Members of the Team South during the survey (F. García)

Dung hunting: an alternative method of monitoring tamaraw abundance in Mts. Iglit-Baco Natural Park

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Introduction

Mts. Iglit-Baco Natural Park (MIBNP) is the largest protected area on Mindoro Island of the Philippines, covering 106,655ha. It supports the largest population of the Critically Endangered tamaraw (*Bubalus mindorensis*), a species endemic to the island (Ishihara et al., 2014, Ishihara *et al*, 2016, Long et al., 2018, Department of Environment and Natural Resources, 2020). Collaboration between the Park Office, local stakeholders and local and international partners has led to finalize and develop the "Protected Area Management Plan' (PAMP) for the next 10 years, almost 40 years after this Protected Area was established. These guidelines set out the actions to be taken in order to manage and develop the park, including the 'Conservation of species, habitats and ecosystems' (Program 1).

One sub-programme laid out in the PAMP is tamaraw conservation. A 'Core Zone of Monitoring' (CZM) of 2500 ha, where the majority of the park's tamaraw population resides, provides a vital refuge for the species. Annual surveys of tamaraw numbers in the CZM have been conducted since 2000 using the point count method, a proxy of tamaraw population size (Ishihara et al., 2014, Long et al., 2018)., which does not account for imperfect detection of animals in time and space. Though easy to implement, this technique requires in practice high visibility in order to detect the animals, so areas of grassland are burnt each year by the park's authorities to open the landscape and increase visibility

around the 18 'vantage points' (Ishihara et al., 2014, Long et al., 2018). One of the objectives of the PAMP is to halt the use of burning in the CZM of MIBNP in the years to come in order to allow for restoration of natural vegetation. With restoration, however, detectability of tamaraws will decrease dramatically, as will the relevance of the point count method to monitor its abundance. Therefore, an alternative method is necessary to enable the continuation of this monitoring.

Over the last century, a number of different methodologies have been developed to assess the relative abundance of species (Seber 1982; Schwarz and Seber 1999). One reference method is the distance sampling (Buckland et al. 2004), applied either on direct observation of animals, or indirectly on presence indices (*e.g.* animal droppings). In the distance sampling method, the detection probability of animals derives from the perpendicular distribution of distance of animals or feces along pre-defined transects. A major assumption of the distance sampling method is that no animals or indices are missed on the transect. This assumption is however often not met in hard terrain or densely vegetated habitats such as cogon grassland in MIBNP. This assumption can be relaxed and accounted for by combining the double observer with the distance sampling method of faeces. This combination of information is often used to study populations in areas of low visibility (Jenkins & Manly, 2008).

This pilot study explores for the first time the use of these methods to assess relative abundance of tamaraws, along with the Vulnerable Philippine brown deer (*Rusa marianna*) and the Vulnerable Oliver's warty pig (*Sus oliveri*), in MIBNP. We first wanted to assess the feasibility of implementation of the combined double observer / distance sampling methods at MIBNP, and to obtain a conversion factor between feces and tamaraw densities to allow for comparison between the long-term abundance time series based on point counts, and the envisioned monitoring method based on feces abundance. The project is part of a collaboration between the D'ABOVILLE Foundation and Demo Farm Inc (DAF), the Laboratoire de Biométrie et Biologie Évolutive (LBBE) (France), and the Philippine Department of Environment and Environment Resources (DENR), represented by the Tamaraw Conservation Program (TCP) and the Protected Area Management Office (PAMO) for MIBNP.

Methods

Distance sampling

Distance sampling is well-practiced in the study of ungulate density (Ellis *et al.* 2005; Valente *et al.* 2014; Kumar *et al.* 2017), and because this methodology can be adapted to use indirect signs, such as dungs, it is suitable in environments where detectability of animals is low (Jenkins and Manly, 2008). In this study we use dungs as an indirect sign of each of the three focal species. The observers record all dungs detected from along a fixed-length transect, along with the perpendicular distance from it. After carrying out three 'test missions', to establish a final methodology for the preliminary study and to build capacity through training of PAMO and TCP staff, a transect length of 500 meters was selected. number of intended replication.

Double observer method

Though valuable, distance sampling of faeces is subject to observer bias, with observers able to miss samples, thus resulting to an unknown underestimation of dung density. Employing a double observer on the top of the distance sampling

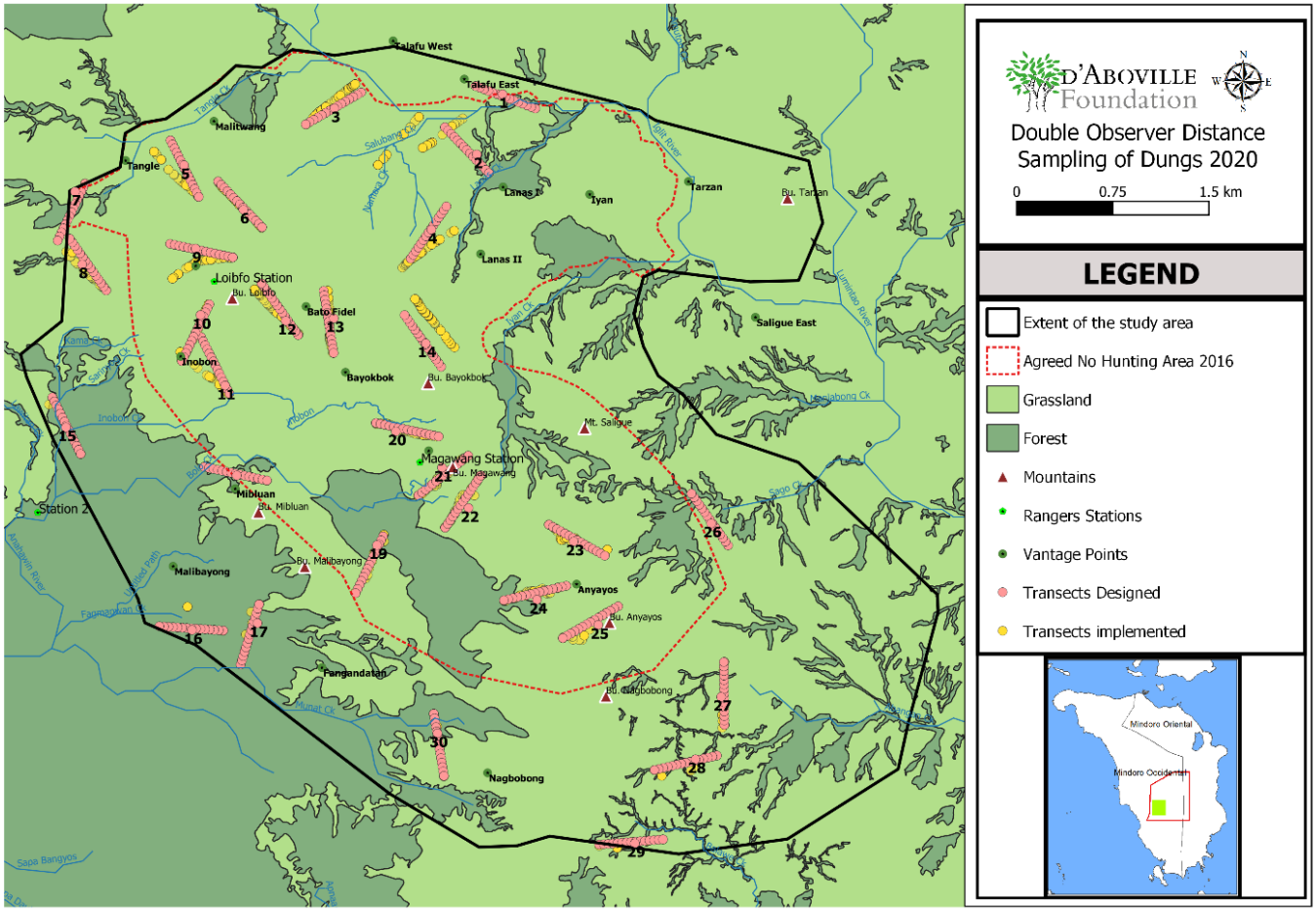


Figure 1 Designed (pink) and implemented (yellow) transects from the Double Observer Distance Sampling of dungs study of 2020 in the Core Zone of Monitoring of Mt. Iglit-Baco Natural Park.

allows to relax the assumption of perfect detection on the transect and correct the estimation (Nichols et al. 2000; Jenkins and Manly, 2008). The two approaches to the double observer method, dependent and independent, were both trialed in the test missions. The dependent approach involves both sets of observers taking recordings along a transect simultaneously, with the second observer only recording samples that were missed by the first. The independent design requires full recordings to be taken by both observers, with no contact between parties permitted to ensure no awareness of the other's observations. In the end, the dependent double observer method was favored and selected for this study because it was easier to implement in the field.

Pilot study

Pilot data was collected from the study site in the CZM from 3-10 February 2020. 30 transects were planned (T1-T30), with only one omitted (T26) due to the topography of its location (Figure 1). Two transects (T1 and T2) were moved at the request of representatives from residing indigenous communities. Two teams - North (covering T1-T15 North of Magawang ranger's station) and South (covering T16-T29 to the South) - each comprised 11 members, including one Indigenous People (IP) representative. Two members of the team would be responsible for opening the path for sub-team 1 (two members) to carry out the first set of observations. Two more members would record the observations of sub-team 1, noting the number, species, perpendicular distance from the transect, the habitat type (grassland or forest), and estimated age of the faeces. Sub-team 2 would then follow behind the group and indicate to the recorders data missed by sub-team 1. The final two members did not participate in the data collection, but were responsible for the

Table 1 Number of dungs per transect (with transect 26 removed from the list) during the Final Pilot Study of Double Observer Distance Sampling of Dungs in MIBNP in February 2020.

Transect	Tamaraw	Philippine brown deer	Oliver's warty pig
1	9	1	2
2	16	4	1
3	31	12	7
4	31	5	7
5	26	4	4
6	42	10	6
7	0	0	0
8	27	0	0
9	45	9	3
10	25	3	0
11	13	0	3
12	53	2	3
13	31	10	2
14	47	26	0
15	1	0	0
16	0	0	0
17	0	0	0
18	0	0	0
19	18	0	0
20	83	3	4
21	99	2	3
22	133	4	2
23	25	14	0
24	73	5	3
25	13	1	0
27	2	4	0
28	6	1	0
29	1	1	4
30	0	1	1
Average	32.4	2.6	1.2

transportation of equipment and provided assistance at field camps.

The following equipment was carried by each team: 1 GPS (Garmin eTrex 10 for North and GPSmap 60CSx for South), 1 set of spare rechargeable batteries and battery charger pack (Panasonic Eneloop), 1 compass, data sheets, notebook and pens, lamps and tarps. All equipment was provided by D'Aboville Foundation (DAF).

Communication and collaboration with communities residing within the study area was maintained as a key element of this operation.

Results

Over the course of this study, 14,607m of transects were covered (7,615m in the North, 6,992m in the South). A total of 850 tamaraw dungs were recorded, plus 122 of Philippine brown deer and 55 of Oliver's warty pig. The number of dungs recorded along each transect are shown in Table 1.

The use of the double observer method resulted in the significant recording of initially missed dung samples. For tamaraw, an average increase in the number of dungs recorded was 19.9% (ranging from 0-46% for each transect). There was a greater discrepancy in the number of Philippine brown deer and Oliver's warty pig dungs recorded, with around 43% of dungs initially missed by sub-team 1 and later observed by sub-team 2.

Results showed that the difference in recordings from sub-team 1 to sub-team 2 varied between the North and South teams. Front team in the North (sub-team 1N) recorded an average of 67.75% of the total dungs (of all three species) along each transects, whereas the front team in the south (sub-team 1S) recorded 84.78% of the total.

Areas with higher density of tamaraw dungs were similar to areas with higher direct observation during the point count 2019. Thus, results of both monitoring methods are converging in terms of distribution pattern of the species within the CMZ. In addition, the general spatial structure of the tamaraw population following a trend of decreasing density from the center of the CZM to its periphery is visible in both operations, sustaining that it is not a bias of the methods.

Discussion

This final pilot study for Double Observer combined to Distance Sampling has enabled the recording of useful biological information in addition to the estimate of dung density. It provides some new information about tamaraw distribution, its interaction with the two other large herbivore species, as well as a better overview of the status of Philippine deer and Oliver´s warty pig within the CZM of MIBNP. Tamaraw dungs were observed in clusters of higher concentrations, particularly in the areas where patrolling is regular, which indicates a clear spatial structure of distribution and the positive role of the presence of rangers on the population dynamic of the species

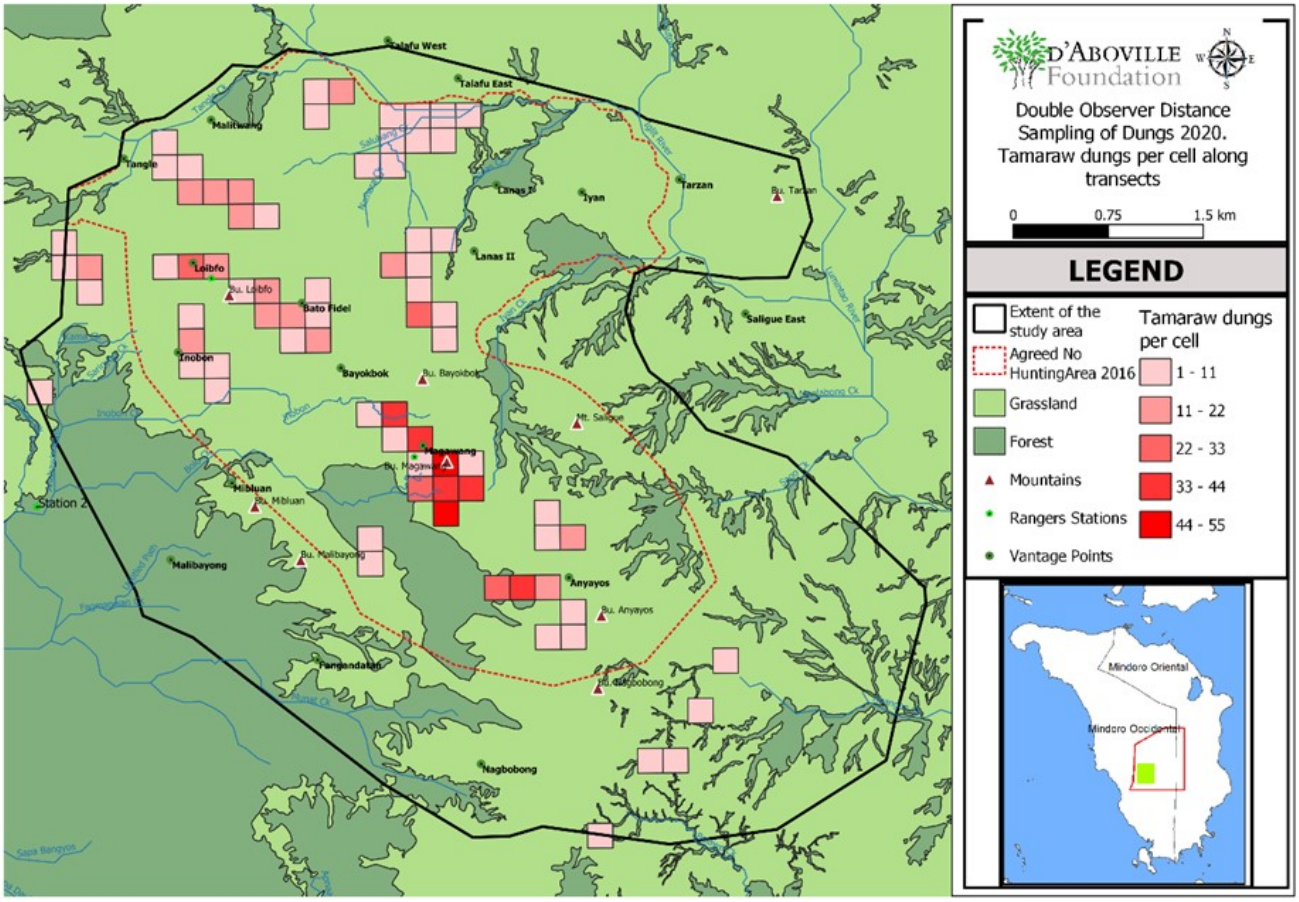
It moreover demonstrates the importance of the double observer method in producing more reliable results. Such technique can help solve the problematic assumptions of traditional distance sampling, avoiding observer bias and observer inaccuracy, and allows us to collect a larger data set using affordable and repeatable methods. The study has highlighted further improvements and modifications of the field protocol and implementation that will be necessary before it is used routinely in the future. For instance, there is a substantial topographic difference between the North and the South parts of the monitoring area, with the South being more mountainous and uneven in terrain. The overall landscape is mountainous and physically challenging, with ecological characteristics that must be taken into account in the future and final design of transects to make it usable and useful in the long run.

However, whilst distance sampling can enable collection of data in areas with lower visibility in any part of the study area, the method provides only an estimate of dung density and not tamaraw abundance. Moreover, important information such as sex ratio and age structure of the population cannot be obtained through indirect signs of presence. A comparison of the data from the point count survey and the distance sampling (Figure 2) will help us to establish a conversion index between the density of animals and the density of dungs. Nonetheless, such monitoring operations using the distance sampling method are practically less intrusive than the point count as used in MIBNP and less expensive, requiring less manpower than the annual count operation.

Next steps

Following this pilot study, all data collected will be more thoroughly analysed to (a) estimate dung density, (b), extract an index of abundance of the tamaraw and (c) determine a detectability rate for correction of the index, while projecting the results into a Bayesian integrated population model (IPM) with the traditional point count method and the double observer point count method.

Results of the distance sampling operation, combined with those of the point count, will provide a more robust and unbiased estimate of the abundance of the tamaraw population in the CZM.



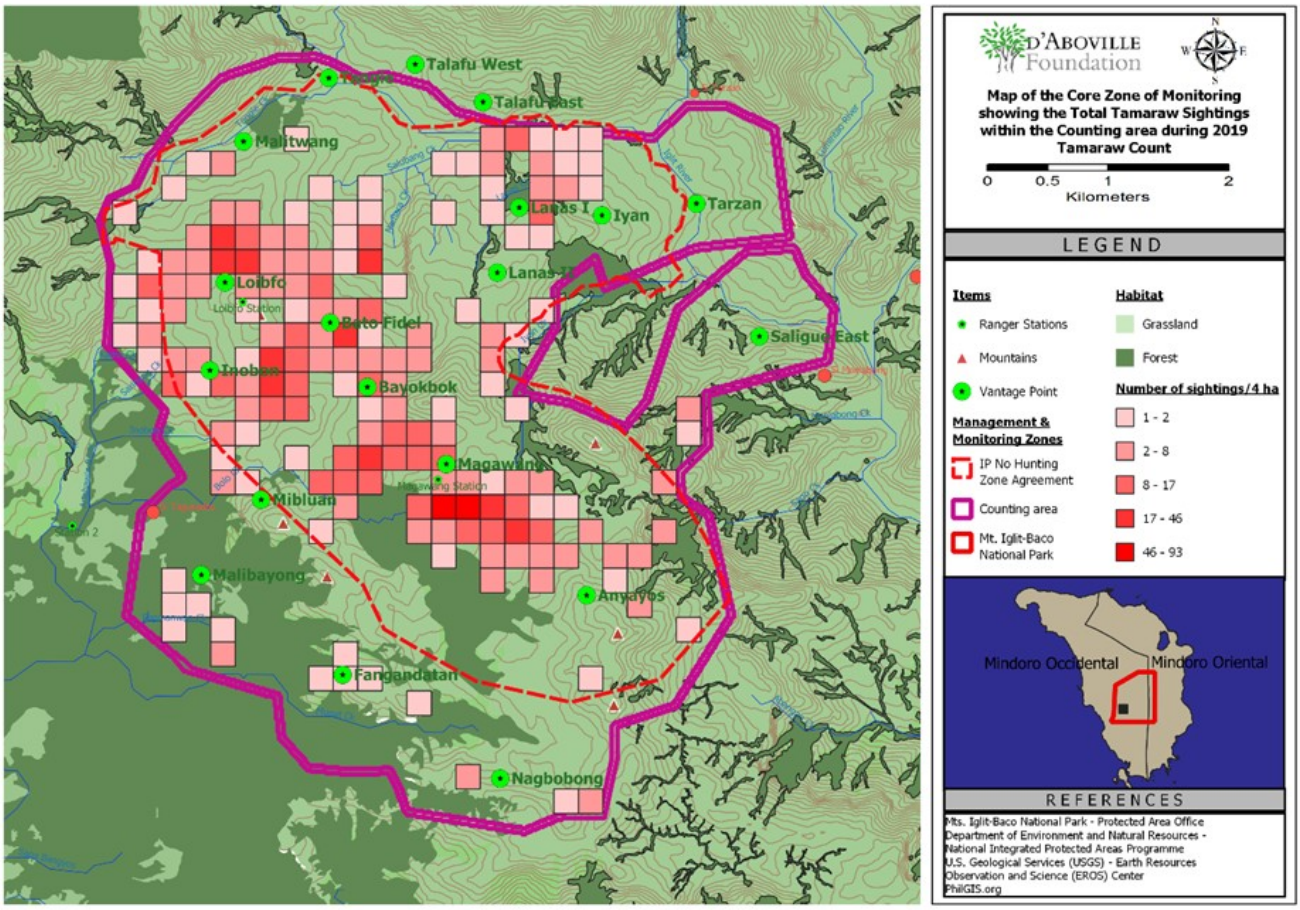


Figure 2. Above: Number of tamaraw dungs found along the transects projected on the grid map of the CZM of MIBNP, showing the relative density of them and spatial distribution pattern **Below:** Map of the Core Zone of Monitoring of MIBNP with the results of the Annual Point Count of tamaraw. We can see represented the density of sightings of the animals per cell. The pattern displayed in the map is similar to the map displaying the results from Double Observer Distance Sampling of Dungs 2020

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