Workshop Report: Structured Decision Making Approach to Tiger Prey Augmentation in Western Thailand Forest Complexes

Prepared for

World Wide Fund for Nature International: WWF

Prepared by

Compass Resource Management Ltd.
604.345.8542
Suite 302- 788 Beatty Street
Vancouver, British Columbia
Canada V6B 2M1
www.compassrm.com

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Executive Summary

Context

This report summarizes the approach, proceedings, and outcomes of a planning process to develop a long-term strategy for ungulate augmentation in Protected Areas across the Western Forest and Kaeng Krachan Complexes. The broad goal of this project is to restore balance between large carnivores and their herbivore prey, while also considering human socio-economic considerations. This work particularly focussed on creating conditions to support the recovery of wild tigers in Thailand, a species of cultural and ecological importance which has been declining worldwide for decades.

While wild tiger populations in Thailand have stabilized in recent years, and may be showing signs of increase in some areas, populations remain well below desired levels in both the Western Forest Complex (WEFCOM) and Kaeng Krachan Forest Complex. Prey availability has been identified as a significant limiting factor for tiger recovery across Thailand, and as such prey augmentation has been identified as a key management lever to support increasing tiger populations.

Compass Resource Management (hereafter “Compass"), a planning firm in Vancouver, Canada, was engaged to design and carry out a Structured Decision-Making process to support the World Wide Fund for Nature (WWF) Thailand and the Department of National Parks (DNP) in Thailand in creating a long term strategic plan for ungulate augmentation across the Western Forest and Kaeng Krachan Complexes. This planning process culminated in a 2-day Structured Decision Making (SDM) workshop in Bangkok, Thailand, where managers from Protected Areas across the forest complexes as well as academics and other experts designed and evaluated different strategies for prey augmentation across the region.

Approach

SDM is a collaborative approach for careful and organized analysis of natural resource management decisions. SDM involves informing decisions from clearly articulated fundamental objectives, recognizing the role of scientific predictions in decisions, dealing explicitly with uncertainty, and responding transparently to societal values in decision making. Compass developed an SDM process to gather and analyze relevant information, create mapping tools to visualize and work with data, and to guide workshop participants in designing and evaluating prey augmentation strategies.

Information Gathering & Processing

Compass gathered available information about wild tigers, ungulates, and other predators in the Western Forest and Kaeng Krachan Complexes, including spatial data, monitoring data, and research conducted in the area. The DNP shared relevant GIS layers and SMART Patrol data, which was compiled into TerraViz, Compass’ online interactive mapping tool for visualizing and working with spatial data. TerraViz allows for users to define relative weights for different spatial features and to generate a weighted composite layer across a given landscape. In this work, TerraViz was used to create habitat suitability maps for tigers and key ungulate prey species across the WEFCOM and Kaeng Krachan Forest Complexes. The habitat suitability maps were each a weighted composite layer created by assigning relative weights to key habitat factors for each species (e.g., elevation, forest type, distance from villages, distance from streams).

Summary and descriptions of available GIS data used in analysis (Table 1 in Report).

Layer	Description	Source
Basic Geographical Features		
Forest Complex	Polygon files of national parks and wildlife sanctuaries extracted from within the Forest Complex layer file	DNP
Ungulate breeding center	Point locations of ungulate breeding centers that supply ungulates for prey augmentation	DNP
Villages	Point locations of villages within and around the forest complex boundaries	DNP
Roads	All roads within forest complex boundaries used for navigation	DNP
Biophysical and Habitat		
Elevation	Raster data layer used to derive slope, roughness, and elevation data for forest areas	DNP
Vegetation Type	Polygons categorized by vegetation type	DNP
Water Bodies	Polygons of water bodies including streams, rivers, lakes, reservoirs	DNP
SMART Data		
Salt lick	Point locations of mineral licks used by ungulates as a source of nutrients	SMART
Threat	Patroller detected incidents such as fires, woodwork, trespassing	SMART
Ficus	Spatial distribution of the ficus plant	SMART
Sambar	Sambar sightings	SMART

Available data and research were critical for building a picture of habitat use and suitability for tigers and ungulates; however there were still some knowledge gaps that remained. To ensure that the planning process was built on the best available information, Compass designed a survey for DNP staff (i.e., Protected Area managers, superintendents, and technical staff) to gather local knowledge about historical, current, and projected species populations, limiting factors, and management capacity in each Protected Area across WEFCOM and Kaeng Krachan Forest Complex. Responses from the survey were also visualized in TerraViz.

Workshop Approach and Design

This planning process culminated in a 2-day workshop in Bangkok, Thailand, in February 2023, attended by approximately 40 participants comprising DNP staff, academics, and other experts. Given the large amount of data and information involved in this planning process, Compass prepared a pre-read package summarizing TerraViz mapping results, key survey findings, and other relevant contextual information.

In collaboration with a project team comprising DNP and WWF-Thailand staff, Compass developed four overarching qualitative objectives to guide the planning process:

- Tiger Recovery
- Prey Sustainability
- Management Capacity and Logistics
- Community Support

Each of these objectives included a range of related considerations to support the design and evaluation of prey augmentation strategies.

Typically in an SDM process, strategies are designed and evaluated prior to the workshop. However Compass was advised that the workshop participants themselves would be best placed to design strategies and evaluate them. Therefore, Compass designed an approach in which the participants were divided into five working group tables and each asked to create a strategy, based on available information and consideration of the four objectives, for where and how to distribute sambar available from Wildlife Breeding Centres in Thailand. Participants were provided with a template for designing and evaluating strategies.

The workshop participants would then collectively discuss the strategies created, and individually evaluate them using real-time methods in the workshop.

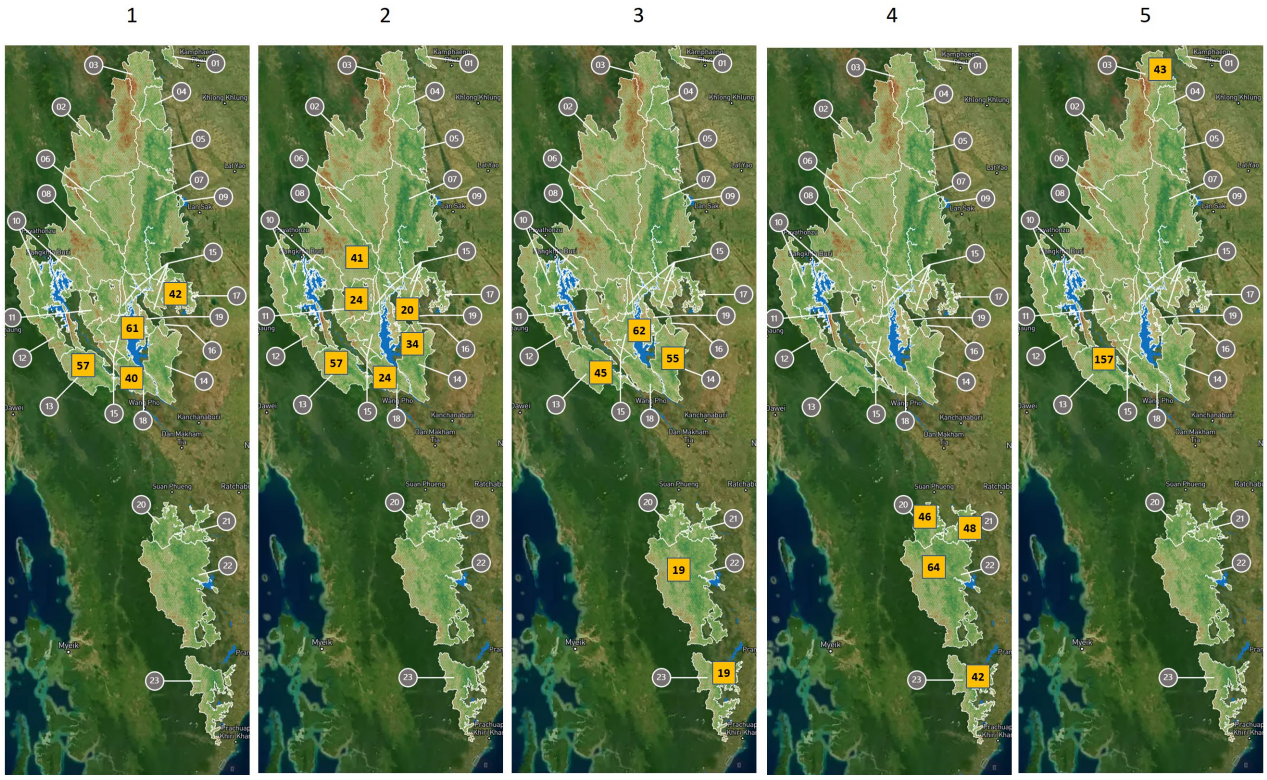
The final session of the workshop was designed as a broad discussion of opportunities, limitations, and other considerations for augmentation and/or translocation of other ungulate species (gaur, banteng, eld's deer) to support a balance of tiger and ungulate recovery.

Workshop Events and Findings

Due to various external constraints, the time available for the workshop was more limited than scheduled, resulting in less time for fulsome discussion. Nevertheless, Compass was able to adapt the agenda in order to still achieve the workshop objectives.

Key workshop sessions and outcomes included:

- An overview of previous ungulate augmentation activities in the Western Forest and Kaeng Krachan Forest Complexes supported by WWF – Thailand presented by Dr. Rungnapa. Dr Rungnapa shared lessons learned from past interventions and resulting effects on tiger populations.
- A summary of available information (e.g., habitat suitability mapping, DNP survey results) on tigers and ungulate species in two forest complexes, with a particular focus on sambar as the key species for prey augmentation. Participants provided feedback and insight, including noting that the village location GIS data layer was out of date; updating this layer allowed for more accurate habitat suitability maps for sambar and other species.
- A strategy development session: Participants broke out into five groups to design a sambar augmentation strategy (i.e., where, when, and how, you would distribute sambar across Protected Areas in both forest complexes), and to evaluate these strategies based on the four overarching objectives. The exercise was well received by participants, and five unique strategies were designed, evaluated, and collectively discussed. A summary of the strategies is pictured below.



An overview of the five strategies designed and evaluated by workshop participants. This figure shows the proposed spatial distribution of sambar across the forest complexes, with the yellow boxes indicating the total number of sambar allocated to a Protected Area over 5 years.

- Direct ranking of strategies: Participants ranked the strategies according to their preference in real-time. While there was a spread in preferences across the strategies, Strategy 3 had the most support from participants. This strategy included a build-out of sambar from southern WEFCOM, combined with introducing sambar to Kaeng Krachan Forest Complex later, as conditions for management capacity and logistics are established.
- Discussion of other ungulate species (gaur, banteng, eld's deer): Participants engaged in a collective discussion of experiences with augmentation and translocation of gaur, benteng, and Eld's deer. The workshop provided a good opportunity to learn more about habitat requirements and conditions for successful augmentation or translocation. However more scientific data and further discussion will be needed to make specific recommendations about these species.

Discussion and Recommendations

Through the two-day workshop, substantial progress was made toward a better collective understanding of habitat and management opportunities and constraints for prey augmentation across the Western Forest and Kaeng Krachan Forest Complexes. Key outcomes included:

- Workshop participants identified particular areas of focus for further prey augmentation planning.
- Workshop participants gained a better understanding of related considerations for management; workshop participants gained clarity about several key issues and identified topics that require further discussion.

- The workshop built the capacity of DNP staff to work together on prey augmentation, and demonstrated that Thai Protected Area managers are keen to engage together in open discussion of strategic issues across their respective areas.

Compass has compiled the following recommendations following the workshop (these are described in greater detail in Section 4.2 in the report):

Recommendation 1: We suggest that DNP and supporting organizations begin more detailed investigations into potential release sites in protected areas 13, 14 and 15.

Recommendation 2: We suggest that DNP and supporting agencies consider hosting a dedicated session to discuss pathways of activities for the expansion of tiger range to Kaeng Krachan Forest Complex specifically.

Recommendation 3: With respect to banteng, gaur and Eld's Deer augmentations, we suggest that DNP and supporting organizations investigate further the conditions under which such introductions or translocations might be necessary or successful.

Recommendation 4: To address the question of "how much information is enough" before performing prey augmentations, we suggest that DNP and supporting agencies consider developing a generic adaptive management framework for this activity.

Recommendation 5: With respect to the question of the 'minimum viable number of animals' to transfer, we suggest that DNP and supporting agencies consider organizing a structured expert judgment process to address the question of how to describe the functional relationship between number of animals introduced versus the probability that a self-sustaining population is established.

Recommendation 6: With respect to the ongoing concern about how prey augmentation might jeopardize World Heritage status, we suggest that DNP formally communicate with UNESCO to seek written assurances that such activities would be looked upon favorably.

Recommendation 7: We suggest that DNP and supporting organizations consider other areas of the endangered species management challenge that might benefit from an SDM approach.

Acknowledgments

Compass wishes to thank:

Michael Roy and Suphisit Jitvijak, who devised and led this initiative with professionalism, dedication and pragmatism.

Thomas Gray, Rungnapa Phoonjampa, Robert Steinmetz, Worrapan Phumanee and Naret Sueaturien provided essential technical input, insights, and much other support throughout.

The WWF-Thailand staff supervised by Suphisit Jitvijak provided invaluable assistance in the implementation of this work. They were Pimpavadee Phaholyothin, Yoganand Kandasamy, Rattaphon Pitakthepsombat, Marisa Sanguankwamdee, Phichet Munpa, Nithiporn Wongbundit, Warut Chaleekarn and Warissara Srisenphila.

Special thanks to On-iriya Fugthaworn for her dedicated support before, during and after the workshop.

We are indebted to the table facilitators during the workshop, who were Dr.Rungnapa Phoonjampa, WWF TH Senior Program Manager (Tiger Recovery); Mr.Suphisit Jitvijak, WWF TH Senior Program Manager (Rewilding); Dr.Worrapan Phumanee, WWF TH Senior Researcher (Tiger Recovery); Ms. On-Iriya Fugthawon, WWF DTL Landscape Manager; and Ms.Marisa Sanguankwamdee, WWF TH Monitoring & Evaluation Manager.

Workshop particpants (in random order) were Phadet Laithong, Puvares Montonphetch, Somying Thunhikorn, Panumas Samseeneam, Khwanrutai Charaspet, Komkrit Setbupha, Krairat Eiamampai, Somphot Duangchantrasiri, Weeraya Ochakul, Kasidis Chanpradub, Aekkapol Plaidaeng, Pakpoom Aramsirirujiravet, Tarasak Nipanan, Pongsawat Niphitpanya, Surasak Anumethangkul, Permsak Kanisthachat, Piya Pinyo, Supareak Klanprasert, Amnat Fongchai, Paitoon Intarabut, Noppadon Prabhong, Kittimasak Sornmanee, Phongpak Srisaiphet, Kitti Kanchanwong, Nichapat Yodarom, Anongnuch Chamnongkul, Pichet Chaisawat, Nuttida Seti, Ratchasit Jongjaratporn, Thirayu Kliangsaad, Thanachart Booneiam, Prawat Puangthong, Surat Soirod, Jirayu Piemrod, Polawee Buchakiet, Somchet Chantana, Natchakorn Rattanapetch, Suphon Polpan, Preechaya Naknongnuch, Phuwiwat Hiransri, Chumphon Kaewket, Thammanoon Themchai, Rattanawee Montreepo, Chayanit Prasanwong, Prakaijit Sangkham, Ronglarp Sookmasuang, Rattaphan Phattanarangsan, Pratheep Meekhatitham, Panudech Gerdmali, Chadaporn Srisai and Banpot Maleehuan.

A complete list of participants and their affiliations is provided in Appendix D.

The Compass team was led by Dan Ohlson and Graham Long, who also facilitated the workshop. Lee Failing provided strategic advice, and the heavy lifting was performed by Clayton Schroeder, Elan Failing, and Hasini Basnayake.

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Context

World Wide Fund for Nature: International (WWF) in Thailand is one of several Non-governmental Organizations (NGOs) supporting the Department of National Parks, Wildlife, and Plant Conservation (DNP), the responsible agency for tiger recovery in Thailand, as it advances tiger recovery through various approaches, including protected area management, law enforcement, public outreach and prey augmentation.

Tiger population numbers in Thailand have stabilized in recent years, and individual tigers are increasingly begin documented in areas where they were presumed locally extirpated, suggesting that the population is beginning to grow, particularly in the Western Forest Complex (WEFCOM). Tiger population growth in the Kaeng Krachan Forest Complex (KKFC), of particular strategic interest to the DNP, has an estimated population of only a few individuals, and growth has not been observed in recent years.

Research is increasingly identifying prey availability as a significant limitation to tiger recovery across its range in Thailand, and tiger prey augmentation is seen as an important catalyst that may accelerate recovery (Phumanee et al. 2021; Steinmetz et al. 2020; Jomborom et al. 2020; Phoonjampa et al. 2021, and others). DNP has a long history of rearing tiger prey and other ungulates for augmentation within tiger current and historic range. It has identified Wildlife Breeding Centers (WBC) able to increase tiger prey breed stock to numbers adequate to augment approximately 200-225 sambar by June 30, 2027. Augmentations or translocations of other prey species may be considered if they can be conducted in addition to planned sambar releases.

WEFCOM and KKFC have a combined total of 21 Protected Areas (Wildlife Sanctuaries, National Parks, and Non-Hunting Areas), two of which – Mae Wong and Khlong Lan – already have active programs. Many of the remaining 19 could be possible locations to distribute the captively-bred sambar, and managers and experts might be expected to disagree about which distribution strategy(s) would be optimal, since a decision would require subjectively balancing a range of factors, including biological objectives for both predators and prey, considerations around management capacity and logistics (e.g. road access), and the extent of local community support, among others.

Compass Resource Management Ltd. (Compass) of Vancouver, Canada, is an internationally recognized leader in helping groups find solutions to similar questions using a Structured Decision Making (SDM) process. SDM is a collaborative approach to organizing the available information to enable groups to develop creative alternative solutions and to evaluate them using criteria experts and managers think are relevant (Gregory et al 2012). Through facilitated collaborative discovery and discussion, SDM can often bring groups of disparate people to consensus on the best available approach(es) to a given situation.

In fall 2022, we (Compass) were contracted to support DNP managers in developing and evaluating alternative strategies to distribute ungulates from these breeding centers in the most effective location(s) using an SDM approach that would help them explicitly balance these factors. A 2-day workshop was arranged for February 1 and 2 in Bangkok, Thailand, at which Protected Area managers from throughout WEFCOM and KKFC, as well as experts and academics from other organizations, would be invited to participate to do so.

This report documents our approach to the planning and execution of this workshop, with findings, conclusions, and recommendations.

Approach

1.1 Analytical approach

Structured Decision Making is an approach for careful and organized analysis of natural resource management decisions. Based in decision theory and risk analysis, SDM encompasses a simple set of concepts and helpful steps, rather than a rigidly-prescribed approach for problem solving. Key SDM concepts include making decisions based on clearly articulated fundamental objectives, recognizing the role of scientific predictions in decisions, dealing explicitly with uncertainty, and responding transparently to societal values in decision making; thus, SDM integrates science and policy explicitly (USGS 2023).

SDM processes are scalable, and can take different forms and degrees of analytical intensity and rigor that vary with the complexity of the problem, the degree of technical and political uncertainty and controversy, the time and budget available and so on. SDM approaches can take as little as a few hours to as long as dozens of meetings over a year or more, and so an initial task is to develop an analytical approach that fits the needs and constraints.

A common first step in SDM processes, after having clarified the decision context and defined the decision to be made, is to develop an understanding of the things that are important to consider (objectives) and to create alternative solutions to the problem at hand. By showing the basic causal links between actions and outcomes, and from understanding the most important mechanisms that can affect them, influence diagrams help inform conversations about the information that is needed and why. We therefore developed Figure 1 based on a literature review and conversations with experts.

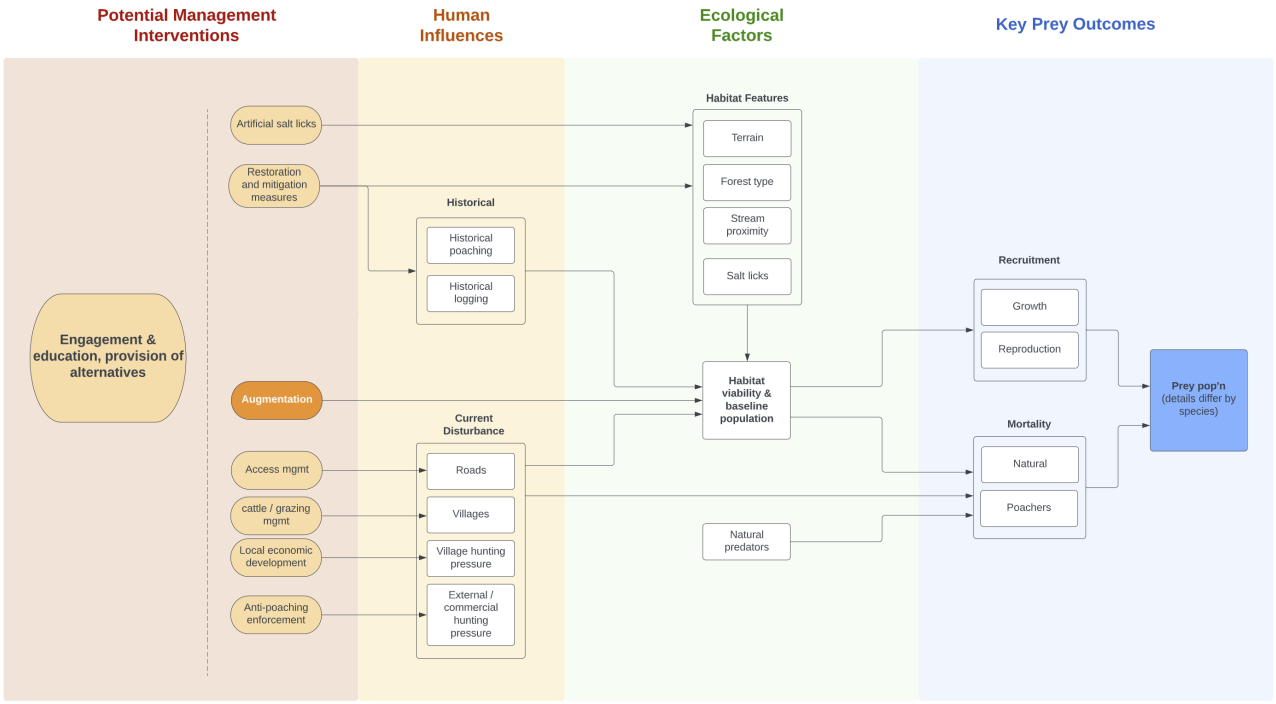

Figure 1: Ungulates influence diagram.

Reading from right to left, a primary goal in this case is to increase the overall self-sustaining ungulate populations. This is a function of both recruitment (reproduction and growth of new animals) and mortality (which can be adversely affected by both natural and human factors). A key influence on both is a confluence of three major components: Ecological factors (which include terrain, forest type, stream

proximity, salt-lick proximity and possibly others, which may vary by species); historical human activities that have an ongoing adverse effect, but which are no longer an ongoing driver (including historical poaching and logging); and current human disturbance, (which includes habitat fragmentation from roads, the proximity of villages, and various types of hunting pressure). Moving further to the left on the diagram, examples of the broader suite of possible management actions can be seen. This project is focused entirely on the augmentation management action, but did so with the broader context of all the interactions shown Figure 1 in mind.

As the figure reveals, successful prey augmentation is dependent on several factors such as:

- Biophysical factors including elevation and shallow patch size of low slope areas along streams.
- Habitat factors such as forest type, proximity to salt licks and sources of water, and connectivity, such as the presence of ecological corridors.
- Anthropogenic factors such as proximity to roads, villages, and livestock, location of ungulate breeding centres, protected area boundaries, historical and current logging practices, hunting pressure.
- Management capacity of individual protected areas, such as availability of patrol and monitoring staff and equipment for monitoring released ungulate populations.
- Community and political support for presence of tigers in each protected area.
- Access to release sites due to lack of roads or mountainous terrain and other logistics of implementation such as temporary enclosures in the protected area for ungulates prior to release.

On more analytically intense projects, we would develop formally stated decision objectives and develop performance measures to help describe the expected performance of each alternative on each objective. However, given the shortness of the workshop and our lack of access to experts to support the development of more quantitative criteria, we needed to pursue a more qualitative approach to both the development of objectives and the estimation of performance of alternatives on the objectives.

1.2 Information gathering and processing

Having identified the required information, we assembled a selection of best available sources. In discussions with WWF Thailand staff, we realized that while much useful information is available in the form of GIS layers and from SMART patrol data, there remained substantial knowledge gaps (for example, on current usage of the land by various animal species) that are not currently available in a quantitative form. However, this does not mean that there is no knowledge – clearly, protected area managers and staff are well positioned to know what evidence exists on this and related questions. For this reason, we worked closely with WWF Thailand to design and implement a survey of DNP managers and staff to fill these gaps with the *best available* information.

1.2.1 GIS Spatial Data and TerraViz

Many of the information needs implied by the diagrams can reliably be extracted from existing GIS databases. This is particularly true for physical features, elevations, proximity to various land and water features, forest cover types and so on. A summary of available data that we made use of is shown in Table 1.

Table 1: Summary and descriptions of available GIS data used in analysis

Layer	Description	Source
Basic Geographical Features		
Forest Complex	Polygon files of national parks and wildlife sanctuaries extracted from within the Forest Complex layer file	DNP
Ungulate breeding center	Point locations of ungulate breeding centers that supply ungulates for prey augmentation	DNP
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Salt lick	Point locations of mineral licks used by ungulates as a source of nutrients	SMART
Threat	Patroller detected incidents such as fires, woodwork, trespassing	SMART
Ficus	Spatial distribution of the ficus plant	SMART
Sambar	Sambar sightings	SMART

The GIS and SMART datasets were compiled in *TerraViz*, Compass's online interactive mapping and analysis tool that visualizes the available GIS habitat and survey data. In addition to displaying individual layers, TerraViz also allows for the combination of layers using whatever user-defined weighting functions are deemed appropriate. For example, users can generate a weighted composite layer that combines elevation and distance to villages (with samples taken in each 1 km^2 hexagonal unit), with the relative weight of each controlled using slider controls, with the outcome displayed as a colour gradient, red (less desirable) to green (more desirable), as illustrated in Figure 2. The ability to add new layers and adjust relative weights allows the Terraviz tool to be flexible to new research or advancements in understanding of key habitat factors for tigers and their prey in the future."

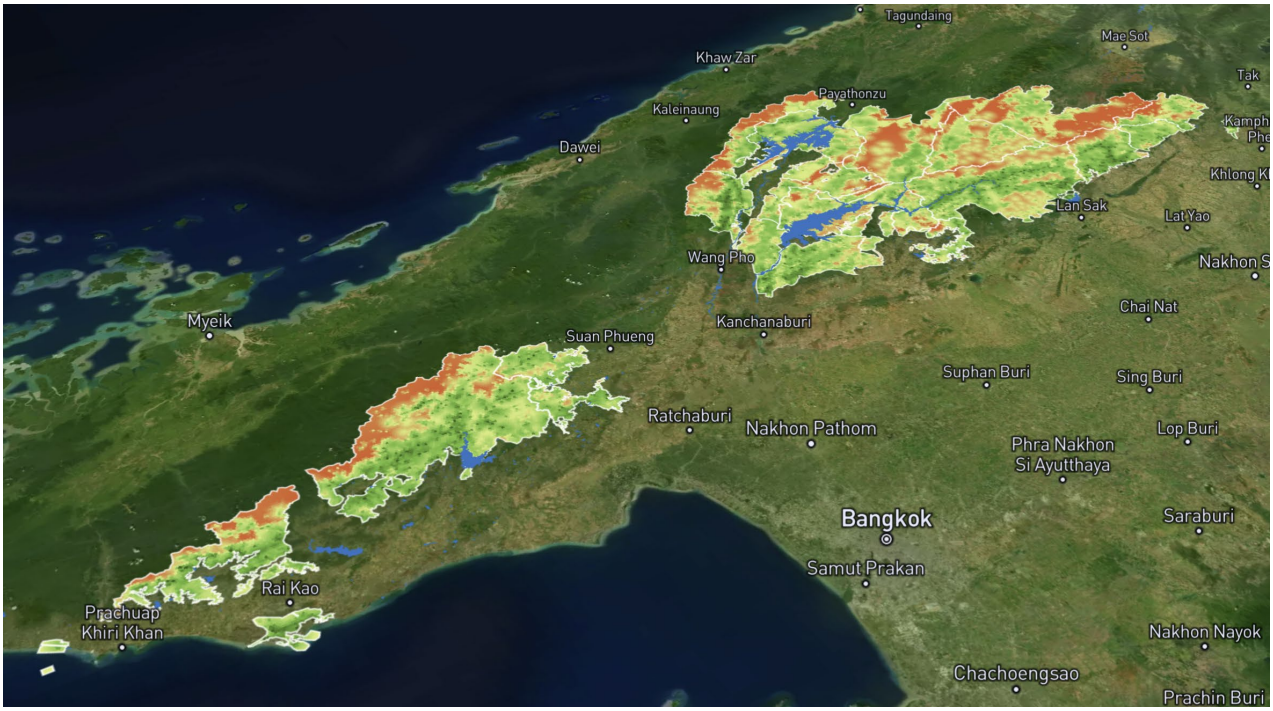

Figure 2: TerraViz interactive mapping tool showing Western and Kaeng Krachan Forest Complexes.

Through a review of the available literature and discussions with experts, we performed a proximity analysis between each hexagon for each species. For example, Sambar: for streams (closer is better), salt licks (closer is better), villages (further is better), and vegetation type (mixed deciduous) to develop weighted composite maps of habitat suitability.

Figure 3 shows a comparison of Jornburom et al (2020) spatially-explicit prediction maps of sambar occupancy probability (left) with updated village distance data, a component of our sambar weighted composite used in TerraViz (right), indicating that the information available in TerraViz broadly corresponds to that available in the published literature. An advantage of TerraViz is that the same analysis can be extended to the KKFC and similar maps can be and were developed for other prey species under discussion in the workshop, including banteng, gaur and Eld's Deer using different GIS layers and weights.

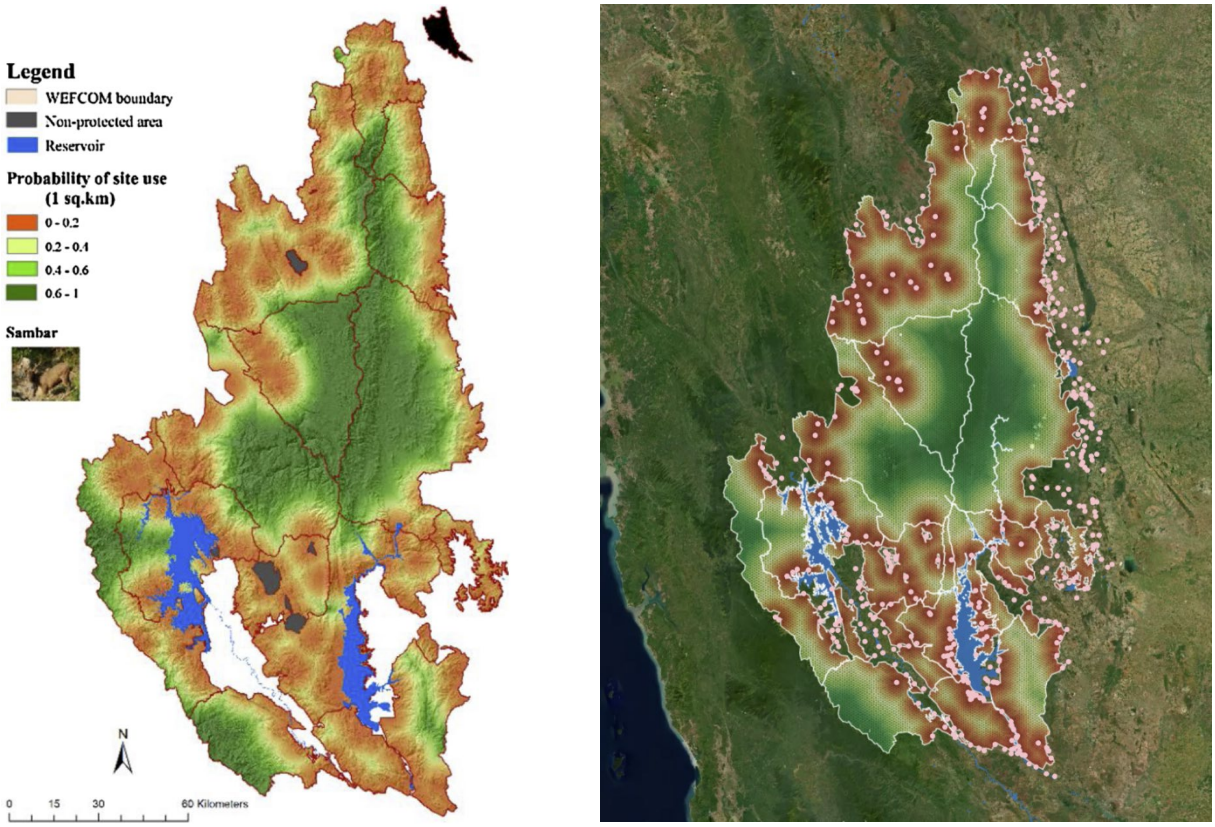

Figure 3: Comparison of Jornburom et al (2020) spatially-explicit prediction maps of sambar occupancy probability (left) with updated village distance data used in TerraViz (right)

TerraViz was also used to spatially display survey findings to help triangulate the available GIS and SMART data layers.

1.2.2 Survey of DNP Protected Area Managers and Staff

To fill in the data gaps, Compass developed a survey that was distributed by WWF-Thailand to protected DNP area managers, superintendents, senior WFF staff, and university researchers to gather local knowledge based on the SMART patrol system and scientific research on historical, current, and projected prey and tiger populations and management capacities in each protected area. The survey responses helped inform discussions on prey release strategies.

The survey contained three sections:

- **Section 1 – Ungulates:** This section included eight questions about ungulate species including Sambar, Eld's Deer, Hog Deer, Gaur, Banteng, Serow, Barking Deer (Muntjac) and Wild Pig/Boar such as:
    - How many animals are estimated in your area both now and in the past?
    - What are the factors that most influence the populations?
    - Is it a good idea to introduce ungulates in this area?
- **Section 2 – Predators:** This section included questions similar to section 1 about Tiger and other predators such as Leopard, Clouded Leopard, and Dhole.

- **Section 3 – Management Implications:** This section included questions about other relevant management factors that should be considered when deciding whether it is a good idea to introduce ungulates in this area.

Survey questions were translated into Thai and WWF Thailand staff undertook face-to-face interviews with the DNP managers and staff. An English version of the survey is presented in Appendix 2 along with a discussion of responses.

1.3 Workshop approach and design

Designing a 2-day SDM workshop to help a broad array of participants reach (or approach) resolution on a complex issue of this kind is challenging, and required careful preparation.

To maximize the opportunity for information exchange and discussion during the workshop, we created a pre-read package that was sent to participants a week or so ahead of the workshop. The package contained 23 pages of GIS and survey responses, along with other contextual information about the workshop and the approach. Sample pages from the pre-read are shown in Figure 4; the full pre-read is available as Appendix 3.

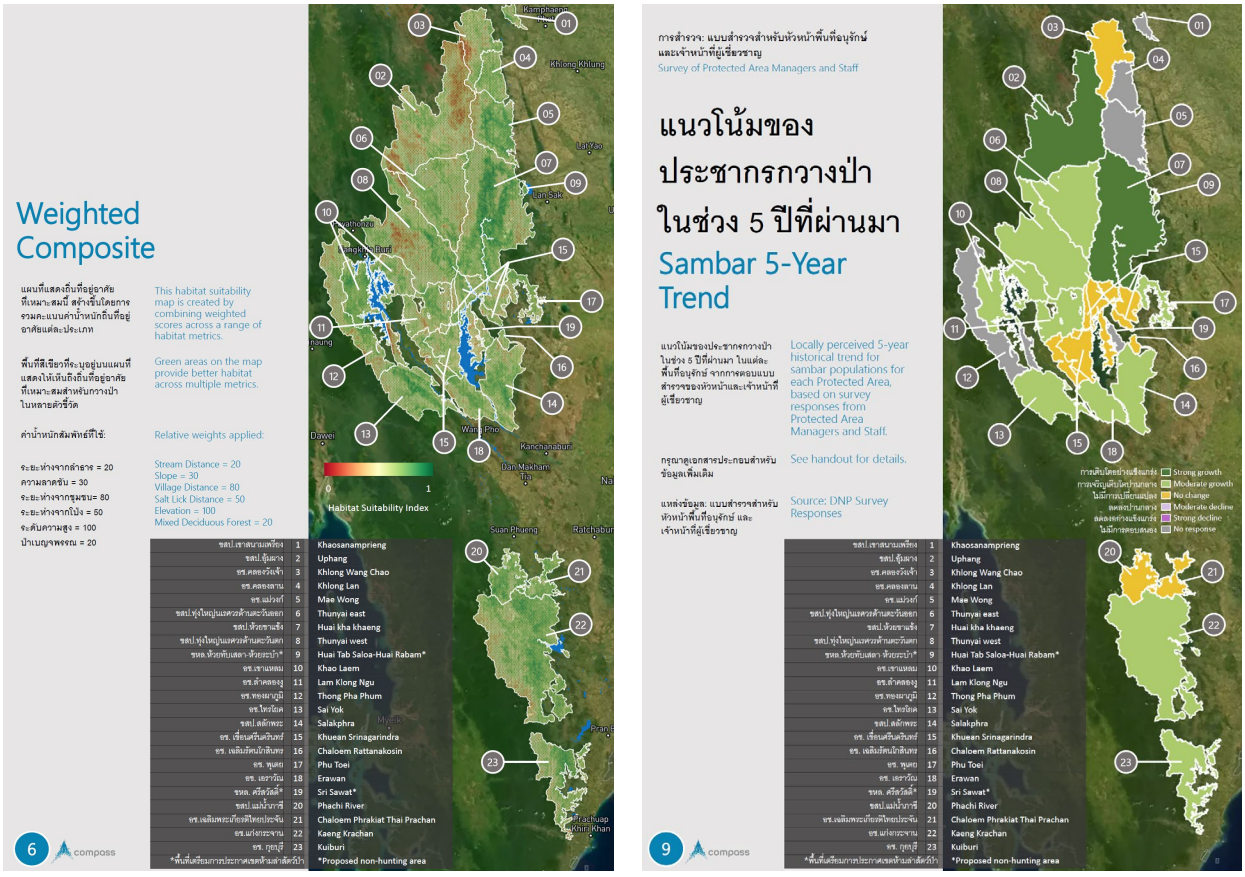

Figure 4: Sample pre-read and poster materials made available to participants

In brief times available with scientific experts in advance of the meeting, we learned that gaining a solid mutual understanding of the issues early on would be crucial. For this reason, we invited Dr. Rungnapa to provide a video and presentation covering this context at the beginning of the workshop.

For the workshop itself, which took place in the Best Western Nada Don Mueang Airport Hotel in Bangkok, WWF Thailand arranged for the use of simultaneous translation between Thai and English throughout the workshop. Participants could tune portable headsets to either language to follow the conversations.

Knowing that it would be difficult to properly specify quantitative objectives and performance measures in the workshop, we instead opted to provide a more qualitative summary checklist of objective 'considerations' shown in Table 2. At the advice of WWF Thailand scientists, the best people to create and evaluate alternatives on the objectives would be workshop participants themselves. This is in contrast to our usual preference for having alternatives be quantitively assessed in advance by subject matter experts in each field, for discussion by managers.

Table 2: Summary of Objectives

Tiger Recovery A primary goal of prey augmentation is to support tiger recovery. In selecting protected areas for prey augmentation, consider: • Is tiger recovery limited by prey availability in this area? • Are the biophysical habitat conditions suitable for tigers? • Is there a source population of tigers nearby to support range expansion? • Are habitat protection measures in place?	**Prey Sustainability** A key driver of the success of a prey augmentation program is the suitability of the habitat and the overall biophysical conditions that will enable prey species to thrive and form self-sustaining populations. In selecting protected areas for prey augmentation, consider: • Are the biophysical habitat conditions suitable for the target prey (sambar, eld's deer, gaur, banteng, hog deer)? • Are habitat protection measures in place? • Given habitat suitability and other relevant ecological factors, how likely is it that prey augmentation would lead to self-sustaining populations?
Management Capacity and Logistics Successful prey augmentation programs require dedicated staff and resources and must address logistical issues. In selecting protected areas for prey augmentation, consider: • Current staff levels and capacities / opportunities to improve • Current experience with re-introduction programs • Existence of high-capacity NGOs to collaborate with • Opportunities to dovetail with existing programs or plans (e.g., for ecotourism, etc.) • Logistics (e.g., road access)	**Community Support** Successful prey augmentation programs require the support of local communities to minimize threats associated with poaching, livestock management and human wildlife conflicts. In selecting protected areas for prey introduction, consider: • History of supporting tiger/predator recovery or prey augmentation programs • Demonstrated interest in or opposition to predator or prey programs • Quality of relationships with prey or predator managers • Evidence of conflicts between humans/communities and predators or prey • Evidence of support for reducing poaching and livestock conflicts

Our general approach to the workshop was to divide the group of approximately 40 participants (protected area managers, staff and other invited experts) into five working group tables that would each create an alternative 'strategy' for distributing sambar based on the information provided and based on consideration of these objectives.

To develop alternative strategies, we created a template printed on an A1 poster and attached to a flip chart easel (Figure 5). The top part of poster indicates the number of sambar assumed to be available in each of the years 2023 to 2027 (i.e., 14 sambar in 2023, 22 in 2024 and so on up to 83 available in 2027). These numbers were provided for discussion purposes by DNP.

Immediately below in the template, participants were tasked with weighing the available information and their own knowledge and experience of the context to create a possible strategy for distributing sambar over this period. In the example shown in this figure, participants of a group chose to distribute the animals into five protected areas (numbers 15, 13, 14, 22 and 23). They chose to put all 14 of the sambar

assumed to be available in 2023 in protected area number 15. The following year, they chose to add 8 more sambar to this area but also add 14 to area number 13 and so on.

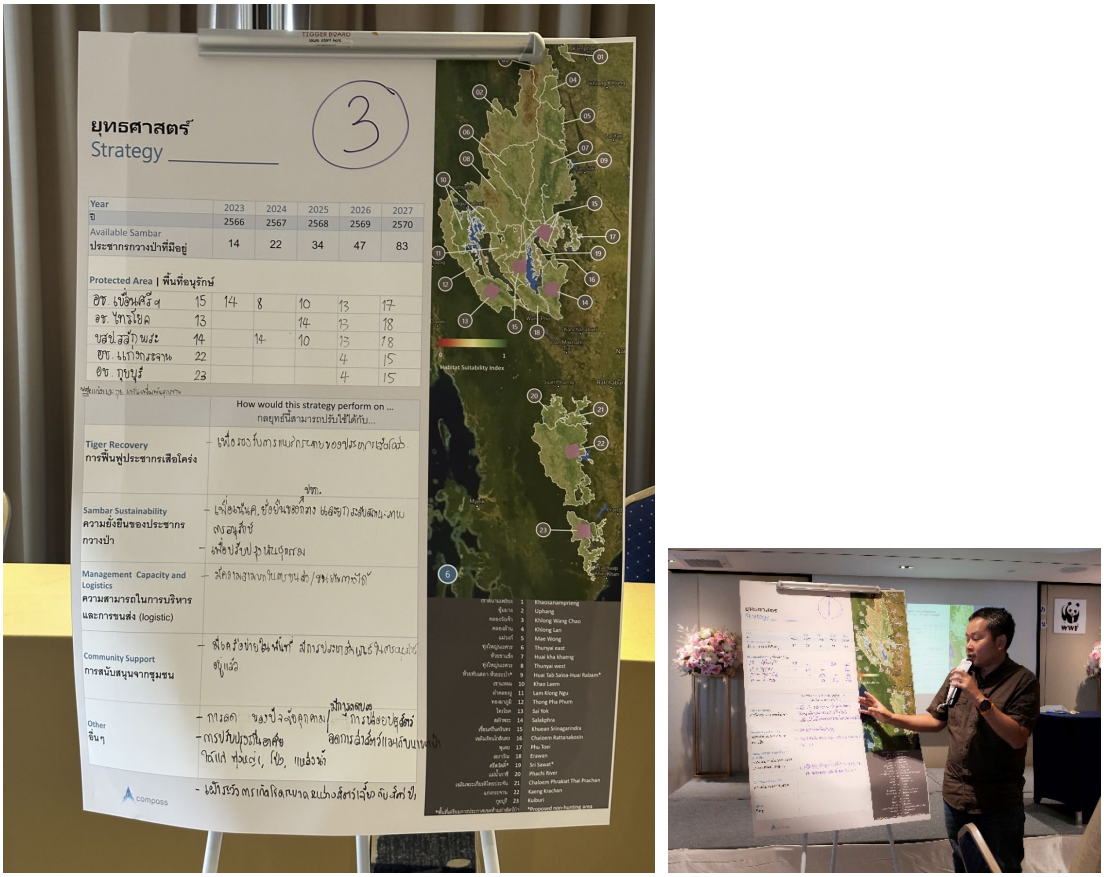

Figure 5: Template for describing alternative strategies

In the lower part of the template, participants were asked to consider and describe how this strategy would affect the four main objective groups we had previously identified – tiger recovery, sambar sustainability, management capacity and logistics, and community support.

Having created five strategies, our intention was for participants to 1) collectively evaluate each of them through conversations and 2) individually evaluate them using various smartphone-based instantaneous feedback technologies. We were particularly interested in looking for commonalities and notable differences between strategies, to understand the reasons why these might be and to facilitate group discussions moving forward.

Later on the second day, our plan was to discuss in a more limited way conditions in which banteng, gaur and Eld's deer might be either augmented or, as it transpired in the case of gaur, translocated. To inform these discussions, we again developed supporting information from GIS, SMART and the DNP survey, as illustrated for Eld's Deer in Figure 6.

Figure 6: Example reference information provided to support discussions on Eld's Deer augmentation.

Workshop Events and Findings

Before the workshop began, we were informed that for various reasons, the time available for discussions would be more limited than had been scheduled. For this reason, some of the following events were more rushed than would have been ideal, and much less time was available for discussion than we would have preferred.

A workshop agenda and participant list is provided in Appendix 4.

After welcomes and introductions, Dr. Rungnapa provided a summary of previous activities supported by WWF Thailand, including its support for four priority activities in upper WEFCOM including Mae Wong NP, Khlong Lan NP, Kholng Wang Chao NP, and Umphang WS. She focused on the issues surrounding the success of prey augmentation and experiences to date. Dr. Rungnapa shared the lessons learned and overall results from the past interventions and trends of the tiger populations.

Discussion points with participants on this presentation included:

1. To the extent possible, it is necessary to monitor the number of prey populations in each area to help understand what factors influence the migration of tigers.
2. Mr.Phanudej, The representative from Sueb Nakasatien Foundation raised a question whether we have information about the appropriate level of sambar and their abundance.
3. The factors that affect the breeding of sambar in nature need to be studied. We should know why the increasing number of prey like sambar is very limited such as lack of appropriate natural habitat, salt lick, etc.

4. Mr. Tammanoon from the Center of National Park Research and Innovation Development (Phetchaburi) raised an issue that Mae Wong and Khlong Lan are under the process of being proposed to UNESCO as a world heritage site. Therefore, we should be careful when reintroducing the sambar in these areas which may affect the genetics of the sambar.
5. Mr. Banpot, Former Director of DNP Wildlife Breeding Division suggested that WWF should consider to develop a project in collaboration with DNP to control the population of the dhole. He noticed that the dhole is one of the main predators affecting the increasing number and abundance of prey populations.

1.4 Sambar augmentation exercise findings

In our presentation of sambar data, two errors were noted: The distance-to-village GIS layer was outdated and showed some villages that no longer exist (this has subsequently been updated). Also, the location number 14 is not Salak Phra WS; it should be swapped with Pho Toei NP (number 17). Due to the effort involved in re-creating all the images, this error is noted but images are not updated in this reporting.

In addition to the factors of relevance we presented, Mr. Tammanoon suggested that the team should also consider additional factors for sambar reintroduction including:

1. Geographic characteristics such as lowland, mountain ridge, etc. that support the migration of the animals.
2. Thailand - Myanmar Transboundary geographic such as rain shadow, temperature, wildfire, precipitation, etc.
3. The team should not use the distance from the villages for consideration but it should be the distance from the agriculture areas.
4. Mixed Deciduous Forest should not be used as a main factor for consideration. The sambars could adapt themselves to sustain in different geographic areas such as evergreen forest.
5. Diversity of Flora classification.
6. Sub basin should be used for consideration rather than the whole national park area. We can develop the map based on the watershed.
7. Threat factors should also be considered.

These factors are noted for future conversations.

The strategy development exercise was well received, and five groups engaged enthusiastically in the challenge. By lunch on day 1, the five strategies shown in had been developed, shown in Figure 7.

	Year	2023	2024	2025	2026	2027	Total
	Available Sambar	14	22	34	47	83	
	Protected Area						
1	15. Khuen Srinagarindra	14			27	20	**61**
	17. Phu Toei		22			20	**42**
	18. Erawan			20		20	**40**
	13. Sai Yok			14	20	23	**57**
2	14. Salakphra	6	8			20	**34**
	11. Lam Klong Ngu			12	12		**24**
	13. Sai Yok	8	8	8	12	21	**57**
	8. Thungyai east				11	30	**41**
	19.Sri Sawat		6	14			**20**
	18.Erawan				12	12	**24**
3	15. Khuean Srinakarindra	14	8	10	13	17	**62**
	13. Sai Yok			14	13	18	**45**
	14. Salakphra		14	10	13	18	**55**
	22. Kaeng Krachan				4	15	**19**
	23. Kuiburi				4	15	**19**
4	22. Kaeng Krachan	6	8	11	15	24	**64**
	21. Chaloem Phrakiat Thai Prachan	2	4	9	12	21	**48**
	23. Kuiburi	2	4	7	10	19	**42**
	20.Phrachi River	4	6	7	10	19	**46**
5	13. Sai Yok	14	22	34	47	40	**157**
	3. Khlong Wang Chao					43	**43**

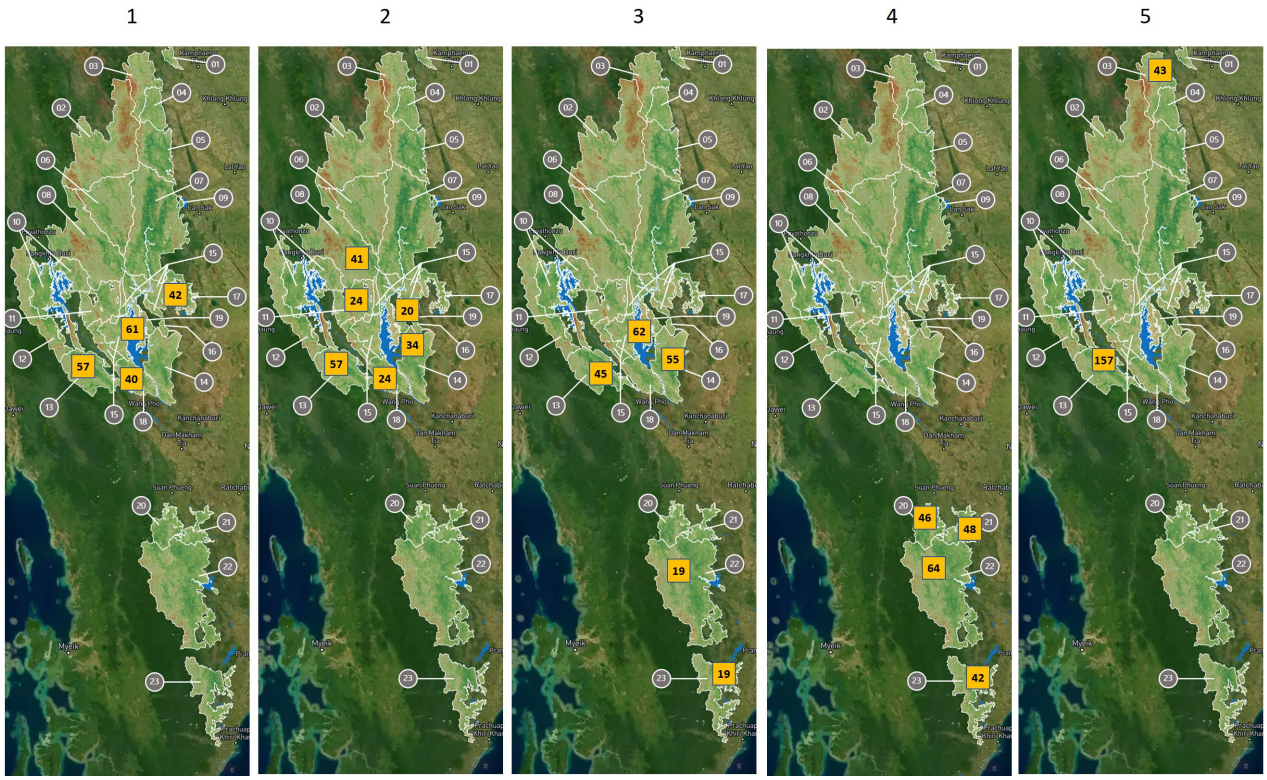

Figure 7: Spatial distribution of sambar over 5 years by 5 independent teams of DNP managers and invited external experts. The table shows the distribution of sambar over time, whilst the maps visually show the spatial distribution of the totals.

Strategy 1. Developed by participants mainly from Middle WEFCOM, with the rationale that these proposed geographic areas have tigers established and an increasing number of the sambar is critical to support tiger recovery strategy in the future. The sambar sustainability also needs strong prevention intervention from the SMART patrol. The logistics for translocation are manageable.

Strategy 2. Developed by participants mainly from South WEFCOM (East), with the rationale that these proposed geographic areas focus on tiger recovery. Therefore, they prioritized the location where tigers

are found. It is necessary to have sufficient prey to prevent them heading to the villages that caused hunting. However, it is necessary to strengthen collaborations among key stakeholders for appropriate management including awareness raising and SMART patrol. The team didn't propose Khuean Srinakarindra as part of their priority area due to the high level of threat which sambar reintroduction may increase the risk factor for tigers.

Strategy 3. Developed by participants mainly from South WEFCOM (West), with the rationale that the key factors that support the decision are abundance of the habitat and suitable environment for tigers including evidence of their presence. The top three proposed locations are connected and there is evidence of the migration amongst these locations. However, tigers are still not established in the areas then increasing prey abundance will bring them to establish in the proposed areas and support tiger recovery. Additional proposed locations in Krang Kranchan and Kuiburi aim for developing genetic diversities.

Strategy 4. Developed by participants mainly from Krang Krachan Forest Complex, with the rationale that their proposed areas are suitable for sambars but they are not suitable for tigers. It aims for sambar sustainability and breeding. These are world heritage areas.

Strategy 5. Developed by participants mainly from Upper WEFCOM, with the rationale that Sai Yok has appropriate geographic areas for sambar reintroduction. Additional information regarding community engagement and support is required in this area.

Key discussion points at this stage included:

- Mr. Somjet, Superintendent of Krang Krachan NP, mentioned one of the long-standing issues as the World Heritage site. There is a concern that the activities for habitat improvement and sambar reintroduction may intervene the natural ecosystem. He suggested that we should also communicate at the international level that there is not an intention to disrupt the natural system but rather to increase the abundance of the ecosystem.
- Mr. Tammanoon suggested that we should also think about the ability and suitability of the selected locations where we are going to release the sambar to avoid competing for resources.
- Mr. Panumas, Director of DNP Wildlife Breeding Division, suggested that the discussion and decision process in this workshop should be documented. This is very important as we are making decisions on the location to reintroduce sambar using a scientific approach. Then the document can be used to present to the related key decision makers in the future.

Some observations on the strategies developed by the five groups include:

- There was relatively little emphasis on the northern area of WEFCOM, with only one group allocating sambar to one northern area. Reasons for this are possibly because as previously noted there are currently sambar augmentation activities in areas 2 and 3 (and these are being treated separately), and that sambar are relatively successful the north generally, and further benefits should be sought in different, more marginal areas.
- Overall, there was a strong focus on the southern WEFCOM area, on both the southwest side and the southeast side. There was a notable preference for area 13, Sai Yok, which was present in four of the five strategies independently developed and that had an overall sambar allocation more than double that of any other single area (Figure 8).

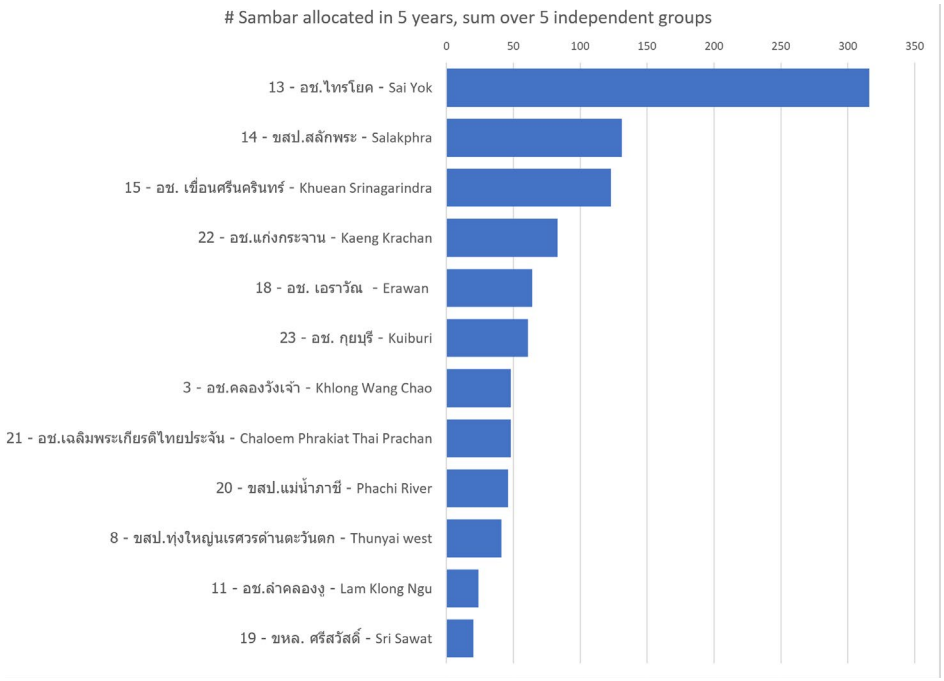

Figure 8: Sambar allocated by 5 independent groups.

- The next two most commonly assigned areas were areas 14 (Pho Toei, incorrectly labelled as Salakphra in the figures) and 15, Khuean Srinagarindra, both of which are in the low land immediately adjacent to the Sinakharin reservoir that is held by the Srinagarindra dam.
- The messages from KKFC are unclear and need to be further discussed. Although areas 22 and 23 are cited by two groups, group 4, comprised mainly of participants from the KKFC, stated explicitly that they distributed sambar there for ungulate sustainability reasons and not for tiger conservation. This, in addition to other comments from members of this group during the meeting about the appropriateness of augmenting sambar in this (or even any) area, may indicate that area managers in this complex have reservations about prey augmentation to support tiger range expansion in this forest complex.

One further observation that warranted group discussion that was not possible due to time constraints was the question of the 'minimum viable' number of animals transferred to an area. Group 5, which contained participants with direct experience of augmentations in northern WEFCOM, allocated most of its sambar to a single protected area. We understand that this is because the probability of developing a long-term self-sustaining population of sambar is in some way proportional to the number of animals moved there each year. We discuss this further in the recommendations.

Examining how different groups allocated sambar gives us clues as to the perceived advantages of certain protected areas. Ideally, we would have had more time to probe the reasoning for each of the allocations and potentially to iterate further on new combinations.

In planning the workshop we were unsure whether to attempt to ask participants to rate the performance of each strategy on explicit criteria related to the objectives. In the event, we did so, but in a manner that was rushed and further compromised by communication difficulties. As a result, we believe the findings of this brief exercise are confounded, and they are not presented here.

Of more value, however, was a 'direct ranking' exercise, in which after discussing the relative merits and challenges of each of the strategies in terms of the objectives, each person was asked to rate their relative preference for each strategy on a 0-100 scale using Compass's smartphone application.

The findings of this exercise are shown in Figure 9.

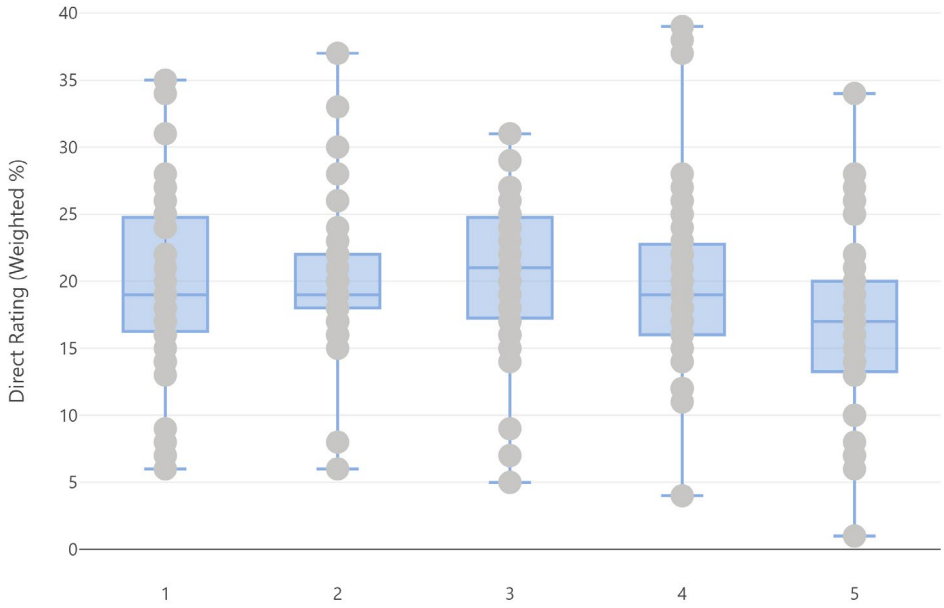

Figure 9: Direct ranking results showing the range of relative preferences assigned to each strategy by participants. Each grey circle is a person's response, and the box captures the interquartile range of responses, with the median response shown by a horizontal line in each box.

From this figure, we can see that:

- Based on the median response, strategy 3 had most support from participants. This strategy included a build-out of sambar from southern WEFCOM, combined with introducing sambar to KKFC later, presumably as conditions for management capacity and logistics are established.
- Strategies 1, 2 and 4 have a similar median response.
- Strategy 5 had the lowest median degree of support (though this might reflect a lack of discussion about the minimum number of animals noted above).

The discussion of these results covered these points:

Mr. Tirayu, representative from Sai Yok NP, the area with most support for sambar augmentation, expressed support for sambar augmentation there, but proposed that additional study of sambar populations be undertaken before adding more population.

Mr. Banpot said that in his opinion, the objective of sambar reintroduction should not be to release them to be a prey. The sambars will also increase abundance of the forest and improve the balance of the ecosystem.

Mr. Phanudej, the representative from Sueb foundation, proposed additional issues that the team should be also considered as follows:

- We also need to consider the existing activities in the national park such as tourism.

- Management capacity of Sai Yok especially in the west that connects with Myanmar. It is necessary to strengthen the capacity of SMART patrol in the targeted area.
- Information regarding the DNA of sambar should be considered for diversity of the genetic.

The issues related to the concerns of the World Heritage status were clarified. Thomas Gray, WWF, informed that the habitat improvement and translocation activities are aligned with the UNESCO's World Heritage guideline. The augmentation process was supported and documented clearly by the IUCN translocation expert group. Mr. Prateep from IUCN Thailand also reaffirmed the information based on his discussion with Mr. Tueman, consultant from UNESCO. They just would like to understand the reason for the interventions and assure that the activities will not affect the existing ecosystem.

Mr. Tammanoon also raised the point that the reintroduction should also be considered to support the connectivity of the corridor. The Maenam Phachi WS is still an important location.

Dr. Longrap from Kasertsart University suggested that we should have a clear target for sambar reintroduction and agreed that it should not only be focused on being a prey.

1.5 Banteng, Gaur and Eld's Deer discussions and exercises

After reviewing the habitat suitability maps and DNP manager survey responses for Banteng, Gaur and Eld's Deer, participants had an opportunity for short discussion on experiences with augmentations and translocations on each in turn. At the conclusion of each discussion, participants were asked to identify which of the protected areas might be suitable for augmentations and their reasons why.

Mr. Phanudej, the representative from Sueb Foundation, thought that the workshop was a good opportunity to learn more about these animals and this process but not sufficient alone be able to make decisions. Additional scientific data to support the decision is required to ensure that there is sufficient information to reach consensus decisions.

1.5.1 Banteng

There was general support for the possibility of banteng augmentation, and several protected areas identified as candidate locations for consideration. Figure 10 shows a count of participants rating each protected area as suitable for banteng augmentation or translocation. Some of the comments provided by participants included:

- Both ecological and human factors must be considered, guarding against potential human-wildlife conflict.
- Large areas with suitable forest types (mixed deciduous) are most suitable.
- Need to plan for and monitor genetic diversity.

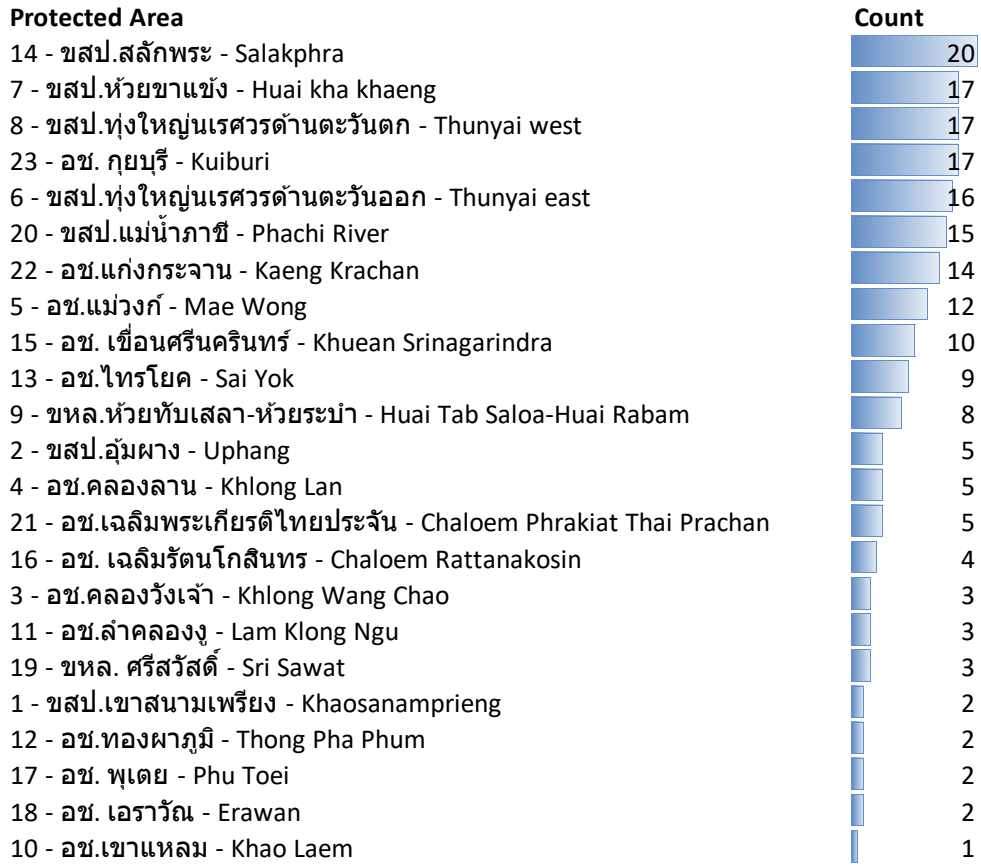

Figure 10: Count of participants rating each protected area as suitable for banteng augmentation or translocation

1.5.2 Gaur

Most participants agreed that translocations for Gaur are not required, however a small number of participants thought it might be valuable in a few protected areas. Figure 11 shows a count of participants rating each protected area as suitable for gaur augmentation or translocation. Some of the comments provided by participants included:

- Gaur populations are currently sufficient, and translocations are not required.
- Some areas have low gaur numbers and are on the edge of areas that would support tiger recovery.
- It is a very large animal and thus difficult and costly to translocate.
- There would be potential for human-wildlife conflict.

Protected Area	Count
3 - อช.คลองวังเจ้า - Khlong Wang Chao	3
13 - อช.ไทรโยค - Sai Yok	3
4 - อช.คลองลาน - Khlong Lan	2
5 - อช.แม่วงก์ - Mae Wong	2
15 - อช. เขื่อนศรีนครินทร์ - Khuean Srinagarindra	2
22 - อช.แก่งกระจาน - Kaeng Krachan	2
1 - ขสป.เขาสนามเพรียง - Khaosanamprieng	1
2 - ขสป.อุ้มผาง - Uphang	1
6 - ขสป.ทุ่งใหญ่นเรศวรด้านตะวันออก - Thunyai east	1
10 - อช.เขาแหลม - Khao Laem	1
11 - อช.ลำคลองงู - Lam Klong Ngu	1
12 - อช.ทองผาภูมิ - Thong Pha Phum	1
14 - ขสป.สลักพระ - Salakphra	1
19 - ขหล. ศรีสวัสดิ์ - Sri Sawat	1
20 - ขสป.แม่น้ำภาชี - Phachi River	1
21 - อช.เฉลิมพระเกียรติไทยประจัน - Chaloem Phrakiat Thai Prachan	1
23 - อช. กุยบุรี - Kuiburi	1

Figure 11: Count of participants rating each protected area as suitable for gaur augmentation or translocation.

1.5.3 Eld's deer

Most participants indicated that there was not much suitable Eld's Deer habitat within the WEFOM and KK Forest Complexes. Nonetheless several candidate protected areas were identified for consideration. Figure 12 shows a count of participants rating each protected area as suitable for Eld's Deer augmentation or translocation. Some of the comments provided by participants included:

- There are very rare. Other habitats in Thailand should be considered for Eld's Deer.
- Most areas near villages in low lying areas would be inappropriate.
- Only in areas with suitable habitat conditions.

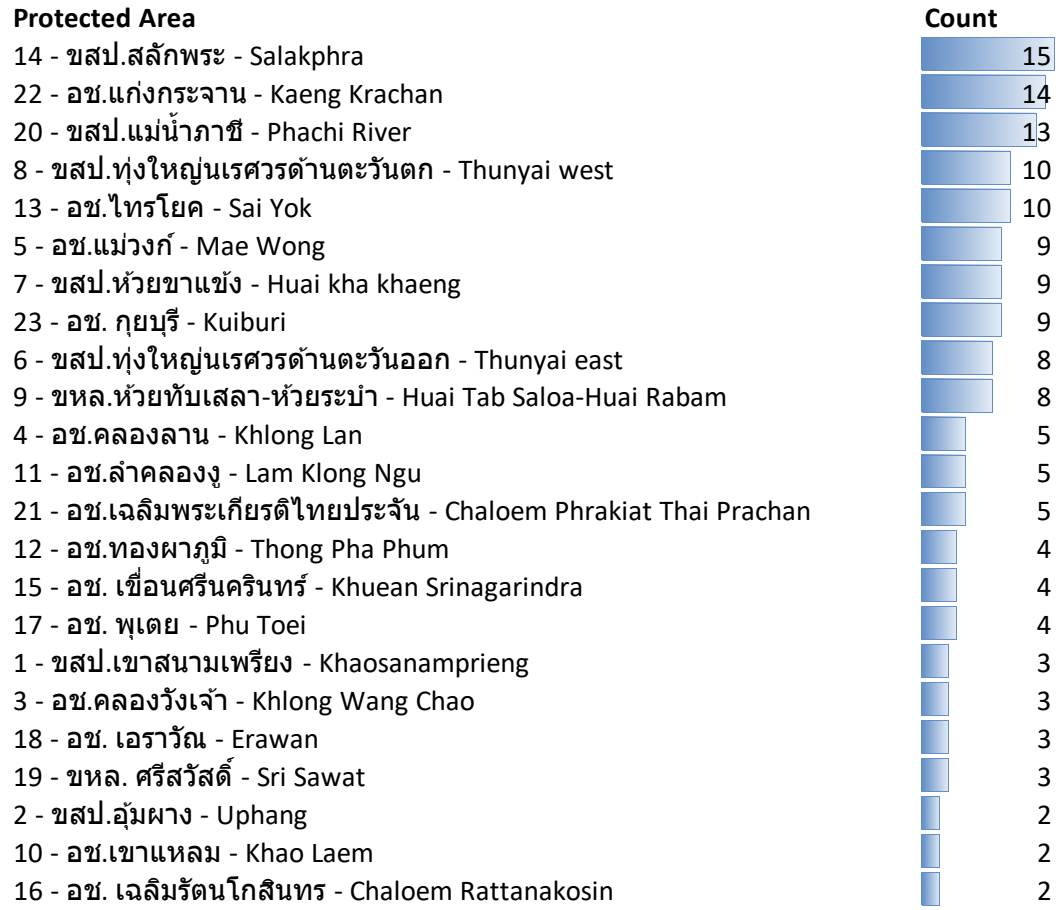

Figure 12: Count of participants rating each protected area as suitable for Eld's Deer augmentation or translocation

Discussion and Recommendations

1.6 Discussion

As was appreciated going into this workshop, the question of exactly which locations and in what sequence to release captive-bred sambar into WEFCOM and KKFC is both technically and politically complex, and a consensus decision on these issues could not be expected to emerge from an initial two-day workshop. However, we believe that substantial progress has been made in at least the following respects:

A reasonably clear pattern emerged that further discussions around sambar augmentations should be focused on the particular aspects of southern WEFCOM, in particular protected area 13, Sai Yok, and the areas around the reservoir.

Sambar introductions to KKFC are also seen as desirable from the perspective of diversifying ungulate populations per se, particularly in areas 22 and 23, though the extent to which they should function as prey for tigers is unclear and needs further discussion.

Leading candidate areas for the augmentation of banteng and Eld's deer were identified, and it was clarified that all but a few managers do not see in the need for translocating gaur.

The meeting clarified that there are differing opinions on the information base required in advance of prey releases. Many participants believe that the current information base is inadequate to release animals, and that releases should only happen under strictly controlled conditions, with clear management objectives and monitoring regimes. We also heard several people express doubts about the wisdom of intervening with 'natural' movements of animals in any case. These doubts are based both on personal attitudes to wildlife management as well as risk attitudes towards committing sins of commission versus omission when implementing a mandate to protect endangered species. In our experience, a diversity of such opinions among biologists and managers appears to be universal and should be embraced and potentially harnessed through consideration of the development of appropriately scaled adaptive management programs (see recommendations below). With captively-bred animals already reaching maturity for release, finding a reasonable balance between learning and doing is as urgent as it is essential.

A related concern, repeated several times during the workshop, concerned the potential negative impact on World Heritage status that moving animals might jeopardize. Despite the issue being addressed directly, there clearly remain concerns.

From a process perspective, the workshop dispelled questions as to whether Thai protected area managers would engage in open debate about strategic issues concerning this topic. In fact, participants enthusiastically engaged in group work to identify and build create strategies for prey augmentation and / or animal translocations, and there was apparently much thoughtful information exchange among knowledgeable people. We hope that DNP recognizes the value of pooling the expertise of its managers and external experts through structured processes of this type.

By doubling down on the same area year after year with all animals available, the probability of a self-sustaining probability in that one area is increased. However, this success would be at the opportunity cost of not increasing the probability of populations elsewhere, potentially foregoing benefits of diversifying geographical spread of populations. There must exist a function (at least theoretically) that relates the number of animals moved to a location against the probability of a self-sustaining herd developing there. Moving two animals (as one group proposed) presumably has a very small but non-zero probability of establishing a herd. Logically, at some point there must be a point of diminishing returns wherein adding more animals has little appreciable impact on changing the probability of success. We assume that the shape of this function is unknown but wonder if there might be opportunities to better understand it using structured expert elicitations directed at this question.

We believe this workshop met its objectives despite considerable reductions in time available for discussion among the participants. It is clear that collaborative SDM processes have the potential to play a useful role in this conservation management context, and we would welcome the opportunity to contribute further to efforts to recover Thailand's endangered species.

1.7 Recommendations

Recommendation 1: We suggest that DNP and supporting organizations begin more detailed investigations into potential release sites in protected areas 13, 14 and 15. These investigations should involve close collaboration with protected area managers in these locations, and should consider the full range of elements known to be relevant, including macro and micro-scale geophysical characteristics,

estimated habitat carrying capacity, as well as management and logistics, community relationship questions, and monitoring designs.

Recommendation 2: With respect to clarifying the pathway of activities that might lead to the expansion of tiger range to KKFC, we suggest that DNP and supporting agencies consider hosting a dedicated session to this issue specifically.

Recommendation 3: With respect to banteng, gaur and Eld's Deer augmentations, we suggest that DNP and supporting organizations investigate further the conditions under which such introductions or translocations might be necessary or successful, with a particular focus on the protected areas identified by the exercise undertaken in this workshop.

Recommendation 4: To address the question of "how much information is enough" before performing prey augmentations, we suggest that DNP and supporting agencies consider developing a generic adaptive management framework for this activity. The framework could be created in collaboration with protected area managers and would address which uncertainties are acceptable in this context and which should be addressed in whatever manner prior to the release of animals. In developing the framework, consideration should be given towards finding a reasonable balance between activities that reduce uncertainties and encourage learning versus those that implement concrete actions in the short term that have the potential to accelerate recovery. Adaptive management can take many forms, but its common thread is the notion of avoiding "paralysis though analysis" in favour of "learning whilst doing".

Recommendation 5: With respect to the question of the 'minimum viable number of animals' to transfer, we suggest that DNP and supporting agencies consider organizing a structured expert judgment process to address the question of how to describe the functional relationship between number of animals introduced versus the probability that a self-sustaining population is established. Although this relationship is unknown, and is dependent on habitat conditions and other factors, it is not that case that, for any given circumstance, experts collectively have no idea at all what the shape of this function is. Convening a panel of experts with experience with sambar biology and management, predator management, augmentations and possibly other related disciplines to follow a well-established methodology (for example, see Hemming et al 2018), would help establish the *best available* information on what this function might be, and this would inform prey augmentation decision making moving forward.

Recommendation 6: With respect to the ongoing concern about how prey augmentation might jeopardize World Heritage status, we suggest that DNP formally communicate with UNESCO to seek written assurances that such activities would be looked upon favorably, as assured by Thomas Gray during the meeting.

Recommendation 7: We suggest that DNP and supporting organizations consider other areas of the endangered species management challenge that might benefit from an SDM approach.

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Appendices

Appendix 1: GIS Data and TerraViz

Appendix 2: Survey of DNP Protected Area Managers and Staff

Appendix 3: Workshop Pre-Read

Appendix 4: Workshop Participant List

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resource management