

# Status Review

## Review of tamaraw (*Bubalus mindorensis*) status and conservation actions

Barney Long<sup>1</sup>, Emmanuel Schütz<sup>2\*</sup>, James A. Burton<sup>3</sup>, Mike Appleton<sup>1</sup>, Rodel Boyles<sup>4</sup>, Josefina de Leon<sup>5</sup>, Grace Diamante<sup>6</sup>, Alvaro Gonzalez<sup>2</sup>, Jeff Holland<sup>7</sup>, Caroline Lees<sup>8</sup>, Ellen Marandola<sup>9</sup>, Virtito C. Natural, Jr.<sup>6</sup>, Maria Teresita Pineda-David Jr.<sup>10</sup>, Chrisma Salao<sup>11</sup>, James Slade<sup>1</sup>, Don Geoff Tabaranza<sup>6</sup>, Elyza Hazel P. Tan<sup>8</sup>, Lito Tiongson<sup>11</sup>, Stuart Young<sup>3,9</sup>

<sup>1</sup>Global Wildlife Conservation, Texas, USA

<sup>2</sup>D'ABOVILLE Foundation, Manila, Philippines

<sup>3</sup>IUCN SSC Asian Wild Cattle Specialist Group, Chester, UK

<sup>4</sup>Department of Environment and Natural Resources (DENR), San Jose, Philippines

<sup>5</sup>DENR Biodiversity Management Bureau, San Jose, Philippines

<sup>6</sup>Mindoro Biodiversity Conservation Foundation Inc, Calapan City, Philippines

<sup>7</sup>Center For Conservation of Tropical Ungulates, Florida, USA

<sup>8</sup>IUCN SSC Conservation Planning Specialist Group, Minnesota, USA

<sup>9</sup>Chester Zoo, Upton-by-Chester, UK

<sup>10</sup>DENR Tamaraw Conservation Program, San Jose, Philippines

<sup>11</sup>WWF-Philippines, Quezon City, Philippines

\*corresponding author: [manuschutz.ph@gmail.com](mailto:manuschutz.ph@gmail.com)

### Abstract

The tamaraw (*Bubalus mindorensis*) is a Critically Endangered wild buffalo species, found on Mindoro Island, Philippines. The number of locations with confirmed tamaraw population has declined to three, and the general species range has contracted. However, the total estimated population size appears to be increasing. Therefore, there are some positive signs for this species, though the population dynamics need to be better understood before this is verified as a strong positive indicator for the species. This paper reviews the population status, threats, and opportunities for the future conservation of tamaraw. This is presented in a historical and socio-economic context, following extensive research.

In the coming months there will be a Mindoro Tamaraw Action Planning Process that will develop a ten-year plan. This will include broad stakeholder engagement and a Population and Habitat Viability Assessment workshop (PHVA). This is the second PHVA process for the tamaraw, the first being in 1996. It is hoped that this workshop will strengthen the already active partnership and also catalyse all partners to increase their efforts and focus on the priority actions that need to be achieved most urgently. This paper highlights the need to look towards a meta-population approach, of protecting and securing multiple populations of tamaraw, rather than focusing efforts on one population. This will increase the chances of conserving the species and its habitats in the long-term.

### Introduction

#### Tamaraw

The tamaraw (*Bubalus mindorensis*) is a dwarf buffalo species, endemic to the island of Mindoro in the Philippines (Heaney et al., 1987; Custodio et al., 1996; Cebrian et al., 2014). The tamaraw probably diverged from the related wild water buffalo (*Bubalus arnee*) into a distinct insular bovine species during the Pleistocene, 1.5 million years ago (Tanaka et al., 1996; Schrieber et al., 1999). Although the tamaraw is currently the only wild cattle species in the Philippines, some evidence sug-

gests that wild *Bubalus* species may have had a wider distribution prehistorically in the Philippines, although this needs to be critically analysed (Beyer, 1957; Custodio et al., 1996; Croft et al., 2006).

The tamaraw is listed as Critically Endangered on the IUCN Red List of Threatened Species (Boyles et al., 2016). There are only three distinct populations known to survive today in Mindoro with a minimum estimate of 409 animals. However, 80% of individuals are presumed to be in only one subpopulation,

in a restricted area of less than 3,000ha within Mounts Iglit-Baco Natural Park (MIBNP), while the total area of occupancy of the species on Mindoro Island may not exceed 10,000 hectares.

Tamaraw were historically found across Mindoro, from sea level to over 1,800 masl (Everett, 1878; Steere, 1888b, 1891). Until 1900, Mindoro maintained 70% forest cover (ESSC, 1999), and the island was sparsely populated due to the prevalence of malaria (Wernstedt and Spencer, 1967). The indigenous Mangyan population (see below) was estimated at no more than 20,000 at this time (Miller, 1912). Human influence on the tamaraw was minimal at the turn of the twentieth century and the species distribution extended throughout the island, including the lowland areas and river basin plains, with an estimated population of 10,000 (Harrison, 1969). The species was still reported in the “North-eastern great plain” of Mindoro, in the foot hills of the Mt. Halcon Range, Calapan region in the first decades of the 20th century (Helbling and Schult, 2004).

Although residing on a forested island, tamaraw have been observed searching for transitional sites where open areas adjoined forest and sources of food and water occurred together (Talbot and Talbot, 1966), and to prefer open grasslands, forest glades, thick bamboo-jungle, marshy river valleys, and low to mid-elevation forests (Rabor 1977).

#### *Mindoro natural landscape*

The island of Mindoro is the seventh largest island in the Philippine archipelago at 10,572 km<sup>2</sup>. It is characterized by its broad mountainous spine centred on Mt. Halcon (2,597 masl) and Mt. Baco (2,489 masl). Mindoro falls within the Philippines biodiversity hotspot (CEPF 2011) and is designated as an important centre for endemic species (Gonzalez *et al.* 2000) with 22 species recognized as endemic to the island (MBCFI 2018).

Historically, Mindoro was entirely forested, but its lowland

plains have been cleared for permanent agriculture and upland forests have been degraded by swidden agriculture, cattle ranching, conversion for agriculture and commercial logging (Helbling and Schult, 2004). By 1988, only 30.01% of the total area of the island remained (Gonzalez *et al.* 2000; De Alban *in prep*). Mindoro suffered a further loss of over 30,000 hectares of forest cover between 1988 and 2015 (Rodriguez, 2015; De Alban *in prep*). A total logging ban was implemented in 2011 and the Department of Environment and Natural Resources (DENR) has initiated a large-scale reforestation program (National Greening Program) including several sites in Mindoro. Despite this however, forests remain threatened (Israel and Lintag, 2013).

#### *The Mangyan Indigenous People of Mindoro*

Mangyan is a generic term that encompasses the eight ethnolinguistic indigenous tribes which are considered to be the original inhabitants of Mindoro. For the last two centuries, government policies have encouraged immigration from other provinces (Schult, 1991). These inter-island immigrants settled mainly in coastal areas, often maintaining their specific cultures, traditions and dialects. This immigration pushed the Mangyans, known to have been coastal dwellers originally, further inland (Helbling and Schult, 1997). Today, many Mangyan communities are experiencing a rapid shift in their traditional land-use system (shifting cultivation and hunting-gathering), progressively adopting more modern lifestyles (permanent settlement and permanent agriculture).

Mangyans are still highly dependent on natural resources for their subsistence and cultural practices (Helbling and Schult, 2004). Since most of Mindoro’s natural areas are now restricted to the interior of the island, where Mangyans are currently living, they are highly concerned by biodiversity conservation programs and natural resource management policies.

The aim of this review is to put the status of the tamaraw into its historical and socio-economic context for the first time. An extensive literature search was undertaken, data were collated from the DENR Biodiversity Management Bureau (BMB),

the Tamaraw Conservation Program (TCP), and on-going efforts by conservation organizations such as the Mindoro Biodiversity Conservation Foundation, Inc. (MBCFI), World Wildlife Fund-Philippines (WWF), Haribon Foundation and D'Aboville Foundation, Inc. (DAF), including qualitative data gathered during field missions, workshop activities, and formal and informal discussions with local communities, DENR personnel and tamaraw rangers.

### Estimated Tamaraw Population Decline

Tamaraw numbers decreased to an estimated 1,000 individuals by 1949, then to 244 in 1953 (Manuel, 1957), 200-250 in 1965 (Hediger, 1965), and by 1969 it was thought that only about 100 Tamaraw survived (Harrisson, 1969b; Alvarez, 1970). In 1971, it was estimated that around 150 - 200 tamaraw remained, including about 80 in the Mount Iglit Game Refuge (Kuehn, 1975, 1976, 1977; National Research Council, 1983). In 1982 the Presidential Committee for the Conservation of the Tamaraw (PCCT) estimated that a maximum of 250 tamaraw remained. Other estimates of numbers include 356 in 1987 (Petocz, 1989b), more than 500 in 1990 (Callo, no date), and 250 in 1994 (Read et al., 1994). However, all these figures are rough estimates.

Table 1 presents population estimates from the areas occupied by tamaraw over the past 30 years. Tamaraw were still found in seven sites in 1987, possibly only four in 1996, and today only three (since no sightings have been reported for several years in Mount Calavite Wildlife Sanctuary). Of these, the very small sub-population of Aruyan-Malati faces imminent threat of local extinction. In Mounts Iglit-Baco Natural Park, the tamaraw range appears to have contracted in the past 30 years towards the so called 'Core Zone of Monitoring' (primary zone of intervention by the authorities encompassing the "annual count zone", the regular rangers patrolling zone and zone of contact with residing Mangyan communities). Tamaraw are no longer seen in many adjacent areas where they used to be present (Ballagit and Mappad Valley, Kinwala plateau, Upper Anahawin Watershed, Upper Kinara-

wan Watershed). Tamaraw were extirpated from the upper Busuanga watershed and Mount Wood on the east side of the Park in the 1990s (Schütz, 2015). Although the number of animals was small, surveys suggest that tamaraw were still roaming the mid-elevation forest between the Core Zone of Monitoring (MIBNP) and the Aruyan-Malati area three or four decades ago, thus connecting these two sub-populations (Figure 1).

### Current Population Status

Based on the annual tamaraw census conducted by the local authorities, there was an estimated minimum population of 401 animals within Mts Iglit-Baco Natural Park in 2017, which is the largest known population representing possibly 80% of the total tamaraw population on Mindoro. Sizes of the other sub-populations are estimates from non-systematic surveys (Figure 2; Table 2). However, it is possible that some sub-populations are larger than expected and that additional small sub-populations could be found outside of the listed sites.

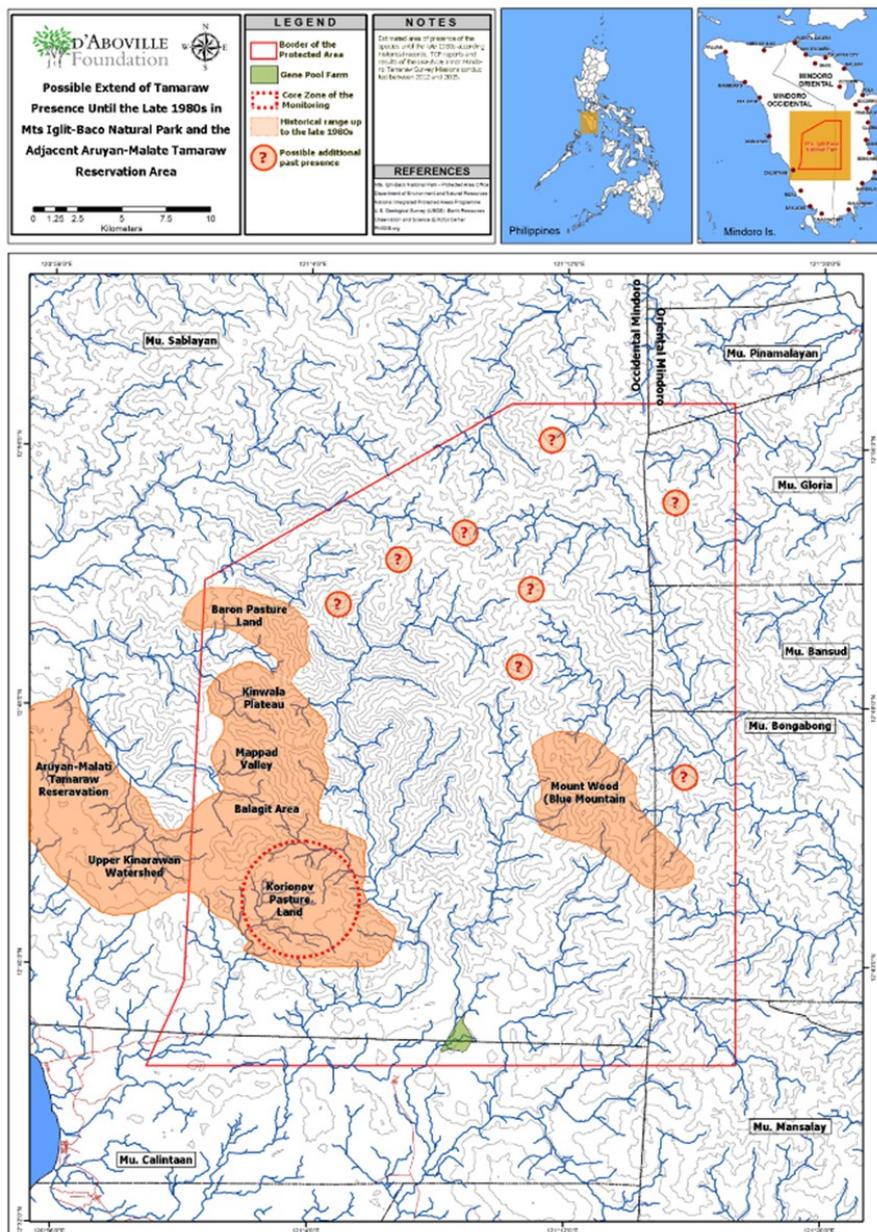
#### *Mounts Iglit-Baco Natural Park*

MIBNP holds the largest number of tamaraw, but this sub-population is now restricted to only one location in the southwest part of the Natural Park, on the Occidental side of the Province. The area consists of a hilly plateau dominated by grasslands, interspersed with numerous wooded creeks, secondary forest fragments and steep hills. This range corresponds to the former cattle ranch of Victor Korionoff, a Russian owner who supported the establishment of the TCP and Natural Park. It was defined as the "Core Zone of Monitoring", concentrating most of the protection efforts, thus substantially lessening pressure on the species following the closure of the cattle ranch. The Natural Park encompasses large tracks of the Ancestral Lands of the Tau-buid and Buhid Mangyan tribes. Furthermore, the living space of several of the Tau-buid communities overlaps the current tamaraw range, between the Lumintao River and the Anahawin River.

**Table 1.** Summary of Tamaraw population estimates from 1987, 1996 and 2017.

Site	Year of population estimate		
	1987 <sup>1</sup>	1996 <sup>2</sup>	2017 <sup>3</sup>
Mount Calavite Wildlife Sanctuary	45	>1	0?
Mount Halcon - Eagle Pass	65	65	0?
Upper Amnay Watershed Region – Eagle Pass			5-70+
Santa Cruz – Pinagturilan	20	0	0
Mounts Iglit-Baco Natural Park (MIBNP), "Core Zone of Monitoring" (5% of PA extent)	145	175	400+
Aruyan - Malati Tamaraw Reservation	41	14-30	10-12
Oriental Mindoro (Municipalities of Victoria - Bansud – Bongabong – Mansalay)	40	0	0?

<sup>1</sup>Petocz (1989b); <sup>2</sup>de Leon (1996); <sup>3</sup>TCP/ Emmanuel Schütz (unpublished)



**Figure 1.** Possible range of the Tamaraw within and around Mts Iglit-Baco Natural Park up to the late 1980s

Table 2. Number of Tamaraw per known sub-population

Subpopulation / area	Number of animals	Year of assessment	Assessment method
Mts Iglit-Baco Natural Park (annual count zone)	401	2017 annual tamaraw count	5 days' simultaneous counts from multiple vantage points
Aruyan-Malati Tamaraw Reservation	10 - 12	2015 verification survey + regular reports of rangers	Indirect signs of presence + Interview of residing indigenous communities
Upper Amnay River	5-70+	2018, three consecutive verification surveys	Indirect signs of presence + Interview of residing indigenous communities
Mount Calavite Wildlife Sanctuary	Unknown, possibly zero	2017	Interview
One tributary of the Bonga-bong River	Unknown, possibly zero	2017	Suggested by local communities
Mt. Halcon Range	Unknown, possibly zero	2016	Suggested by local communities



Figure 2. Distribution of current possible Tamaraw sub-populations

When the Philippine authorities introduced formal and regular monitoring through an annual census method in 2000

(Tamaraw Annual Population Count), the area inhabited by tamaraw was estimated around 5,000 ha within the core zone of monitoring. The aim of the count is to define a minimum realistic number of tamaraw within the suspected core area of presence of the species; the "tamaraw counting zone" encompasses 18 vantage points, covering nearly 2,200 hectares. A simultaneous multi-vantage point count method is used over five days every April. The method involves the burning of the grasslands a few weeks ahead of each count in order to increase visibility and attract tamaraw to the new grass growth (Ishihara et al., 2014).

The first count in 2000 reported the presence of 154 animals. Since then, numbers recorded have increased steadily to reach 401 individuals in 2017 (Figure 3) (TCP, consolidated data of the Annual Tamaraw Population Count Operation). These population estimates have been a valuable indicator for determining the population trend (see Figure 3), but there are concerns on the method and its accuracy. The population estimates for 2000 and 2001 may not have been as reliable as those from following years, as staff were becoming familiar with the survey method and few binoculars were available. The method is probably highly sensitive to weather conditions, as well as to how many experienced observers are participating and the way they are assigned among the different vantage points. The risk of double counting is substantial and the possibility of error increases as the tamaraw population and animal density increases within the counting zone. In 2018, the count established the presence of 523 animals, raising additional concerns on the accuracy and reliability of the method. The drastic increase from 401 to 523 (30% increase) in one year could be explained by a decrease in off-take from poaching in recent years, an over estimation in 2018, or an underestimation in previous counts, but changes in TCP management and changes in personnel conducting the count might have influenced the result as well. More accurate analysis of the 18 years of count data shall help to identify a margin

of error and the method's limitations.

While the tamaraw population in MIBNP has been increasing in size over the past two decades, it has been contracting in distribution (Figure 4). The area of presence was estimated to be around 5,000ha in 2000, but only 2,500 ha in the dry season (outside traditional Mangyan hunting season) of 2017, a 50% decrease. (Schütz 2018; Figure 4). Meanwhile, the result of the annual count more than doubled. This raises multiple questions including: (1) does the annual count accurately assess the tamaraw population in the Core Zone of Monitoring; (2) is the population increasing or is a more dispersed population being concentrated into the Annual Count Zone; (3) is the population contracting in area of occupancy due to external threats, habitat changes, or better protection; (4) what is the impact on the population of current habitat management, especially the annual grassland burning conducted to enable the counts; and (5) what is the impact of the establishment of the 1,600 ha No Hunting Zone. This written agreement was the result of talks in 2016 with residing Tau-buid communities and subsequent ground delineation with GPS.

#### *Aruyan-Malati Population*

The Aruyan-Malati Tamaraw Reservation is situated immediately adjacent to the Sablayan Prison and Penal Farm in the Municipality of Sablayan, Occidental Mindoro, West of MIBNP (Figure 5). The area is characterized by its hilly landscape dominated by secondary forest, interspaced with open areas from slash and burn agriculture conducted by resident Mangyan communities. The results of a field survey conducted in 2007 by local authorities indicated the presence of an estimated 15 to 20 tamaraw, with an area of occupancy of 3,600 ha (R.M. Boyles, unpublished). In 2015, the population was estimated to be only 10 to 12 animals (DENR TCP (2015) Memorandum: Report on the Tamaraw population assessment in Aruyan-Malati. Latest reports from ranger patrols suggest the presence of two or three family groups and a few solitary males with a scattered distribution due to a high degree of disturbance (Schütz, 2018; Figure 5). In December

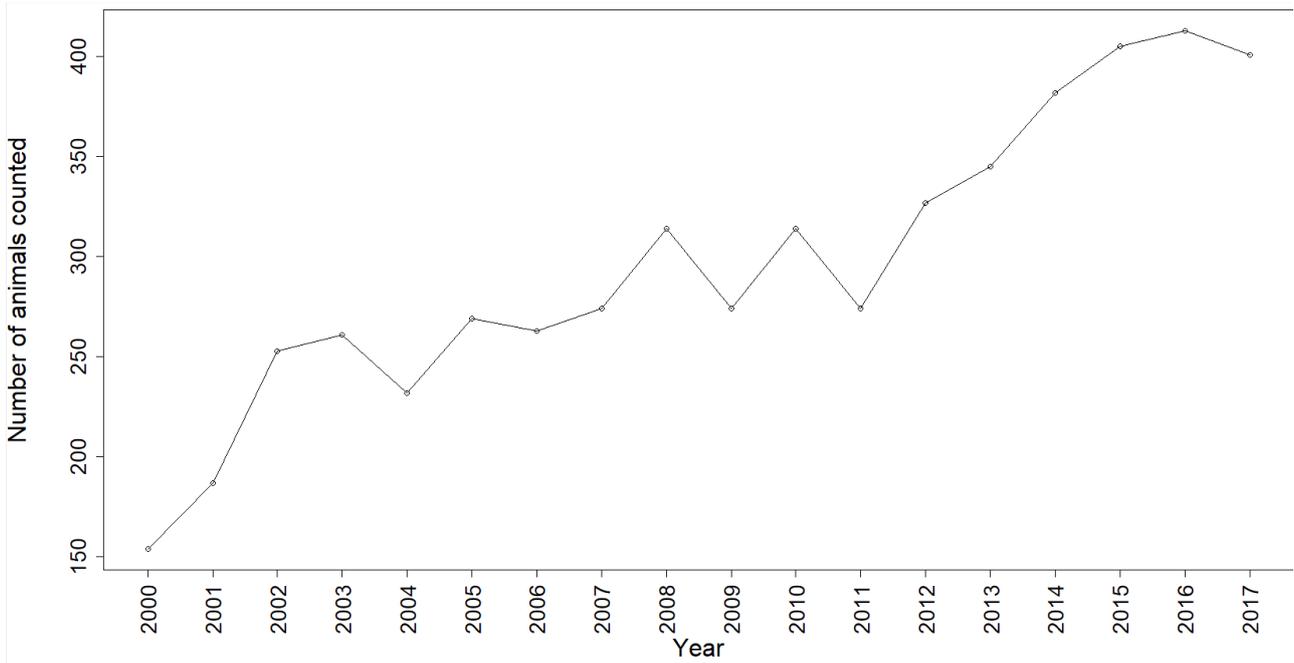


Figure 3. Population size and growth of tamaraw population in Mounts Iglit-Baco Natural Park from 2000 to 2017 from consolidated data of the Annual Tamaraw Population Count

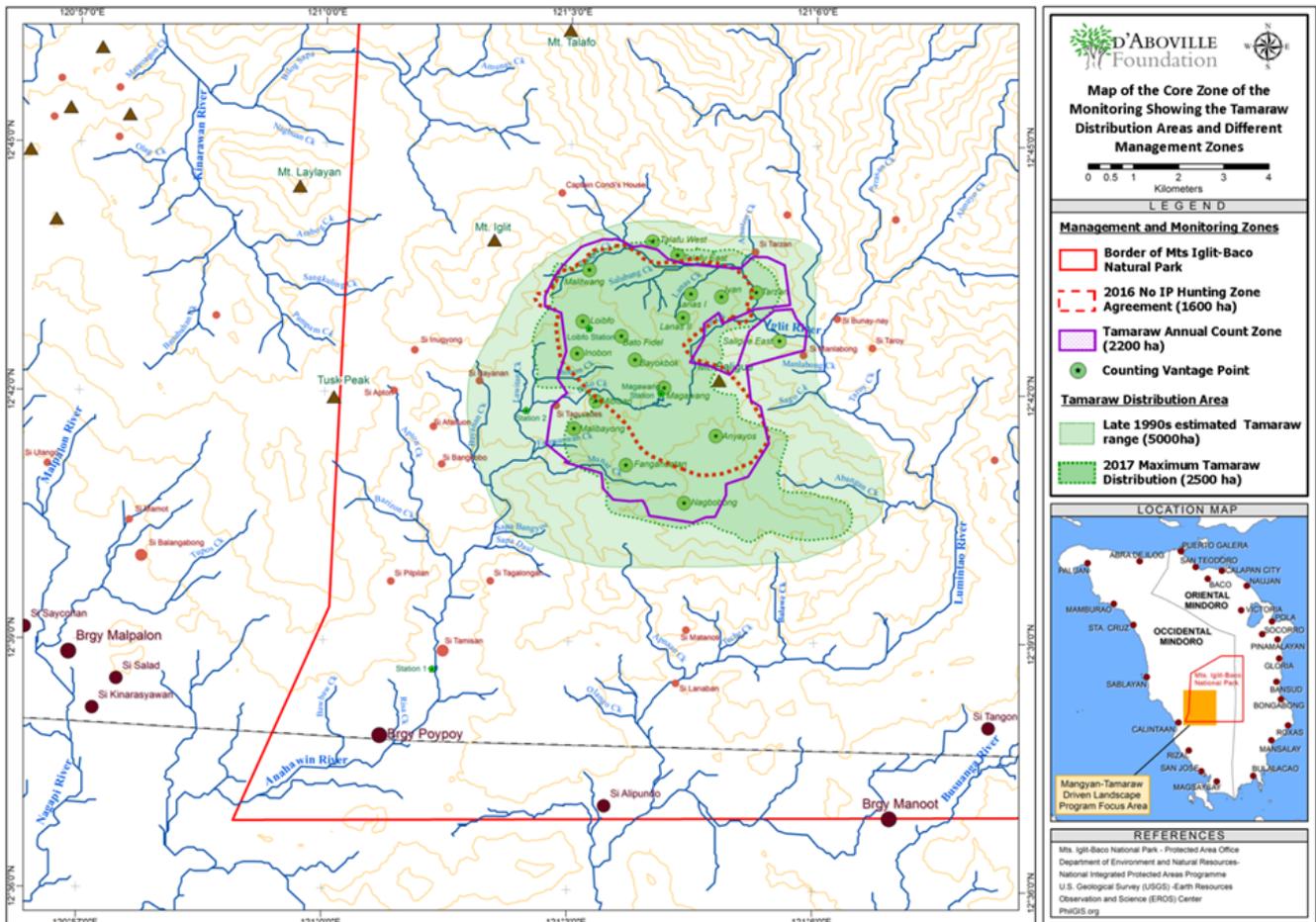


Figure 4. The distribution of Tamaraw within the Core Zone of Monitoring in Mounts Iglit-Baco Natural Park between late 1990s and present day and different Management Zones

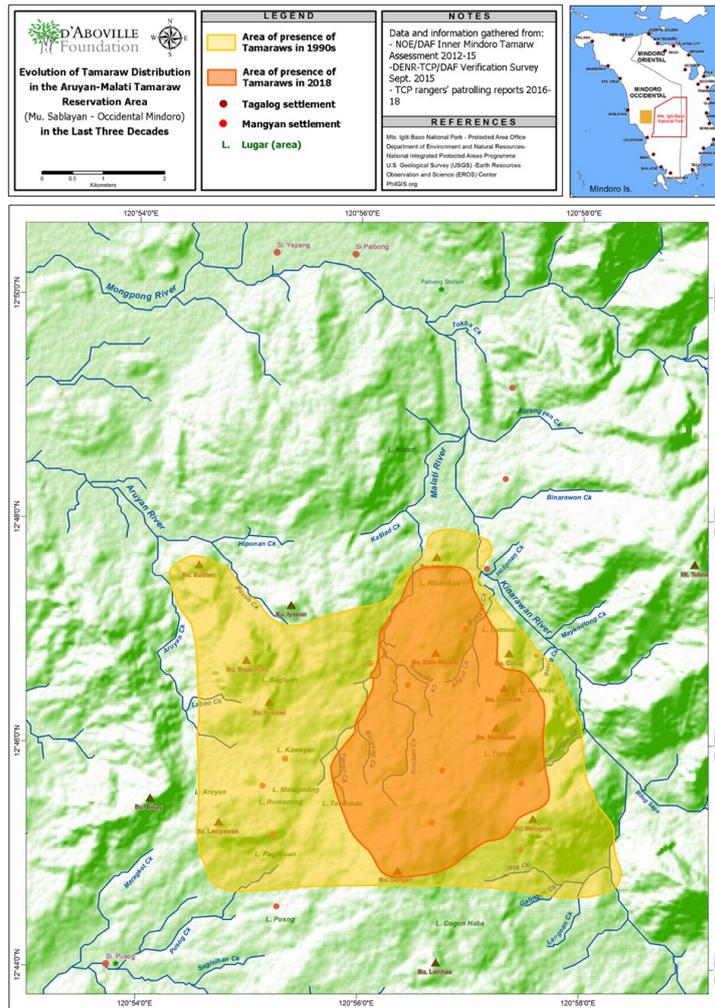


Figure 5. The Aruyan-Malati Tamaraw Reservation subpopulation

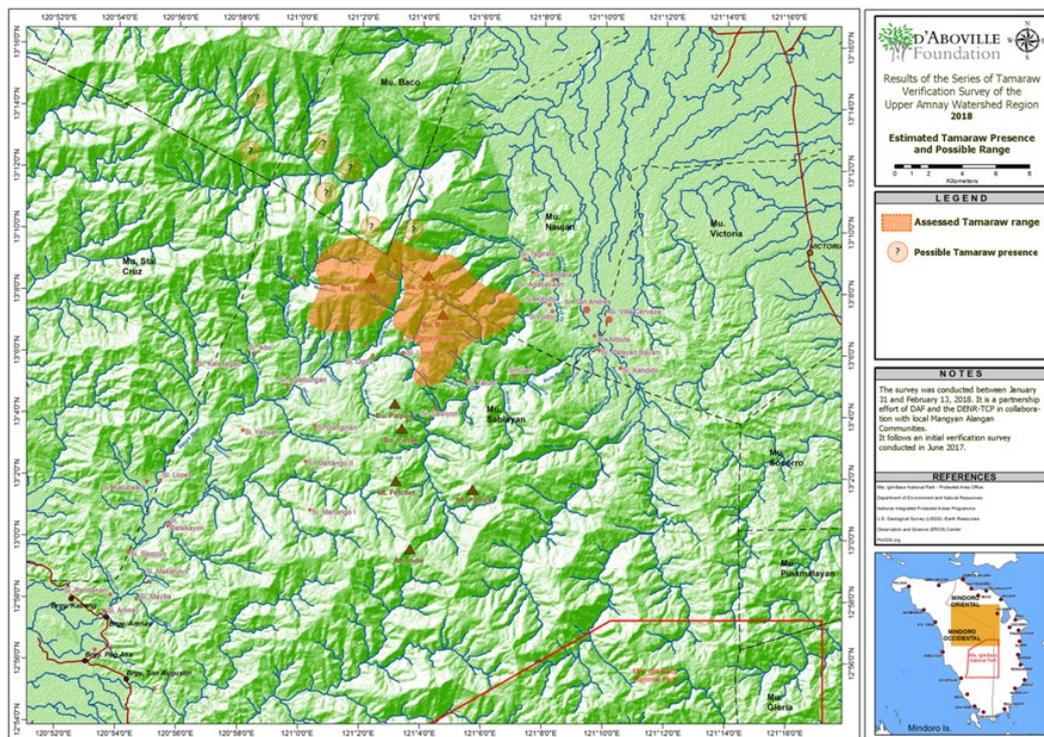


Figure 6. Location and possible range of the Tamaraw population of the Upper Amnay Watershed Region

2017 a group of 3 animals were caught on a camera trap (DENR TCP, 2017a). This area benefits from a local ordinance from the Municipality of Sablayan to protect the tamaraw. However, there is still a need to enhance the capacities of local stakeholder for the protection of the area. There is an ongoing process that this area be proclaimed as a Critical Habitat by the DENR that will further improve its protection.

#### *Eagle Pass Region*

The Eagle Pass region on the border between Oriental and Occidental Mindoro has been producing regular reports of tamaraw presence for decades (E. Schütz, unpublished). In 2017 and 2018, a series of four surveys in the Upper Amnay Watershed Region (Municipality of Sablayan and Naujan) confirmed the presence of a tamaraw population much larger than the Aruyan-Malati Tamaraw sub-population, with an area of occupancy greater than 6,000 ha (Figure 6). This finding makes it the second largest known tamaraw population in Mindoro and the largest in terms of distribution (TCP/DAF 2018, unpublished). Here, tamaraw are confined to mountain habitats (mossy forest, mountain tropical forest and dwarf vegetation), adopting browsing behaviour and a more fibre rich diet than the grassland populations. This demonstrates the ecological flexibility of the species. Additional surveys should provide a clearer picture of the status of this sub-population in terms of size and distribution. This finding substantiates the “rediscovery” of the species in Oriental Mindoro. This tamaraw population is located on the officially recognized Ancestral Domain of the Mangyan Alangan Tribe and is outside of any protected area (but there is a move since 2017 to legally protect Amnay Watershed, among other watershed areas in Mindoro provinces through the proposed “Mindoro Watershed Reservation Act” – please see House Bill No. 4617 authored by Hon. Cong. Josephine Ramirez-Sato). Besides these main population sites, Mt. Halcon and the area east of Mt. Wood still produce sporadic reports of tamaraw (E. Schütz, unpublished). However, it is hard to validate such information, so further investigation is required.

#### **Causes of the range and population collapse**

##### *Habitat degradation and land-use pressure*

Throughout the twentieth century there was a progressive decline in the tamaraw’s range, probably due to conversion of natural habitats into agricultural lands. The San Jose Sugar Hacienda was established in 1910 under the American administration, and copra (dried coconut flesh used to extract oil) became the island's predominant cash crop (Helbling and Schult, 1997), promoting immigration from other islands and so further accelerating clearance of the lowland forest of Occidental Mindoro.

The Philippines shifted from being a timber importer to an exporter in 1900, but it was not until after 1946 that commercial logging, driven by the world timber market, accelerated deforestation in the Philippines (Maohong, 2012). Deforestation in this case was a two-step process; forest degradation by logging, followed by forest removal for agriculture, mainly small, subsistence cultivation. It was the logging industry’s encroachment into inner Mindoro that drove both the range contraction and the fragmentation of the tamaraw population. By 1960, forest cover on Mindoro was down to forty per cent of its original extent (Gonzalez *et al.* 2000).

Deforestation combined with poor soil, recurrent fire, and the long dry season has facilitated the development and persistence of grasslands dominated by *Imperata cylindrica* (Cogon grass) across the middle elevations of Occidental Mindoro. Following this drastic habitat shift in the first decades of the 20th century, major land owners, including international companies, established cattle ranches on these mid-elevation grasslands. Tamaraw were considered competitors to cattle, and combined with the impact of trophy hunting, their population was reduced and the lowland habitats were lost, restricting the species to more mountainous terrain, including the Mounts Wood, Baco, Sinclair, Halcon and Calavite areas. The decline in ranching activity in the 1970s was an opportunity for the indigenous Mangyan communities to re-occupy their Ancestral Lands, bringing these communities into conflict

with tamaraw over land and so restricting the species' expansion.

Today, frequent grassland burning, both by Mangyans and local authorities, is likely to result in the progressive reduction of the quality and diversity of the habitats in the long term. Observations suggests the expansion of several invasive plant species within these managed grasslands, in particular *Chromolaena odorata* (locally called Hagonoy) which may reduce the suitability of the grassland for tamaraw (E. Schütz, unpublished).

#### *Hunting and poaching*

Since World War II, traditional hunting using spears and pit-traps, along with poaching using high-powered rifles and automatic weapons appears to have been rife despite tamaraw being protected by law since 1936 (Rabor, 1961; Talbot & Talbot, 1966; National Research Council, 1983). In the late 1960's there were reports that hunting intensified. Due to their aggressive behaviour, tamaraw were considered a prized game species, and were hunted by prominent Philippine families and by foreigners alike; until the 1980s trophy hunting remained a 'gentleman's sport' for the elite and there are even reports of the use of helicopters (E. Schütz, unpublished). Concurrently, there are anecdotal reports that insurgent groups based in the mountains were hunting tamaraw for food, but the scale of this is not known (E. Schütz, unpublished).

The inhabitants of lowland areas of Mindoro are reported to poach deer and pigs, using guns and dogs, which can also kill tamaraw. Mangyan indigenous communities maintain traditional hunting practices such as spear and snare trapping for deer or pigs, with tamaraw being occasionally killed (E. Schütz, unpublished). A population and habitat viability study (de Leon et.al., 1996) demonstrated that even low off-take levels are likely to have a major impact on survival of tamaraw populations.

The newly confirmed tamaraw population of the Upper Amnay Watershed Region is increasing in size according to the

local IP communities. At present, it is likely to be relatively safe from poaching and hunting disturbance due to its remoteness and decreasing land-use pressure from residing Mangyan Alangan communities. However, this population remains under threat in the medium-long term due to unrestricted access by poachers into the area, and the cross-Mindoro road, currently under construction, which will greatly facilitate access to this part of the island (Tabaranza, *et al.* in prep). The "Mindoro Watershed Reservation Act" under House Bill No.4617 will hopefully provide stronger protection for the Amnay Watershed.

On a general manner the improvement of infrastructure on Mindoro is facilitating access to the remaining natural areas, therefore putting tamaraw at further risk.

#### *Disease*

Disease is thought to have had a significant negative impact on the tamaraw population. Multiple cattle diseases were found in the domestic livestock herd of the Philippines throughout the early 1900s with Rinderpest and Surra reported to be common across the country, and foot-and-mouth present in a few provinces in 1913 (Anon, 2015). The sharp decline in the population of tamaraw from 1900 to 1949 was attributed to the outbreak of rinderpest in the Philippines around 1930 (Grzimek, 1990); no specific evidence exists to confirm this decline or the attribution to rinderpest, although it seems quite plausible.

It is believed that the risk to tamaraw from disease is lower than in the recent past, as cattle no longer occur in the same areas as current tamaraw populations. However, cattle grazing in MIBNP continues in areas close to the Core Zone of Monitoring, and areas where there is risk of habitat crossover should be monitored.

#### *Effects of small population size*

As populations decline to low numbers they become increasingly at risk from stochastic events. Small, localised

populations are more likely to be lost in catastrophes such as fires or floods; their numbers are more likely to fluctuate dangerously in response to otherwise normal year-to-year variation in environmental conditions, or as a result of variability in sex-ratios, birth and survival rates; and the inevitable genetic deterioration of small populations can result in depressed fitness and reduced adaptability (Frankham et al., 2002). Further, where populations are both small and living at low density, the difficulty of locating potential mates and the inflated risks associated with isolation from conspecifics may further depress population growth (referred to as the “Allee Effect”) (Allee and Bowen, 1932; Courchamp et al., 2008). As a result of these effects, the current small size and fragmentation of the tamaraw population poses a serious threat to its long-term survival, with populations at Upper Amnay River and at Aruyan-Malati particularly at risk.

#### *Indigenous Peoples and their relationship with tamaraw*

Among the eight Mangyan tribes of Mindoro, two still share their living space with the tamaraw, and will strongly influence the long-term fate of the species. The Mangyan Alangan Tribe gained recognition of its Ancestral Domain Claim following the enactment of the Indigenous People Right Act of 1997 or IPRA law (Republic Act No. 8371). This gives them full authority over their land and use of its natural resources, covering most of the Amnay Watershed, in the Municipality of Sablayan, Occidental Mindoro and Bucayao Grande River in the Municipality of Naujan, Oriental Mindoro, thus encompassing the entire distribution of the tamaraw subpopulation. Specifically, these tamaraw are located within the living space of several upland communities, numbering a few hundred people. These communities participated in the tamaraw verification surveys in 2017 and 2018. The livelihoods of these communities mainly depend on subsistence use of local natural resources and shifting agriculture, but they are expressing a desire for access to a more modernized life (E. Schütz, unpublished). Consequently, they are progressively reducing their pressure on higher elevation forests where the tamaraw are distributed. The territory of the Mangyan Tau-buid tribe encompasses the

tamaraw sub-population of Aruyan-Malati and MIBNP. Half of their territory is inside the MIBNP and extends on the western side across the Aruyan Malati range and Sablayan Penal and Prison Farm (SPPF). The Tau-buid have to date been unsuccessful in securing their Certificate of Ancestral Domain Title (CADT) partly because their ancestral land claims overlap with the SPPF and MIBNP.

The Tao-buid are the most heterogeneous of the Mangyan tribes. Communities residing at lower elevations are progressively moving to permanent settlement and adopting perennial agriculture (including rice and corn), while restricting access of non-residents. Upland communities on the other hand continue traditional hunting and shifting agriculture (mostly sweet potatoes, mungo beans and a few other crops), with little engagement with outside communities and authorities. Young people are increasingly moving to lower Tau-buid settlements, while a few members have chosen to move further inland to find free space for their families. Today, the range of the tamaraw is restricted within the territories of six communities, where traditional hunting is still being practiced outside the agreed no-hunting zone. The Buhid Tribe has secured its Certificate for Ancestral Domain Title (CADT) which covers large areas in the East of MIBNP, including areas which were formerly occupied by tamaraw and could be suitable for recolonization.

The National Commission on Indigenous Peoples (NCIP) is the agency of the Government of the Philippines responsible for protecting the rights of indigenous peoples, as established by the Indigenous Peoples Rights Act of 1997. This Act provides that any programme affecting or targeting IPs or IP land must go through an NCIP mediated processes, including obtaining the Free and Prior Informed Consent (FCIP) from the concerned IP community.

Many of the pressures affecting the tamaraw have also impacted the indigenous Mangyan communities. During World War II, Mangyans retreated further inland as coastal settlers moved into their lowland forest territories during Japanese

occupation. As peace returned, these areas were permanently occupied and soon converted into agricultural land. Expansion of cattle ranching further restricted Mangyan living space. The alternative to proposed resettlement by the authorities, was to occupy the remaining forested areas of inner Mindoro, further encroaching on the remaining tamaraw range. Meanwhile, the Mangyan population increased from around 35,000 people in 1940 to nearly 75,000 in 1990 (Helbling and Schult, 1997).

Despite above statement which result from recent situation, it is likely that the traditional swidden agricultural system of the Mangyans (burning of forest plots, cropping, fallow period and forest regeneration over long cycles), which creates a spatial and temporal mosaic of habitats at different successional stages, created suitable ecological conditions for tamaraw. Yet, this 'harmonious co-existence' progressively reached its limits as the human population grew, the extent of the wilderness shrank and swidden cycles became necessarily shorter. Today, most Mangyan communities are beginning to engage with conventional agriculture to address the limitations of their traditional land-use system. This may result in additional permanent land conversion with detrimental effects on the possible range of tamaraw, but decreasing pressure on surrounding forest. Based on their experiences and in the absence of the security provided by Ancestral Domain, the Taubuid remain distrustful of the plans, actions and motivations of outsiders.

### Conservation interventions

#### *Protection*

The killing of tamaraw, their wounding, or removal from their habitat were first prohibited under the Commonwealth Act No. 73 of 1936 (subsequently amended by Republic Act No. 1086 of 1954). DENR Administrative Order No. 48, S. of 1991 established the national list of threatened Philippine wildlife, which includes the tamaraw (Cebrian et. al., 2014). (This list has been updated and superseded by DAO 2004-15).

Mts. Iglit-Baco Game Refuge and Bird Sanctuary was established through Proclamation No. 557 of 1969, and was upgraded to a National Park by Republic Act No. 6148 in 1970. This area held the largest known population of tamaraw at the time of its establishment, and still does today. Mts Iglit-Baco National Park was declared an ASEAN Heritage Park in 2003.

Mounts Iglit-Baco National Park predates the National Integrated Protected Area System (NIPAS) Act (1992), which established a new categorization of protected areas. The anachronistic category and function of the National Park (an area "withdrawn from settlement, occupancy or any form of exploitation") was inconsistent with the presence of Mangyan communities and complicated planning and management. The Expanded National Integrated Protected Areas System Act of 2018 finally declared Mts Iglit-Baco as a Natural Park. This new status should facilitate recognizing the presence of the different Mangyan communities residing within the boundary of the Protected Area and legitimizing their rights to use and manage natural resources.

An initial Management Plan and system of zones for the Park was produced in 2003, but no full management plan exists for MIBNP. A formal management planning and rezoning process began in 2018. Hopefully it will be implemented from the beginning of 2019 that would greatly help guide and articulate conservation measures and habitat management in the area. The park was assigned a Management Effectiveness Tracking Tool (METT) (Stolton et al., 2002) score of 72.2% in 2013, just below the average score for ASEAN Heritage Parks of 74.8% (Mardiastuti et al., 2013).

Mount Calavite Wildlife Sanctuary, which was first established in 1920 as Mount Calavite Game Refuge and Bird Sanctuary, primarily to conserve the tamaraw and other wildlife species found in the area. At present, all other known tamaraw populations are found outside of protected areas.

*Coordination of Tamaraw Conservation*

In 1979, the Presidential Committee for the Conservation of the Tamaraw was formed, which led to the creation of the Tamaraw Conservation Program (TCP) under the supervision of the DENR. However, the establishment of the TCP did not include creation of regular personnel specifically assigned to the program and instead the DENR has only delegated a regular personnel from other units to become the program coordinator. Additional personnel are hired on contractual basis. The program's original mandate has not been reviewed despite changes in governance, policies and conservation challenges. Between 1995 and 2005, the TCP was managed under the Protected Area and Wildlife Bureau (DENR-PAWB; now Biodiversity Management Bureau or BMB), then moved to the management of the DENR Regional Office (MIMAROPA Region). Due to limited resources, the TCP gradually concentrated its efforts on the MIBNP sub-population. In 2018, the TCP has 30 staff and one coordinator, including 4 support staff (office), one Field Operation Officer and 25 rangers deployed in 2 different Locations (5 in Aruyan Malate and 15 in MIBNP) and 5 in the Gene Pool Farm.

*Captive population management*

In 1980, the TCP established the Gene Pool Farm as a captive breeding facility for the Tamaraw in Mindoro. This facility is a 280 ha fenced enclosure in Manoot, Municipality of Rizal in Occidental Mindoro. Between 1982 and 1984, twenty tamaraw were captured from Aruyan-Malati (Custodio et al., 1996), consisting of at least ten males and six females (Escalada, 1996). However, currently only a single adult male, who was born at the facility, remains in captivity. The lack of successful breeding is likely due to a combination of the management and husbandry methods used, to disease, and to regular changes in management responsibility. (Oliver, 1993; Lawas and De Leon, 1996; Callo, 1999).

The first two animals were captured in February 1982, an adult male and female, subsequently mostly adult males were captured. Of the 20 animals captured, a few died during trans-

portation, or during the days or months after release. The reason for these deaths is attributed to dehydration during transport and injuries during capture in pit fall traps. Further captures occurred in 1984. Additional captures were attempted in 1986 in the rainforest near Eagle Pass, Municipality of Naujan and in Mt. Halcon, but two individuals died in the process, due to simultaneous capture in a single trap (Escalada, 1996).

By 1990, 11 animals remained; eight were transferred from the 280 ha enclosure to individual enclosures, with one pair being housed together ("Charlie" and "Mimi"). The remaining three animals not recaptured eventually escaped. The smaller enclosures were to facilitate study and animal husbandry. A total of five tamaraw calves were born between 1990 and 1999. The first calf survived for one year, with the cause of death being due to internal parasites. The same pair bred again and the female produced two calves which were still-born. This same female was re-paired with another male and bred once again, but this pregnancy resulted in an aborted calf. Testing revealed that this female had become infected with the Blue Tongue Virus and Leptospirosis which causes stillbirths and abortions. In 1997 one of the females gave birth to the fourth tamaraw calf, which died during the birthing process. By 1999 the captive population consisted of only four tamaraw (two males and two females) and the only reproducing female gave birth to the fifth calf, which is the sole remaining tamaraw in captivity today. Although considered a failure by many, the fact that animals were able to breed and live to old age demonstrates that with better and more modern animal husbandry techniques, a conservation breeding program could, in fact, play a very valuable role in tamaraw recovery efforts.

*Population Modelling and Conservation Planning*

In 1996, at the invitation of the Department of Environment and Natural Resources, a three-day tamaraw conservation planning workshop was facilitated by the IUCN SSC

Conservation Planning Specialist Group (CPSG), working in partnership with the University of the Philippines Los Banos Foundation and the IUCN SSC Asian Wild Cattle Specialist Group. The workshop followed a process known as Population and Habitat Viability Assessment (PHVA), which was designed by CPSG with the explicit aim of enabling diverse groups of stakeholders to build achievable species conservation plans quickly and collaboratively, using the best available information and relevant science-based tools. Key to the PHVA process is the integrated use of population simulation models, built using the software tool VORTEX (Lacy and Pollak, 2017), which help workshop participants to visualise and evaluate the relative impact on the species' long-term viability, of specific threats and of alternative management strategies. To ensure that the views and values of relevant stakeholders are accounted for in the planning process, workshops are carefully designed and facilitated to encourage full participation. This is particularly important for ensuring uptake and support for the implementation of recommended activities.

The results of the 1996 modelling work emphasized the vulnerability of all remaining tamaraw populations due to their small size and particularly when challenged by even relatively low rates of poaching. For example, modelled populations of 50 tamaraw showed a 100% probability of extinction at poaching rates of three animals per year, with a mean time to extinction of 18 years (de Leon *et al.*, 1996).

At the time of the 1996 PHVA it was considered possible that as many as six extant populations of tamaraw remained in Mindoro, but only two were confirmed to exist. Those were in Iglit-Baco National Park (est. n=20-175 individuals) and Aruyan (est. n=14-30 individuals) (de Leon *et al.*, 1996). The PHVA made some critical recommendations for the conservation of remaining populations, including creating a dedicated protection force in the Iglit Ranges and Aruyan, island-wide surveys and regular censuses using appropriate methods, filling important data gaps relating to tamaraw and the threats to its persistence, developing management plans for key sites, and

increasing the participation of and benefits to local communities of tamaraw conservation initiatives (de Leon *et al.*, 1996).

Twenty-two years after the PHVA workshop, it is clear that measures to implement its recommendations have achieved success for the tamaraw. In MIBNP for example, where all the recommendations have been implemented to varying extents, by the TCP and the park staff (with assistance from all concerned local government units and recent support from the D'Aboville Foundation, Mindoro Biodiversity Conservation Foundation, Inc., WWF-Philippines, and the Far Eastern University), the number of tamaraw has increased steadily over the years (Table 1). However, in areas where recommended conservation action has not been taken, or has been insufficient, populations are now presumed extirpated (e.g. Mount Calavite, Santa Cruz, and Bongabong), at high risk (e.g. Aruyan-Malati), or at risk of further decline (e.g. Upper Amnay Watershed Region).

In December of 2018, the DENR and provincial government offices will host a second PHVA workshop which will review progress since 1996, evaluate new information, assess current challenges and opportunities, towards a new Mindoro Multi-Population Conservation Plan for Tamaraw which will re-invigorate and re-direct efforts to support recovery and conservation of the species.

### Discussion

The metapopulation of the tamaraw has collapsed in the past hundred years, and even in the twenty years since the first PHVA workshop was conducted. At least one sub-population has been lost and two others are approaching extirpation, while exchange of animals between subpopulations has ceased.

Seeing the increase in the MIBNP population as an unqualified conservation success is not however wise at this point. Although numbers appear to have been increasing annually, the distribution of the population has undergone a significant

contraction (Figure 4). It is not clear whether the population has really increased, or whether we are just observing an increase in density of the population within the count area. Urgent studies are required to answer this question and understand the population dynamics in the count zone. Whatever the answer, the population is clearly not free from pressure, and new solutions are needed to stabilize and then reverse this concentration of the population, enabling the species to expand again in both number and distribution.

These solutions will have to include the clarification of the zones of use within MIBNP, strengthening the collaboration with the IP communities inside the park and enforcing protection of tamaraw against illegal activities by those entering from outside the park. The implementation of the Park Management Plan in 2019 will be a first step to achieving this.

The increase of the Iglit-Baco population of tamaraw provides hope that the small, isolated populations remaining in the Upper Amnay Watershed Region and in Aruyan-Malati could also recover. However, it is clear from the PHVA models that this cannot occur if even low levels of hunting or poaching are allowed to continue. Therefore, urgent measures are required at both sites to eliminate all hunting or poaching; otherwise it is likely that the tamaraw will soon be isolated to a single population, concentrated in a decreasing area. Putting all the tamaraw in one shrinking basket is not a strategy that is likely to lead to effective recovery of the species.

Twenty-two years after the 1996 PHVA workshop, it is clear that measures to implement its recommendations have achieved some success for the tamaraw. However, continuing assessment and adaptation of conservation actions are necessary in the fast-changing human and environmental landscape of Mindoro. In December 2018, the DENR and provincial government offices will host a second PHVA workshop to create the Mindoro Tamaraw Action Plan. Coordinating conservation management of all tamaraw populations as a meta-population will be essential for successful implementation of the recom-

mendations from this workshop. This multi-site planning and implementation approach requires the resources of a range of partner organisations, working in collaboration with local communities and other stakeholders, coordinated by a single lead body.

#### Acknowledgements

The authors would like to thank the staff of the DENR-BMB and MIMAROPA Region for their support and collaboration. We also acknowledge the extremely hard work that the staff of TCP and Mts. Iglit-Baco Natural Park face in their field work to protect tamaraw.

#### References

- Allee WC, Bowen E (1932). "Studies in animal aggregations: mass protection against colloidal silver among goldfishes". *Journal of Experimental Zoology*. **61** (2): 185–207
- Alvarez, J. B. (1970). Philippine tamaraw, here to stay. *IUCN Publ. New Series* 18:46-51.
- Anon, (1915). Report of the Philippine Commission to the Secretary of War July1, 1913, to December 21, 1914. Annual Reports, War Department. Fiscal Year Ended June 30, 1915. Government Printing Office, Washington
- Anunciado, R. V. P., Eduardo, S.L., Momongan, V.G. & Escalada, R.F. (1994). Parasites of the captive tamaraw, *Bubalus mindorensis* (Heude, 1888) (Mammalia: Ruminantia). *Philippine Journal of Veterinary Medicine* 31(1): 5-10.
- Beyer, H.O. (1957). New fossil mammals from the Pleistocene strata of the Philippines. *Natl. Res. Counc. Philippines Bull.* 41:220-239.
- Boyles, R., Schutz, E. & de Leon, J. (2016). *Bubalus mindorensis*. The IUCN Red List of Threatened Species 2016: e.T3127A50737640. <http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T3127A50737640.en>. Downloaded on 17 April 2018.
- Callo, R.A. (no date). *The tamaraw: its status, habit and population*. Unpublished manuscript.

- Callo, R.A. (1999). Can tamaraws in their natural habitat coexist with cattle and carabaos? *Canopy International* 25 (4): 2-3.
- Cebrian, M.R., Boyles, R.M., de Leon, J.L. & Burton, J. (2014). Species account: Tamaraw *Bubalus mindorensis* Heude, 1888. In *Ecology, Evolution and Behaviour of Wild Cattle: Implications for Conservation*. Eds. Melletti, M. & Burton, J. Published by Cambridge University Press. Pp.310-317.
- Courchamp, F., Berec, J., & Gascoigne, J. (2008). *Allee effects in ecology and conservation*. Oxford, New York, USA: Oxford University Press.
- Critical Ecosystem Partnership Fund. (2011). *Ecosystem Profile: the Philippine Hotspot*; Final Report.
- Custodio, C.C., Lepiten, M.V. & Heaney, L.R. (1996). *Bubalus mindorensis*. *Mammalian Species* 520: 1-5.
- de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. & Seal, U. S. (1996). Tamaraw (*Bubalus mindorensis*) Population and Habitat Viability Assessment Report. University of the Philippines Los Banos College, Laguna, Philippines, 15-17 May 1996. IUCN SSC Conservation Breeding Specialist Group. Apple Valley, Minnesota.
- DENR TCP (2017a). Accomplishment Report for the Month of December 2017
- DENR TCP (2017b). Memorandum: Report on the result of the 2017 Tamaraw Count
- Escalada, R. F. (1996). Tamaraw Capture Report. In Tamaraw (*Bubalus mindorensis*) Population and Habitat Viability Assessment Report. Eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U. S. pp.152-154.
- Everett, A.H. (1878). Mr A.H. Everett on Anoa *Depressicornis*. *Proceedings of the Zoological Society of London* 1878: 792.
- Frankham, R., Ballou, J.D., & Briscoe, D.A. (2002) *Introduction to Conservation Genetics*. Cambridge University Press: Cambridge and New York.
- Grzimek, B. (1990). *Grzimek's Encyclopedia of ecology*. Van Nostrand Reinhold Co. pp.705.
- Harrisson, T. (1969a) The tamaraw and Philippine conservation. *Biological Conservation*, 1:317-318.
- Harrisson, T. (1969b). The tamaraw and its survival. *International Union for the Conservation of Nature and Natural Resources Bulletin (New Series)*, 2:85-86.
- Heaney, L.R., Balete, D.S., Dollar, M.L., Alcala, A.C., Dans, A.T.L., Gonzales, P.C., Ingle, N.R., Lepiten, M.V., Oliver, W.L.R., Ong, P.S., Rickart, E.A., Tabaranza Jr., B.R. & Uzzurum, R.C.B. (1998). A synopsis of the mammalian fauna of the Philippine Islands. *Fieldiana: Zoology (New Series)* 88: 1-61.
- Hediger, H. (1965). Der Mindoro-Buffel, das seltenste Wild. *Z. Saugetierk* 30: 249-53.
- Helbling, J. & Schult, V. (1997). Demographic Development in Mindoro. *Philippine Studies* vol. 45, no. 3, 385-407. Ateneo de Manila University.
- Helbling, J. & Schult, V. (2004). *Mangyan survival strategies Alangan (Philippine people)*. New Day Publishers. 226 pages.
- Herrera, J.R.V., Masangkay, J.S., Monongan, V.G. & Limcumpao, J.A. (1993). Serum antibody profile of captive Tamaraw (*Bubalus mindorensis*) to selected bacteria and viruses. *Philip. J. vet. Med.* 30(2): 63-64.
- Ishihara, S., Boyles, R. M., Matsubayashi, H., Barrio, A., Cebrian, M. Ishida, A. Lapitan, M. R., Atabay, E., Cruz, C. L. & Kanai, Y. (2014). Long-term community-based monitoring of tamaraw *Bubalus mindorensis* on Mindoro Island, Philippines. *Oryx*. 49. 1-8. 10.1017/S0030605314000313.
- Israel, D.C. & Lintag, J. H. (2013). Assessment of the Efficiency and Effectiveness of the Reforestation Program of the Department of Environment and Natural Resources. Final Report. Philippine Institute for Development Studies. <https://www.dbm.gov.ph/wp-content/uploads/DBM%20Publications/FPB/ZBB-2012/c.pdf>
- W. (1975a). Tamaraw in Mts. Iglit Baco Game Refuge, Philippines. *Tigerpaper* 2(3): 26.

- Kuehn, D.W. (1975a). Tamaraw in Mts. Iglit Baco Game Refuge, Philippines. *Tigerpaper* 2(3): 26.
- Kuehn, D.W. (1975b). Tamaraw: Endangered Buffalo of the Philippines. *National Parks and Conservation Magazine* 50(3): 18-20.
- Kuehn, D. W. (1977). Increase in the Tamaraw. *Oryx* 13(5): 453, 455.
- Lacy, R.C., & Pollak, J.P. (2017). Vortex: A Stochastic Simulation of the Extinction Process. Version 10.2.6. Chicago Zoological Society, Brookfield, Illinois, U.S.A.
- Lawas, N. R. & de Leon, J. (1996). The tamaraw conservation program: Past, present, and future thrusts and direction. In *Tamaraw (Bubalus mindorensis) Population and Habitat Viability Assessment Report*. Eds. de Leon, J., Lawas, N., Escalada, R., Ong, P., Callo, R., Hedges, S., Ballou, J., Armstrong, D. and Seal, U. S. pp. 119-123.
- Mardiastuti, A., Simarangkir, A.R., Kusriani, M.D., Buchori, D & Suryadi, I. (2013). Management Effectiveness of ASEAN Heritage Parks. GIZ-ASEAN Centre for Biodiversity. Los Banos.
- Manuel, G.C. (1957). Status of Tamaraw, *Anoa mindorensis* (Huede). *Proc. Eighth Pacific Sci. Cong. (Manila 1953)* 3A:1463-74.
- Maohong, B. (2012). Deforestation in the Philippines, 1946–1995. *Philippine Studies* vol. 60 no. 1: 117–130
- Miller, M. 1912. The Mangyan of Mindoro. *Philippine Journal of Science* 7 (3): 13546
- National Research Council (1983). *Little-known Asian animals with a promising economic future*. National Academy Press. Washington D.C. USA.
- Oliver, W. L. R., (1993). Threatened endemic artiodactyls of the Philippines: status and future priorities. *Int. Zoo Yb.*, 32: 131–144.
- Petocz, R. (1989). Status of the tamaraw (*Bubalus mindorensis*). *Asian Wild Cattle Specialist Group Newsletter*, 2: 1-4.
- Rabor, D. S. (1961). The state of conservation of Philippine mammals with special reference to the deer and the tamaraw. *Proc. 8<sup>th</sup> Pac. Sci. Congr. 1953*. Nat Res. Counc.Phil. Quezon City, Vol. VI:173-81.
- Rabor, D.S. (1977). *Philippine Birds and mammals*. University of the Philippines Press, Quezon City, pp.284.
- Read, B., Morris, D., Loskutoff, N. and Ellis, S. (1994). *Preparatory document for the Bovid Conservation and assessment and management plan: Participants' First Draft, 20 April 1994*. IUCN SSC Captive Breeding Specialist Group. Apple Valley, MN USA.
- Rodriguez, F. (2015). What's Eating Up Mindoro's Forests?; Rappler, <https://www.rappler.com/science-nature/environment/105742-mangyan-mindoro-forests>
- Schult, V. (1991). The Genesis of Lowland Filipino Society in Mindoro. *Philippine Studies*: vol. 39, no. 1: 92–103. Ateneo de Manila University.
- Schütz E. (2015). *Tamaraw population survey and current status*. Tamaraw Program - Conservation and Enhancement of the Natural Heritage of Mts Iglit-Baco National Park. Project Report.
- Steere J.B. (1888). Letter to the secretary. *Proceedings of the Zoological Society of London* 29: 413-415.
- Steere J.B. (1891). The island of Mindoro. *The American Naturalist* 25: 1041-1054.
- Stolton, S., Hockings, M. and N. Dudley, N. (2002). Reporting Progress on Management Effectiveness in Protected Areas. A simple site-level tracking tool developed for the World Bank and WWF. WWF International, Gland, Switzerland.
- Tabaranza, D.G.E., Natural, V.C.Jr., Tan,E.H.P., Bata, E.B., Barcelona, G.S., Encado,M. Casuncad, J.R. and Belmonte, J.M. (*in prep*). Report on the survey of Tamaraw population in Mt. Gimparay.

Talbot L. M. & Talbot M. H. (1966). The tamaraw (*Bubalus mindorensis*). Observations and recommendations. *Mammalia*, 30: 1–12.

UNDP Philippines. (2012). Evaluation of the integrated programme for the empowerment of indigenous peoples and sustainable development of ancestral domains (ip-eipdads) project - phase II – Final Report

Wernstedt, F.L. & Spencer, J.E. (1967). The Philippines Island World – A Physical, cultural and Regional Geography, University of California Press