Conservation Planning Workshops for the Javan Leopard (*Panthera pardus melas*)

Provisional Report

Workshop organizers: IUCN Conservation Planning Specialist Group; Taman Safari Indonesia

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Cover photo: Javan leopard, Taman Nasional Baluran, courtesy of Copenhagen Zoo

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Conservation Planning Workshops for the Javan Leopard (*Panthera pardus melas*) Jakarta, Indonesia

Species Distribution Modeling and
Population Viability Analysis Workshop

28 – 29 January 2018

Population and Habitat Viability Assessment Workshop

30 January – 2 February 2018

PLANNING COMMITTEE

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Subject to final approval by the Directorate General of Kementerian Lingkungan Hidup dan Kehutanan (KSDAE) Ministry of Environment and Forestry

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EXECUTIVE SUMMARY

Workshop purpose

The Javan leopard (*Panthera pardus melas*) is endemic to the Indonesian island of Java, where it functions as the top predator. Habitat conversion and fragmentation as well as hunting in this densely human-populated landscape has led to severe population decline and local extinctions in the past two decades, and this subspecies is now listed as Critically Endangered by the IUCN. Human-leopard conflicts lead to killing or capture of problem leopards, which can further reduce the viability of these small populations.

A governmental national *Javan Leopard Conservation Strategy and Action Plan for 2016-2026* has been developed to address this critical situation. The IUCN SSC Conservation Planning Specialist Group was approached to provide species distribution modeling (SDM) and population viability analysis (PVA) modeling to inform decisions that need to be taken to deliver the plan's recommendations, such as meta-population management, priority areas for corridors/buffers, conflict mitigation strategies, *ex situ* management strategies, and monitoring and research priorities. The conservation planning workshops outlined in this report were conducted on invitation from the Minister of Environment and Forestry of Indonesia.

All data used in the SDM analyses, including leopard presence data and leopard conflict data, were provided by the workshop participants to support PVA and PHVA discussions and are owned by the Ministry of Environment and Forestry of Indonesia or other contributing organizations per agreement.

Model development

In order to initiate development of the SDM and PVA models, a two-day SDM and PVA development workshop was held at Taman Safari Indonesia in May 2017 and was attended by the Indonesian Ministry of Environment and Forestry of Indonesia (MOEF), representatives of the Javan Leopard Forum (Forum Konservasi Macan Tutul Jawa), and NGO and zoo biologists working on Javan leopard conservation. The CPSG team introduced SDM and PVA tools and how they might support management decisions. Model inputs were discussed and revised for both types of models (spatial and population). An overview of the *ex situ* population from the *International Studbook* was reviewed, and its conservation role and management will be considered as part of a One Plan Approach to leopard conservation. The preliminary SDM model identified areas that are unsuitable or are likely areas for leopard occurrence. During the second half of 2017, the modeling group worked to improve the presence database, run a final SDM model to identify populations and areas for potential connectivity, and used that information to develop the *VORTEX* PVA model.

Participants reconvened for two days in January 2018 prior to the PHVA workshop with the purpose of completing the SDM and PVA models as much as possible; creating draft proposals for priority leopard populations, locations and potentials for corridors and buffer zones; and generating numerical information on the likely population dynamics of leopards in the remaining fragmented populations and on potential effects of corridors

Species Distribution Modeling (SDM)

Data collected on wild Javan leopard presence from 2007-2017 provided by participants resulted in 641 presence points valid for SDM analysis. The resulting spatial distribution model explains the current distribution of leopards on Java, with land cover being the main variable influencing the model. Suitable patches for leopards extend across Java in isolated patches, with 19 large suitable patches identified. Larger good patches with confirmed leopard presence are mainly concentrated in

West Java. Species presence in eastern Central Java and East Java need to be confirmed by new field surveys, especially in the production forests. This model can inform the PVA (meta-population structure) and serve as a basis for selecting new areas for surveying for Javan leopard presence. *The SDM model relates to national action plan activities 1.6-1.7 and 2.1-2.5.*

Population Viability Analysis (PVA)

The combination of leopard population and habitat fragmentation across Java, combined with significant and perhaps increasing levels of human-leopard conflict, suggest reason for concern for the future viability of wild Javan leopard populations. Uncertainty in demographic rates, population size and distribution, and rates of human-caused threats for leopards prevent precise estimates of viability; however, connectivity of leopard populations is likely important to prevent local extinctions. Small populations may require regular supplementation, either naturally or through translocation. Loss of adult leopards, especially females, due to conflict or other threats may jeopardize population viability. This PVA suggests important data gaps to guide future research and potential issues for management consideration in Javan leopard conservation. *The PVA model relates to national action plan activities 1.1-1.5.*

2018 PHVA Workshop

The final PVA-SDM development workshop was immediately followed by a 3½-day multi-stakeholder Population and Habitat Viability Assessment (PHVA) workshop in collaboration with the Indonesian Ministry of Environment and Forestry, Javan Leopard Forum, IUCN SSC Cat Specialist Group, NGOs and *ex situ* conservation partners. The aim of this species conservation planning workshop was to complete data input for the SDM and PVA models, and to use the outcome of these models to revise, complete and operationalize the recommendations in the national action plan. Participants used these quantitative analyses for making management decisions within the framework of the *Javan Leopard Conservation Strategy and Action Plan.*

After reviewing the current status of Javan leopard populations and the preliminary results of SDM and PVA modeling, the PHVA participants convened into five working groups for much of the workshop to discuss actions recommended over the next ~three years. Group themes were developed based on activities outlined in the *Javan Leopard Conservation Strategy and Action Plan*.

Data Gaps for Leopard Management

There is significant uncertainty in leopard distribution and density across Java as well as the degree of human-leopard conflict. It is important to increase the power and reliability of the species distribution model (SDM) by increasing the survey efforts. Data on population distribution, density, connectivity, and threats will enable valuable population viability analyses (PVA) and guide effective management action decisions, and is essential to develop a science-based metapopulation management plan for Javan leopards. *These issues relate to national action plan activities 1.1-1.7, 2.1-2.5, 3.1 and 5.1.*

The *Survey Protocols Working Group* discussed recommendations for developing survey protocols to compile critical field data, including recommended work flow, pre-survey and survey activities, data collection, and related issues. The group also compiled current information and data gaps for recommended survey locations.

The *Survey Challenges Working Group* acknowledged the issues of lack of sufficient presence / absence data in some important areas, particularly production forests and the challenges in obtaining permits for survey and monitoring activities. There are also challenges with data access, compilation and analysis that prevent existing data from being used most effectively for leopard conservation. The group outlined recommendations to help address all three of these challenges.

Leopard-Human Conflict Mitigation

Leopards live in a mosaic of fragmented habitats, including areas that overlap with humans. With increasing pressure of habitat loss and declining prey populations, leopards may move out of protected areas, sometimes leading to conflicts between leopards and people that can end in the loss of leopards from the wild. *The Leopard-Human Conflict Mitigation Working Group* classified three types of conflict and the causes leading to each type. The group then recommended mitigation and adaptation activities and responsible parties to deal with and reduce conflict events. *These issues related to national action plan activity 3.4.*

Ex Situ Management

Ex situ populations have the potential to contribute to species conservation if clearly defined, designed and implemented. The Ex Situ Management for Conservation Working Group evaluated potential conservation roles of Javan leopards held in captivity by applying the *IUCN SSC Guidelines for the Use of Ex Situ Management for Species Conservation*. This included a discussion of leopards that are periodically rescued as a consequence of leopard-human conflict, resulting in a recommended decision tree on the fate of those individuals (release, rehab and release, or retain in captivity). After evaluating relative conservation benefits, costs, and feasibility, the group made initial recommendations for development of an *ex situ* insurance population that can also be used for training conflict teams, research and public education. *These issues relate to national action plan activities 4.1-4.5 and 5.2.*

Integrated Management

Javan leopards live across West, Central and East Java in three different types of forest (Conservation Forest, Protection Forest, Production Forest) that are managed by three different authorities, as well in human settlements, plantations and other areas. The Integrated Management Working Group discussed the importance of collaboration among all stakeholders for Javan leopard conservation, and made recommendations regarding wildlife surveying and monitoring, training and conflict mitigation. *These issues relate to national action plan activities 3.2 and 3.5.*

Conclusion

The discussions and recommendations resulting from the SDM and PVA modelling analyses and the PHVA conservation planning workshop are provided in this report as support to advise activities outlined in the *Javan Leopard Conservation Strategy and Action Plan for 2016-2026.*

Note: This is a provisional report as of May 2020, subject to final approval by the Directorate General of Kementerian Lingkungan Hidup dan Kehutanan (KSDAE) Ministry of Environment and Forestry.

MODELING REPORT: Species Distribution Modeling (SDM)

SDM Modeler: Katia Maria P. M. B. Ferraz, CPSG Brasil

Introduction

Species Distribution Modeling (SDM) can be very useful to inform and guide decisions in conservation. Model results can help to set priorities for many different purposes, such as field surveys, law enforcement, functional connectivity, conflict mitigation and others.

SDM searches for associations between species presence and a set of environmental variables (topographic, climatic, anthropogenic and/or landscape) to predict the potential species distribution across a landscape (Franklin 2009, Peterson *et al.* 2011). We used SDM as a tool in the PVA and PHVA workshops for Javan leopard conservation planning (May 2017 and January 2018) to model Javan leopard distribution across the island of Java. We developed model conceptualization, model building, and model validation in an interactive process that involved the active participation of Javan leopard specialists during these workshops.

Note: Subsequent to the PHVA workshop, Wibisono *et al.* (2018) published an SDM analysis designed to identify priority conservation landscapes and actions for Javan leopards. While the details of methodology and results differ between the workshop analysis and this publication, both reveal the fragmented nature of leopard habitat patches and population (see Wibisono *et al.* 2018 for details).

Methods: Species Distribution Model (SDM)

All data used in these analyses were provided by the workshop participants to support PVA and PHVA discussions and are owned by the Ministry of Environment and Forestry of Indonesia or other contributing organizations, following pre-existing data sharing agreements.

Presence records (camera trapping, feces and tracks) were provided by the workshop participants exclusively for the modeling workshops, resulting in 805 GPS points for the last ten years (2007-2017) (Figure 1). Of these, 641 presence points were considered as valid points for modeling as some were outside of the range of the gridded layers, and only 404 points were unique GPS points. We spatially rarify presence points at 5 km to avoid spatial autocorrelation using the SDMToolBox (v. 1.1.c, Brown 2014), resulting in 80 GPS random points selected for modeling.

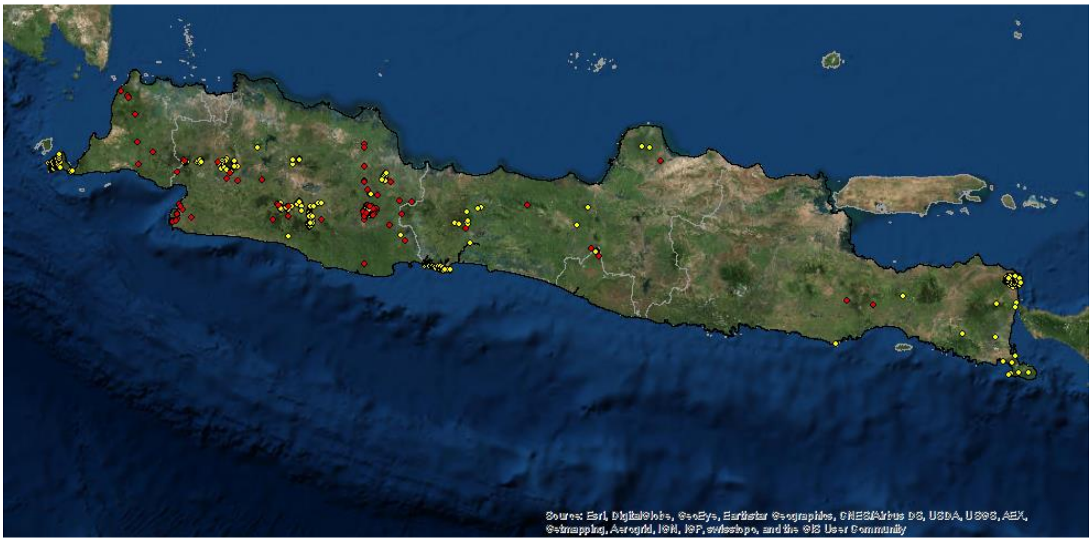


Figure 1. Presence (yellow) and conflict (red) GPS points for Javan leopards.

Leopard-human conflict points (100 points provided, but only 94 unique GPS points) were also provided by the specialists for the same time period (Figure 1), but were not used for modeling as they represent a preliminary and partial view of Javan leopard conflicts on the island. There was a consensus decision that conflict points from Javan leopards should be modeled separately from presence data with no indications of conflicts (e.g., camera trapping survey), as it can result in a different prediction to be used for conflict mitigation purposes.

We selected functional predictors related to bioclimatic variables, topography and landscape to run models, and the correlated variables were eliminated (> 0.7). We ran many models with different combinations of predictors and discussed the model results with the participants during the workshops. All suggestions and inputs from the participants were incorporated into the model. Finally, we used eight predictors to build the final model (Table 1). We resampled all predictors to a spatial resolution of about 1 km.

Table 1. Predictors for Javan leopard distribution model.

Predictors	Description	Source
Bioclimatic - bio2 (mean diurnal range) - bio4 (temperature seasonality) - bio5 (max temperature of warmest month) - bio12 (annual precipitation) - bio19 (precipitation of coldest quarter)	Gridded climate data, version 1.4	http://www.worldclim.org/
Land cover	Land cover classes from 2015	Direktorat Inventarisasi dan Pemantauan SDH. 2016. Peta Penutupan Lahan Indonesia 2016. Direktorat Inventarisasi dan Pemantauan SDH, Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia
Ruggedness - derived by altitude from SRTM (https://www2.jpl.nasa.gov/srtm/) and calculated by the Vector Ruggedness Measure (VRM) Toolbox for ArcGis	Terrain ruggedness as the variation in three-dimensional orientation of grid cells within a neighborhood	
Human Population Density	Gridded Population of the World, Version 4 (GPWv4) Population Density Adjusted to Match 2015 Revision of UN WPP Country	http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-adjusted-to-2015-unwpp-country-totals

We used Maxent (3.4.1, Phillips et al. 2006, Phillips & Dudík 2008, Phillips et al. 2017), the most well-known and used SDM algorithm, to run the predictive model. Maxent estimates a target probability distribution by finding the probability distribution of maximum entropy, subject to a set of constraints that represent incomplete information about the target distribution (Phillips et al. 2006). We set the default parameters plus random seed, write plot data plot, with bootstrap (30% of random test percentage and 10 replicates). The final result is a probabilistic model with pixel value ranging from 0 to 1.

We used the maximum test sensitivity plus specificity Cloglog threshold (0.261) to cut the probabilistic model, resulting in a binary map with suitable (1) and unsuitable (0) patches for Javan leopards. The higher the suitability value, the higher the probability of finding the species in the field;

therefore, suitability is mainly related to the probability of the species presence. For this exercise we assumed that suitable areas meant good patches for Javan leopards. Suitable patches up to 100 km^2 were selected as larger good patches for the Javan leopard and as a starting point for further discussions and also for corridor modeling.

Results

The current distribution model for Javan leopards was considered a good model with AUC = 0.916 ± 0.028 (Figure 2), omission about 12% and p = 0. About 95.67% of the whole database of presence points provided for modeling was well predicted by the model in areas considered suitable for the species occurrence, but only 38.51% was predicted in highly suitable areas (≥0.75).

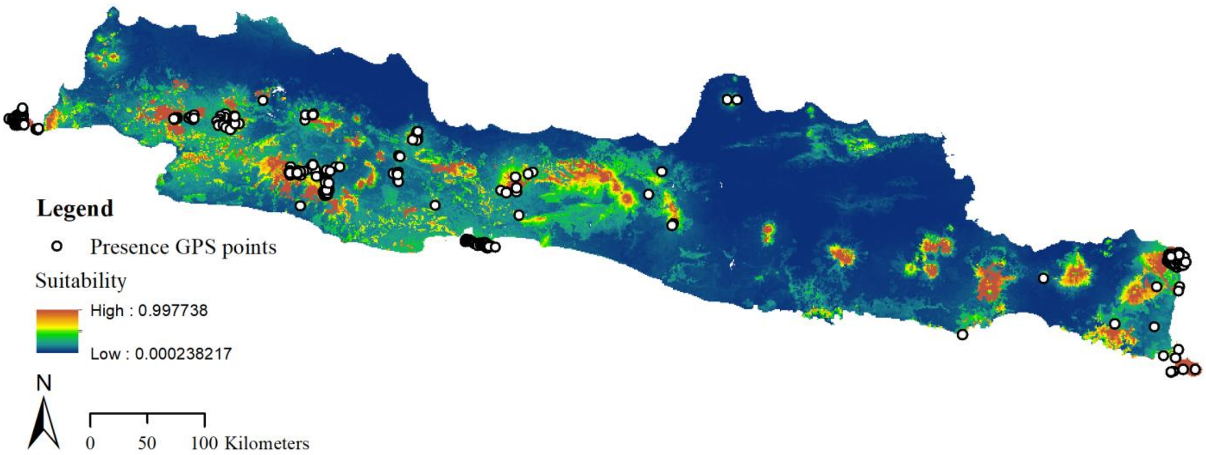


Figure 2. Current distribution model for the Javan leopard based on the presence database provided for modelling.

Land cover was the main variable that influenced the model, explaining about 58% of the model prediction (Figure 3). Higher probability of species presence was mainly in three land cover types: secondary dryland forests / logging (0.93%), savanna (0.91%) and primary dryland forest (0.90%). About 51.32% of the presence points used for modeling were in secondary dryland forests/logging.

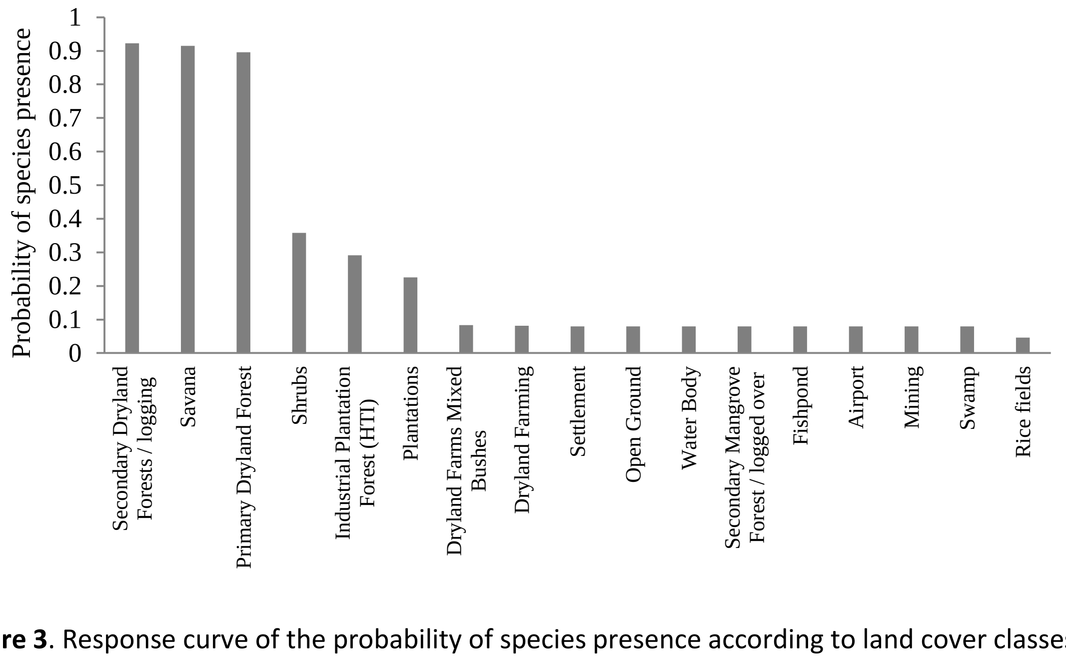
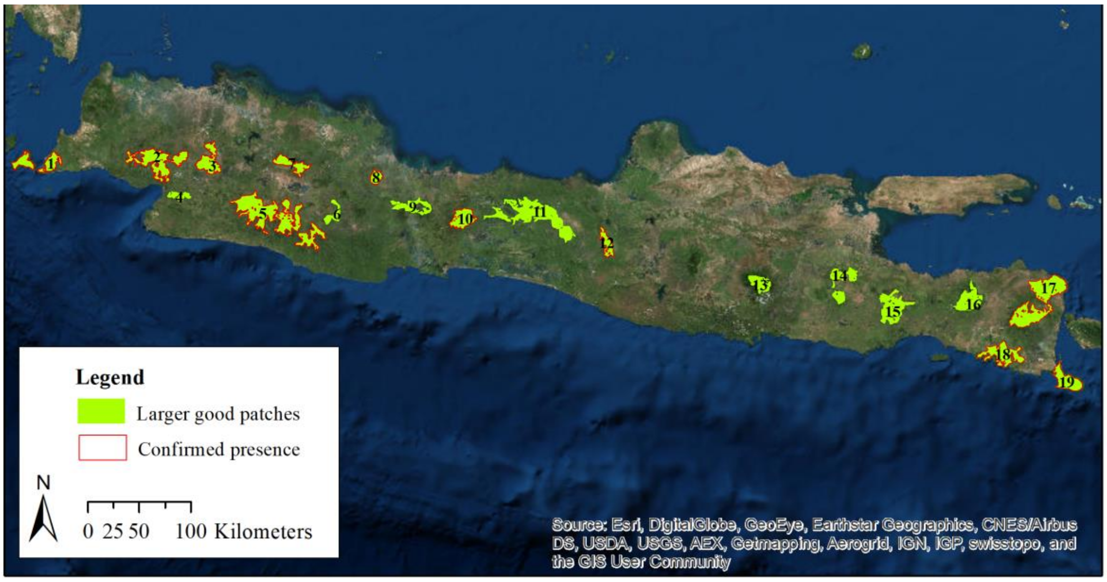


Figure 3. Response curve of the probability of species presence according to land cover classes.

Probability of species presence in production forest areas (industrial plantation forest, HTI) was very low (0.29%), contrary to what was expected. Only 21.05% of the presence points used for modeling were in production forest, suggesting that more data points from this land cover type may help to improve the predictability for this land cover type. More sampling using camera traps should be done in production forest to confirm species presence and the suitability of this land cover type for leopards.

Suitable patches (i.e., good patches) totaled an area of 10,128.21 km^2 for Javan leopards (7.89% of the island). The larger good patches map resulted in 19 suitable patches for Javan leopards, totaling 9,004.87 km^2 (Figure 4). Larger good patches with confirmed species presence by GPS points are mainly concentrated in West Java. Eastern Central Java and East Java have few good patches, with most of them with no species presence confirmed by GPS points. It is urgent that new surveys be implemented in the larger good patches with no species records to confirm leopard presence.

The model was approved as a good model for explaining the current distribution of Javan leopards and was accepted by all participants to be used for conservations decisions by the working groups, as appropriate, during the PHVA workshop. The main purpose of the use of this model was to serve as basis for selecting new areas for survey efforts to confirm Javan leopard presence, especially in production forest and the smaller good patches.



ID	Landscape	Area (km^2)
1	Ujung Kulon	380.1
2	Halimun-Salak	726.0
3	Gede-Pangrango	367.3
4	Jampang	126.0
5	Bandung Selatan	1528.0
6	Galunggung	144.3
7	Bandung Utara	258.9
8	Ciremai	116.8
9	Pambarisan	296.2
10	Slamet	332.6

ID	Landscape	Area (km^2)
11	Dieng	1088.5
12	Merapi-Merbabu	182.4
13	Ngleman	233.4
14	Arjuna Wilarang	349.0
15	Bromo-Tengger-Semeru	540.0
16	Yang	391.0
17	Baluran-Ijen-Raung	1097.6
18	Meru-Betiri	491.9
19	Alas Purwo	354.5

Figure 4. Larger good patches (≥ 100 km^2) with confirmed species presence.

Conclusions

Good patches for Javan leopards extend across Java in isolated patches. Highly suitable areas for species distribution are concentrated in West Java. Larger good patches with confirmed species presence are also mainly concentrated in West Java.

Species presence in eastern Central Java and East Java needs to be confirmed by new field surveys, especially in the production forests, providing new GPS points for improving the distribution model.

Model results made it possible to: 1) update the Javan leopard distribution on the island; 2) identify the gaps in the sampling database; 3) evaluate the suitability of the landscape for the species occurrence; 4) identify good patches for Javan leopards to be considered for different conservation purposes; and 5) identify the need for more field surveys to confirm the species presence in production forest and small good patches.

Recommendations

1) Generate different models, one for leopard presence and the other for human-leopard conflict, as the resulting predictions may vary, and model results should be used for different purposes in conservation;
2) Continue updating the distribution model for Javan leopards, including new presence points;
3) Continue updating the conflict database for further modeling;
4) Prioritize new surveys in the larger good patches identified by the model but with no species records to confirm its presence;
5) Prioritize surveys in the production forests in order to confirm the species presence, especially in eastern Central Java and East Java; and
6) Run a conflict model and a corridor model to be analyzed and used with the SDM, improving and supporting decisions for Javan leopard conservation.

For more information on species distribution modeling published subsequent to the PHVA workshop, refer to Wibisono *et al*. (2018) at: https://doi.org/10.1371/journal.pone.0198369. This analysis emphasizes the importance of maintaining connectivity among protected areas and is being used to update the IUCN Red List assessment for Javan leopards.

Contributors

The following individuals provided the data used in the SDM modeling:

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MODELING REPORT: Population Viability Analysis (PVA)

PVA Modeler: Kathy Traylor-Holzer, IUCN SSC Conservation Planning Specialist Group

The purpose of this Population Viability Analysis (PVA) was to develop a *VORTEX* population model for the Javan leopard (*Panthera pardus melas*) that could be used to identify those factors that are most critical to population viability, identify important data gaps that impact leopard viability and management decisions, provide a general assessment of viability for the taxon, and provide guidance on the relative benefit of various management strategies. PVA results informed discussions by the PHVA working groups regarding research and management recommendations.

The simulation software program *VORTEX* (v10.2.17) was used to conduct the Javan leopard PVA. *VORTEX* is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. *VORTEX* models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by either creating individuals to form the starting population or importing individuals from a studbook database and then stepping through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate both demographic stochasticity and annual environmental variation. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of *VORTEX* and its use in population viability analysis, see Lacy (1993, 2000) and Lacy *et al.* (2017).

Computer modeling is a valuable and versatile tool for quantitatively assessing risk of decline and extinction of wildlife populations, both free ranging and managed. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA). The usefulness of a PVA is dependent upon the quantity and quality of data available on the biology of the species, its current population status, and current and future threats. Limited data mean limited applicability of the results; however, PVA often can provide useful information even with a modest amount of data.

Javan leopard PVA model development

A preliminary *VORTEX* biological model for Javan leopards was developed based on input values used to model African leopards in South Africa (Daly *et al.* 2005), with some modifications to better represent Javan leopards. This preliminary model was reviewed, discussed and revised by Javan leopard experts (government, NGO and zoo representatives) at a two-day model development workshop held at Taman Safari Indonesia in May 2017. A revised PVA model was reviewed during another two-day model development workshop held in January 2018 immediately prior to the PHVA, resulting in the final base model that was used during the PHVA as a basis for sensitivity testing and viability projections. The model operates on a one-year time step, with projections running for 100 years into the future (500 iterations per scenario). The final values used in the baseline model are described below.

Species biology model inputs

Breeding structure

Javan leopards are generally solitary except for females with dependent offspring or during breeding. The mating system is polygyny, with males typically breeding with females that occupy overlapping or adjacent territories. While there are no true pair bonds or paternal care, there is some probability that a male may sire consecutive litters with the same female, as adults may maintain their territories for many years. This breeding structure was modeled as long-term polygyny, with breeding females given a 50% chance of mating with the same male as they did for their previous litter. A male's territory usually overlaps with that of 2-3 females, but up to 5 females have been observed overlapping a male in Baluran. A maximum of 5 female mates per year was set for each adult breeding male; in the model this would only occur with highly female-biased sex ratios. All males age 4 years and older were considered as potential breeders in the model, with no difference in reproduction based on age.

Reproductive rates and lifespan

Age of first reproduction was set at age 3 years for females and age 4 for males, similar to that used for African leopards (Daly *et al*. 2005). Female reproduction may vary with age, with young females not always rearing a litter their first year, and with older females potentially losing fertility, as seen in captivity for Javan leopards (Sultan and Kern 2018) and other large felids. The probability of an adult female with no dependent offspring producing a litter in a given year was modeled as follows: 50% (age 3); 95% (ages 4-13); 50% (age 14 and older). Offspring stay with their dam for almost two years, during which time the female does not breed again. The model prevented adult females with any dependent young from reproducing. Factoring in expected mortality of dependent offspring (see below), these rates translate into an inter-birth interval (IBI) of 1.75 years (i.e., average time between consecutive litters for a female).

There are few data available regarding reproductive lifespan in females in the wild. One wild female produced litters until she was at least 12 years old but not later despite continued presence of her mate, possibly suggesting reproductive senescence. Some participants believed that Javan leopards may remain reproductive as they age given the absence of top carnivore competitors after the extirpation of Javan tigers. It was decided not to impose reproduction senescence in the model, i.e., adults remain capable of reproduction until death. Maximum age was set at 18 years, based on camera trap data indicating at least one wild male living to this age. At least one captive-born Javan leopard lived to be 20 years.

African wild leopard litters range from 1 to 4 cubs, with mean litter size = 1.92 (see Daly *et al.* 2005). Both field and studbook data suggest that Javan leopards have smaller litters. Captive data from the Javan leopard studbook (Sultan and Kern 2018) indicate a maximum of 2 cubs, with 79% of litters consisting of singletons. Two cubs are seldom observed in camera traps in the wild, with singletons typically observed. Litter size was modeled as 80% with one cub and 20% with two cubs (i.e., mean = 1.2 cubs at birth), with equal sex ratio at birth.

Mortality rates

Little data are available for mortality rates in wild Javan leopards. In addition to natural causes of mortality (e.g., injury, disease, aging processes), Javan leopards are lost from the population through hunting, human-leopard conflicts and other human-related threats.

In the absence of significant threats such as hunting, Javan leopard populations would be expected to be capable of growth typical for their life history characteristics. Mortality rates for Javan leopards that assume the absence of such threats were estimated based on consideration of studbook captive data (for juvenile mortality) and on expert opinion informed by Javan leopard, African leopard and large felid life history traits.

In a pattern typical of many species, first-year mortality starting at birth was estimated to be relatively high, followed by moderate sub-adult mortality, relatively low mortality for prime age adults, and increasing mortality in aging individuals (see Table 2 for age-specific rates used in the model). In some polygynous species, dispersing males experience higher mortality than females; however, there is no evidence of higher injuries or mortality for male vs female Javan leopards and so no sex-related differential mortality was applied in the model. First-year mortality was adjusted (lowered) so as to avoid double-counting deaths of dependent young if their dam died (incorporated directly upon dam's death in the model). These mortality rates were adjusted to produce deterministic growth rates expected to match generation time and other life history traits associated with intrinsic growth rate.

Table 2. Annual mortality rates and EV used in the Javan leopard *VORTEX* base model and sensitivity testing. Survival rates are given for clarification only; only mortality rates were used in the model.

Age class (yr)	**Base model values**			**Sensitivity testing values (base survival rate = 's')**									
	Annual mortality rate (%)	**EV (%)**	**Annual survival (%)**	**Survival rates (%)**					**Resulting mortality rates (%)**				
				1.1s	**1.05s**	**Base**	**0.95s**	**0.9s**	**1.1s**	**1.05s**	**Base**	**0.95s**	**0.9s**
0	30	6	70	77	73.5	70	66.5	63	23	26.5	30	33.5	37
1	10	2	90	99	94.5	90	85.5	81	1	5.5	10	14.5	19
2	14	2.8	86	94.6	90.3	86	81.7	77.4	5.4	9.7	14	18.3	22.6
3-9	7	1.4	93	100	97.65	93	88.35	83.7	0	2.35	7	11.65	16.3
10-15	10	2	90	99	94.5	90	85.5	81	1	5.5	10	14.5	19
16-18	20	4	80	88	84	80	76	72	12	16	20	24	28

When combined with the above reproductive rates, this survival schedule leads to an annual intrinsic (deterministic) growth rate of 4.8% and a generation time (i.e., average age of reproduction) of ~8 years. These attributes are reasonable for a mammal species with this general life history, little competition, and a population that is not under excessive threat, and are similar to other large felid species. Deterministic growth rate is lower and generation time higher than in the African leopard model (Daly *et al*. 2005) due to smaller litter size and longer lifespan observed in Javan leopards.

Variation in demographic rates

Actual reproductive and mortality rates vary from year to year in the real world and can impact population viability, especially for small populations. The *VORTEX* model incorporates stochastic (chance) variation in four ways that represent the sources of stochasticity outlined by Shaffer (1981). First, the actual proportion of leopards surviving and reproducing each year varies around the mean rate due to chance based on population size. Secondly, annual variation in environmental conditions (EV) can lead to good or poor survival and/or reproduction from year to year. This was incorporated into the mortality rates in the model by adding EV as a standard deviation of 20% of the mean rate for all mortality rates (see Table 1), and SD=10 for reproductive rate. EV for reproduction and survival were correlated, such that model years that are good for survival are also good for reproduction and vice versa.

A third source of variation are catastrophic events, which could be natural (e.g., fire, disease) or anthropogenic (e.g., toxin contamination). For example, many Javan leopards were lost when Mount Merapi erupted in 2010. A non-specific catastrophic was added to the model that represents the loss of 50% of that population at a very low frequency (~once in 54 years, or 1.85% risk per year). This is the default setting for the model and is based on an assessment of 88 vertebrate populations that found the risk of severe population decline ($\geq$ 50%) to be approximately 14% per generation (Reed *et al.* 2003).

Genetic processes are also incorporated into the model, both as the random loss of genetic variation (genetic drift) and as inbreeding depression (lower viability of inbred individuals). *VORTEX* models inbreeding depression as reduced survival in inbred juveniles; the severity of the effect is determined by the number of lethal equivalents (LE) in the model. O'Grady *et al*. (2006) concluded that 12 lethal equivalents spread across survival and reproduction is a realistic estimate of inbreeding depression for wild populations. The leopard model incorporated the default setting of 6.29 LEs as the recommended conservative estimate of inbreeding impacts.

Regulation of population size

No density-dependent reproduction or mortality was incorporated into the model. When population size (N) exceeds carrying capacity (K), population size is controlled by the probabilistic removal of sub-adults (distributed as 30% for two-year-old females, 30% for two-year-old males, and 40% for three-year-old males), followed by probabilistic additional removal of young or old leopards if necessary (i.e., leopards under 4 years old or over 13 years old) to bring the population approximately back to K. This simulates potential higher mortality and/or dispersal rates for young or old leopards if the habitat patch is saturated, preserving the survival of prime age adults, which are most likely to retain territories successfully in crowded conditions. Sub-adult males are believed to be more likely to disperse given the polygynous mating system and social structure and so are given a higher probability of leaving the population than sub-adult females.

Sensitivity testing of mortality rates

Mortality rates for the base model were derived to produce a reasonable age structure, survivorship and other population characteristics expected for a large, healthy leopard population capable of positive growth. Actual mortality rates for Javan leopards may be quite different, especially for populations subjected to hunting or removals due to conflict. Depending upon the mating system and other life history characteristics, species may be more vulnerable to increased mortality of certain age and/or sex classes. Sensitivity testing was conducted to explore the relative impact of proportional changes in survival for juveniles (first year), sub-adults (ages 1 and 2), and adults (age 3+). Survival was changed $\pm$ 5% or $\pm$10% of the base value (see Table 2 for specific values used). For this comparison it is more appropriate to apply proportional changes to survival rather than to mortality. The model was initiated with the starting population (stable age distribution) at the habitat carrying capacity, with no future loss of habitat and no connectivity with other leopard populations. All scenarios were run with N=K=500 to minimize results being driven by random stochastic impacts affecting small populations. For comparison, base stochastic growth rate (r_{stoch}) = 0.031.

Impact of survival by age

The survival rates of juveniles, sub-adults and adults all influence population growth rates in the Javan leopard model. However, the same proportional change in adult survival has the greatest impact and, if large enough, can lead to population decline. A $\pm$5% change in juvenile survival leads to small changes in growth (r_{stoch}= 0.025 and 0.038, respectively), while similar changes in sub-adult survival have larger impacts (r_{stoch}= 0.013 and 0.052) that influence population size. A $\pm$5% change in adult survival has a significant impact on population growth (r_{stoch}= -0.026 and 0.086), with reduced survival leading to strong population decline, substantial extinction risk (PE_{100Y}=0.216), and reduced genetic diversity. To put this in context, a 5% reduction in adult survival represent the loss of about one additional adult per year for every ~32 leopards in a population.

Impact of survival by sex

In polygynous species it is the survival of breeding age females that is most important, as females are the limiting sex on reproduction and population growth. When a ±5% change in survival was applied to only one sex for sub-adults or adults, model results suggest that this magnitude of change in males has very little impact on the population. In contrast, applying this change to females has major impacts in growth, population size, extinction risk and loss of genetic variation (Figure 5). The loss of an adult female not only lowers the reproductive potential of the population but also leads to the death of any dependent offspring she may have.

Decreasing adult male survival by greater amounts leads to slower growth and limited ability for even a large population to recover from a catastrophic event. Reductions in male survival of 40-50% result in significant demographic and genetic impacts and extinction risk. These results assume that surviving males breed successfully with up to 5 female mates. Impacts of lower survival for any sex or age class will be greater for actual leopard populations, which are significantly smaller than 500 animals; however, these results demonstrate the importance of monitoring and minimizing the loss of females from Javan leopard populations.

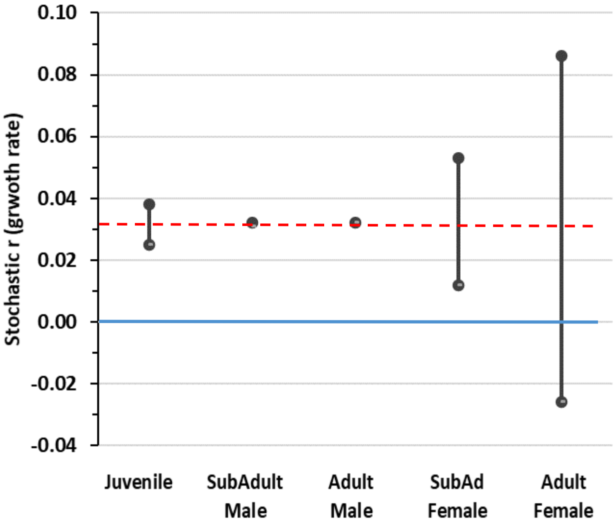

Figure 5. Sensitivity analysis results (stochastic growth rate) for ±5% change in annual survival. Blue line indicates no growth; red dashed line indicates base value of 0.031.

Factors affecting population viability

The *VORTEX* model for Javan leopards was developed based on the best available data and expert opinion of the participants at the PVA and PHVA workshops. This base model represents a single isolated leopard population in the absence of significant threat (e.g., poaching or habitat loss) and with the potential for positive growth if habitat availability permits. If applied to a hypothetical large panmictic (interbreeding) population of 500 leopards, model results indicate a generally healthy population with an overall stochastic annual growth of ~3%, retention of high levels of genetic variation, the ability to recover from severe short-term decline, and no risk of extinction over 100 years in the absence of additional threats.

Unfortunately, Javan leopard populations are not large and also are not free from threat. This subspecies is endemic to the island of Java, where habitat conversion and fragmentation as well as hunting across this densely human-population landscape has led to severe population decline and local extinctions in the past two decades. As evidenced by the species distribution modeling conducted in concert with the PHVA, Javan leopard populations are small and fragmented across the island with limited connectivity (Figure 6). There are no reliable population estimates of wild Javan leopard populations, but few contiguous habitat patches are likely to contain more than 40-50 leopards, and most are subject to hunting and human-leopard conflict.

Estimates of population size and fragmentation

Population size and structure can greatly influence the viability of wildlife populations. Small isolated populations are more vulnerable to stochastic processes such as random fluctuation in demographic rates, variation in environmental conditions, and genetic drift (Shaffer 1981). Understanding the approximate size and degree of connectivity of Javan leopard populations across Java will help to estimate the vulnerability of this taxon to stochastic processes and its risk of severe decline or extinction.

The *Javan Leopard Conservation Strategy and Action Plan for 2016-2026* reports a decline in Javan leopard populations over the past 15 years due to declines in habitat and prey populations in combination with an increase in poaching activities (LHK 2015). An initial estimate from this report of total population size across Java based on extrapolation of available habitat and leopard density is 491-546 individuals, with population estimates given for 48 habitat areas based on multiple scientific studies. Connectivity among these areas is uncertain.

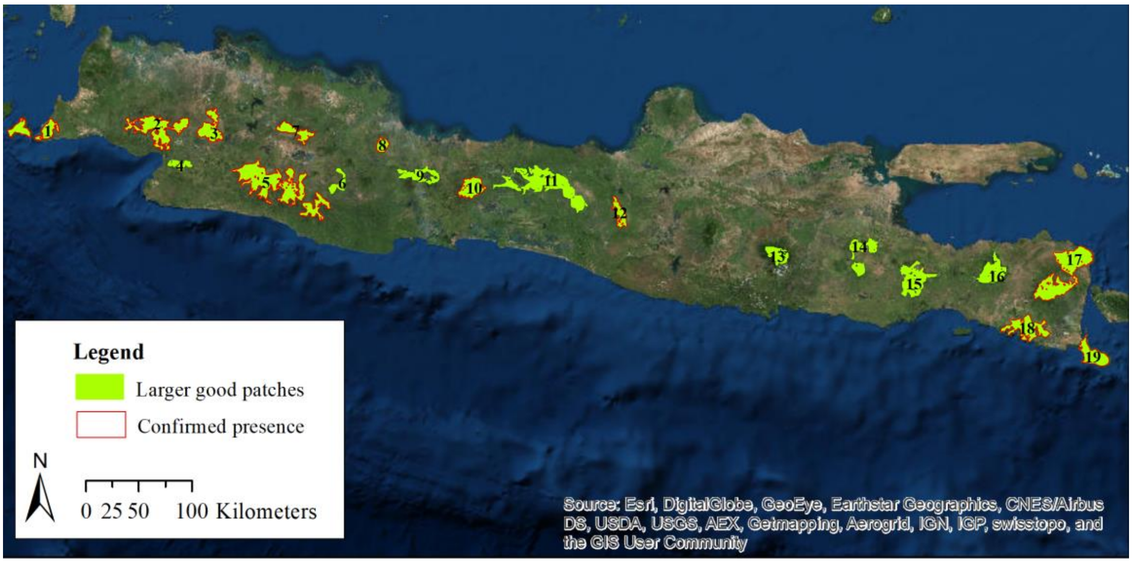

Figure 6. Map indicating larger good patches (≥ 100 km^2) for leopards on Java (from SDM results).

Species distribution modeling (SDM) conducted in conjunction with this PVA and the PHVA workshop identified 19 larger good patches, i.e., patches ≥100 km^2 that are considered suitable and have a high probability of Javan leopard presence as predicted by bioclimatic, land cover, ruggedness and human population density. Eleven of these 19 areas have confirmed leopard presence. Few data are available regarding leopard occurrence in production forests, so it is possible that there are additional good patches in this habitat type. Details of this analysis can be found in SDM section of this report. As can be seen in Figure 6, most of these patches appear isolated, with any dispersing leopards needing to navigate areas of higher human density and potential conflict.

Workshop participants were not confident in providing estimates on leopard population size, connectivity, and level of threats (e.g., hunting, conflicts) for these identified habitat patches. Based on patch size, population estimates for specific locations in the *Javan Leopard Conservation Strategy and Action Plan*, and rough estimates provided by PHVA participants for some areas, however, many Javan leopard populations may be fewer than 30 leopards and perhaps few or none larger than 60-70.

Without good information on population numbers, trends and threats such as hunting intensity, it is not possible to generate precise viability projections for Javan leopard populations or for the entire subspecies in the wild. However, as with survival rates, sensitivity analysis can be used to explore the impact of factors such as population size on leopard population viability. This analysis can help:

- Define the scope of uncertainty in model results for leopard populations;
- Identify the primary factors affecting population viability;
- Identify important data gaps in current knowledge; and
- Inform research and management decisions for Javan leopards.

Impact of population size on viability

Scenarios were run on populations at carrying capacity for isolated populations with N=K=10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 to encompass the probable range of fragmented Javan leopard populations. Additional scenarios for populations of 200, 300, 400 and 500 were run to better assess the population size necessary for long-term viability across various demographic and genetic measures. As with the sensitivity testing for survival, all scenarios were initiated with stable age distributions and assumed no connectivity and no additional threats such as hunting or habitat loss. Scenario results (500 iterations per scenario) are presented in Table 3.

Table 3. Model results for isolated Javan leopard populations of various size modeled for 100 years. N=population size; K=carrying capacity; GD=gene diversity; PE=probability of extinction. Mean N_{100Y} and GD_{100Y} are calculated at Year 100 and for only those iterations in which the population did *not* go extinct.

Population size (N=K)	Growth rate (r_{stoch})	Mean ±SD N_{100Y}	Mean GD_{100Y}	PE_{100Y}	Mean N_{100Y}/K
10	--	--	--	1	--
20	-0.0108	8±3	0.490	0.986	0.40
30	-0.0099	12±7	0.570	0.842	0.40
40	-0.0064	15±11	0.594	0.682	0.38
50	-0.0028	22±14	0.672	0.526	0.44
60	0.0001	28±19	0.708	0.400	0.47
70	0.0037	37±22	0.758	0.316	0.53
80	0.0059	42±27	0.766	0.222	0.53
90	0.0073	48±29	0.790	0.200	0.53
100	0.0116	59±32	0.816	0.156	0.59
200	0.0240	147±61	0.908	0.028	0.74
300	0.0281	229±90	0.936	0.008	0.76
400	0.0305	312±115	0.954	0.006	0.78
500	0.0312	397±141	0.963	0	0.79

As expected, small populations have lower viability than larger ones. The smaller the population, the slower the growth rate and faster the decline in population size, the faster the loss of genetic diversity and accumulation of inbreeding, and the higher the risk of extinction. Isolated populations of 30 or fewer leopards have a high risk of extinction (>84%) within 100 years, with any persisting populations becoming smaller and highly inbred. Populations of 40-70 leopards fare better but still have relatively low viability, with high extinction risk, substantial decline in population size over time, and loss of genetic variation equivalent to a full sibling population. Model results suggest that a panmictic (interbreeding) population of 200-300 leopards, free from additional threats, is required to meet common indicators of viability. Populations of this size have relatively low risk of extinction

(<3%), retain at least 90% gene diversity, and generally show positive growth and the ability to recover from short-term catastrophic decline. Additional threats may lower the viability of populations of this size.

Impact of fragmentation

While precise estimates for fragmented Javan leopard populations are not available, it is probable that most populations may not be viable long term if isolated, even in the absence of additional threats such as habitat loss, hunting or decline in prey. To further illustrate the negative stochastic impacts of population fragmentation, a scenario was developed to compare one interbreeding population of 300 leopards with 15 isolated populations of 20 leopards each (total N=300).

Figures 7 and 8 illustrate the results for the single population (blue line) and the combined population of 15 sub-populations of 20 leopards each (red line). While both scenarios begin with 300 leopards at carrying capacity, demographic and genetic stochastic (random) processes lead to strong decline when the population is highly fragmented (Figure 7). Isolation also leads to loss of genetic diversity (Figure 8); this leads to extreme levels of inbreeding in isolated populations (mean F=0.4937) but low inbreeding in a large single population (mean F=0.0508). The single population has little extinction risk over 100 years (PE=0.008), while the fragmented group of sub-populations has a risk of complete extinction of PE=0.544 in 100 years, with a mean of 10 leopards in iterations that do not go extinct.

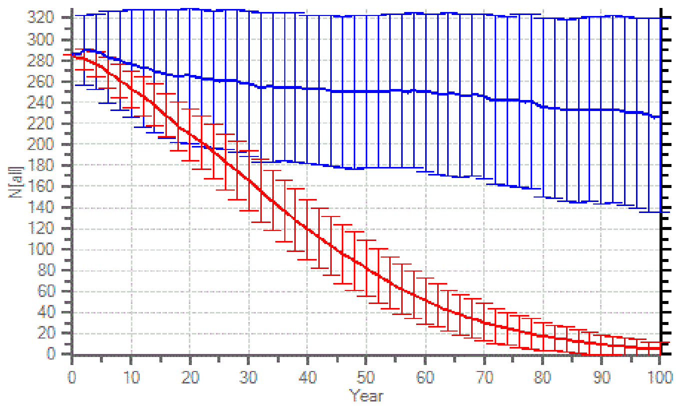

Figure 7. Mean population size (N) for all iterations for a single population (blue) and combined 15 isolated populations of 300 leopards total. Error lines represent ± 1 SD.

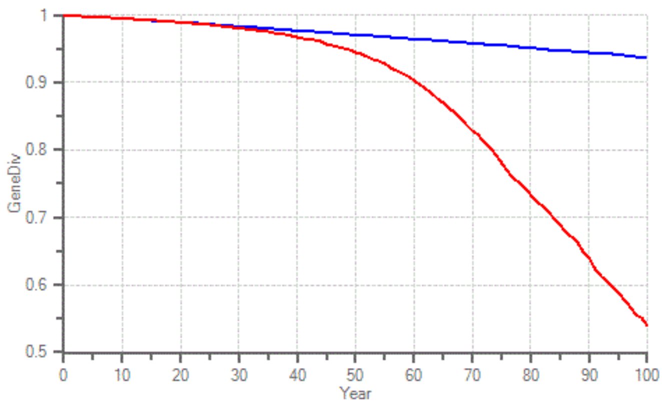

Figure 8. Mean gene diversity (GD) for a single population (blue) and combined 15 isolated populations of 300 leopards total.

Impact of supplementation

Many of the occupied habitat patches may support a small number of leopards and are expected to have low viability if isolated, even without additional threats. The periodic addition of leopards to such populations, whether through natural connectivity or by managed translocations, has the potential to demographically and genetically supplement small populations and improve their size and persistence. Scenarios were developed to explore the supplementation of one young, unrelated adult female, or one young unrelated adult male, once every 2, 5 or 10 years to a small population of leopards (initial N=K=20). These scenarios assume that young adult supplements have normal adult survival, are able to secure territories, and have a high probability of breeding.

All supplementation scenarios led to demographic and genetic benefits, including larger mean population size, higher genetic diversity, lower inbreeding, and lower risk of extinction given the model assumptions. Supplementing with either sex helps to counteract the random loss of genetic variation through genetic drift, assuming supplements are as likely to survive and breed as resident adults. In contrast, demographic impacts differed by sex. The addition of young adult females increases the reproductive potential of the population and therefore its stochastic growth rate. This, in turn, significantly decreases extinction risk (Table 4).

These supplementation scenarios are based on simplifying assumptions but demonstrate how periodic supplementation potentially can improve the viability of small populations. Natural dispersing leopards may be more likely to be males, whereas intentional human-mediated releases may be managed to address specific demographic and/or genetic needs of a population. Any management actions to improve connectivity (e.g., through corridors) or to supplement populations through translocation should be assessed carefully to consider all potential impacts, risks and feasibility concerns not addressed in this modeling exercise.

Table 4. Model results for a population of 20 Javan leopards over 100 years, with and without supplementation. N=population size; K=carrying capacity; GD=gene diversity; PE=probability of extinction. Mean N_{100Y} and GD_{100Y} are calculated at Year 100 and for only iterations in which the population did not go extinct. M=adult male; F=adult female.

Supplements	**Growth rate (r_{stoch})**	**Mean N_{100Y}**	**Mean GD_{100Y}**	**PE_{100Y}**	**Mean N_{100Y}/K**
None	-0.0108	8±3	0.490	0.986	0.40
1M/10yr	-0.0068	11±5	0.771	0.830	0.55
1M/5yr	-0.0071	14±5	0.837	0.774	0.70
1M/2yr	-0.0120	16±4	0.902	0.758	0.80
1F/10yr	0.0023	12±6	0.751	0.530	0.60
1F/5yr	0.0181	16±5	0.818	0.282	0.80
1F/2yr	0.0502	18±3	0.888	0.202	0.90

Exploration of general viability of specific Javan leopard populations

During the PHVA workshop, several participants provided rough population estimates (minimum, maximum, and best guess) for some of the Javan leopard populations, along with estimates of habitat carrying capacities, estimated migrants into the population, and estimated losses (via hunting and other threats). For each population, scenarios were run to explore the relative viability of such populations using these best estimates and also with periodic supplementation.

Note that these are not official estimates and may not be accurate; therefore, ***these results should <u>not</u> be considered as precise viability estimates for these populations, but rather as a guide*** *to provide a sense of the relative viability for Javan leopards in these areas.*

Table 5 provides the model inputs for these nine populations. General findings for each population are given below. For simplicity the term “supplement” is used to represent new, unrelated young adult leopards that enter a population; such leopards could represent natural migrants through habitat corridors and/or could be achieved through human-mediated translocations. Potential negative consequences such as increased disease risk or behavioral consequences are not included in these scenarios and would alter the results.

Table 5. Model inputs for nine select Javan leopard populations for current population size (Est N=best estimate for current population size; Min N=estimated minimum size; Max N=estimated maximum size), carrying capacity (best, minimum and maximum estimates as for N), estimated natural migrants into population, and estimated losses from hunting or other methods. M=adult male; F=adult female.

Population	Est N	Min N	Max N	Est K	Min K	Max K	Est. migrants	Est. losses
Baluran	35	31	47	46	42	58	none	none
Ujung Kulon	35	25	39	88	63	98	none	none
Alas Purmo	38	36	44	62	62	62	none	none
Meru Betiri	20	18	30	87	87	87	none	none
Malabar	8	7	12	15	15	15	1M per 5years	none
TNGGP	24	22	26	40	40	40	1M per 5years	1 adult per 5 years
Syawal	6	5	8	12	12	17	1M per 5years	1 M each year; 1F per 10 years
Halimun Salak	40	35	46	135	135	135	1M per 5years	1-2 M each year; 1F per 4 years
Guntur Pap	8	6	10	15	15	15	1M per 5years	1 M each year

Baluran *(best estimates: N=35; K=46; isolated; no losses)*

Projected poor viability without frequent supplementation, including females

This population shows the potential to grow initially since it is estimated to be below K but is projected to generally decline over time, with high loss of genetic diversity (GD_{100Y}=0.66-0.75) and high risk of extinction (PE_{100Y}=0.45-0.67). One successful supplement (young adult leopard) every 5 years provides genetic benefits such that the population maintains ~85% gene diversity with only moderate levels of inbreeding. If these supplements are all females, this rate of supplementation provides a significant demographic boost as well, eventually stabilizing population size after several decades at around its current size and reducing extinction risk to ~5% over 100 years. If supplements are males only, more frequent supplementation is required to gain significant demographic benefits. Adding one adult male every year helps to slow population decline and reduce extinction risk to PE_{100Y}=0.28. While frequent male supplements may promote high gene diversity and low inbreeding, the continued small number of breeding females in the population combined with small size makes the population vulnerable to demographic stochastic events unless additional females are added.

Ujung Kulon *(best estimates: N=35; K=88; isolated; no losses)*

Projected poor viability without frequent supplementation, including females

In the absence of additional threats and assuming a stable age/sex distribution and little inbreeding to date, this population shows the potential to grow substantially since it is estimated to be significantly below the carrying capacity of the habitat. Population projections show high variation in numbers but, on average, suggest that the population is likely to decline slowly over time if it remains isolated, with significant loss of genetic diversity (GD_{100Y}=0.72-0.80) and high risk of extinction (PE_{100Y}=0.31-0.54). One successful supplement (young adult leopard) every 5 years provides genetic benefits such that the population maintains ~87% gene diversity with only moderate levels of inbreeding. Supplements of either sex provide demographic benefits as well, helping to stabilize mean population size well above current levels and reducing extinction risk. Female supplements provide the greater benefit, maintaining a larger population on average with very low risk of extinction (PE_{100Y}=0.025), while supplementing with only males requires adding a male every 1-2 years to achieve a similar size and still results in a moderate risk of extinction (PE_{100Y}=0.14) due to lower potential for the population to recover from stochastic events.

Alas Purwo *(best estimates: N=38; K=62; isolated; no losses)*

Projected poor viability without frequent supplementation, including females

In the absence of additional threats and assuming a stable age/sex distribution and little inbreeding to date, this population shows the potential to grow initially since it is estimated to be significantly below the carrying capacity of the habitat. Population projections show high variation in numbers but, on average, suggest that the population is likely to decline below current levels over time if it remains isolated, with significant loss of genetic diversity (GD_{100Y}=0.71) and high risk of extinction (PE_{100Y}=0.39-0.44). One successful supplement (young adult leopard) every 5 years provides genetic benefits such that the population maintains ~86% gene diversity with only moderate levels of inbreeding. Supplements of either sex provide demographic benefits by slowing decline and reducing extinction risk. Female supplements provide the greater demographic benefit, maintaining a larger population that, on average, stabilizes above its current size with very low risk of extinction (PE_{100Y}=0.02), while supplementing with males once each 5 years still leads to high extinction risk (PE_{100Y}=0.24). Adding a male every 1-2 years improves average population size but still results in a moderate risk of extinction (PE_{100Y}=0.18) due to lower reproduction potential for the population to recover from stochastic events.

Meru Betiri *(best estimates: N=20; K=87; isolated; no losses)*

Projected poor viability without frequent supplementation, including females

This population is estimated to be currently small but with significant available habitat to expand. In the absence of additional threats and assuming a stable age/sex distribution and little inbreeding to date, this population shows the potential to grow substantially if it is below the carrying capacity of the habitat. Population projections show high variation in numbers but, on average, suggest that the population is likely to stabilize or decline slowly over time if it remains isolated, with significant loss of genetic diversity (GD_{100Y}=0.69-0.74) and high risk of extinction (PE_{100Y}=0.41-0.65). One successful supplement (young adult leopard) every 5 years provides genetic benefits such that the population maintains ~86% gene diversity with only moderate levels of inbreeding. Supplements of either sex provide demographic benefits as well, allowing the population to grow faster and helping it to stabilize well above current levels with less extinction risk. Female supplements provide the greater benefit, maintaining a larger population on average with low risk of extinction (PE_{100Y}=0.063), while supplementing with only males requires adding a male every 1-2 years to achieve a similar size and still results in a moderate risk of extinction (PE_{100Y}=0.23-27) due to lower reproductive potential for the population to recover from stochastic events.

Malabar ***(best estimates: N=8; K=15; 1 male migrant per ~5 years; no losses)***

Projected very poor viability without frequent supplementation of both sexes

This small population has high risk of extinction (PE_{100Y}=0.88-0.91) even with periodic male migrants, and extinction is essentially certain within 100 years if isolated (median time to extinction = 29 years). Periodic migrants or supplements of either sex can boost genetic diversity to lower inbreeding impacts, but this likely to be insufficient to avoid extinction unless females are added as well as males. The addition of one male and one female per 5 years improves genetic diversity to moderate levels (GD_{100Y}=0.88) and reduces extinction risk of the population to ~2%. Good connectivity to other leopard populations and/or regular supplementation of both sexes will likely be necessary to maintain a Javan leopard population in an area with such low carrying capacity.

TNGGP ***(best estimates: N=24; K=40; 1 male migrant per ~5 years; loss of 1 adult per ~5 years)***

Projected poor viability without frequent supplementation, including females

This population shows the potential to grow initially since it is estimated to be below K but then is projected to generally decline over time. If isolated, decline is more steady and leads to significant loss of genetic diversity (GD_{100Y}=0.59) and a high risk of extinction (PE_{100Y}=0.72). The estimated level of migrants above slows decline and improves GD (GD_{100Y}=0.85), but extinction risk is still high (PE_{100Y}=0.44-0.48). Additional supplements improve genetic diversity above 90%, maintain a slightly larger population, and reduce extinction risk. However, females must be supplemented to provide increased reproductive potential to withstand stochastic effects. The additional supplementation of one young adult female per 5 years lowers the extinction risk to PE_{100Y}=0.07. Like many of the other small Javan leopard populations, frequent male supplements may promote high gene diversity and low inbreeding but cannot counteract the vulnerability of the small population to demographic stochastic events unless additional females are added.

Syawal ***(best estimates: N=6; K=12; 1 male migrant per ~5 years; loss of 1 male each year and 1 female per ~10 years)***

Projected very poor viability without frequent supplementation of both sexes plus reduced losses

This small population has high risk of extinction (PE_{100Y}=0.85-0.95) even with periodic male migrants, and extinction is essentially certain within 100 years if isolated (median time to extinction = 21 years). Periodic migrants or supplements of either sex can boost genetic diversity to lower inbreeding impacts; however, extinction risk remains high even with female supplementation (e.g., PE_{100Y}=0.84 with addition of 1 female per 5 years) due to the periodic losses of leopards from the population along with other demographic stochastic events. Reduction in leopard losses along with good connectivity to other leopard populations and/or regular supplementation of both sexes will likely be necessary to maintain a Javan leopard population in an area with such low carrying capacity.

Halimun Salak ***(best estimates: N=40; K=135; 1 male migrant per ~5 years; loss of 1-2 males each year and 1 female per ~4 years)***

Projected poor-moderate viability without periodic supplementation, including females

This population is estimated to be currently small but with significant available habitat to expand. With the level of migrants and losses estimated above, this population shows the potential to grow substantially and then stabilize, on average, at approximately twice its current size, although population projections show high variation in numbers. Periodic migrants and larger population size enable the population to retain modest genetic diversity (GD_{100Y}=0.89) but with significant risk of extinction (PE_{100Y}=0.13-0.20). Additional supplements of either sex provide genetic and demographic benefits, allowing the population to grow faster and larger with slightly less extinction risk. Female supplements provide greater benefit, lowering extinction risk to only PE_{100Y}=0.01. Despite periodic losses, this population is more robust due to its larger potential future size if it can successful expand into available habitat. Periodic supplementation, especially with females, can enhance and preserve reproductive potential and allow this population to recover from demographic stochastic events.

Guntur Pap ***(best estimates: N=8; K=15; 1 male migrant per ~5 years; loss of 1 male each year)***
Projected very poor viability without frequent supplementation of both sexes plus reduced losses

This small population has high risk of extinction (PE_{100Y}=0.87-0.89) even with periodic male migrants, and extinction is essentially certain within 100 years if isolated (median time to extinction = 28 years). Periodic migrants or supplements of either sex can boost genetic diversity to lower inbreeding impacts; however, extinction risk remains high even with female supplementation (e.g. PE_{100Y}=0.62 with addition of 1 female per 2 years) due to the periodic losses of leopards from the population along with other demographic stochastic events. Reduction in leopard losses along with good connectivity to other leopard populations and/or regular supplementation of both sexes will likely be necessary to maintain a Javan leopard population in an area with such low carrying capacity.

Summary of population-specific viability exploration

Exploration of potential viability of nine Javan leopard populations given rough best estimates of current population size, carrying capacity, connectivity and human-caused losses (e.g., hunting) suggests that none of these nine populations is likely to be viable long term without active management. Small population size leads to demographic and genetic impacts that result in high extinction risk, even in the absence of hunting or additional habitat loss. Frequent supplementation (natural or mediated) may be necessary to maintain healthy leopard populations, with smaller populations needing more frequent supplementation than larger ones. Management actions to control or eliminate additional losses are also important. Survival (and reproduction) of adult females is key to the persistence of these small populations.

Important Knowledge Gaps

Given the results of this PVA and small population biology principles, the following factors were identified as the most important knowledge gaps for assessing the viability of wild Javan leopard populations and to guide effective management strategies for conservation of this taxon.

Population size and degree of fragmentation: Species distribution modeling helps to identify potential suitable habitat and expected distribution of Javan leopards; however, there are no leopard presence data in some identified suitable patches, and insufficient leopard data for production forest and other potential additional areas. Better estimates are needed for current leopard populations and the degree of connectivity and successful movement of leopards among these habitat patches. Good estimates of distribution, population size and effective connectivity will enable more reliable and population-specific long-term viability projections and also will inform effective management actions.

Demographic rates, especially mortality: Better understanding of wild Javan leopard reproductive rates and age- and sex-specific mortality rates will improve viability projections and may inform management decisions. Understanding the causes of mortality is also important in order to reduce or eliminate threats.

Dispersal: Better understanding is needed on how leopard population size is regulated in small habitat patches, including the sex and age of dispersing leopards. It would be valuable to understand how frequently females are pushed out of available habitat and their resulting fates (i.e., successful dispersal to other leopard populations vs death or capture).

Removal rates: Information on the rate of removal of leopards from wild populations is critical to understanding population viability and critical management actions that may be needed. Removals may include deaths from hunting, snaring or poaching, or the capture and removal of wild leopards, for example, due to human-leopard conflict. Knowledge of sex-specific rates is valuable, as the loss of females has a much greater impact on population viability. Approximate age class (i.e., sub-adult, prime age adult, old individual) and general health also would be useful to compile for killed, captured or confiscated leopards.

Population-specific threats: Threats such as hunting or road kill may differ among different habitats and leopard populations. It is important, both for viability projections and especially for management actions, to understand the type and level of threat for each population. Trends over time for each population would also be useful in understanding current and future viability.

Conclusions

Despite the uncertainty in demographic rates, population size and distribution, and the rates of various human-caused threats of wild Javan leopards, there is sufficient information available for PVA methods to provide useful information to help guide future research and potential management.

General PVA conclusions are as follows:

- Javan leopard distribution is likely to be fragmented across Java, with many suitable habitat patches supporting small populations of probable low viability.
- Connectivity between areas occupied by leopards may improve viability of these populations provided that leopards can disperse between areas with good survival and are able to become established in the recipient population.
- Small leopard populations are likely to require regular supplementation, including with some female leopards, to remain demographically and genetically healthy, whether this occurs naturally or is human-induced.
- The loss of adult leopards due to conflict, hunting or other causes may jeopardize the viability of small populations. Occasional loss of males is less likely to be an issue, while the loss of females can jeopardize small populations by reducing its reproductive potential for growth.
- Good estimates of population size, trend, and threats (causes and sex-specific rates) are required in order to accurately understand the long-term viability of specific leopard populations. That said, most leopard populations on Java may be facing significant risk of decline and extinction unless threats are mitigated, population size is expanded, and/or safe connectivity is established (or achieved through translocations).

The combination of leopard population and habitat fragmentation across Java, combined with significant and perhaps increasing levels of human-leopard conflict, suggest reason for concern for the future viability of wild Javan leopard populations. This PVA suggests important data gaps and potential issues for management consideration in Javan leopard conservation. On an optimistic note, the leopard is a highly adaptive and successful carnivore that can persist in a variety of environments and can tolerate human disturbance. These traits have enabled the Javan leopard to persist with the expansion of human development across the island, while the Javan tiger did not. The flexible nature of this carnivore species may help to enable its successful conservation in a changing and highly disturbed environment.

WORKING GROUP REPORT: Survey Protocols

Working group participants: Agung Siswoyo, Agus Ariyanto, Agus Deni, Agus Priyanto, Anton Ario, Dani Hermawan, Dede Aulia Rahman, Haryo T Wibisono, Irene M.R. Pinondang, Nur Khaliq

This working group was developed to discuss how to achieve the following tasks:

1. Identify and, where needed, adapt and/or develop new protocols to survey/monitor:
   - Leopard presence
   - Prey presence
   - Human-leopard conflict
   - The perception of leopards by people in the region
2. Develop a structure/methodology to:
   - Compile all information on past and future survey efforts on Java in a regular and standardized way; and
   - Create mapes of these survey efforts.

ISSUE: Data gaps for Javan leopard PVA

Various threats to the Javan leopard have increased in the last several years. For example, there is an increase in the incidence of human-leopard conflicts in several locations, both in protected areas and in centers of human activity, from 2009-2018. This trend mainly occurs in one part of West Java, one of the three largest landscapes on the island of Java.

Despite the threats faced by leopards, the conservation of leopards in Java over the past ten years has continued to expand, both in terms of knowledge of ecology and research methods, as well as in the number of parties involved. Based on studies conducted by many parties, including UPT within the Directorate of KKH KLHK (National Park and BKSDA), experts, research institutions, universities, NGOs and volunteers, we have a good understanding of where Javan leopards still remain across Java. However, there has never been an assessment of Javan leopard population status across all of these landscapes.

Population viability analysis (PVA) is a method used to evaluate the threats facing populations of certain species, potential extinction or population decline, and possibly population recovery (Akçakaya & Sjögren-Gulve, 2000). PVA is a model that uses species-specific data as well as computer simulation modeling. Early in its development, the PVA model was only used to assess the minimum viable population for endangered species, but today the use of PVA has evolved from the start of simulating a simple population trend to complex modeling involving spatial and temporal variations. PVA modeling can be done using self-designed scripts, or software that is already available, including: ALEX (Possingham & Davies, 1995), GAPPS (Brook *et al*., 1999), INMAT, RAMAS, STELLA (High Performance System 2001) or VORTEX (Lacy, 2000).

The main challenge in conservation is in making the best decision to prioritize limited resources for conservation (money, energy, knowledge). PVA modeling can help through a methodological approach using all best available knowledge of the species to be protected, and further incorporating them with uncertainty in nature and environmental variability. This process is carried out quantitatively to make risk predictions of each conservation management option available. Thus, PVA is useful for prioritizing research planning and data collection to address data gaps important for predicting species viability (e.g., mortality rate from hunting per age class), assessing susceptibility factors of a population, assessing the impact of threats of anthropogenic pressure, and ranking the existing management options (modified from Akçakaya & Sjögren-Gulve, 2000).

Although it has many benefits, one disadvantage of PVA is the often incomplete data available especially for endangered species. PVA can be useful in consolidating all best knowledge we have for these endangered species, and ultimately raising attention to the knowledge gap that should be targeted at future research needs (Akçakaya, 2000; Akçakaya & Sjögren-Gulve, 2000).

Recommendations for survey protocols

Significant data gaps for Javan leopards limited the ability of PVA to produce precise estimates of Javan leopard viability and to evaluate specific potential management actions (see PVA section of this report). This working group discussed recommendations for developing protocols to compile such data. This can lead to a better understanding of the status and viability of Javan leopard populations across Java and the threats impacting these populations, and can guide future management decisions for the species. Table 6 summarizes the main discussion points and recommendations regarding field survey protocols. Recommended survey locations and existing data are listed in Table 7. Figure 9 below outlines the decision tree for data collection and type.

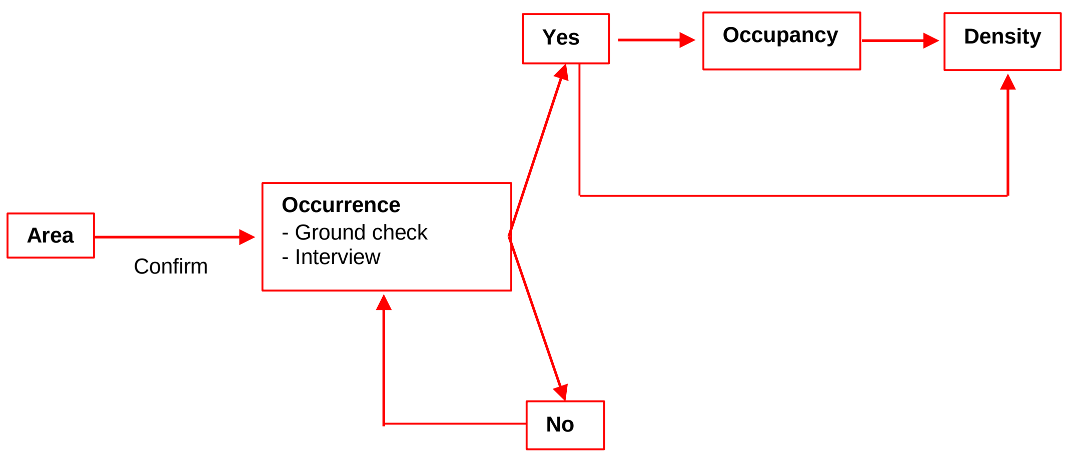

Figure 9. Pre-survey workflow. Timeline = every 5 years.

Table 6. Discussion matrix.

Pre Survey	Survey	Data Management	Important Issues Related to Data and Survey Locations
Prior to the survey, information was extracted regarding the presence or absence of a Javan leopard at a site - this stage follows the workflow (Figure 9) If possible, there should be training to improve skill to recognize scent marks and footprints so that results do not depend only upon information from communities / local people. Scent marking is related to intercultural forms of communication. Most of the traces of leopard presence are scent marking. UPT suggestion,: 1. Bromo Tengger Semeru: working area based on geographical grid (size 1x1 km^2). 2. Gunung Gede Pangrango: information extracted before the survey is conducted. not yet surveyed areas are the next priority. 3. Ujung Kulon: Focus of the survey so far is only on the Javan rhinoceros, but Javan leopards also captured by camera traps; future needs are to consider camera trap placement with the main focus on Javan leopards. 4. Meru Betiri: Surveys are expected not only in conservation areas but also in production areas. It is hoped that there will be protocols regarding conflict outside the conservation area, including protocols within the boundaries of work areas, human resource and funding needs. Includes division of labor, main tasks and joint work for all areas and outside conservation areas.	For the needs of further survey, a new survey protocol will be developed (occurrence, occupancy and density). The occurence survey protocol refers to the survey protocols for **25 priority species** that have been prepared by Anton Aryo (Appendix III). The occupancy survey protocol refers to **the occupancy protocol for the Javan rhinoceros** that have been prepared by Haryo T. Wibisono, with some adjustments in accordance with the ecological condition of the Javan leopard. The density survey protocol follows the SECR (Spatially Explicit Capture-Recapture) model developed by Gopalaswamy (2012, 2014).	Collect / develop standard formats for data compilation. Timeframe for data compilation (proposed once a year) Data center, data validation and data distribution under the responsibility of KKH KLHK and Formata Directorates Periodically the latest data will be sent throughout BKSDA and TN for offices associated with the management of Javan leopards.	The Directorate of KKH KLHK needs to communicate with other institutions related to extracting data and / or information (the existence of Javan leopard) for locations outside its working area. The data center node is the UPT (Tahura area under the responsibility of the district / city / provincial government, National Park under the responsibility of the National Park, Nature Reserve and Wildlife Reserve under the responsibility of BKSDA, and production forest under the responsibility of Perum Perhutani). UPT together with experts, NGOs and academics designate the location of the survey based on information and / or evidence of the presence of Javan leopards and locations that are thought to have high suitable habitat and has an areas > 100 km^2 (result from Maxent). In some sites with small areas (<100 km^2) but suspected or known to be inhabited by Javan leopards, site-specific recommendations need to be made for example in CA Nusa Kambangan case (Table 7) Data sharing agreement (discussed in other survey working group): 1. Standard format of report 2. Data center 3. Data distribution 4. Form of data sharing agreement

Table 7. Recommended survey areas.

SITE	Area size (km^2)	Confirmed evidence	Occurrence	Occupancy	Density	Notes
West Java						
Ujung Kulon National Park	380	YES			YES	
Gede Pangrango National Park	367	YES			YES	
Halimun Salak National Park	726	YES			YES	
Ciremai National Park	148	YES			YES	
Bandung Selatan (Simpang-Tilu-Malabar-Guntur-Papandayan-Limbung-Cikuray-Masigit-Tambak Ruyung)	1528	YES		YES	YES	
Bandung Utara (Sanggabuana-Burangrang-Tangkuban Perahu-Karembi Masigit)	259	YES		YES	YES	
Mount Galunggung	144,3	NO	YES			Priority
Jampang	126	YES		YES		
Pambarisan	296	YES		YES		
Small patches (<100km^2)						
Mount Karang	50				YES	
Cikepuh	81	YES			YES	
Sawal	77	YES			YES	
Central Java						
Mount Slamet	332	YES		YES	YES	
Peg Dieng	1088	YES		YES	YES	
Merapi-Merbabu National Park	182,4	YES		YES	YES	
Ngleman	233,4	NO	YES			Priority
Small patches (<100km^2)						
Nusakambangan Nature Reserve	93	YES			YES	
Muria	90	YES			YES	
Cabak	0,3	YES			YES	
Mount Lawu	85	YES		YES		
Mount Pandan	90	YES	YES			
Ungaran	50	YES		YES		
East Java						
Arjuna-Welirang	349	YES		YES		
Bromo Tengger Semeru National Park	540	YES		YES	YES	
Yang Plateau	391	YES		YES		
Baluran-Ijen-Raung	1097,6	YES		YES	YES	
Meru Betiri National Park	491,9	YES			YES	
Alas Purwo National Park	345,5	YES			YES	
Small patches (<100km^2)						
Mount Kawi	80	NO	YES			Priority
Sempu Island	8,8	YES			YES	

WORKING GROUP REPORT: Survey Challenges

Working group participants: Wahyu Murdyatmaka (Alas Purwo National Park); Senjaya Mercusiana (Gunung Halimun-Salak National Park); Robi Gumilang (Gunung Ciremai National Park); Hariyawan Agung Wahyudi (FORMATA/Copenhagen Zoo)

Issues

1. No information is available on Javan leopard presence/absence in production forest areas in northeastern Central Java and northwestern East Java.
2. The current process of obtaining permits is difficult and lengthy and is an obstacle to conducting survey and monitoring activities required to assess the status of the population and to develop and evaluate conservation actions. Problems causing this issue are not identified, and a mechanism to overcome these problems such that permits can be processed in a short amount of time is not yet developed.
3. Currently it is often difficult to access and compile information that is required to design more effective and timely conservation of Javan leopards. Problems causing this issue, and ways to overcome these problems, are not identified.

Issue 1: Lack of presence/absence data in production forest areas

Protected forest and production forest areas in Java are managed by Perum Perhutani, which has limited resources to do biodiversity surveys, especially for Javan leopards. In addition, there is a lack of biodiversity survey/research in northeastern Central Java and northwestern East Java, since these areas are defined as production forest. None of the NGOs are focusing on biodiversity monitoring.

There is some information about leopard sightings from local communities and also from Perum Perhutani staff; however, since there are no records with GPS locations as well as evidence that can be verified, almost all information on leopards in this landscape is classified as non-reliable data.

A specific issue in Nusakambangan Island is the permit required to enter this area because almost all areas are classified as restricted access since this area is used for prisons. The permit should come from the Ministry of Law and Human Rights. Since species conservation is not yet a focus of the Ministry of Law and Human Rights, it is difficult to get a permit to do surveys on this island, unless done in Nusakambangan Nature Reserve. Unfortunately, the area of the nature reserve in Nusakambangan is very small compared to the needs of Javan leopard sustainability.

<u>Recommendations for Issue 1:</u>

1. Perhutani Unit I and Unit II together with BKSDA Jawa Tengah and BBKSDA Jawa Timur are expected to provide information about leopard sighting in every forest patch in northeastern Central Java and northwestern East Java landscape (see Figure 10 for map and initial locations).
2. If possible, Perhutani Unit I and Unit II together with BKSDA Jawa Tengah and BBKSDA Jawa Timur are expected to provide presence/absence data that includes GPS locations and evidence, as well as date when data were collected.
3. If solution 2 cannot be conducted, Perhutani Unit I and Perhutani Unit II together with BKSDA Jawa Tengah and BBKSDA Jawa Timur are expected to coordinate with KKH and FORMATA regarding mobilizing support in doing presence/absence surveys in location(s) that are not covered.
4. Data will be compiled by KKH and put into the island wide database to update the model.

MAP OF FOREST PATCHES IN NORTH-EAST CENTRAL JAVA AND NOTH-WEST EAST JAVA

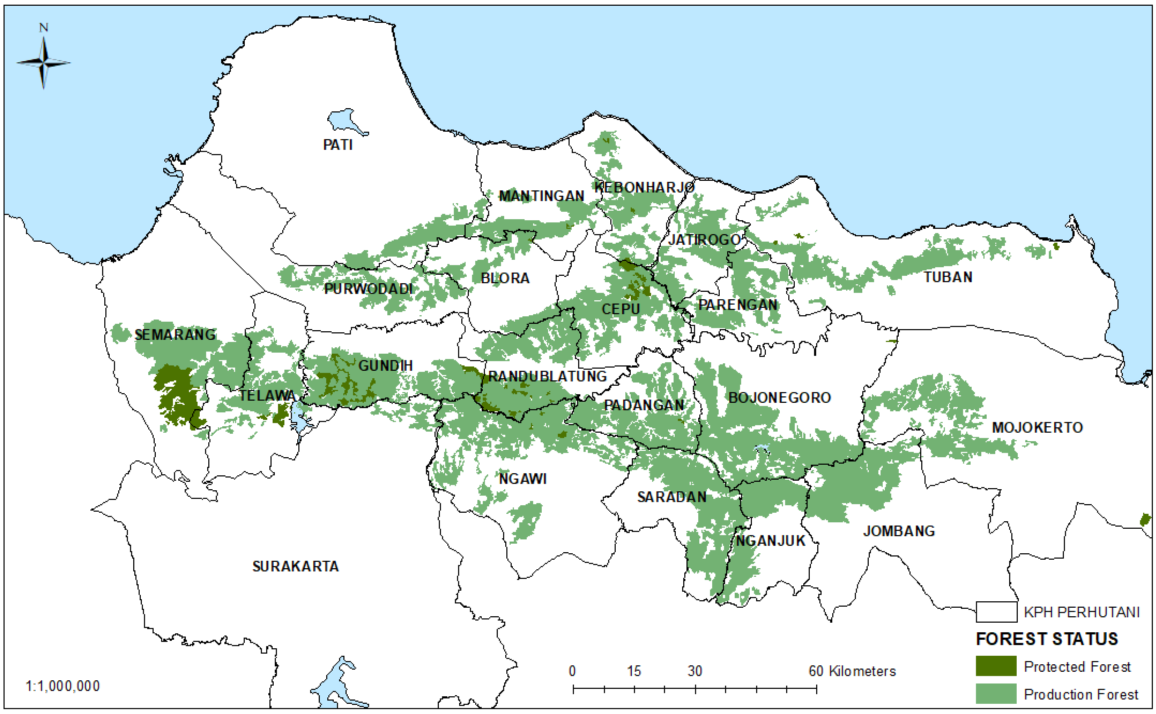

Figure 10. Map of forest patches in northeastern Central Java and northwestern East Java.

Issue 2: Permits

Regulation regarding permits to do research in Indonesia, especially for international organizations, is strict and needs approval from multiple ministries. All activities/programs should be conducted based on specific locations mentioned in the Memorandum of Understanding (MoU). This causes difficulties in some situations when needs come from locations outside of those agreed in the MoU, although the needs come from Indonesia's National Park or other habitats. Such situations cannot be responded to in a short amount of time.

Recommendations for Issue 2

1. National Park(s)/BKSDA(s)/local NGOs can possibly have the opportunity to get support from international organizations by borrowing equipment, tools or training, based on the needs, to avoid breaking regulations that can possibly be a breach of the MoU.
2. International organization(s) can give support through donation(s), which is not against Indonesian Law through local NGO(s). Local NGO(s) will follow up on the needs through collaborative activities with the National Park or BKSDA or other management authorities (Perum Perhutani/ Plantation company/Ministry of Law and Human Rights).

Issue 3: Data compilation

There are some issues in compiling data from various habitats:

1. Data collector in KSDAE is still not optimal in compiling data from National Parks or other conservation areas.
2. Some leopard habitats are located outside of conservation areas, e.g. protected forest and production forest, and are managed by Perum Perhutani, not under KSDAE. Also there are some areas located in plantations, which are under Ministry of Agriculture, as well as Nusakambangan

Island, which is managed under Ministry of Law and Human Rights. The mechanism for conducting surveys as well as data sharing is not yet developed between ministry.

3. Standardized data structure is not yet developed, especially for data that come from different survey methods such as camera traps or presence/absence surveys. This leads to difficulties in compiling all data collected in one data structure that can be analyzed for island-wide purposes.

Recommendations for Issue 3

We propose the following principals regarding data collection purposes:

1. Collected data/information should be able to support adaptive management, which means it consists of both raw and analyzed data. There is no need to wait until the data are published as a scientific paper.
2. Acknowledgement must be considered.

Based on those principals, we are proposing recommendations:

1. Parties who are collecting data should immediately share data to management authority(s) [KKH/National Park/BKSDA/Perum Perhutani].
2. In order to accommodate the opportunity of gaining data/information from the public in areas outside of conservation areas, BKSDA is expected to receive data/information and issue the letter of data submission as acknowledgement.
3. In order to compile data nationally, KKH should standardized the data structure and distribute to parties (point 1 & 2)
4. KKH will collect data from parties (point 1 & 2) and together with FORMATA conduct further analysis.

WORKING GROUP REPORT: Leopard-Human Conflict Mitigation

Working group participants: Hendra Gunawan, Erwin Wilianto, Vitriana Drajat, Leny Hapsari Dewi

Background

The Javan leopard (*Panthera pardus melas*) is a species of protected wildlife in Indonesia. As an endemic animal of Java, leopard habitat spread evenly from the western to the eastern end of Java; in addition, the leopard is also found on Nusa Kambangan Island and Kangean Island. Leopards live not only in conservation areas, but also in production forest managed by Perhutani. The wild population of leopards is expected to decline, due to habitat loss, fragmentation, reduced prey animal populations, illegal hunting activities, and conflicts with humans.

Conflict between humans and animals is a complex problem that can result in a variety of losses, ranging from material losses, to the death of victims or the leopard itself. The conflict between humans and leopards can result from the increasingly damaged and diminished leopard habitat, the conditions of the leopard itself, and the community surrounding leopard habitat. The increase in conflict is a real threat to the sustainability of the leopard. The weak handling of conflicts and the absence of conflict mitigation protocols has resulted in no decline in the level of conflict between humans and leopards.

Goal

The task of this working group was to:

1. Identify the cause of conflict between the leopard and man; and
2. Formulate mitigation efforts and adaptation of leopard conflicts with humans.

Definition

Before identification, it is important to define the meaning of leopard conflict in order to be clear in its causes. Based on group discussion, the working group agreed that the definition of leopard conflicts was the interaction between the leopard and the man who inflicted harm.

Identification of causes

Discussion by the group in the identification of the leopard-human conflict (*Panthera pardus melas*) led to the classification of three types of conflict based on the situation, namely the emergence of leopard into settlements or outside forest areas; leopard attacks on farm animals; and the capture of leopards by humans either intentionally or not. Until now, no cases have been found in which a leopard attacked a human. Table 8 provides information on which party is harmed.

Table 8. Types of conflicts and disadvantaged parties.

No.	Type of Conflicts	Indemnification party
1.	Emergence of leopard in settlement or outside forest area	Potential damage to the leopard (captured/injured/death) Potential loss to humans (livestock attacked, humans attacked)
2.	Leopard attack on farm animals	Human (loss of livestock)
3.	Leopard caught by human	Leopard (injured/death)

Conflict Type 1. Emergence of leopard in settlement or outside the forest area
The emergence of leopards outside of forest areas can be due to various factors:

a) Searching for new territory
The causes of leopards seeking new territories are:

i. Overpopulation, which is a condition in which an area is no longer adequate to accommodate the number of animals due to natural factors of animals. Search for mates, territorial disputes, and situations when old or weak males are driven out by the dominant male are situations that encourage the search for a new territory.

ii. Habitat reduction, namely the change in the function of forest areas due to illegal forest, utilization of the region (legal and illegal), and the policy of cultivation of land that is not under the supervision of the rules can increasingly reduce forest areas that can serve as the leopard habitat.

iii. Habitat fragmentation, the development of road access, and settlements on land surrounding the forest or bordering the conservation area so that leopards no longer have safe access to forest areas that may support leopards.

b) Seeking prey animals
Ideally, leopards have sufficient wildlife prey within the forest to support life naturally from this habitat. Leopards may seek prey outside of forest areas due to:

i. Decreased prey populations, where the number of prey animals is no long adequate and are difficult to find.

ii. Leopards usually follow the movements of their prey. In certain seasons, prey may spend time in the forest border areas to eat or drink, which is common during planting season, the season ahead of harvest, and in the dry season. As such, it is possible that the leopard follows prey that move towards the plantation of a community bordering the forest.

c) Region support decreased power
Declining habitat quality causes the leopard not to live comfortably in the forest area so that the leopard has no shelter to reproduce.

d) Disorientation
The leopard can become disoriented or move out of its natural trails due to a number of reasons, such as illness. This condition can occur when juvenile leopards become separated from their mother.

Conflict Type 2. Leopard attack on farm animals
Leopard attacks on cattle can occur due to the following situations:

a) Lack of sufficient prey in the habitat (this can be caused by competition among prey species, hunting, and reduction in food resources that support prey species)

b) Given the opportunistic nature of leopards, this species does not depend on one or several specific prey species but tends to choose prey that are easily acquired and have little possibility to defend itself. In this case, farm animals found close to leopard habitat may become the target of leopard predation.

c) Cattle are not contained, so the presence of livestock released in the forest provide the opportunity for easy prey.

d) Livestock enclosures are easily accessible by leopards. The existence of cattle enclosures on the edge of the forest (or even within the forest), with a enclosure design that is easily entered by a leopard, will naturally invite attacks from a leopard.

e) Leopard is in the natural process of learning how to hunt.

Conflict Type 3. Leopard caught by human

The capture of leopards by humans can happen intentionally or accidentally.

a) Intentional

In the case of deliberate capture, the cause of capture is identified is as follows:

i. Retaliation by the people who lost animals that were eaten by leopards. Leopard capture is usually done by poisoning or trapping, so often leopards are dead.

ii. Leopard are captured for profitable commercial purposes. In this circumstance, the leopard is alive.

b) Inadvertent

Iinadvertent capture is when the leopard enters a trap or snare that is destined for other species. This can lead to injury or death, or the leopard may be found alive.

Conflict Management

After the cause of conflict is identified, the next consideration is mitigation and adaptation to the events. In the management of conflicts, the basic principles that must be held are:

a) Humans and wildlife are equally important
b) Site specific
c) There is no single solution
d) Landscape scale
e) Multi-party responsibilities

Information listed below can also be found in Table 9.

Mitigation

Mitigation is an important activity undertaken as a precaution in the event of a conflict, as follows:

Leopard appears in the settlement/outside the forest area:

a) Leopard capture and evacuation by moving (translocation) of leopards that are believed to be transient (i.e., not attached to the habitat area) due to various reasons;

b) Restoration of habitat ecosystem to restore the quality and ability of the habitat to support leopards;

c) Determination of the buffer area, focusing the management of areas with leopards so that the areas can accommodate the needs of the leopard with a wide area of exploration;

d) Creation of animal corridors is important, so that leopards can connect with other populations in separate forest areas without having to pass through dangerous open areas;

e) Incorporating the needs of leopards in the policy of regional spatial planning;

f) District management policies by examining and conducting:

i. Regulation, if none exists

ii. Development and implementation of operational guidelines, e.g., procedure for determining the buffer area, critical habitat and corridors

iii. Supervision of implementation, which needs to be done primarily related to the vulnerability of deterioration of forest quality as leopard habitat, e.g., in areas directly adjacent to leopard habitat

iv. Synergy/harmonization of legislation between stakeholders, e.g., regulation for the implementation of the designation of buffer areas, animal corridors, critical habitat, and animal removal in the area of local government is the Ministry of Home Affairs

g) Habitat improvments for leopards, as it is important that the forest has good quality;
h) Habitat improvement for prey species, to provide natural prey for survival and reproduction;
i) Prevent cultivation of land in the forest areas of the leopard habitat.

<u>Leopard attacking cattle</u>

a) Habitat improvement for leopards
b) Habitat improvement for prey species
c) Prevent cultivation of land in the forest areas of leopard habitat
d) Livestock must be contained
e) Enclosures must be made stronger and safer
f) Community empowerment through training and diversification of business
g) Community outreach
h) Education/local content for young generations through formal and non-formal education

<u>Leopard caught</u>

a) Community awareness
b) Education of younger generations
c) Community empowerment program
d) Securing conservation areas with the community

Adaptation

Forms of adaptation that are important to do when a conflict occurs:

<u>Leopard appears in the settlement/outside the forest area</u>:

a) Animal
b) Animal removal (translocation)
c) Reintroduction of prey species
d) Law enforcement for hunting of prey species
e) Law enforcement for hunting of leopards
f) Removal of grazed cattle in the region
g) Strengthening the cattle enclosure

<u>Leopard attacking cattle</u>

a) Compensation of livestock owners
b) Removal of leopard
c) Community outreach
d) Support for construction of strong enclosures
e) Provision of land for the provision of livestock feed

<u>Leopard caught</u>

a) Leopard removal
b) Medical examination/wound treatment, or necropsy if dead
c) Law enforcement

Parties Involved

The parties who have a responsibility of mitigation of conflict leopard are listed below, as follows:

Ecosystem Restoration, Habitat Improvement and Animal Reintroduction

- KKH
- BKSDA/TN
- Forestry Service
- LK SPECIAL
- NGOs
- BPDAS
- Perhutani
- Plantation
- PEMDA
- Surrounding communities
- Area utilization
- Private

Animal Evacuation

- KKH
- BKSDA/TN
- Conservation institutions
- Livestock Service office
- Medical

Storage, Incentives, Indemnity and Community Empowerment Programs

- Forestry service
- Livestock Service Office
- Agriculture Service
- Social service

Young Generation Education

- KKH
- West Java BKSDA
- Education and Culture Office
  NGOs
- Directorate

Law Enforcement

- BKSDA/TN
- Directorate of Law Enforcement
- Police

Spatial Policy, Legislation and Implementation Supervision

- Bappeda
- Ministry of LHK
- Ministry of Home Affairs
- Ministry of PUPR
- Service Environment
- Forestry Service
- NGOs
- Perhutani
- Plantation
- Forestry Service
- Police
- R & D Agency

Table 9. Conflict management

No.	Type of conflict	Mitigation	Parties	Adaptation	Parties
1.	Leopard appears in settlements/outside forest areas	**1.** Animal capture and removal **2.** Restoration of habitat ecosystem **3.** Determination of buffer area **4.** Develop corridors **5.** Include leopard habitat in the policy of the Spatial Plan area **6.** Habitat improvements for leopard **7.** Habitat improvement for prey species **8.** Prevent the cultivation of land in the forest areas of leopard habitat **9.** District management policies by examining and conducting: a. Regulatory b. Manufacturing of operational guidelines and implementation c. Supervision of implementation d. Synergy/harmonization of legal regulations between the stakeholders	**1.** BBKSDA /TN **2.** Perum Perhutani **3.** Perkebunan (plantation) **4.** Bappeda **5.** DLH **6.** Dinas Kehutanan (Forestry Service) **7.** Kementerian Kehutanan (Ministry of Forestry **8.** BPDAS **9.** Kepolisian (police)	**1.** Animal **2.** Animal removal (translocation) **3.** Reintroduction of prey **4.** Law enforcement for hunting prey species **5.** Law enforcement for hunting leopards **6.** Crack down and remove the grazed cattle in the region **7.** Strengthen the livestock enclosure	**1.** BBKSDA /TN **2.** Perum Perhutani **3.** Kementerian Dalam Negeri (Ministry of Home Affairs) **4.** Kementerian PUPR (PUPR Ministry) **5.** Perkebunan (plantation) **6.** Bappeda **7.** DLH **8.** Dinas Kehutanan (Forestry Service) **9.** Kementerian Kehutanan (Ministry of Forestry) **10.** BPDAS **11.** Kepolisian (police) **12.** NGO **13.** Swasta (private)

2.	Leopard attacking cattle	**1.** Habitat improvement for prey species **2.** Prevent cultivation of land in the forest area of leopard habitat **3.** Livestock must be paired **4.** Make enclosures stronger and safer **5.** Community empowerment through training and diversification of business **6.** Community outreach **7.** Education/local content for younger generations	**1.** BKSDA/TN **2.** Masyarakat Desa (village community) **3.** Perhutani **4.** Perkebunan (plantation) **5.** Dinas Peternakan (livestock service) **6.** Dinas sosial (social service) **7.** Dinas pendidikan dan kebudayaan **8.** BPDAS	1. Compensation of livestock owners 2. Leopard removal 3. Community counseling 4. Robust cage-making assistance 5. Provision of land for the provision of livestock feed	**1.** BKSDA/TN **2.** Masyarakat Desa (village community) **3.** Perhutani **4.** Perkebunan (plantation) **5.** Dinas Peternakan (livestock service) **6.** Dinas sosial (social service) **7.** Dinas pendidikan dan kebudayaan (education and culture office)
3.	Leopard caught	**1.** Community counseling **2.** Young generation education **3.** Community empowerment program **4.** Safeguarding conservation area with the community	**1.** BKSDA/TN **2.** Masyarakat Desa (village community) **3.** Perhutani **4.** Perkebunan (plantation) **5.** Dinas Peternakan (livestock service) **6.** Dinas sosial (social service) **7.** Dinas pendidikan dan kebudayaan (education and culture office)	**1.** Leopard removal **2.** Medical examination/ wound treatment/ necropsy **3.** Law enforcement	**1.** BKSDA /TN **2.** Medis / LK (medical/LK) **3.** Livestock service **4.** Direktorat Gakkum **5.** Kepolisisan **6.** Muspika

WORKING GROUP REPORT: *Ex Situ Management for Conservation*

Working group participants: Anni Sa (Hamka University); Ardyta Widianti (TSI); Christian Kern (Tierpark Berlin); Kristin Leus (CPSG Europe); Drajat Dwi (KKH, Ministry of Forestry and Environment); Faris Ranggawardana (KKH, Ministry of Forestry and Environment); Joko Nugroho (KKH, Ministry of Forestry and Environment); Keni Sultan (TSI); Shan Dar Tao (NTNU); Toni Sumampau (TSI); Karen Goodrowe Beck (CPSG facilitator)

The task of this working group was to evaluate the potential for *ex situ* management to contribute to the conservation of Javan leopards. The discussion followed the decision steps outlined in the IUCN SSC *Guidelines for the Use of Ex Situ Management for Species Conservation* (IUCN 2014).

Categorization of Javan leopard populations

The group first reviewed three categories of Javan leopard populations: 1) wild population; 2) conflict animals; and 3) local and global captive population.

For the wild population, we know that the distribution of this species is fragmented. Small populations living in small, isolated suitable habitat patches may be challenged both genetically and demographically. Individuals can be lost from these populations due to conflict or poaching. Even a small rate of loss, especially of female leopards, can potentially have a major impact on these small populations and therefore on this species.

For conflict animals, there is an existing protocol for the Sumatran tiger, but not for the Javan leopard. However, there is some consensus of how to deal with conflict animals, as follows:

1. Veterinarians from PKBSI or local nature conservation agency will evaluate leopard's behavior and physical condition.
2. If health and physical condition is good, the animal will be released into the wild. Otherwise, the animal will be transferred to a rescue center or zoo for rehabilitation or medical treatment.
3. If the animal recovers, it will be released back to the wild.
4. If the situation is such that the animal will no longer be able to survive in the wild, it will become part of the captive breeding program if it recovers. If the animal cannot recover, euthanasia is considered to be an option.

The priority is to release the animal back to wild if feasible. All steps above are based on this ideal. For now, any leopards removed from the wild due to conflict are transferred to one of three types of facilities: 1) rescue center (two in Java); 2) Indonesian zoos; or 3) Taman Safari Indonesia (TSI).

According to the Javan Leopard International Studbook (Sultan and Kern 2018), there are 47 Javan leopards in captivity, with 6 individuals in Europe and 41 individuals in Indonesia. Among those in Indonesia, 30 individuals are wild born and 11 are captive born (F1~F3 generations). There are 28 potential founders (14 males, 14 females), and only 3 males have offspring in captivity. Difficulties related to captive breeding include: 1) there is only one animal in most facilities, with only certain facilities having the capability to hold multiple individuals; 2) facility space is usually too small and is not designed for a breeding program; 3) it is challenging to use conflict leopards for the breeding program because they are not habituated to humans; 4) conflict leopards may suffer from physical injuries (e.g., lost limb) that can create difficulties for breeding; and 5) most facilities are not experienced in working collaboratively regarding a conservation breeding program.

Potential conservation roles of the *ex situ* population

The group then discussed the potential roles of short-term and long-term *ex situ* programs in the conservation of Javan leopards. The first is to establish an insurance population that can serve as a living genetic representation of the species, and provide benefits for future breeding and restoration program. Second is to serve a function as part of short-term rehabilitation necessary in order to release the leopard back to the wild. Third is for research, including genetics, behavior and disease, which will help support future translocation or releasing strategies. A fourth role is to provide training for conflict rescue teams. A fifth role is to include the *ex situ* population in public education activities to raise awareness and potentially change attitudes and behavior in local communities in leopard-conflict areas.

Role 1. *Ex situ* population can play a role in the conservation of Javan leopards by providing place for **short-term rehabilitation** and assessment before the animals return to the wild, so they are not lost from the wild population.

Role 2. **Insurance population** that serves as a living genetic representation of the wild population and could serve as potential source for restoration (release) if needed.

Role 3. **Conducting research** with the *ex situ* population can assist in the conservation of the wild population through:

a. **Genetic research**: sampling and profiling of every incoming conflict leopard to know the genetic profile of the wild population (including genetic flow and relatedness) and help develop meta-population management.
b. **Behavior research**:
    i. Understand the breeding behavior of Javan leopards in order to improve the chance of successful reproduction and rearing of cubs.
    ii. Establish standards of facilities for captive management of Javan leopards.
c. **Disease research**: establish baseline data from conflict leopards to understand their health status and diseases that occur in the wild. Studying the *ex situ* population to understand disease effects and transmission in order to improve leopard's health, both *in situ* and *ex situ,* and reduce disease transmission.

Role 4. **Training for a leopard conflict rescue team** includes two parts: 1) investigate and resolve the conflict event in the local area; and 2) safely capture and medically assess the conflict leopard. Local conservation agencies are responsible to identify the nearest facilities that can support such action. Therefore, facilities such as zoos should be able to support the field conflict reaction team.

Role 5. Conducting public education:

a. To generate awareness among the general public of the existence and critically endangered status of the Javan leopard by connecting zoo visitors, local communities around *ex situ* facilities, and NGOs associated with conservation of Javan leopards to the animal.
b. With local communities in conflict areas to help understand the reasons for conflict and to enable *ex situ* facilities to collaborate with NGOs to develop programs to potentially change attitudes within local communities.

Proposed flow chart for conflict leopards

The working group developed a flow chart to describe these potential ex situ roles and how a conflict leopard might be assessed for release, short- or long-term *ex situ* management, or euthanasia (Figure 11). The group did not define a "treatable" animal but divide this category into releasable vs non-releasable (see IUCN 2013 and other guidelines and protocols for more guidance).

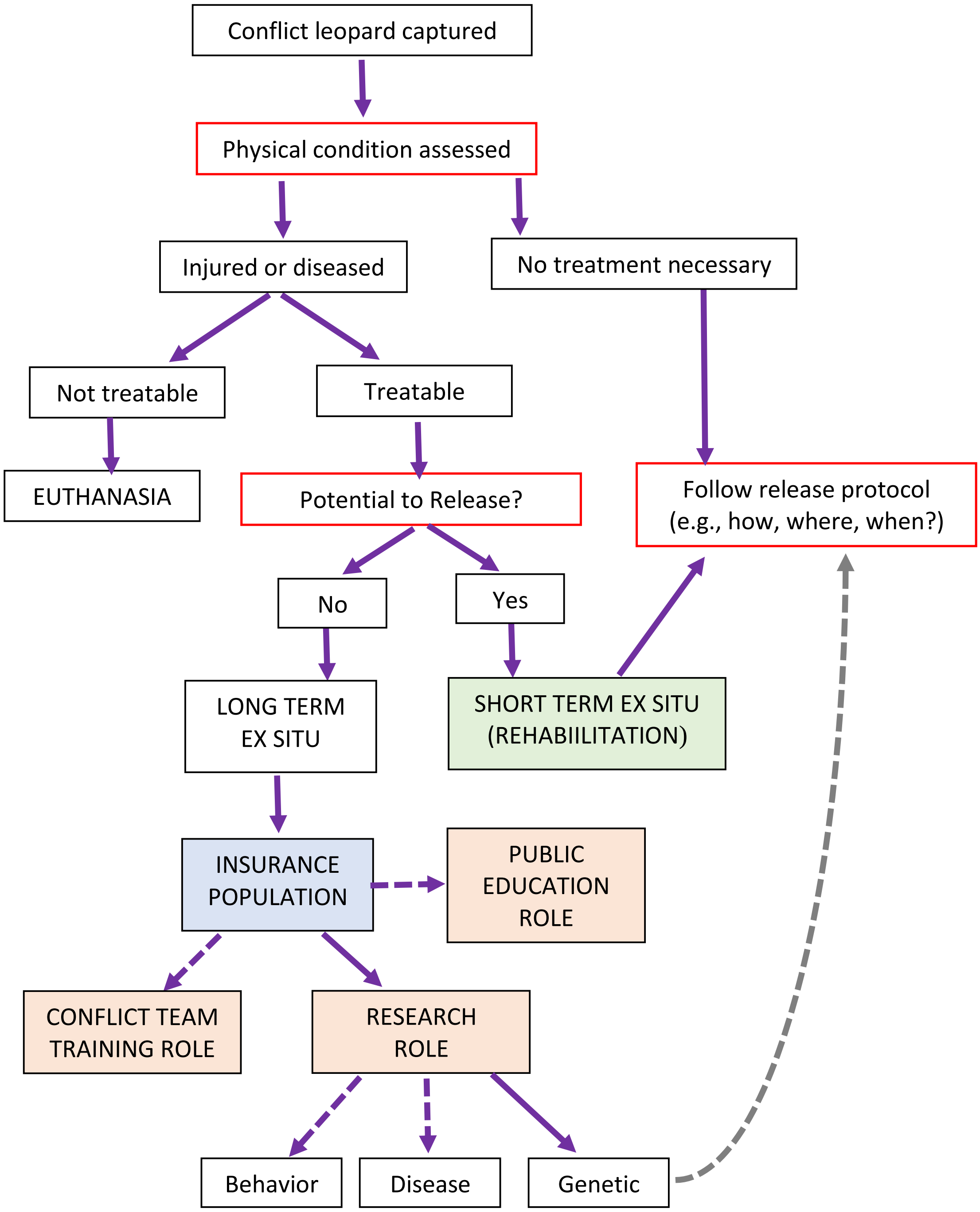

Figure 11. Flow chart outlining decisions for potential *ex situ* management of conflict leopards.

Evaluation of benefits, costs and feasibility

Guided by the decision steps in the IUCN *ex situ* management guidelines (IUCN SSC 2014), the working group considered the relative benefit (conservation value), cost (resources required and potential risks), and feasibility for the *ex situ* conservation roles and programs proposed in their discussions. These included the rescue and rehabilitation of conflict leopards, establishment of an insurance population, conducting research for conservation purposes, training of conflict leopard reaction teams, and public education to raise awareness.

Short-term Rehabilitation

<u>Benefits</u>

This role is considered to have a high conservation value given the current status of the Javan leopard wild population. Suitable habitat is highly fragmented, resulting in small populations that cannot afford the permanent loss of conflict individuals. Returning conflict individuals to the wild is desirable provided it is done responsibly and that suitable habitat is available.

<u>Costs</u>

This role requires a lot of manpower. Also, it takes a lot of time to build capacity for team members. Transport costs can be significant if the animal is located in a remote area. Rehabilitation requires large enough space at facilities, medical supplies for medical treatment, and the ability to hold the animal short term for rehabilitation and release.

<u>Feasibility</u>

Given that similar protocols and experiences exist for conflict Sumatran tigers in Indonesia, the feasibility of this conservation role is considered high.

Insurance Population

<u>Benefits</u>

An insurance population is considered to be of high conservation value for the Javan leopard. Given its fragmented distribution in the wild and the challenges to solving the conflict between humans and leopards, an insurance population provides a chance to preserve this species against severe decline or extinction in the wild.

<u>Costs</u>

Establishing an insurance population will require better collaboration among holding facilities, an increase in the number of leopards managed in captivity, and perhaps an increase in the number of facilities. Better husbandry and veterinary care will be needed for the Javan leopard ex situ population. Based on these reasons, the relative cost is considered high.

<u>Feasibility</u>

Communication between management agencies and facilities will need to be improved, as well as husbandry. Feasibility is considered to be medium.

Training for Conflict Rescue Team

<u>Benefit</u>:

This role has high conservation value, based on the fact that this role provides capacity of human resource to support the conflict rescue program.

<u>Cost</u>:

The cost is considered to be medium. A lot of experience can be transferred from the people who work on the rescue of conflict Sumatran tigers.

<u>Feasibility</u>:

Feasibility is considered high, as there are some rescue experiences with conflict Sumatran tigers.

Research (Behavioral)

Benefit:

Behavioral research on the *ex situ* population was considered to have low conservation benefit because it was not considered to have direct impact on conservation of the wild population.

Cost:

The cost is considered medium because we need time and resources to conduct the research.

Feasibility:

Feasibility is considered high, since the expertise exists in Indonesia.

If an insurance population is created, behavioral research is likely to be conducted to improve captive management. However, it is not considered to play a role in the conservation of Javan leopard.

Research (Genetic)

Benefit:

Genetic research is considered to be of high benefit because it can support translocation efforts, genetic profiling of the leopard population, and genetic management of the *ex situ* population.

Cost:

Cost is considered to be medium because it is mostly laboratory work. It takes less manpower, and establishing collaboration between facilities is considered to be easier.

Feasibility:

This role is highly feasible because it is possible to get the permit for conducting research and collaboration with other facilities and NGOs.

Research (Disease)

Benefit:

There were two different opinions within the group on this matter: one considers disease research to have a high benefit since we have no knowledge of the current status of diseases among Javan leopards, while others considered it to have low benefit since no major impact has been observed. The group agreed to consider the benefit of this role as medium.

Cost:

Cost is considered to be medium because it is mostly laboratory work. It takes less manpower, and establishing collaboration between facilities is considered to be easier.

Feasibility:

This role is highly feasible because there are existing expertise and resources for fulfilling this role.

Public Education

In addition to the more direct conservation roles above, the group acknowledged the potential benefit of public education using captive animals. The connection between the living animals and visitors to the *ex situ* facilities potentially cause people to have more concern for the animal. People in areas where there is conflict have negative attitudes toward leopards, which are considered to be a threat not only to livestock but also for human safety. Public education is not only essential for the general public but also for the local community in conflict area. This role includes two purposes: one is to generate awareness of the existence and endangered status of the Javan leopard by connecting the zoo visitor, the local community near the facilities, and Javan leopard conservation NGOs to the leopard; and the second is to understand the reasons for conflict, so *ex situ* facilities may collaborate with NGOs to develop programs to potentially change the attitudes of the local communities. The working group did not have time to evaluate the benefits, costs and feasibility of this role in more detail.

Recommended characteristics of the *ex situ* program

Due to limited time, the group focused on discussing the characteristics of two important aspects of the *ex situ* program for the conservation of Javan leopards. More discussion is needed for these and other recommended roles of research, training and education.

Short-term Rehabilitation

In the past, most of the rescue cases of conflict leopards in Java were released in a relatively short time, with only one individual kept in captivity before release. However, a facility is still needed that is designed for short-term rehabilitation of Javan leopards. This includes providing an enclosure with sufficient space and also medical supplies and expertise for continuous treatment. A meta-population translocation plan is needed with potential release localities and the process for getting permission for release by the DG in a short amount of time. Protocols such as limiting human contact and indirect feeding are important during the rescue process to ensure that the leopard can be released back in the wild.

Insurance Population

The group did not have a complete understanding of the number and types of holding or breeding space for Javan leopards in existing *ex situ* facilities on Java. However, it was believed that space is insufficient to hold a large population. Instead, it is possible to hold a relatively small population and supplement it with the non-releasable conflict animals. A potential risk is that most conflict events are caused by young males. Females serve an important role both genetically and demographically in the wild population.

The population size needed to function properly as an *ex situ* insurance population is unknown at this time, as it will depend in part on the number of non-releasable animals and also on the level of management and collaboration among facilities. To give an idea of scale, an *ex situ* breeding population of ~100 individuals could maintain an acceptable amount of gene diversity, assuming the addition of 2 unrelated rescue individuals every 5 years (Figure 12). An effective program requires management at the population level and the ability to carry out breeding and transfer recommendations for individual leopards. Getting permission from the D.G. in a timely manner is important.

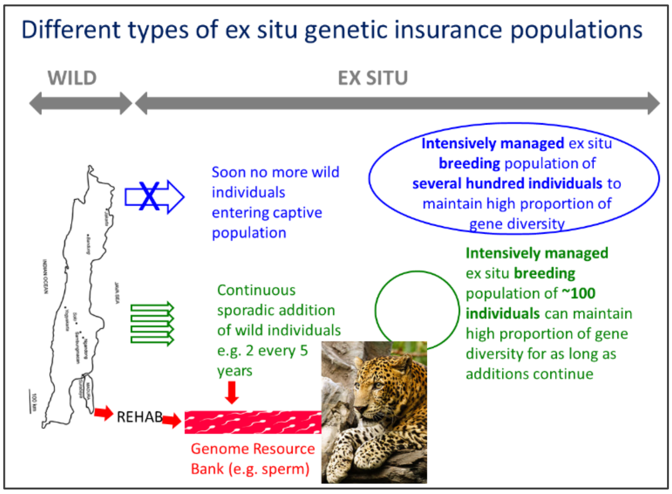

Figure 12. Diagram of different types of insurance populations.

The following conditions are needed in order to keep captive animals healthy: 1) a large enclosure for the leopard to demonstrate natural behavior; 2) direct sunlight; 3) proper nutrition and diet for Javan leopards; 4) behavioral enrichment; 5) security measures for keepers and the animals; and 6) conditions sufficient to prevent stereotypic behavior. In order to achieve these conditions, we need to establish reliable collaboration with facilities that are willing to commit to the *ex situ* program.

Also, protocols are needed with the Ministry to approve and distribute breeding and transfer recommendations in conjunction with a process within PKBSI to make such recommendations based on studbook data by the studbook keeper.

The possibility of establishing a sperm bank for Javan leopards should be investigated to preserve genetic diversity and maintain a healthy *ex situ* population. This is especially important for conflict males that do not produce offspring in the *ex situ* population through natural breeding.

PKBSI offered to take the lead to work with its members and the animal rescue centers (PPS) to continue the work that could be completed during the workshop and to work on the implementation of the recommendations. The work that is already being done to implement the *ex situ* programs for banteng, anoa, babirusa and Sumatran tiger will be useful for the Javan leopard *ex situ* program.

WORKING GROUP REPORT: Integrated Management

Working group participants: Bambang (PERHUTANI- KPH Cepu); Candra Dwi Laksana (PERHUTANI- KPH Sukabumi); Didik Raharyono (Peduli Karnivor Jawa); Mochamad Iqbal (Baluran National Park); Ida Ayu Ari Janiawati (Bali Safari and Marine Park); Desy Satya (KKH/Ministry of Forestry)

Issue

The Javan leopard is known to be distributed across a wide area in Java. Leopards inhabit not only three major areas – Protected Forest, Conservation Forest, and Production Forest – but also are found in human settlements, plantations, and other areas. In order to conserve the Javan leopard, integrated management among stakeholders is needed. All stakeholders need to agree to Javan leopard conservation. This working group report outlines some conclusions and recommendations regarding these issues and how we can solve this issue for Javan leopard conservation.

Discussion

In this group we discussed the following:

1. BKSDA/KSDHE may find it difficult to collaborate with other stakeholders because Javan leopards might be distributed outside conservation areas. Based on PP NO. 72 2010 about State Company it is stated that Protected Forest and Production forest in Java and Madura belong to PERHUTANI (Production Forest). Coordination is needed between KSDHE as a role in conservation forest and PERHUTANI as a company who manages production forest. During the discussion, PERHUTANI agreed to collaborate with KSDHE to collect many data and information about Javan leopards to address the lack of data regarding Javan leopards in non-conservation areas. Areas have been divided into several zones such as production zone, HCV (High Conservation Value), Wild Zone (never been surveyed yet it is believed that there are Javan leopards present, as they hear vocalizations of prey species).
2. PERHUTANI has conducted environmental surveys such as climatic survey and also wildlife survey, but these are only reported for their own archive. To do wildlife monitoring they were using very basic tools and limited human capacity to do special monitoring for wildlife, so the data might be not reliable and accurate. We agree to collaborate with the university to do training for wildlife survey for PERHUTANI staff.
3. Integrated management also needs to collaborate with other stakeholders such as local governments, ministry (Ministry of Law), and plantation companies (Ministry of Agriculture).
4. Additional information of Javan leopard distribution/presence:
   - Site 7094 KPH Cepu, found Javan leopard (BKPH Cabak, area: 30Ha); this site now has become a Natural Reserve.
   - Site 39 D (BKPH Cikawung, RPH Takokak) found 2 (suspected) --> located near Gede Pangrango National Park.
   - Site 33 B (BKPH Jampang kulon, RPH Cisujen) found 2 (suspected)--> on Secondary Forest in PERHUTANI.
     - *HAS (Secondary Forest) definition stated in PK SMPHT 01-004.
   - Site 28 A (BKPH Pelabuhan Ratu, RPH Buniwangi) found 5 (suspected) ---> on Protected Forest in PERHUTANI Forest Class.
   - Protected Forest lawu and Jobo Larangan BKPH Lawu Utara, KPH Surakarta). Only anecdotal data, just verbal communication from citizen researcher.

- In Wonogiri (BKPH Purwantoro).
- Nusa Kambangan not in conservation area (belongs to Ministry of Law and human rights)
- Teak Forest in Bojonegoro and Caruban
- Kendeng Utara
- Kendeng Lembu (Plantation Company/PTPN)

Recommendations

To resolve the issues identified regarding integrated management, we suggest the following recommendations:

1. Collaboration in wildlife survey and monitoring. Collaborate with all stakeholders, such as Ministry of Forestry and Environmental (KKH/KSDHE), Ministry of Law and Human Rights (Nusa Kambangan Island), Ministry of Agriculture (Plantation Company).
2. Increase skills and human capacity of PERHUTANI staff to do wildlife survey through training and workshop.
3. Review the protocol (P.48/Menhut-II/2008) about Conflict Mitigation between Human and wildlife animals to identify stakeholders who are involved in management.

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APPENDIX I: PHVA workshop participants

PARTICIPANT LIST (*Workshop Opening only)
JAVAN LEOPARD POPULATION AND HABITAT VIABILITY ASSESSMENT (PHVA)

AGENCY	REGION	CONTACT
Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem, Kementerian Lingkungan Hidup dan Kehutanan	Kebijakan dan Program Nasional	Wiratno*
Direktorat Keanekaragaman Hayati, Ditjen KSDAE	Kebijakan dan Program Nasional	Bambang Dahono Adji*
Direktorat Bina Pengelolalan Ekosistem Esensial	Kebijakan, Bimbingan Teknis di Bidang Ekosistem Esensial	Antung Deddy Radiansyah*
Ketua Perhimpunan Kebun Binatang se-Indonesia	Konservasi Ex-situ	Rahmat Shah*
Subdirektorat Pengawetan Jenis, Direktorat Konservasi Keanekaragaman Hayati , Ditjen KSDAE	Kebijakan dan Program Nasional	Desy Satya Chandradewi
Balai Besar Konservasi Sumber Daya Alam Jawa Barat-Banten	Kawasan Suaka Alam Jawa Barat	
Balai Besar Konservasi Sumber Daya Alam Jawa Timur	Kawasan Suaka Alam Jawa Timur	
Balai Konservasi Sumber Daya Alam Jawa Tengah	Kawasan Suaka Alam Jawa Tengah	
Taman Nasional Ujung Kulon	Ujung Kulon	
Taman Nasional Gunung Halimun-Salak	Kawasan Konservasi Gunung Halimun-Salak	
Taman Nasional Gunung Gede-Pangrango	Kawasan Konservasi Gunung Gede-Pangrango	
Taman Nasional Gunung Ciremai	Kawasan Konservasi Gunung Ciremai	
Taman Nasional Gunung Merbabu	Kawasan Konservasi Gunung Merbabu	
Taman Nasional Gunung Merapi	Kawasan Konservasi Gunung Merapi	
Taman Nasional Bromo-Tengger-Semeru	Kawasan Konservasi Bromo-Tengger-Semeru	
Taman Nasional Alas Purwo	Kawasan Konservasi Alas Purwo	Wahyu Moerdyatmoko
Taman Nasional Baluran	Kawasan Konservasi Baluran	Muhammad Iqbal
Taman Nasional Meru Betiri	Kawasan Konservasi Meru Betiri	
KPH Cepu, Perum Perhutani Divre Jawa Tengah	Hutan Lindung-Hutan Produksi Jawa Tengah	
KPH Kebon Harjo, Perum Perhutani Divre Jawa Tengah	Hutan Lindung-Hutan Produksi Jawa Tengah	
KPH Randu Belatung, Perum Perhutani Divre Jawa Tengah	Hutan Lindung-Hutan Produksi Jawa Tengah	
KPH Bandung Selatan, Perum Perhutani Divre Jawa Barat	Hutan Lindung-Hutan Produksi Barat	
KPH Cianjur, Perum Perhutani Divre Jawa Barat	Hutan Lindung-Hutan Produksi Barat	
KPH Garut, Perum Perhutani Divre Jawa Barat	Hutan Lindung-Hutan Produksi Barat	

AGENCY	REGION	CONTACT
KPH Sukabumi, Perum Perhutani Divre Jawa Barat	Hutan Lindung-Hutan Produksi Barat	
KPH Sumedang, Perum Perhutani Divre Jawa Barat	Hutan Lindung-Hutan Produksi Barat	
Puslitbang Hutan, KLHK	Riset Macan Tutul	Hendra Gunawan
Puslit Biologi LIPI	Riset	Gono Samiadi
PKBSI	Konservasi Ex situ	Tony Sumampau
Forum Konservasi Macan Tutul Jawa (FORMATA)	Database cooridinator	Adi Susmianto
Studbook Keeper Macan Tutul Jawa	Studbook Keeper	Keni Sultan
Koppenhagen Zoo	Populasi Baluran	Hariawan A. Wahyudi
Conservation International Indonesia	Data Monitoring Populasi	Anton Ario
Fauna and Flora International	Data Monitoring di Nusa Kambangan	Donny Gunaryadi
Biodiversity Society	Data monitoring di Slamet dan Dieng	Nur R Fajar (jaynrahman@gmail.com)
Peduli Karnivora Jawa	Data Monitoring Populasi	Didik
Fakultas Kehutanan IPB	Riset Macan Tutul	Ketua DKSHE
Forum Harimau Kita	Data Monitoring Populasi	Erwin Wilianto

INTERNATIONAL PARTICIPANTS

NAME	AGENCY	ROLE
Bengt Holst	Copenhagen Zoo / CPSG Europe	Workshop organizer / facilitator
Kristin Leus	Copenhagen Zoo / CPSG Europe	Workshop organizer / facilitator
Kathy Traylor-Holzer	IUCN SSC Conservation Planning Specialist Group (CPSG)	PVA modeler
Katia Ferraz	IUCN CPSG Brasil	SDM modeler
Christine Breitenmoser	IUCN SSC Cat Specialist Group (CSG)	IUCN felid conservation specialist
Carl Traeholt	Copenhagen Zoo	TN Baluran field project
Christian Kern	Tierpark Berlin	Ex situ felid expert
Karen Goodrowe Beck	Point Defiance Zoo / CPSG	Group facilitator / reproductive speciaist
Shan-Dar Tao	National Taiwan Normal University	Spatial modeling / workshop support

APPENDIX II: PHVA workshop agenda

Population and Habitat Viability Assessment (PHVA)
for the Javan Leopard (*Panthera pardus melas*) Workshop

30 January – 2 February 2017, Aviary Hotel, Bintaro, Banten

Tentative Agenda

Time	Activities	Executor
19.00-	Ice Breaker	
Tuesday, 30 Januari 2018		
08.00 – 09.00	Registration	Panitia
09.00 – 09.30	**Opening of Workshop**	MC
	Opening speech by Chief FORMATA	Hendra G
	Speech by IUCN SSC	Bengt H & Christine B
	Keynote speech and opening ceremony	Dirjen KSDAE
09.30 – 12.00	*Photo session, press conference, coffee break*	
	Participant introductions	Facilitator
	Introduction of CPSG workshop process: purposes and workshop goals	Kristin Leus
	Section I:	
	Development of the Javan Leopard Conservation Action Plan in Indonesia 2016-2026	Ministry of Environment and Forestry
	Human - Javan Leopard Conflict	Hendra Gunawan
	Recent status: Distribution, Population, and ecology of Javan Leopard in East Java and Central Java Region	Hariyawan A. Wahyudi
	Recent status: Distribution, Population, and ecology of Javan Leopard in Banten and West Java Region	Anton Ario
	Human - Javan Leopard Conflict	Hendra Wahyudi
	Population Status of Javan Leopard in Captivity	Christian Kern
12.00 – 13.00	Lunch	
	Section II:	
13.00 – 14.00	Introduction to Vortex modelling of Javan Leopard	Kathy Traylor-Holzer
	Introduction to Habitat modelling for Javan Leopard	Katia Ferraz
14.00 -15.00	Conclusion from the PVA and SDM models	
15.00 – 15.15	Coffee break	
15.15 -15.30	Working group topics and instruction	
15.30 – 17.00	Working group session	
Wednesday, 31 January 2018		
08.00 – 09.00	Registration	
09.00 – 09.20	The assignation of East Java as biosphere reserve by Unesco – could it impact on conservation of the Javan Leopard?	Hans Thulstrup
09.20 – 12.00	Working group session	
12.00 – 13.00	Lunch	
13.00 – 14.30	Plenary : Working group feedback	
1430 – 15.00	Working group session	
15.00 – 15.15	Coffee break	
15.15 – 17.00	Working group session	

Thursday, 1 Februari 2018		
08.00 – 09.00	Registration	
09.00 – 10.00	Working group session	
10.00 – 10.15	Coffee Break	
10.15 – 12.00	Working group session	
12.00 – 13.00	Lunch	
13.00 - 15.00	Plenary: working group feedback	
15.00 – 15.15	Coffee break	
15.15 - 17.00	Workshop group session	
Friday, 2 February 2018		
08.00 – 09.00	Registration	
09.00 – 10.00	Plenary: working group feedback	
10.00 – 10.15	Coffee Break	
10.15 - 11.00	Plenary: working group feedback	
11.00 - 11.30	Closing of the Workshop	

APPENDIX III: PROTOKOL SURVEI Macan Tutul Jawa

PROTOKOL SURVEI Macan Tutul Jawa

a. Taksonomi
   - Suku: Felidae
   - Jenis: *Panthera pardus melas*, Cuvier, 1809

b. Status Konservasi
   - Dilindungi (PP No.7 Tahun 1999)
   - Kritis (*critically endangered*)*;* IUCN *Redlist* (2008)
   - Appendiks I CITES (2002)

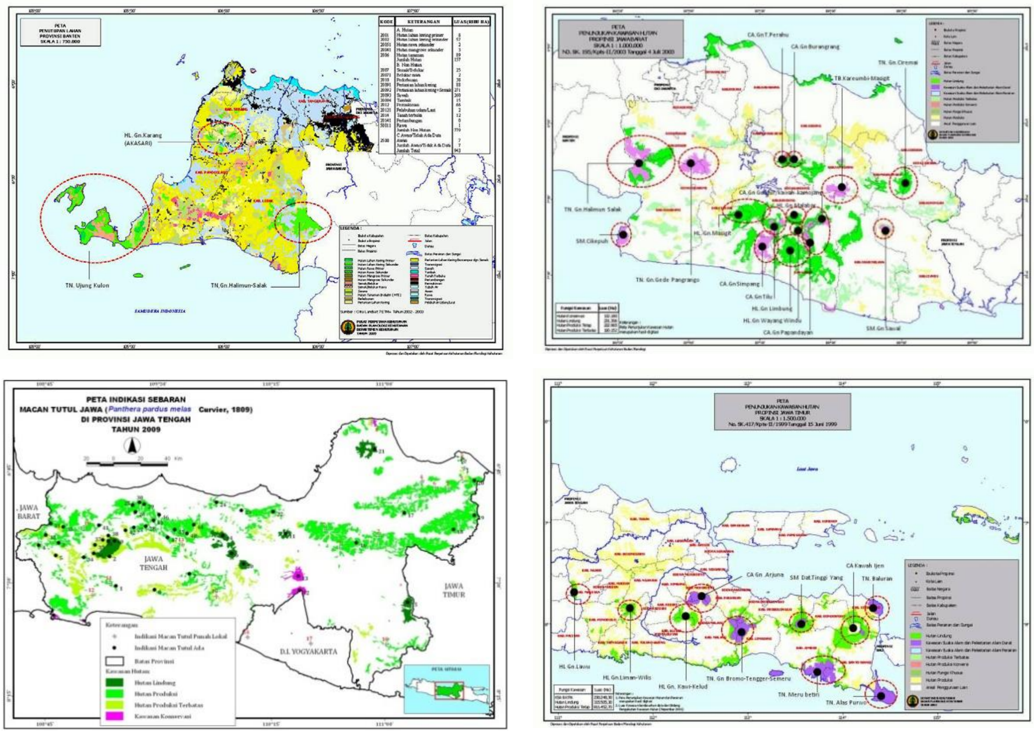
c. Sebaran dan Populasi

Penyebaran macan tutul jawa merata dari ujung barat pulau Jawa hingga ujung timur pulau Jawa, terutama di kawasan konservasi seperti taman nasional, cagar alam dan suaka margasatwa. Selain di kawasan konservasi, mereka juga diketahui hidup di kawasan non konservasi seperti hutan lindung dan hutan produksi yang dikelola oleh Perum Perhutani. Selain itu satwa ini diketahui juga hidup di pulau Kangean dan Nusakambangan (Gunawan, 2010). Perkiraan populasi macan tutul jawa di seluruh Jawa antara 350 – 700 individu (Santiapillai & Ramono, 1992), berkisar antara 491-546 individu (Ario, *et al*, 2008). Kepadatan populasi macan tutul jawa berdasarkan survei dengan *camera trap* diketahui satu individu per 6.67 km2 di Taman Nasional Gunung Halimun Salak (Syahrial dan Sakaguchi, 2003). Satu individu per 6,5 km2 Di Taman Nasional Gunung Halimun Salak (Ario, 2007), satu individu per 7,7 km2 di Taman Nasional Gunung Gede Pangrango adalah (Ario *et al*, 2009), dan satu individu per 7,6 km2 di Hutan Lindung Gunung Malabar (Ario *et al*, 2014).

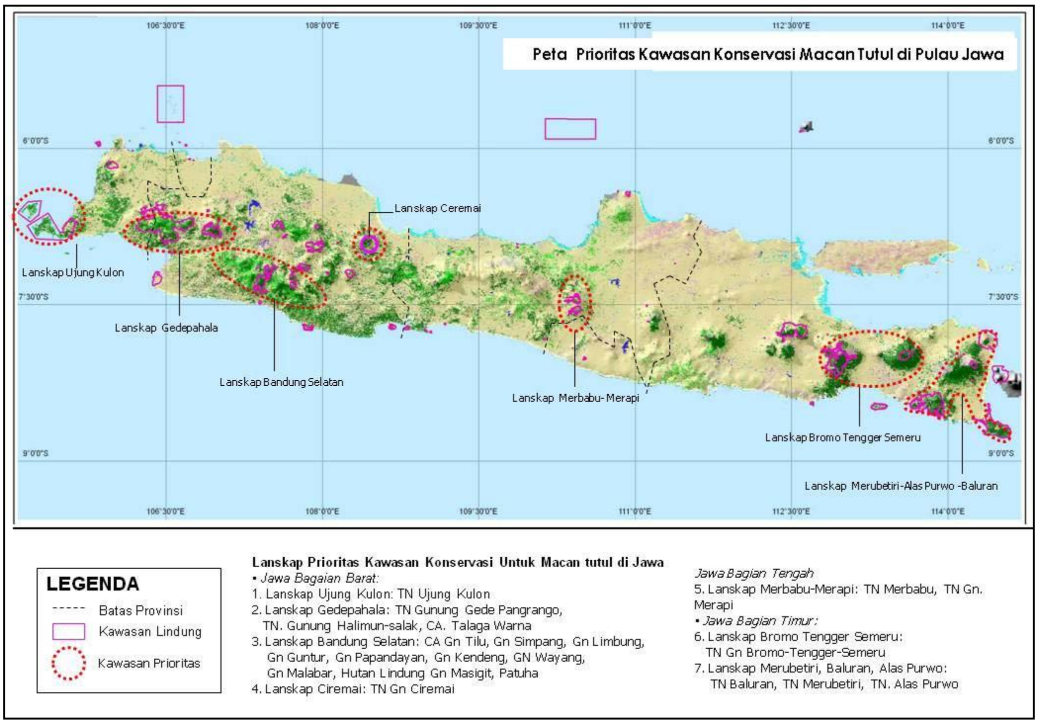
d. Ancaman

Jumlah macan tutul jawa yang tersisa di alam diperkirakan terus berkurang akibat penyusutan habitat, berkurangnya satwa mangsa, aktivitas perburuan liar, dan maraknya konflik antara macan tutul jawa dan manusia (Gunawan, 2010; Ario, 2010). Ancaman serius yang masih terjadi hingga saat ini menuntut segera dilakukannya upaya konservasi yang terintegrasi dan kolaboratif antara pemerintah pusat, pemerintah daerah, akademisi, LSM, perusahaan, media, dan pemerhati macan tutul jawa lainnya.

e. Peta Sebaran Nasional



f. Peta kawasan prioritas konservasi Macan tutul jawa



Situs Prioritas
Lokasi kegiatan pemantauan dilakukan pada situs monitoring yang telah ditetapkan pada setiap Unit Pelaksana Teknis (UPT) Ditjen KSDAE Kementerian LHK RI. Disarankan agar terintegrasi dengan Strategi dan Rencana Aksi Konservasi Macan Tutul Jawa/SRAK 2016-2026, maka lokasi pemantauan juga berdasarkan kawasan lansekap prioritas konservasi Macan tutul jawa.

Luasan area pemantauan
Dalam penentuan situs pemantauan dianjurkan untuk mempertimbangkan kriteria keterwakilan seluruh kawasan studi antara lain tipe habitat, kualitas habitat, ketinggian dan topografi, kondisi biofisik lanskap, kekompakan kawasan, keberadaan habitat dan biodiversitas fauna flora indikator, aksesibilitas dan tingkat kerawanan. Parameter-parameter tersebut dapat mempengaruhi keberadaan/ kehadiran dan/atau kelangsungan hidup spesies yang hendak diduga.
Luasan setiap UPT berbeda satu sama lain. Tidak disarankan menggunakan ektrapolasi dalam menentukan populasi suatu spesies berdasarkan perwakilan blok area pemantauan. Disarankan menggunakan penilaian populasi berdasarkan area pemantauan yang telah ditetapkan. Meskipun tidak ada ketentuan baku dalam menentukan luasan minimum area pemantauan macan tutul jawa yang dapat mewakili seluruh luasan kawasan, setiap UPT yang memiliki situs pemantauan macan tutul jawa disarankan untuk menggunakan area luasan pemantauan tidak kurang dari 6.000 hektar (60 km^2).

Metode Survei

<u>Jumlah Anggota</u>
Membutuhkan dua tim dalam pelaksanaan pemantauan. Dalam satu tim pelaksana berjumlah 3-4 orang/tim, yang berasal dari staf UPT maupun keterlibatan mitra UPT maupun masyarakat lokal.

<u>Peralatan Utama</u>
Dalam satu tim pemantauan membutuhkan peralatan sebagai berikut:

- Kamera pengintai, pada luasan situs pemantauan minimum 6.000 hektar (60 km^2) setidaknya membutuhkan 40 unit (30 unit untuk kamera berpasangan di lapangan, 10 unit sebagai cadangan)
- Kartu memori (*memory card*) berjumlah 40 buah (30 untuk pemasangan di lapangan, 10 buah sebagai cadangan)
- Baterai Alkaline dengan jenis dan jumlah yang disesuaikan dengan jenis kamera pengintai yang digunakan.
- Kamera digital 1 buah per tim
- Rantai pelindung dan gembok *camera trap* sebanyak 30 buah
- Tali *bungee* sebanyak 30 buah per tim
- GPS 1 buah per tim
- Kompas 1 buah per tim
- Alat komunikasi HT 1 buah per tim
- Peta lapangan / kerja 1 lembar per tim
- Lembar isian data (secukupnya)

<u>Waktu Kegiatan</u>
Waktu pelaksanaan survei dilakukan pada peralihan musim hujan dan musim kemarau, karena pada masa tersebut, tanda-tanda keberadaan macan tutul jawa dan mangsanya umumnya lebih mudah terdeteksi dan teridentifikasi. Kegiatan dilakukan pengulangan setiap tahunnya atau setidaknya dua tahun sekali.

Teknik Kegiatan

1. Tahap persiapan

- Mempersiapkan peta kerja yang telah dibuat sistim *grid cell* ukuran 2 x 2 km. Untuk luasan *sampling area* minimal 60 km^2 terdapat 15 *grid cell*.
- Mempersiapkan perencanaan kerja (tim pelaksana dan waktu yang dibutuhkan). Terdapat dua tim dalam pengoperasian minimal 30 unit kamera pengintai. Setiap tim terdiri dari 3-4 orang yang setidaknya mengoperasikan 15 kamera pengintai dalam kurun waktu 7 hari (dengan asumsi setiap hari, tim dapat mengoperasikan 4 kamera pengintai dalam dua petak contoh). Namun hal ini tentunya tergantung dari kondisi di lapangan.
- Dalam setiap petak contoh, kamera pengintai akan beroperasi setidaknya 15 hari per kamera.
- Mempersiapkan logistik dan peralatan yang dibutuhkan, serta membiasakan dengan peralatan yang akan digunakan.

Usaha Pendataan

Sebagai panduan umum, usaha pendataan minimal adalah 350 hari rekam/100 km^2, di mana satu hari rekam (*trapdays*) adalah 24 jam kamera aktif. Rumus penghitungan hari rekam per kamera untuk mencapai usaha pendataan yang diinginkan adalah:

$$Td = \frac{\left(\frac{T}{100}\right) * A}{S}$$

Di mana:
Td = hari rekam per stasiun kamera
T = target hari rekam / 100 km^2 (minimal 350 hari rekam)
A = luas kawasan yang dipantau
S = banyaknya stasiun kamera

2. Tahap Pelaksanaan

2.1. Penempatan Kamera Pengintai

Kamera pengintai ditempatkan di lokasi-lokasi yang berpeluang terdeteksinya macan tutul jawa berdasarkan jejak yang ditinggalkan (tapak kaki, kotoran, bau urine, dan cakaran di batang pohon). Umumnya macan tutul jawa di kawasan hutan pegunungan menggunakan punggungan hutan sebagai jalur yang umum digunakan. Pada setiap *grid cell* ditempatkan dua kamera pengintai (berpasangan) yang ditempatkan berhadapan, dengan jarak antar kamera pengintai setiap *grid cell* sejauh 2 km. Pada kamera berpasangan, keduanya dapat dioperasikan untuk pengambilan foto atau salah satunya untuk foto dan satunya lagi untuk video.

2.2. Pengoperasian Kamera Pengintai

Dalam setiap pengoperasian kamera pengintai, setiap unit dipastikan telah di set untuk waktu (jam, tanggal, bulan dan tahun) selain itu juga set *time delay* (disarankan 1 menit) antar jepretan kamera pengintai. Setiap jenis *camera trap* memiliki sistem yang berbeda namun prinsip kerjanya sama. Pengecekan kamera pengintai dilakukan setidaknya setiap 15 hari untuk mendapatkan perolehan gambar, mengganti *memory card* dan mengganti batrei. Hasil perolehan data dalam *memory card* untuk setiap kamera pengintai dipindahkan dalam *database*.

Catatan: *untuk meningkatkan efektifitas kerja setiap tim dalam UPT, apabila terjadi kehilangan kamera pengintai pada saat pemantauan berlangsung, hal tersebut merupakan konsekuensi penggunaaan alat penelitian yang ditinggalkan di lapangan tanpa pengawasan rutin.*

3. Tahap Pelaporan
3.1. Ringkasan data

- Memilah hasil foto yang dapat dijadikan sebagai data (foto/video independen)
- Mengelompokkan hasil foto kanan dan kiri
- Mengidentifikasi setiap individu berdasarkan pola tutul
- Apabila mendapatkan hasil foto berupa macan tutul jawa melanistik (macan kumbang) identifikasinya relatif lebih sulit, namun dengan hasil kamera pengintai yang pencahayaan kuat, maka hasil foto dapat terlihat pola tutulnya. Selain itu dapat juga dengan melihat ciri-ciri khusus seperti bentuk ekor dan guratan luka pada tubuh.

3.2. Analisa data

a. Usaha pendataan (*Sampling effort*):
   - Hari rekam (*trap days*), merupakan jumlah hari dimana kamera pengintai dianggap aktif merekam objek yang melintas di depannya. Satu hari rekam adalah 24 jam camera trap aktif. $\Sigma i{=}1\ TNi$, dimana i lokasi camera trap dan TN total hari rekam pada setiap lokasi ke-*i* (Kawanishi *et al*., 1999).
   - Laju keberhasilan jebakan kamera pengintai (*capture rate*) macan tutul jawa dan mangsa potensial dihitung dengan $CR = ni/\Sigma TN$, dimana CR adalah laju jebakan, *ni* jumlah foto/video independen spesies ke-i dan ΣTN adalah total hari rekam.
   - RAI (Relative Abundance Index): indeks kelimpaharan relatif per 100 hari rekam.
     $RAIi = n/\Sigma TN \times 100$, dimana *RAIi* adalah *relative abundance indeks, ni* adalah jumlah foto/video independen spesies ke-*i* dan ΣTN adalah total hari rekam (Kawanishi & Sunquist, 2004; O'Brien *et al*., 2003).

b. Memperkirakan kepadatan populasi
   $D = N / A(W)$, dimana *D* kepadatan macan tutul jawa yang diperoleh, *N* ukuran populasi (by CAPTURE), dan *A(W)* sampling area termasuk luasan penyangga.
   Luasan penyangga *sampling (W)* merupakan pendekatan standar untuk poligon penyangga dengan setengah *Mean Maximum Distance Moved* / MMDM (jarak linear maksimum rata-rata) individu yang sama terfoto kembali dilokasi yang berbeda (Wilson and Anderson, 1985; Karanth and Nichols, 1998).

   $W = (\Sigma d / m) / 2$, dimana *W* luas garis batas yang diperoleh, *d* jarak maksimum pergerakan, dan *m* jumlah jarak maksimum yang dibandingkan.

   Terdapat berbagai pilihan paket perangkat lunak (software) yang dapat digunakan untuk melakukan analisa kepadatan dan kelimpahan harimau sumatera dan satwa liar lain yang memiliki corak individu yang khas. Tiga perangkat lunak yang umum digunakan berikut panduan penggunaannya adalah:
   - DENSITY (http://www.otago.ac.nz/density/).
   - secr (paket analisa di dalam Program R: https://www.r-project.org/).
   - SPACECAP (http://www.mbr-pwrc.usgs.gov/software/spacecap.shtml).

   Petunjuk penggunaan (*user manual*) untuk *DENSITY* dan *SPACECAP* dapat diunduh dari link tersebut di atas. Sedangkan untuk paket *secr*, petunjuk penggunaan dapat diakses dan diunduh setelah paket *secr* dipasang (*install*) dan di muat (*load*) pada Program R.

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Lampiran

Lembar Data Operasional Camera Trap

Wilayah pemantauan: | Anggota Tim:
Blok pemantauan: | Tanggal berangkat:
Musim: | Tanggal pulang:

Identitas (ID)			Koordinat		Alt (mdpl)	Tipe Hutan	PASANG		AMBIL		Keterangan
Lokasi	Kamera	Kartu	Latitude	Longitude			Tanggal	Jam	Tanggal	Jam	

Lembar Data Hasil Camera Trap

Location ID	Latitude_ South	Longitude_ East	Alt (asl)	Set up date	Set up time	End date	End time	Image ID	Genus Species	Date captured (yyyy/mm/dd)	Time captured (hh:mm:ss)	Age	Sex	Count	Notes