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Tapanuli Orangutan Conservation Project (TOCOP)
Proposed Orang-utan Survey Summary

Background:

In the Tapanuli region of North Sumatra, the critically endangered Sumatran orang-utan (*Pongo abelii*) occurs within several forest blocks collectively referred to as the Batang Toru forest ecosystem. The Batang Toru orang-utans – the only remaining subpopulation south of Lake Toba – have recently been found to be genetically distinct from the rest of the species occurring further north (Nater et al., 2011, 2013). Genetic divergence of the populations is believed to have resulted from isolation through past eruptions of the Toba volcano as well as the short-distance dispersal patterns typical of female Sumatran orang-utans.

The Batang Toru subpopulation is highly threatened by ongoing habitat loss and fragmentation. Given the genetic uniqueness of this population and the fact that most of the forest in this area has no protected status, urgent action is needed in order to preserve this crucial reservoir of genetic diversity of Sumatran orang-utans (Nater et al., 2013). The Sumatra Rainforest Institute (SRI) has recently launched the Tapanuli Orang-utan Conservation Project (TOCOP), which aims to address the conservation of the remaining orang-utans within three forest blocks in the Batang Toru forest ecosystem (Dolok Sibual Buali Nature Reserve, Dolok Sipirok Nature Reserve and Lubuk Raya forest; **Table 1**). These forest blocks have been chosen as the focus of the current project because they are isolated and fragmented from the rest of the Batang Toru forest ecosystem, are poorly studied, and, unlike other parts of Batang Toru, are not currently the subject of conservation initiatives.

Table 1: Size and estimated orang-utan populations of the three study areas

Forest block	Size (ha)	Estimated orang-utan habitat (ha)*	Estimated no. orang-utan	Estimated carrying capacity	References
Dolok Sibual Buali	5000	1500	8-27	47-56	Djojoasmoro 2008; Kuswanda *et al.* 2003; Kuswanda and Bismark 2007
Dolok Sipirok	6700	2100	22-40	Unknown	Kuswanda 2013
Lubuk Raya	3000	Unknown	Unknown	Unknown	N/A

* forest below 1000m above sea level (asl) as seen from satellite imagery (source: Rijksen & Meijaard, 1999)

The small orang-utan populations of the three study areas face numerous threats typical of protected areas in Indonesia, including deforestation, expansion of road networks, illegal logging, hunting, and fire (Gaveau, et al., 2016). Encroachment by independent farmers is the main cause of illegal forest clearing in Indonesian protected areas (Gaveau et al., 2012). Aside from habitat loss, encroachment also increases conflicts between humans and orang-utans, as orang-utans are increasingly driven to raid agricultural crops. These issues are compounded by the lack of effective law enforcement in Indonesia, which results largely from insufficient funding for park management (Smith & Walpole, 2005).

Collection of baseline data on the distribution and abundance of populations is a vital first step in primate conservation, as it allows measurement of the effects of local threats to the population, as well as assessment of the effectiveness of conservation measures (Wich & Marshall, 2016). In addition, identification of key areas of habitat will be important in order to effectively target future conservation efforts. There is an urgent need for up-to-date population data for the three study areas; the most recent estimations of orang-utan populations were carried out in 2005 in Sibual-buali and 2010 in Dolok Sipirok (see below section), and no population data is available for Lubuk Raya.

Previous surveys:

A number of studies have been carried out within the study areas; these are summarised briefly below.

Dolok Sibual Buali Nature Reserve:

- Kuswanda et al. (2003) – states around 27 orang-utans present in Sibual-buali.
- Kuswanda (2005) – study of the potential habitat in Sibual-buali and estimation of orang-utan population. <u>Note that this paper is not available online and would be useful to obtain from the author</u>
- Kuswanda and Bismark (2007) – a study of the potential orang-utan carrying capacity of Sibual-buali based on fruit and leaf productivity. Carrying capacity estimated at 47-56 individuals.
- Djojoasmoro (2008) – 9 month study between April 2002 - Jan 2003, during which orang-utans were habituated and followed (15 individuals estimated but only 7 successfully followed).
- Hawari et al. (2015) – study of the density of the orang-utan population in an area bordering Sibual-buali (Bulu mario Village), the dominant tree species used for nesting and the relative importance of trees located within Bulu mario Village.
- Simanjuntak et al. (2015) – study conducted in the village of Aek Nabara, bordering Sibual-buali, which aimed to estimate orang-utan density, determine the tree species used for nesting, and assess the relative value of trees in the village area.
- Batubara et al. (2016) – study of changes in land cover and condition in Sibual-buali between 2003-2016. Vegetation of reserve mapped as 5 different classes: primary dry forest, secondary dry forest, scrub, vacant land, water bodies and not identified (clouds and cloud shadows).
- Cahyani et al. (2016) – identification and mapping of the nesting trees used by orang-utan in the buffer zone of Sibual-buali (Bulu Mario, Aek Nabara and Huraba villages).

Dolok Sipirok Naure Reserve:

- Kuswanda (2011) – study of habitat components, habitat selection and factors affecting orang-utan presence in Sipirok. Four different habitat types were identified: primary forest 900-1200 meters asl, primary forest 600-900 m asl, secondary forest and agricultural dry land and shrubs. The highest proportion of orang-utan food trees was found in primary forest 600-900 m asl.
- Kuswanda and Pudyatmoko (2012) – study of habitat type selection by orang-utan in Sipirok. It was found that orang-utan preferentially selected primary forest 600-900 m asl, followed by secondary forest.

- Kuswanda (2013a) – 4 month study of orang-utan numbers in 2010. Stratified by habitat type (primary >900 m, primary <900 m, secondary, shrubs etc), used randomly placed transects for nest counting. Estimated 22-40 individuals present.
- Kuswanda (2013b) – 6 month study of the habitat resource factors influencing the presence of orang-utan in Sipirok.

Lubuk Raya Protected Area:

No surveys have been carried out in Lubuk Raya due to the steep and difficult terrain.

Recommended methodology for surveys:

The following steps outline the recommended stages for the survey component of the TOCOP project:

1. Drone training and deployment
   Ready-made conservation drone to be purchased. Within Asia, these are available from www.hornbillsurveys.com. SRI / BBKSDA staff could be trained in the use of drones by organisation such as Hornbill Surveys, or through use of an expert orang-utan scientist with experience in use of conservation drones. Two possible contacts with drone experience in Sumatra are James Askew (University of Southern California) & Matt Nowak (Sumatran Orang-utan Conservation Program). The conservation-specific drone could be programmed to fly straight and equally-spaced transects across the whole of the three forest blocks, flying at a slow enough speed to record clear video imagery and / or still photographs and a low enough altitude to allow orang-utan nests to be clearly observed.

   Use of a drone for the TOCOP program will have many benefits, such as being able to obtain up-to-date aerial imagery, which will be particularly useful at Lubuk Raya where heavy cloud cover obscures current satellite images. This aerial imagery can be utilised in preliminary vegetation stratification (**step 2**) as well as aerial identification of orang-utan nests (see **step 4**), avoiding the need for time-consuming and logistically difficult ground surveys. This will be particularly advantageous in Lubuk Raya due to the difficult terrain, but will also save time and resources when surveying the other two forest blocks.

   Budget items required: Drone and drone software, video camera, training costs, rent of SRI's Sipirok office for one year as a base for the project

   Staff required: SRI or BBKSDA staff to be trained in drone operation for use throughout the TOCOP project. Liaison with researchers with experience in drone use in tropical forest ecosystems required.

2. Vegetation stratification / preliminary mapping
   Preliminary vegetation stratification can be carried out using aerial imagery interpretation. Drone footage will provide higher quality aerial imagery for preliminary vegetation stratification than is currently available from satellite imagery. Stratification will also utilise topographic mapping if available, soil type mapping, rainfall mapping, aspect etc, as well as local knowledge of forest types and disturbance levels.

Basic mapping has been done for Dolok Sibual-buali (Batubara et al., 2016); the reserve was classed into primary dry forest, secondary dry forest, scrub, vacant land, water bodies and unidentified. Basic mapping has also been carried out for Dolok Sipirok; this reserve was mapped by Kuswanda (2013) into the following units: primary forest (above and below 900m asl), secondary forest, shrubland, mixed bush/garden, dryland farming and paddy fields. This basic mapping could provide some guidance for preliminary stratification.

No mapping has been done for Lubuk Raya due to the lack of studies in this forest. In addition, the frequent presence of dense cloud over the mountain makes assessment of vegetation from existing aerial imagery impossible.

Budget items required: costs of obtaining any existing mapping (topographic, soil type, rainfall etc)

Staff required: Can be carried out internally by SRI staff with GIS capability

3. On-ground vegetation surveys and mapping

The aim of this component of the project would be to create a ground-truthed vegetation map for the three study areas, which would be a useful reference for future work, as well as allowing identification of the extent and location of suitable orang-utan habitat.

Once vegetation is stratified as much as possible into preliminary vegetation zones (see **step 2**), vegetation plots can be randomly assigned in ArcGIS within each vegetation type. Random and representative samples are required in order to satisfy the assumptions of scientific sampling design – therefore the number of plots needed will be determined by the size of the area of each vegetation zone. **Table 2** provides a rough guide to how a suitable number of plots could be determined; however, this is based on Australian conditions, and may need modification to suit the very different environment (in consultation with relevant experts). Plots must also be randomly placed within the landscape – subjective placement should be avoided unless the plot position generated is in a river / on the edge of a cliff etc. An appropriate and standardised size for the quadrats should be determined in consultation with botanists with knowledge and experience of working in tropical forest ecosystems. Floristic plots of 10 m x 100 m (0.1 ha) have been used in the Batang Toru east and west blocks by Wich *et al.* (2014) and may be appropriate for this present study.

At each of these quadrats, collection of full floristic data (cover / abundance of all tree species) and structural data (e.g. mean tree heights, diameter at breast height (DBH) and tree density) should be collected. In addition to these quadrats, as many rapid vegetation assessment points as possible (recording dominant species and their cover / abundance for each structural layer) should be collected to assist in mapping. These rapid points should be collected opportunistically, for example whilst walking between quadrant locations.

This data will allow determination of vegetation types and identification of areas with suitable feed and nesting trees and other important structural characteristics for orang-utan. To determine suitability of areas for orang-utan, the species identified in the study plots can be compared with a published orang-utan food list for all sites where orang-utan occur (Russon, 2009). A preliminary diet list has also been developed for Batang Toru east and west blocks (Wich et al., 2014) and this would be very useful to obtain from the authors.

Table 2: Minimum number of transects / plots required per zone area (OEH 2014)

Vegetation zone area (ha)	Minimum number of transects/plots
0–4	1 transect/plot per 2 ha (or part thereof) or 1 transect/plot if vegetation is in low condition
> 4–20	3 transects/plots or 2 transects/plots if vegetation is in low condition
> 20–50	4 transects/plots or 3 transects/plots if vegetation is in low condition
> 50–100	5 transects/plots or 3 transects/plots if vegetation is in low condition
> 100–250	6 transects/plots or 4 transects/plots if vegetation is in low condition
> 250–1000	7 transects/plots or 5 transects/plots if vegetation is in low condition More transects/plots may be needed if the condition of the vegetation is variable across the zone
> 1000	8 transects/plots or 5 transects/plots if vegetation is in low condition or in a homogenous landscape in the Western Division More transects/plots may be needed if the condition of the vegetation is variable across the zone

The vegetation units assigned should preferably align with those units used by other researchers in nearby areas. For example, Wich *et al.* (2014) have conducted initial assessments of the floristic composition of the nearby Batang Toru east and west blocks, and have identified three main forest types: heath forest, lowland forest and mixed dipterocarp forest.

This stage of the survey will require staff with extensive experience in flora identification in order to accurately identify plants to species-level. Other researchers working in the Batang Toru region have used botanical experts from the Forest Research Institute in Pekanbaru, Riau (Wich et al., 2014).

The accessibility of the three study sites is an important consideration for any on-ground survey work. Much of Sibual-buali is close to roads, so it is mostly possible to walk in and out each day. On the other hand, Sipirok is not easily accessible from roads, so researchers would need to stay in the forest during the survey period. It is likely that Lubuk Raya is similarly difficult to access from roads.

Budget items required: GPS units with high sensitivity chip for improved accuracy whilst working under canopies (e.g. Garmin 60 Csx), 2-way radios, tape measure, food costs, cost of constructing temporary camp in Sipirok and Lubuk Raya for use during surveys, travel costs.

Staff required: Preferably 2 field teams, each consisting of 1 expert in flora identification plus 1 additional staff member from BBKSDA or SRI to assist with field work. Will also require local guides.

4. Orang-utan abundance estimates

It is notoriously difficult to obtain accurate abundance or density estimates for orang-utans. Although direct counts (in which all individuals in a population are detected and counted) are the preferred method of measuring primate abundance where possible (Wich & Marshall, 2016), orang-utans are cryptic, solitary, arboreal and generally live at low densities. A direct count would require a massive sampling effort to locate, habituate and follow individual orang-utans, especially in large areas of difficult terrain with dense vegetation like the three forest blocks in this study, and as a result would incur high costs. There is also significant risk of double-counting and / or missing some individuals which may move out of the study area in response to human presence. Direct counting is therefore considered impractical in most orang-utan studies. Instead, orang-utan researchers generally rely on counts of indirect sign to census populations of the species. The counts are conducted within a defined area and are then converted into an estimate of abundance.

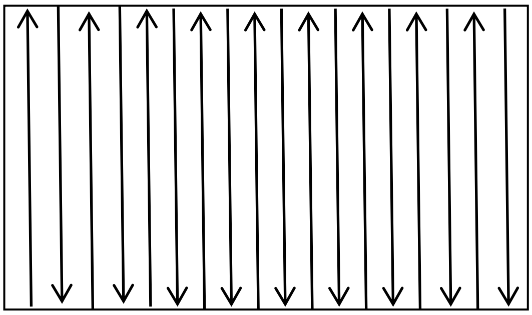
Nest counting, in which the sleeping platforms (nests) that orang-utans build each night are used to calculate the density of individuals in an area, is the most commonly used survey method for orang-utan. All nests visible from a line transect or in a plot are counted; nest counts are then converted into nest densities by dividing the number of nests counted by the area surveyed, which is estimated using a detection function (line transects surveyed using distance sampling methods). Nest densities are then converted into orang-utan density estimates using the following formula:

$$D_{ind} = D_{nest} / p * r * t$$

in which D_{ind}=density of individuals, D_{nest}=density of nests, p= proportion of nest builders in the population, r = number of nests built per individual per day, and t = nest decay time. P, r and t must be based on known data from similar environments (e.g. other similar forest types within similar climatic zones of Sumatra).

Aerial surveys are useful for surveying primates that leave conspicuous signs; this includes orang-utan nests. When compared with traditional ground-based surveys of orang-utan nests, aerial surveys allow large areas to be surveyed more efficiently, require lower human investment, and are a more efficient way to survey remote or inaccessible areas. Drones are increasingly being utilised for aerial primate surveys, and have several advantages over helicopter-based aerial surveys, including lower cost, lower sound levels, ease of manoeuvrability ability to fly at a lower altitude, less danger to researchers, slower flight speed, and ability to provide downward visibility (Wich & Marshall, 2016).

The aerial imagery captured by the drone in **step 1** is to be used in orang-utan nest counting. The use of a drone with a pre-programmed flight path will allow the ideal sampling unit layout for primate surveys to be achieved: enough units (in this case transects) to provide widespread and high coverage of the study area (Wich & Marshall, 2016). See the diagram below for an example of study area coverage using programmed transects. This method is to be preferred given the low abundance of orang-utan present in the forest blocks, as it maximises the area sampled. However, if total coverage is not possible for whatever reason, then the study area can instead be stratified into different habitat types using aerial photographs and the results of the vegetation surveys, and transects distributed accordingly to achieve a stratified random sampling design.



Perpendicular distance from the drone to the nest (required for density estimations using the program Distance) can be calculated using the drone's altitude data. Nests are to be classified according to age and standard nest count methodology (see above) can then be applied to obtain a density estimate.

The percentage of habitat actually occupied by orang-utans can be calculated as the ratio between the total length of completed aerial transects and the length flown over areas with no visible orang-utan nests. This percentage can then be applied to the total size of each forest block in order to estimate the final size of habitat occupied by orang-utans. The estimated orang-utan densities are then multiplied by the estimated size of orang-utan habitat occupation to obtain overall population estimates (estimated number of individuals).

It is important to note that some nests will not be detected by the drone imagery, as they may be located closer to the ground and thus will be obscured by vegetation. Conferring with orang-utan researchers who have utilised drones in their work will hopefully allow for determination of a suitable corrective factor for our data to account for this issue.

The methodology for this step should be developed in consultation with researchers with experience in drone use and orang-utan survey experience. See **step 1** for some possible contacts. It would also be very helpful to collaborate with researchers with experience in using the program Distance, to assist in calculating orang-utan density estimations for the study areas.

Budget items required: see **step 1**, plus travel and food costs whilst in the field

Staff required: SRI / BBSKDA staff trained in drone use during **step 1**, plus orang-utan expert to assist with methodology and interpretation of results (can be done remotely)

4a. If the imagery captured in **step 4** is not sufficient to clearly detect and classify orang-utan nests, then ground-based nest surveys may be necessary. If at least the presence/absence of nests is able to be detected from the above drone photography, this could be used to stratify the study area into areas of higher/lower orang-utan abundance for ground surveys. More ground transects would then be located in the higher abundance areas and less in the low abundance areas.

This would be useful because in areas where overall orang-utan densities are low, or where densities vary greatly across the study area, there are unlikely to be a sufficient number of nest sightings to obtain a representative sample of the study area if transects are distributed randomly across the study area. Stratification increases sampling efficiency and reduces the number of transects with zero detections. If aerial imagery is not suitable for stratification, stratification can instead be based on pilot vegetation data, forest disturbance levels, or local knowledge of orang-utan distribution.

Ground surveys would involve counting all nests visible from each line transect. Trees should be physically marked (for example, using metal tree tags) to avoid double-counting. Perpendicular distance from the transect to each nest (required for density estimations using the program Distance) can be measured using a range finder or a tape measure. Nests are to be classified according to age and standard nest count methodology (see **step 4**) can then be applied to obtain a density estimate. Again, it would be very important to consult with experienced orang-utan researchers when developing the methodology.

Budget items required: range finder/tape measure for measuring perpendicular distance from transects to nest trees, metal tags for marking nest trees, food and travel costs, cost of maintaining temporary camp in Sipirok and Lubuk Raya as discussed in **step 3**

Staff required: Preferably 2 field teams, each consisting of 1 BBKSDA staff member with experience in orang-utan nest counting, 1 SRI staff or volunteer, and a local guide. Also requires an orang-utan specialist to review methodology and assist in result interpretation

5. Population demographics

Nest count methodology (**step 4**) provides an estimate of population size and distribution; however, no information on population structure can be obtained. To obtain information on the population demographics of orang-utan in the study areas, in particular to determine whether orang-utans are still breeding successfully inside the forest blocks, remote cameras will be utilised. These are to be located in areas identified during steps 1-4 to have the highest orang-utan abundance. There are a still a few issues to work through here – Sumatran orang-utans are the most arboreal of all great ape species and thus placing cameras at ground-level as has been done in surveys for Bornean orang-utans is not likely to be successful. Possibly several aerial observation platforms could be constructed in areas known to be frequented by orang-utan, and a camera positioned at each.

Otherwise use of cameras could be targeted at fruiting trees in an attempt to capture footage of orang-utans attracted to the resource. The drone could be utilised here for regular phenological monitoring over the forest blocks, allowing detection of fruiting events (and potentially identification of tree species through canopy, fruit and flower characteristics; Koh and Wich 2012) which could then be targeted with remote cameras if they were a preferred orang-utan feed species. There are a number of problems with this, however, such as the possibility of tree movement setting off cameras too frequently and draining the battery / filling up the SD card.

It would be very useful to speak to some researchers who have utilised cameras for orang-utan monitoring, to obtain advice about possible study design and recommended camera models. For example, James Askew (University of Southern California), Matt Nowak (Sumatran Orang-utan Conservation Program), and John Abernethy (Liverpool John Moores University) are orang-utan researchers with experience in utilising remote cameras in the Leuser ecosystem.

Note that a past study in Dolok Sibual-buali which attempted to gain an estimate of the orang-utan population through habituation and following of individuals (Djojoasmoro 2008) identified orang-utan of all ages in the reserve (adults, young adults, adolescents, juveniles and infants). This type of information is not available for Dolok Sipirok or Lubuk Raya. Camera surveys must be undertaken at a time of year that maximises the chances of encountering young.

Budget items required: Remote cameras (16 are already owned by BBKSDA – these could be used for the two reserves but not Lubuk Raya as the latter is outside the jurisdiction of BBKSDA), memory cards, python locks for attaching cameras securely to trees, rechargeable AA batteries, food and travel costs for fieldwork.

Staff required: To be determined based on methodology, as determined in consultation with experts. Would expect at least 2 BBKSDA/SRI staff for camera deployment, and at least 1 local guide.

6. Corridor identification

An estimated 50-500 individuals are needed for a viable orang-utan population (Caldecott & Miles, 2005). Based on mean home ranges (5-25 km^2 for males and 1-10 km^2 for females), this would require at least 50-600km^2 of occupied forest (depending on habitat suitability; Caldecott *et al.* 2005). Therefore, if the populations of the three forest blocks in question are isolated to the extent that there is no migration between them or between them and other forest blocks (e.g. Batang Toru), the low population and the small size of the forest blocks means that their orang-utan populations are not likely to be viable in the long term.

This reinforces the importance of identifying, protecting and establishing suitable corridors for orang-utans to move between the reserves and between the reserves and other larger blocks. Identification of existing or potential orang-utan corridors could be achieved through interviewing villagers in the surrounding settlements to find out where orang-utan have been seen moving from one area to another, and examining the updated aerial imagery to be provided through use of a drone (see **step 2**).

Some important potential and existing corridors have already been identified: Rijksen and Meijaard (1999) recommended joining Sibual-buali and Batang Toru across the Batang Toru river (the two areas being currently separated by a road and the river), and conserving a stretch of alluvial valley forest along the river Batang Toru.

Once important corridors have been identified, farmers in the surrounding areas can be targeted for participation in SRI agroforestry programs in order to improve and maintain habitat connectivity for orang-utans.

Budget items required: travel and food costs if field work undertaken

Staff required: This stage of the project could be carried out by SRI staff, who have existing relationships with the communities surrounding the three protected areas.

7. Ongoing monitoring program
   A repeatable orang-utan population monitoring program is essential in order to determine whether management actions to be implemented as part of the overall TOCOP program are effective conservation strategies. Due to the typically high cost of ground-based orang-utan population surveys in Indonesia, surveys are often not conducted at the frequency required for proper analysis and monitoring of population trends (Koh & Wich, 2012). The use of drones for survey will hopefully have the effect of reducing costs of repeated surveys following the outlay for the initial survey. Nest counting for monitoring should be repeated utilising the same methodology as during the baseline survey.

   According to Kuswanda (2013), monitoring of orang-utan populations should be performed at least once every two years in order to be able to measure changes. For long-term monitoring of population trends, it is important to repeat the surveys at the same time of year so as to minimise the effect of seasonal or temporal variables.

   Note that when analysing monitoring data from multiple years, the use of trend analyses rather than simple comparisons between successive surveys is recommended, as it allows for greater power of analysis.

Budget items required: to be determined depending on methodology used in the baseline survey **Staff required:** to be determined depending on methodology used in the baseline survey

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