditionally been the main staple food of Mongolia during the colder seasons (with dairy being the main staple during the summer), and the Mongolian climate demands an annual meat consumption of 84 kg per person for optimal nutrition *(*Maytsetseg and Riichiro 2006*)*. Although Mongolian herders have consumed marmot meat in the late summer/early fall for generations, urban consumers have recently begun to demand marmot meat, with indications of a significant volume being supplied and consumed. The price (~$30/marmot) urban residents are reportedly paying for this fresh or barbequed meat is considerably higher than the price of a single marmot skin (A. Fine, *pers. comm*.). As Wingard and Zahler (2006) demonstrate, harvesting marmots during the spring pup-bearing season (April-June), as would be necessary for such urban consumption in the summer, results in the incidental mortality of pups who cannot survive if their mothers are hunted, which is why the traditional autumn hunting season should be upheld.

If marmots are extirpated and become unavailable as a local food source, other sources of wild meat may be exploited instead. These include species such as Mongolian gazelle, which sells for 1000-1500 MNT/kg (Parkinson *et al.* 2008) or $0.83-1.25[2]; taimen, with a market value of $20-60 per fish (Wingard and Zahler 2006); lenok, valued at $3 per fish (Wingard and Zahler 2006); and other species such as Tibetan hare, muskrat, Asiatic wild ass, saiga antelope, red deer, Siberian ibex, argali, wild boar, Mongolian gazelle, black-tailed gazelle, Ussurian moose, Yakut moose, Siberian roe deer, Daurian partridge, Altai snowcock, black grouse, white ptarmigan, graylag goose, gadwall, Pallas' sandgrouse, northern pike, Siberian whitefish, Potanin's osman, common wild carp, catfish, Arctic grayling and Eurasian perch (Wingard and Zahler 2006). Since wildlife species are available to a limited subset of all local people – for example, fish and waterfowl are only available near rivers or lakes, argali and ibex in the mountains, saiga antelope in the Gobi, moose and ptarmigan in the northern forests, etc (P. Zahler, *pers. comm.*) – people may be forced to turn to local livestock markets for their protein needs if local harvest of marmots is unreliable. In August 2005, the prices of (domestic) meat sold by vendors in the Khuchit Shonhor meat market were: 2200-2500 MNT/kg ($1.96-2.23/kg[3]) for mutton, 2000-2400 MNT/kg ($1.79-2.14/kg) for beef, 1100-1300 MNT/kg ($0.89-1.16/kg) for horsemeat, 1800-2000 MNT/kg ($1.61-1.79/kg) for goat and 1750-2000 MNT/kg ($1.56-1.79/kg) for camel (Maytsetseg and Riichiro 2006). According to the World Bank (2008), 2007 Mongolian gross national income[4] was US$1290. Assuming that livestock meat costs $1.69/kg on average[5], meeting the annual per capita protein needs at the marketplace would require $141.96/year, a full 11% of annual income.

Wingard and Zahler (2006) estimated that the total in-country trade value of marmot meat and medicinal products is $4 million annually. The 2004 Mongolian harvest of 3.3 million *M. sibirica* valued at $7 each and 66,000 *M. baibacina* valued at $10 each means that the total value of meat available from all marmot

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[2] Exchange rate determined using the currency converter at www.oanda.com on 12/5/2008.
[3] Currency conversions for these August 2005 domestic meat prices were obtained from www.oanda.com for 08/31/05.
[4] This estimate was obtained using the Atlas methodology, which accounts for differences in exchange rate as well as inflation. For more information on how this is calculated, see: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20452009~isCURL:Y~menuPK:64133156~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html
[5] This number was obtained by averaging the prices of various livestock species that were listed in Maytsetseg and Riichiro 2006.

hunted in Mongolia, including that eaten locally and not traded, would be $23,760,000. This number represents 0.61% of the total 2007 Mongolian GDP. If the same number were hunted as in 2004 but traded in the urban meat trade (at a value of $30 each), this trade would be worth $99,000,000 or 2.5% of GDP.

Medicinal Products

Traditionally, marmot meat, organs, and oil are used in Mongolia; and demand for these items remains strong to this day (Parkinson *et al.* 2008). Marmot oil, in particular, has many uses including treating burns and frostbite (Parkinson *et al.* 2008). Cortisol-rich marmot oil is also used to supplement the diet of children, to treat ailments such as tuberculosis, to condition leather (Wingard and Zahler 2006) and as a livestock tonic (Pratt *et al.* 2004). Following meat, the most popular domestic marmot products were the oil (5% of marmot consumers primarily used the oil), followed by kidneys, lungs, and stomachs (Wingard and Zahler 2006). Each marmot, whether Altai or Siberian, provides a $1 gallbladder, $1 kidneys, $2.50 lungs, and $3 worth of oil at market (Wingard and Zahler 2006), making the total medicinal worth of each marmot $7.50. At least one Mongolian pharmaceuticals company, Monos Pharma Trade, has come up with innovations based on traditional Mongolian medicinal ingredients, including marmot fat (Lkhagvadorj 2004). Marmot fat has been used in the treatment of tuberculosis (Petrosian *et al.* 1999), and is considered a “universal medical cure” in Polish folk medicine, a distinction that led to the overexploitation of marmots in that nation (Oleksyn and Reich 1994). Patients at Ulaanbaatar hospitals were found to use wildlife products in spite of the fact that such use is prohibited. Out of 228 observations of wildlife use at the Trauma Hospital and the Burns and Rehabilitation Centre in Ulaanbaatar in 2007-2008, nearly a quarter of these (54) were products sourced from marmots (Parkinson *et al.* 2008). These products included meat, organs (liver, kidney, gallbladder, “gland meat”) and oil, and were used to treat ailments such as wounds, stomach pain, illnesses of the lungs, liver, and kidney, and for bone-setting (Parkinson *et al.* 2008). Most of these products are likely brought in by family members and may be brought from rural marketplaces in the country; this assumption was made because many species of wildlife found in hospitals were not observed during surveys of Ulaanbaatar’s food and materials markets (Parkinson *et al.* 2008).

As previously noted, marmots are harvested primarily for their fur and thus the number of animals traded for medicinal purposes is probably a proportion of the total number of those harvested for fur. Furthermore, trade in medicinal products from marmot is concentrated in-country, with only very small amounts likely to be traded internationally (A. Fine, *pers. comm.*). Also, although the health value of marmot fat and the value of marmot stomach as a livestock tonic were both noted by Mongolian interviewees in Batshireet and Mongonmort, the economic value of such uses was not quantified (Pratt *et al.* 2004). Therefore, while the total estimated national harvest of 3,366,000 million marmots (at an approximate medicinal value of $7.50 each) would mean that the total medicinal value of all marmots hunted in Mongolia was $25,245,000 or 0.65% of the 2007 Mongolian GDP, the actual monetary value of such trade was likely much less. This is not to minimize the medicinal importance of the species; marmots obviously play an important cultural role for local Mongolian people and this health value is not fully captured by considering trade for monetary gain alone.

Decorative Items

In graves examined at the large Neolithic cemetery at Lokomotiv (an ancient burial site 70 km downstream from Lake Baikal), burials were accompanied by goods such as tools for fishing and hunting and other artifacts. The second most abundant category of goods found were marmot incisors (from *Marmota sibirica*). These were likely decorative in nature, probably used to adorn clothing and headgear (Mooder *et al.* 2005). Additionally, marmot oil has household uses that go beyond medicinal purposes, including its use as a leather conditioner (Parkinson *et al.* 2008, Wingard and Zahler 2006). While these types of uses underscore the traditional importance of marmots to Transbaikalian and Mongolian cultures, they are unlikely to play a large role in contributing to off-take levels or the Mongolian economy (A. Fine, *pers. comm.*).

Official Estimates of Marmot Value

Each Altai marmot (*M. baibacina*) is worth $13 (fur) plus $10 (meat) and each Siberian marmot (*M. sibirica*) is valued at $10 (fur) plus $7 (meat); each marmot, whether Altai or Siberian, provides a $1 gallbladder, $1 kidneys, $2.50 lungs, and $3 worth of oil at market (Wingard and Zahler 2006). This means that the total market value of a Siberian marmot was $24.50 in 2006, and that each Altai marmot was worth $30.50 at that time. Due to the recent decline in the price of Marmot skins (to $3 each, per Parkinson *et al.* 2008), each Siberian marmot is currently worth $17.50 and each Altai marmot is worth $20.50 at the market, considering typical meat prices. However, if marmot meat is traded for urban consumption in Ulaanbaatar, the meat will bring is considerably more money (currently approximately $30 per animal, per A. Fine), thereby increasing the potential total value per animal to $40.50.

According to the Mongolian Law on Hunting, a poacher who illegally takes an animal will be fined an amount equal to “twice the assessed species ecological and economic value” in addition to confiscation of equipment (Parkinson *et al.* 2008). Ideally, such economic assessments should be closely tied to market value, with the understanding that such market-based assessments may need to be updated yearly if the market changes and the fees should be sufficiently higher than the market value in order to be an effective deterrent (Wingard and Zahler 2006).

In 2001, each Altai marmot was assessed an ecological and economic value of 4,000 MNT ($3.32)[6] and each Siberian marmot was valued at 3,000 MNT ($2.49) (Governmental Resolution #264, 2001, attachment 2). Since this valuation is about $22 less than the total market value of each Siberian marmot at that time, this number was a vast underestimation which did not properly consider economic, let alone ecological, value. Furthermore, since it was possible to make about $24.50 per marmot at that time, a fine of only about $5 was quite unlikely to discourage illegal hunting. Likewise, at a market value of $30.50 each, fining Altai marmot hunters $6.64 was not a viable disincentive to their activity. The payment for hunting or trapping marmots in hunting reserves was 800 MNT ($0.66) for Altai marmot and 600 MNT ($0.50) for Siberian marmot. The authorization fees for household hunting and trapping were the same as the hunting reserve use fees for each species (Governmental Resolution #264, 2001, attachment 3).

Marmots were re-assessed at a substantially higher rate in 2005. Male marmots are now valued at 25,000 MNT ($20.77), females at 32,500 MNT ($27.01) and juveniles at 42,500 MNT ($35.31) (Governmental Resolution #248, 2005, attachment 1). Although these values are more realistic, they still underestimate the environmental value of marmots since they barely exceed the economic value alone (marmots are currently worth $17.50-$40.50 at the marketplace). Luckily, the fines that these valuations carry (between $41.54-70.62 per animal depending on age and sex), if enforced, are much more likely to serve as an effective deterrent as they exceed the potential trade value. Hunting reserve use payments also rose in 2005, to 5,000 MNT ($4.15) for hunting and trapping (whether for commercial, cultural, or scientific use), and the authorization fee for household hunting and trapping rose to 7,500 MNT ($6.23) (Governmental Resolution #248, 2005, attachment 2).

Although these fees are quite reasonable compared to the potential market value of each marmot, fees which must be paid in advance of hunting activities are largely ignored because there is the potential for paying a use or permit fee and then being unsuccessful in the hunt (Pratt *et al*. 2004). Therefore new methods for fee collection should be investigated.

Estimating Sustainable Levels of Harvest

Stephens *et al.* (2002) speculate that constant-yield estimators (such as that proposed by Robinson and Bodmer 1999, as cited in Stephens *et al.* 2002), even if they lead to reasonable estimates of annual production, will be associated with high probabilities of extinction for social species such as the Alpine marmot. Furthermore, the authors of these estimators have noted that they actually determine *the rate at which hunting becomes unsustainable* rather than a sustainable rate of harvest using the calculated annual yield (Stephens *et al.*

[6] Exchange rate determined using the daily rate currency converter at www.oanda.com on 12/5/2008.

2002). Therefore it is important to interpret them as maximum levels of harvest, not recommended levels of harvest.

The recommendation that Stephens *et al.* (2002) make for fluctuating populations of social species such as marmots, is to employ a “threshold-harvesting approach”. This method involves establishing a threshold population below which no harvest is allowed. They suggest employing a conservative threshold of 75%, in order to minimize the risk of population extinction, especially for those populations for whom an accurate yearly census is unlikely. For a large (historically-sized) population of 40 million, surveys that found a population dipping below 30 million would be cause for a hunting ban. Setting 5 million animals as the population baseline (per 2001 estimates) would necessitate the trigger of a ban if the population declined to fewer than 3.75 million animals.

Discussion

How do changes in population affect ecosystem services?

When marmots abandon burrows, they may fill in and be unusable to other species. As Murdoch *et al.* (in press) observed, corsac foxes that regularly used a particular large burrow system were no longer seen in the area after the marmot colony went extinct and their burrows filled with sand. Foxes are unlikely the only species to use marmot burrows as protection against climate and predation, as other small mammals, reptiles and insects may also take refuge there (Adiya 2000 as cited in Murdoch *et al.* in press). Also, active marmot colonies tend to be associated with higher numbers of burrows belonging to other species than are inactive colonies (Townsend 2006). Therefore, disappearing colonies may have a major effect on the overall biodiversity of an area, as both associated small burrowing species and species that use marmot burrows as protection/shelter may also be lost from the area. Additionally, new marmot burrows are associated with improved forage quality, which gradually declines as succession to dominant steppe vegetation occurs (Van Staalduinen and Werger 2007). Therefore, extirpation of marmots from an area reduces available vegetative nitrogen around colonies, providing a poorer quality of forage for associated herbivorous and omnivorous species.

Declining marmot populations contribute to a smaller overall prey base for animals such as raptors, wolves and other carnivores. Declines in marmot numbers could lead to declines in predator numbers, an increased reliance on livestock and/or other wildlife as "substitute" prey, or both. Large predators are valued ecologically, as well as culturally, by local people in Mongolia for their role in keeping down disease levels; in fact, even if their predation of weak or diseased animals involves livestock it is viewed as beneficial (Pratt *et al.* 2004). Furthermore, the low economic value of wolves, in combination with the high cost of bullets needed to kill one, is currently deterring their persecution in retaliation for livestock losses (Pratt *et al.* 2004). However, if such losses were to rise above current levels (as natural prey sources continue to decline), people, and their livestock, will likely come ever more frequently in contact with wolves and conflict will undoubtedly increase. In this case, large predators would be struck with a double decline – their numbers would first decrease due to declining wild prey, and the remaining animals would seek livestock to supplement their diets and might thereby meet an early demise at the hands of livestock owners protecting their assets.

Raptors were often detected in the presence of prey species such as pikas, voles and gazelle calves (Townsend and Zahler 2006); perhaps some or all of those species may supplement or replace marmots in their diets. For Eastern Steppe carnivores, the best candidate rodent to act as a "replacement" food source is most likely the Daurian pika, because other rodents such as ground squirrels and Mongolian gerbils rarely occur at high enough densities to support high levels of predation and Brandt's vole populations are cyclical, therefore making them an unreliable replacement (P. Zahler, *pers. comm.*).

How do changes in population affect local livelihoods?

Marmots are an important food and medicine source to local Mongolian people. While more than half of Mongolia's total population earn up to 70% of their income from trade in livestock products, this is a resource which can easily be affected by poor weather, disease outbreaks, predation and other factors (Havstad, Herrick and Tseelei 2008). The World Bank (2008) estimated Mongolia's gross national income (GNI) in 2007 at US$1290, up from only $410 for 2000. The fairly high total market value of Siberian ($17.50-40.50) and Altai ($20.50-40.50) marmots means that the marmot trade likely provides an easy supplement to many peoples' meager incomes.

It is estimated that there were 139,000 Siberian marmot hunters in 2006, who averaged an annual harvest of 23.6 animals (with a maximum individual harvest of 1000) and the total harvest was estimated at 3,300,000 (Wingard and Zahler 2006). The average hunter would have made $413-955.80 annually (32-74.1% of 2007 GNI), depending on current skin price and whether the meat was sold to urban or rural consumers. Those who harvested the maximum individual harvest would have made $17,500-$40,500 (1356.6-3139.5% of GNI), and the total harvest would be worth $57,750,000-133,650,000 (1.5-3.4% of 2007 GDP).

It is estimated that there were 1,400 Altai marmot hunters in 2006, who averaged 46.8 animals (with a maximum individual harvest of 100) for an estimated total harvest of 66,000 (Wingard and Zahler 2006). The average hunter would have made $959.40-1,895.40 annually (74.4-146.9% of 2007 GNI), depending on current skin and meat price obtained, those who harvested the maximum individual harvest would have made $2,050-4,050 (158.9-314% of GNI), and the total harvest of Altai marmots would be worth $1,353,000-2,673,000 (0.03-0.07% of 2007 GDP).

The high market value of marmots means that marmot hunters can significantly boost their economic standing by continuing to hunt. Furthermore, the government's officially provided valuations of marmots undervalue their true worth to Mongolia. While, if consistently applied, these values' associated fines may serve to curb hunting, the values themselves seem to barely account for economic worth alone, and therefore greatly underestimate the ecological value of marmots to the steppe.

Recommendations

It is clear that marmot hunters can significantly boost their economic standing relative to that of the average Mongolian by continuing to hunt. Therefore significant disincentives must be implemented to prevent or deter excessive hunting. Once stocks are allowed to recover they must then be managed effectively so that people can continue to reap economic rewards from this resource, not just now but into the future as well.

Furthermore, the true value of marmots should reflect their immense ecological value to the steppe ecosystem. While the Mongolian government should be commended for trying to place a value on the worth of wildlife both ecologically and economically, this officially produced number significantly underestimates the true value of marmots to Mongolia. It closely approximates the economic value of all marmot parts in the marketplace, but does not add an additional amount for the important ecological value that marmots provide to the steppe.

Considering market value alone (by adding the cost of all parts together), each Siberian marmot was worth $24.50 in 2006 and is currently worth between $17.50 and $40.50. The official determination of marmots' ecological plus economic value, however, is only $20.77-$35.31 each, depending on the age and sex of the animal. While, admittedly, assigning a monetary value to ecological values is difficult; the keystone role of marmots in their environment suggests that their ecological value should be *at least* equal to their economic value, if not greater. Therefore, each marmot should be valued between $35 and $81, and the associated fines for violating hunting regulations such as the current ban would be $70-162 per marmot. Such amounts would be even more likely to curb hunting than current fines, if they were consistently enforced and collected.

Assigning a higher value to marmots that encompassed their full market value while also fully reflecting their importance to the environment of the steppe is an important first step. This "true" value could also be used as an education tool; if people were aware that the full value of each marmot is much higher than the sum of the prices that its parts bring in at the market, they may be encouraged to protect the species. Also, recognition of their true worth may make the government more likely to invest an appropriate amount in their conservation.

In order to allow Mongolian populations of marmots to recover, and to subsequently ensure their sustainable management, Clark *et al.* (2006) make the following recommendations, each of which will be addressed in greater detail below:

1- Current protective measures need to be enhanced and enforced

2- Population trends should be monitored in order to develop sustainable harvest rates.

3- Habitats should be protected, perhaps through “community based initiatives”.

4- The public needs to be educated on the status of marmots in Mongolia and the existing laws that are in place to protect them.

5- Reintroduction attempts need to be reviewed.

6- The recommendations in *the Silent Steppe* should be implemented.

1. Current protective measures need to be enhanced and enforced

Prior to 1990, gun ownership was closely regulated and confined to members of hunting associations and, because no accessible markets existed at that time, any poaching that these people did was for personal consumption (Pratt *et al*. 2004). Now many people in Mongolia own guns and are using those, as well as the opening of markets, to obtain a new livelihood in wildlife poaching. Therefore, better regulation of the sale and ownership of guns is recommended in order to curb this problem (Parkinson *et al*. 2008). The Mongolian people are still in transition; many still remember being able to rely on the government to provide for them in every way- including in the provision of jobs and the protection of the environment (Pratt *et al*. 2004). The new market economy that emerged in the 1990s requires cash for things that were previously provided by the state (e.g., health care and education). Since the government no longer provides jobs, there are many who are unemployed and hungry; and since the government no longer (reliably) protects Mongolia's natural resources, there is plenty of wildlife around to be harvested for cash; regardless of whether this harvest is sustainable or not, the resource itself is often perceived as free for the taking (Pratt *et al*. 2004).

One of the observations made during the wildlife trade surveys of 2007-2008 was that there was a significant lack of enforcement of the current laws (Parkinson *et al*. 2008). Law enforcement is arguably the most important factor in controlling levels of hunting, and so the current low levels of enforcement capacity are working against effective control (Wingard and Zahler 2006). Since financial gain is the main reason that people tend to poach (Pratt *et al*. 2004), the application of fines might be an effective deterrent to implement. Unfortunately, fines have traditionally tended to be unrelated to market price and were rarely enforced (Pratt *et al*. 2004). The 2005 revisions to the assessments for marmot poaching fines were much more realistic given their market value; however, if fines are not consistently enforced they will not effectively deter hunting. Furthermore, as

Parkinson *et al*. (2008) correctly noted, more laws are needed and the fines levied for illegal trade should be increased to at least the severity of current poaching penalties. Unfortunately, a combination of increased corruption, under-funding, and empathy with the plight of people who are just trying to make ends meet leads to an environment where penalties tend to remain weak and rarely enforced (Pratt *et al*. 2004). Law enforcement activities are hindered because their implementation is understaffed and the officers are usually underpaid and poorly equipped (Wingard and Zahler 2006).

In addition to the need to increase the capacity of local law enforcement and to strengthen anti-poaching laws and fines for illegal trade, there also exists a real need to better educate local people on the regulations concerning illegal hunting and trade; greater efforts must be made to educate the public about the problem of illegal wildlife trade and its implications for the survival of species which they value, and to train them in the identification of species which are illegal to purchase (Parkinson *et al*. 2008). The current penalties for illegal trade may be sufficient, but must be consistently enforced and disseminated so that they effectively deter the illegal killing of marmots. Additionally, it would be beneficial to foster better oversight of the preparation of wildlife medicine (Parkinson *et al*. 2008).

One relatively cost-effective method proposed for law enforcement is to monitor marmot colonies for leg-hold traps during the intensive marmot season (August and September), as well as during the December through January corsac fox season, to reduce poaching as well as incidental catch of non-target species (Murdoch *et al.* in press). As for hunting permits, Pratt *et al*. (2004) found that people were unlikely to obtain them because they consider that money potentially wasted (if they are unable to catch the animal for which they bought a permit). Their surveys found that people seemed more willing to consider paying a percentage of the value of the actual amount of their kill. Because hunting permits are not obtained and their required use is not enforced, people tend to view wildlife as "free" (Pratt *et al*. 2004). If the appropriate hunting reserve use or household hunting and trapping fee was paid for each marmot that was caught, an additional $4.15-$6.23 per marmot would be generated. This money could be put toward reserve management, census efforts and wildlife law enforcement. At the official 2004 hunting quota of 100,000 animals (Wingard and Zahler 2006), this would generate $415,000-623,000 annually (0.01%-0.016% of GDP), and because Mongolia currently puts only about 0.5% of their GDP towards the environment (World Bank 2006), any additional income that could be generated would be useful. Given the ingrained dislike of pre-paid hunting fees, perhaps the government could consider instituting a policy of collecting this fee per animal caught in reserves, or perhaps instituting a refundable tagging program, where numbered tags could be purchased for the appropriate fee, but could be turned in for refund if no animal was caught. The money generated by this collection could be used to pay rangers to monitor hunting and collect appropriate fees in a self-sustaining system.

Consistent enforcement of fines for unauthorized hunting would also generate funds that could be used for environmental protection, or even earmarked for specific marmot conservation activities. The estimated actual harvest of *M. sibirica* in 2004 was 3.3 million (Wingard and Zahler 2006) and the 2005 assessed fines for illegal hunting varied between $41.54-70.62 per animal (double the amount of the assessed economic and ecological value, depending on age and sex of the individual killed, as per Governmental Resolution #248, 2005, attachment 1). So, if we consider that the official hunting quota (from 2004) was only 100,000 animals (Wingard and Zahler 2006), this means that around 3.2 million animals were harvested illegally; if fines had been collected for each of these animals, an additional $132,928,000 to $225,984,000 (3.4%-5.8% of GDP!) could have been generated. Obviously, it is unrealistic to expect 100% enforcement; but it is important to note that there is a substantial amount of potential revenue that is lost when enforcement opportunities are not pursued.

Additional recommendations related to law enforcement include: the establishment of an anonymous “wildlife hotline” whereby people could report violations of hunting and trade laws; encouraging participation in violation reporting by increasing the rewards offered for such reports; provision of wildlife issue education to Mongolian legal professionals such as judges; providing enforcement incentives to authorities; increasing the capacity of the border authorities and encouraging their coordination with Russian and Chinese counterparts; increasing anti-corruption legislation and activities; implementing a process of wildlife registration and tagging; providing better support to the “mobile anti-poaching units”; and increasing inter-agency cooperation, especially through the development of a wildlife trade database to share data among the various enforcement agencies involved (Wingard and Zahler 2006).

2. Population trends should be monitored in order to develop sustainable harvest rates.

Townsend and Zahler (2007) recommend long-term research on marmot population fluctuations and productivity; with a special focus on a comparison of exploited and non-exploited populations. Given the limited resources available to support such research, census efforts undertaken in the Eastern Steppe should maximize the amount of information gathered with a minimum of time and effort. This can include counting animals after the young emerge, making counts of "families" (rather than burrows or individuals), and repeating counts during both the morning and evening active periods. This method may maximize efficiency of census efforts; in fact, just one day of this type of survey was found to be at least 90% accurate (Mashkin 2007).

Stephens *et al.* (2002) recommend a “threshold-harvesting approach” for the sustainable harvest of social species such as marmots. This approach can result in variable yields from year to year and/or years in which hunting is not allowed (due to the population falling below the threshold level), recommendations which may not be acceptable to hunters in many countries (Stephens *et al.* 2002). However, since Mongolia has already demonstrated a desire to undertake strong measures to ensure the continued existence of this important species by their implementation of a four-year ban on hunting marmots, this is an ideal environment in which to apply this method.

The threshold-harvesting method is most safely employed for species for which an annual survey is completed in order to set that year's quota. Because Mongolian law already requires a yearly survey be funded by hunting companies anywhere that industrial hunting takes place (Clark *et al*. 2006), threshold-harvesting may be a good option for Siberian marmot hunting policy. Obviously, it is imperative that there is no conflict of interest in the survey process if a threshold-harvesting approach is to be successfully implemented; because the hunting companies finance the population surveys in this scenario, it is important that the entity carrying out the actual surveys be an unbiased third party. One possible solution would be to finance or subsidize the survey activities through the collection of the appropriate hunting reserve use or household hunting and trapping fees (or fees assessed after harvest, as suggested in above section). The money generated through the appropriate collection of fees could provide funding for unbiased oversight of the yearly population surveys- perhaps by the Mongolian Academy of Sciences as Wingard and Zahler (2006) recommend. These surveys would be crucial; they would allow a determination of whether or not the population remained above the threshold level that they have set. If the population falls below the threshold level, a hunting ban would need to be enacted and, more importantly, enforced, until the population rebounds. As Wingard and Zahler (2006) further point out, the implementation of quotas based on these surveys cannot be discretionary if they are to be effective- if the Ministry of Nature and Environment is the agency which is responsible for setting quotas, they must agree to implement the quotas that the independent agency (e.g., the Academy) has recommended.

In addition to the institution of annual population counts, Wingard and Zahler (2006) make the following recommendations: research should be conducted on long-term trends in population and range changes; population trends over time should be used to inform the development of future hunting regulations as well as determine appropriate quotas which encourage sustainable levels of harvest; populations which are declining should not be hunted; and hunting seasons should be evaluated and adjusted as needed.

3. Habitats should be protected, perhaps through "community based initiatives".

If populations of wildlife were allowed to increase and demand simultaneously declined (i.e., if household use rather than export to China was the only cause of hunting), open access models could theoretically be viable. In the current economic environment, however, competitive hunting pressure for valuable species is likely to lead to their extinction (Pratt *et al*. 2004). Therefore conservation of economically valuable species (such as marmots) in Mongolia must be inexorably linked to the development of sustainable livelihoods so that hunting pressure can subside. Then a new paradigm can be created whereby people are empowered and encouraged to conserve their own natural resources.

The 1991 constitution established wildlife as a common resource of the people which belongs to the government (Wingard and Zahler 2006). However, governmental protection of wildlife remains hindered by corruption, under-funding, weak penalties and rare enforcement (Pratt *et al*. 2004). Currently, local people have no responsibility for the wildlife that surrounds them, so even though they may recognize that the current levels of harvest are unsustainable they have little incentive to conserve. They feel pressure to provide for their family and realize that if they do not use the resources right now, someone else is likely to (Pratt *et al*. 2004). Therefore, the future economic potential of wildlife is not considered in the present economic climate. Better strategies for community-based solutions, which take into account the differing needs of individual communities, should be developed and a system of community-based management should be implemented nationwide (Wingard and Zahler 2006). This would require increased legal support- including legal recognition of community organizations- and a clearly defined power structure that defines the responsibilities of all entities involved, whether community-based, local or national (Wingard and Zahler 2006).

Protected areas are generally recognized as being "protected" only on paper, not in practice; for example, although hunting is prohibited in protected areas, exploitation of wildlife continues in recognized areas such as the Khan Khentii Special Protected Area (Pratt *et al*. 2004). If the Mongolian government encouraged the development of local ownership and initiated a program of management rights this may, in combination with the initiation of sustainable livelihood activities, help to encourage conservation of their nation's disappearing resources (Pratt *et al*. 2004). Stakeholder involvement in policy decisions is crucial to this process, as is the provision of economic alternatives to wildlife consumption (Wingard and Zahler 2006). Groups such as the Eastern Mongolian Community Conservation Association are currently working to promote local conservation efforts, encouraging herders to become involved in the sustainable use and conservation of the grasslands on which they depend (Wildlife Conservation Society 2008). Supporting local stakeholders' efforts to conserve their own natural resources should be a high priority of conservation efforts in Mongolia. Conservation efforts on the grassland steppes should emphasize conservation not only of the grasses on which the livestock depend, but also of the thriving community of grassland species that live on a healthy steppe.

An idea as simple as encouraging traditional hunting practices may easily, and cheaply, lead to better conservation of marmots. For example, the religious hunting bans that the Buryats, a Transbaikalian pastoralist people, have adopted in some locations appear to be an effective agent of marmot conservation in the areas where they are enforced (Badmaev 1994). Additionally, the traditional Mongolian hunting costume's tasseled daluur elicits marmot alarm calling and avoidance of those hunters who wear it (Formozov *et al*. 1994). This alarm calling behavior may protect hunter and prey alike, allowing hunters to avoid sick animals which do not call and ensuring that at least some proportion of the population will be able to avoid being shot. Rather than requiring all hunters to adopt the daluur, the government could encourage its use through an education campaign as a feasible, cheap and easy marmot conservation intervention.

4. The public needs to be educated on the status of marmots in Mongolia and the existing laws that are in place to protect them.

As previously mentioned, in Mongolia there is a real need to educate local people about the current wildlife hunting and trade regulations, the problem of illegal wildlife trade, and which species are illegal to purchase (Parkinson *et al*. 2008). Lenti Boero (2007) found that marmots were a good focus of environmental education efforts aimed at increasing students' emotional investment in nature and conservation. Marmots in his study were used to raise the students' "environmental consciousness" and he believes that they are a good topic for environmental education programs aimed at primary and secondary students and/or tourists. Students can be encouraged to build an emotional "relationship" with marmots and may eventually choose to assist with field-based counts and/or web-based investigations into the conservation of these species.

One education initiative of WCS's Eastern Steppe Living Landscape Program is the "Eastern Steppe Conservation Trunk" which aims to provide conservation education highlighting the value of natural resources to rural communities via a trunk filled with conservation curriculum materials which travels from school to school across the steppe (Wildlife Conservation Society 2008). Lenti Boero's (2007) observations indicate that marmots may be well-suited to such an initiative, and it is worth considering their inclusion in this "traveling trunk"; in fact, marmots may be an ideal centerpiece for the program. Their inclusion may not only serve to educate the public but may potentially inspire interested locals to assist with field censuses of these animals.

Furthermore, tourists traveling to Mongolia should be educated about illegal wildlife trade. This could even be done during the visa application process so that the necessary materials could be funded through income generated by visa application fees- even if this meant slight increases in such fees (Wingard and Zahler 2006).

5. Reintroduction attempts need to be reviewed.

Reintroductions of small groups of bobac marmots have been successful in Russia (Kolesnikov 2007). Similar introductions of Siberian marmots may be a viable approach if populations continue to decline, as they are unlikely to successfully re-colonize on their own for quite some time (P. Zahler, *pers. comm.*). For the highest potential of success, groups of at least 6 "reproductive units", or families, would be needed for each release, with subsequent releases of additional individuals to increase genetic diversity of the colony (per Kolesnikov 2007). For these releases to be successful in the long-term, this would need to be coupled with an improvement in the political-economic situation of Mongolians such that people no longer relied mainly on wildlife for their livelihoods and other economic alternatives existed for them. In other words, this option should only be undertaken if the above recommendations are also implemented.

6. The recommendations in the Silent Steppe should be implemented.

The *Silent Steppe* report (Wingard and Zahler 2006) is an excellent reference which includes a comprehensive list of recommendations. For the full list, please view pages 65-80 of that document. The authors are correct to point out that their recommendations should not be implemented independently of one another and that successful conservation requires the conscientious application of a suite of interventions which can act in concert to ease the current situation. Besides those interventions already mentioned above, they make specific recommendations for better delegation among the agencies involved in wildlife legislation and enforcement and they note the need for clearer assignment of responsibilities among such entities. For example, the Mongolian Academy of Sciences would assume responsibility for conducting population surveys and setting hunting quotas, while legislation and establishing of enforcement protocols would be the purview of the Ministry of Nature and Environment and cross-border trade issues would be jointly handled by the State Border Defense Agency and the Mongolian Central Customs Authority.

The importance of establishing self-sufficient funding mechanisms is stressed as an important first step which is necessary for long-term conservation success; equally important is a thoroughly researched, reasonable and accurate budget to cover the costs of recommended management activities (Wingard and Zahler 2006). Again, some of the funding to support marmot-specific conservation activities could likely be generated through consistent collection of appropriate hunting fees as well as enforcement of poaching penalties. But, in order to successfully implement the necessary interventions, revenue projections from such fees as well as amounts required for each activity would need to be correctly estimated and established budgets would need to be reviewed and updated as situations change.

Conclusion

The ability of Mongolia to support sustainable wildlife populations into the future is tightly intertwined with the achievement of sustainable livelihoods for its people. Both require multiple approaches which include establishing local property rights, increasing government support, and expanding alternative employment options (Pratt *et al.* 2004). Until Mongolian people achieve a basic level of economic security, they will likely continue to pursue species that can meet their economic needs as well as those that can supplement their household consumption. Unfortunately, marmots meet both criteria and, as a result of their value, they have experienced unsustainable levels of harvest since 1990. In order to curb their declines, and to encourage a population recovery, a combination of several interventions will be necessary. These interventions, outlined in the previous sections, include addressing shortcomings in law enforcement, increasing education initiatives on wildlife issues, establishing scientifically-based harvest quotas and encouraging community involvement in conservation activities. Perhaps most importantly, an appreciation of the true value of these animals to the Mongolian people is necessary. The governmentally produced number significantly underestimates the total value of marmots to Mongolia; it closely approximates the market value of marmots, but does not add an additional amount that appropriately reflects the environmental value of marmots on the steppe. The keystone role that marmots play suggests that their ecological value should be at least equal to their economic value, if not greater. Assigning a value to marmots that better encompassed both the full market value and the value of their importance to the steppe environment may better encourage their protection.

Once humans in the area are able to achieve a more stable economic footing, measures taken to conserve wildlife will be more likely to succeed. The importance of encouraging sustainable development and initiatives for economic independence cannot be overstated. Without this, the recommended conservation activities have little chance of being implemented successfully. In this way, the future of the Siberian marmot in Mongolia is inexorably linked to the secure economic future of the Mongolian people; anyone who wishes to promote marmot conservation will need to be aware of the limitations of such activities if they occur in the absence of sustainable livelihoods. Without a secure economic future for the Mongolian people, marmots, a truly valuable species, could be lost from the steppe.

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This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID), under the terms of the TransLinks Cooperative Agreement No.EPP-A-00-06-00014-00 to The Wildlife Conservation Society. TransLinks is a partnership of WCS, The Earth Institute, Enterprise Works/VITA, Forest Trends and The Land Tenure Center. The contents are the responsibility of the partnership and do not necessarily reflect the views of USAID or the United States government.