

Final Evaluation Report

Your Details	
Full Name	Ryan Gregory Rodrigues
Project Title	Linking individuals, populations and landscapes for dhole (<i>Cuon alpinus</i>) conservation in India
Application ID	28708-1
Date of this Report	24th July 2022

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Assessment of potential connectivity across potential dhole source populations.				
Identification of dhole conservation landscapes in India.				
Estimates of genetic diversity for dhole landscapes.				
Dissemination of information.				

2. Describe the three most important outcomes of your project.

a). Countrywide map of dhole connectivity

Possibly harbouring the largest population of dholes across their range, India represents a global stronghold for the species. However, most dhole populations are confined to protected areas that consist of insular forest patches of varying degree of habitat quality. As with other large carnivores, such as tigers, these patches alone cannot sustain populations in the long term; it is crucial to ensure functional connectivity with a network of interconnected populations. Combining countrywide dhole distribution data with remotely sensed and spatial data (known to influence dhole ecology) allowed us to conduct the first study that investigated connectivity across all potential source populations of the species within its range limits in India. Our results reveal that conservation efforts should be focused on the central Indian conservation landscape because it houses a relatively high number of potential dhole source populations but with comparatively lower coverage of protected areas and lesser connectivity among source patches. Similar results for the Western-Eastern Ghats conservation landscape suggest that it is a critical stronghold for dhole populations, harbouring a high number of potential source populations and a comparatively high percentage of Protected Areas. The information generated as part of this project is of crucial importance for the conservation of dholes and other forest-dependent species that have similar dispersal requirements and can potentially go on to serve as a foundation to inform and guide policy makers and stakeholders in planning conservation and development (including infrastructure projects such as roads and railway lines).

b). Identification of dhole conservation landscapes

Adopting novel methods based on graph theory allowed for identifying dhole 'conservation landscapes' in India; we identified three clusters– one in the Western-Eastern Ghats complex, a second in central India and a third in northeast India. These conservation landscapes were identified based on the species' ecology and may be interpreted as potential metapopulations of dholes in India. Further research on dhole population dynamics across these conservation landscapes is required to

understand whether these conservation landscapes in fact function as metapopulations. The current project represents the first attempt at identifying conservation landscapes for dholes that can also potentially be viewed as management units at regional scales. To record and preserve genetic diversity of the species, a more in-depth analysis of the genomics and genetics within and across these conservation landscapes is required, particularly to delineate evolutionarily stable units and conservation units.

c). Genetic diversity estimates of dhole conservation landscapes

For the purpose of estimating genetic diversity, we collaborated with state forest departments and the Wildlife Institute of India (WII) to obtain tissue samples that are representative of the geographic regions that dholes currently inhabit. Because of the lockdown, we were unable to conduct field surveys in the Western Ghats nor able to obtain tissue samples representative of the Eastern Ghats. We extracted DNA from the tissue samples and conducted whole-genome resequencing for samples from three sources: (i) previously collected tissue samples from Western Ghats, (ii) Central India samples obtained from the Wildlife Institute of India, and (iii) samples collected during surveys in northeast India. Whole-genome resequencing of the samples allows us to access information across the entire genome. This, in turn, ensures robustness of the results of our analysis and ensures that information can be shared publicly so that other researchers can access the data. Based on our genetic analyses, we found that wild dholes — compared to captive dholes — harbour discernibly higher genetic diversity. Notably, dholes from across India show similar levels of genetic diversity. Given the limited sample size, more focused studies on genetic diversity will need to be conducted to test and validate these results. Further analyses of inbreeding and genetic clustering will likely yield a better understanding of the magnitude of genetic information shared between landscapes and the degree to which dhole populations are potentially threatened by geographic and genetic isolation.

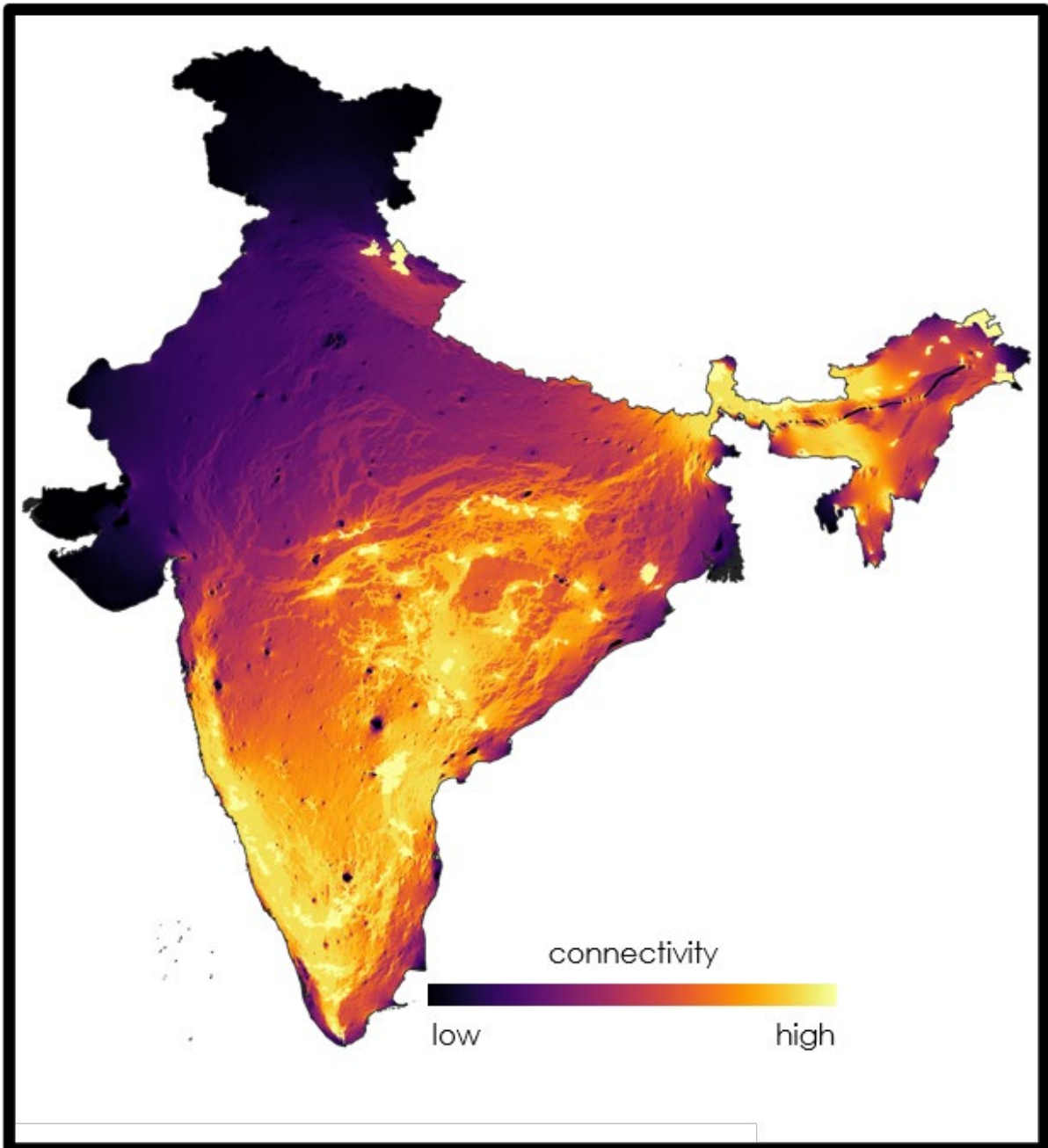


Figure 1. Regions of high and low connectivity across India

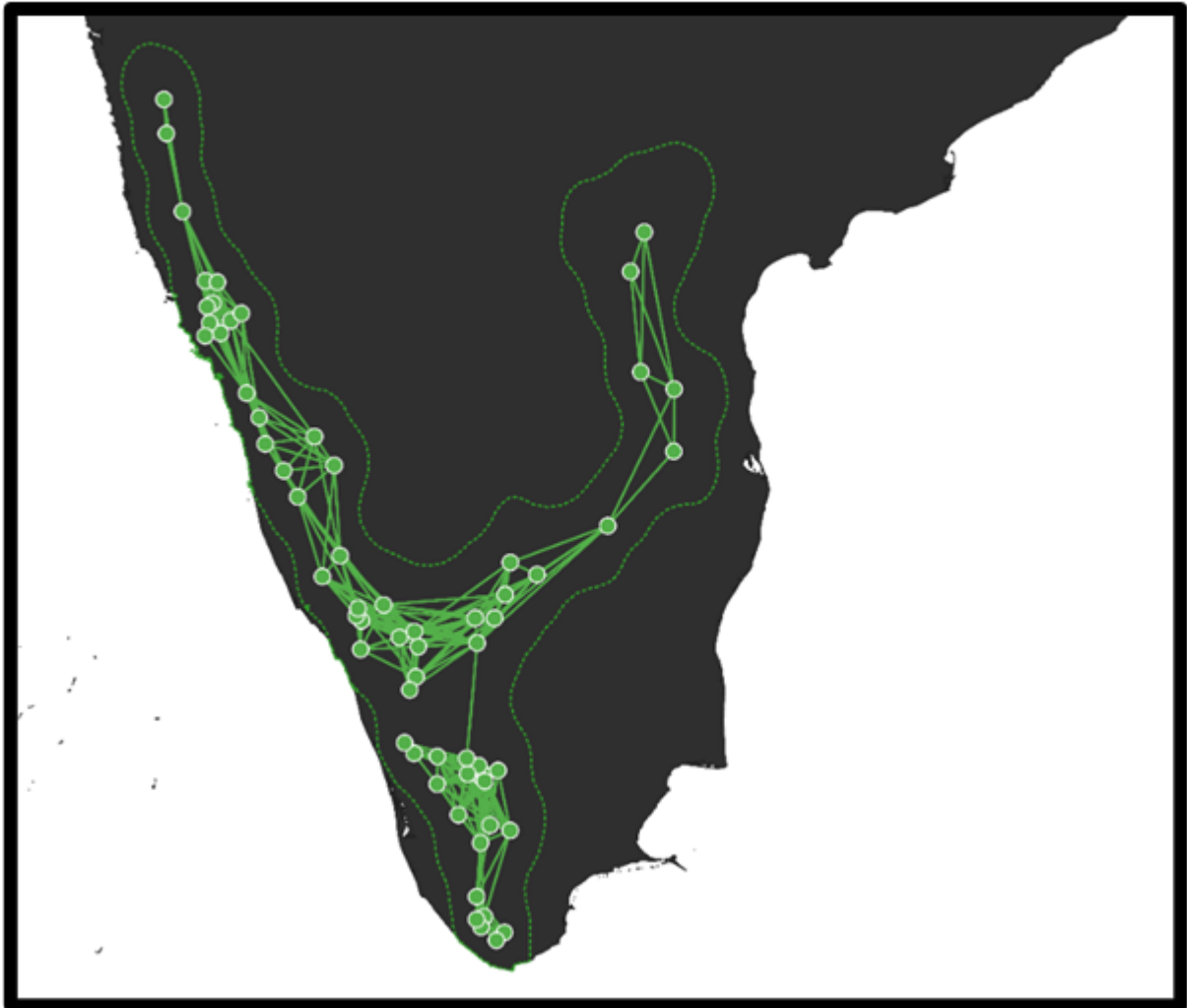


Figure 2. Western-Eastern Ghats Dhole Conservation Landscape. Network representation of potential dhole source populations and their connections.

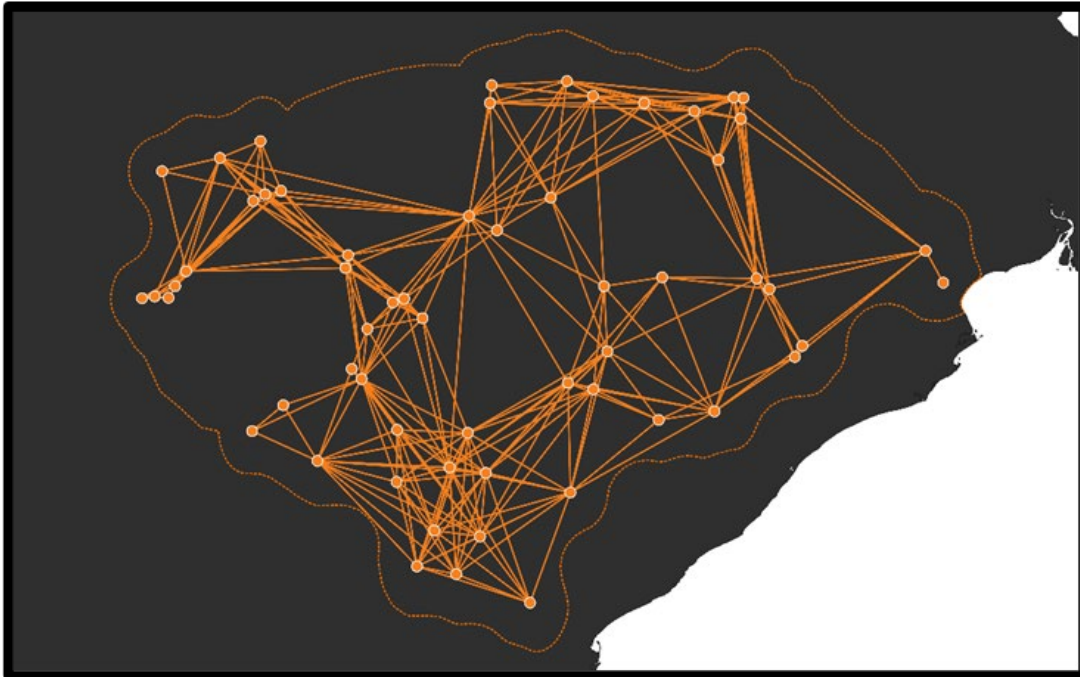


Figure 3. Central India Dhole Conservation Landscape. Network representation of potential dhole source populations and their connections.

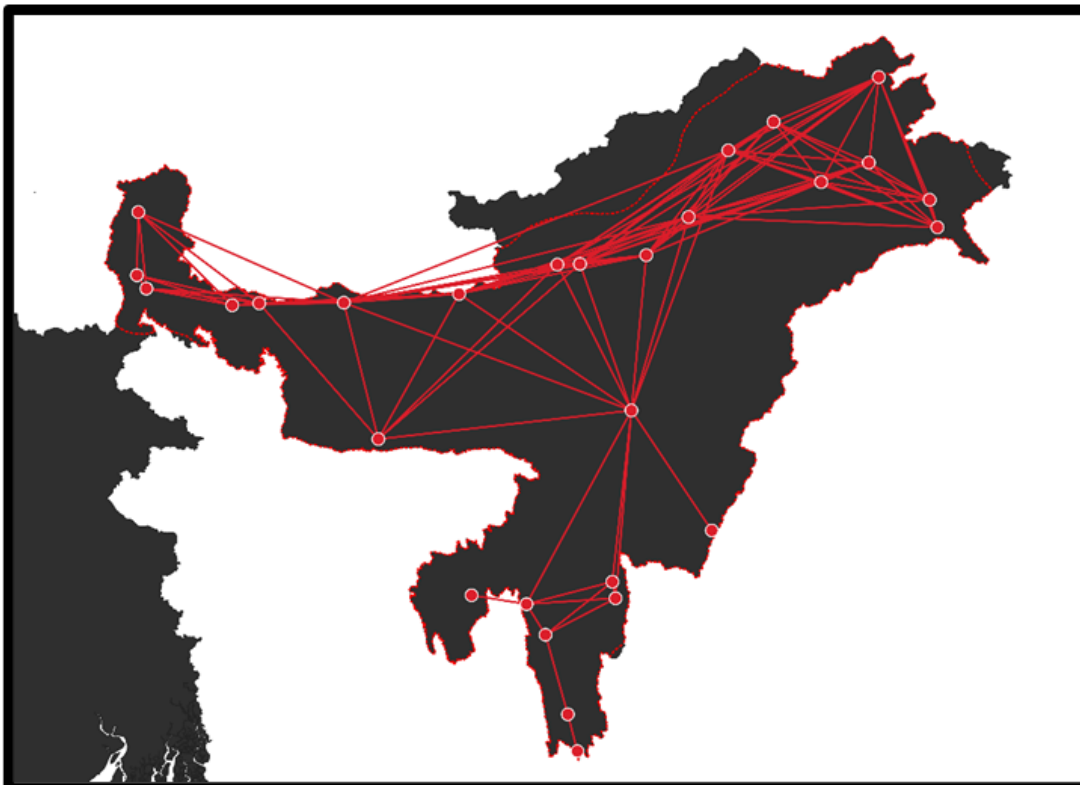


Figure 4. North-East India Dhole Conservation Landscape. Network representation of potential dhole source populations and their connections.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

In the execution of the project, we primarily faced difficulties in the field sampling and outreach components of our project due to the following reasons:

i. Geopolitical issues and cultural context in Northeast India

- Northeast India was at the forefront of protests against the Citizenship Amendment Bill that was promulgated by the Indian Government in December 2019. The subsequent protests and unfortunate cases of violence that occurred resulted in most locals being wary and cautious of people from mainland India. These circumstances made it difficult to openly approach and interact with local residents. Additionally, even after the protests had dissipated, there were instances of spontaneous state-wide curfews declared. These curfews impeded and delayed field work for the project.
- Our initial study design entailed collaborating with the Arunachal Pradesh Forest Department to obtain access to dhole pelts and skins. After discussions with Forest Department officials and other researchers, with experience working in northeast India, we revised our sampling strategy to directly involve local communities instead. However, dholes appeared to be heavily persecuted across the region with most communities harbouring discernibly negative attitudes towards the species. Therefore, a tactful approach was undertaken to ensure that community sentiments were respected. Given the sensitive nature of the work involved, we obtained human ethics clearance for our project from WCS–India (Application No. HR/02/20).

ii. COVID-19 outbreak and lockdown

- Due to the COVID-19 outbreak and subsequent lockdowns that occurred, we were unable to conduct the remainder of our field work that entailed sampling in the Western Ghats and collecting samples representative of the Eastern Ghats. Additionally, the lockdown period induced a series of fund shortages with our collaborating partners that resulted in delays with laboratory work requiring whole-genome resequencing of the samples and computational analyses of the genomes.

iii. Computational logistics

- Owing primarily to the large amount of data that required processing and analysing input files at the country-wide scale, we faced difficulties with troubleshooting and execution of the spatial data and connectivity analyses. Following several trial and error attempts, and different software programmes, we were able to eventually complete the analysis.

4. Describe the involvement of local communities and how they have benefited from the project.

The Covid-19 outbreak, and pandemic lockdowns did not allow us to undertake extensive field work, nor did it allow us to conduct our initial plans for outreach and workshops with local stakeholders and communities. However, prior to the Covid-19 outbreak, we were able to engage with local communities. Our local driver, guides

and survey assistants were all recruited from local communities. At each potential sample site, we met with village headmen to interact and brief them about the project, and to request permission for conducting field work. Throughout the duration of sampling and our stay with local communities, we ensured that we contributed to the local economy. After the outbreak had tapered, we were able to distribute posters and organise outreach events for a limited number of Kerala Forest Department field staff.

5. Are there any plans to continue this work?

This work was done as part of a larger project that aims to generate information pertinent to understanding the ecological requirements of dholes, and to ensure their long-term conservation through the formulation and implementation of science-based strategies. We would like to take the project ahead in the following ways:

i) Our preliminary analyses indicate that spatial heterogeneity and patchy distribution of resources in the landscape play a crucial role in determining landscape permeability. To ensure successful connectivity measures are adopted by the Forest Department and local stakeholders, it is important to understand how these factors affect dhole movement. We aim to examine connectivity within conservation landscapes at finer spatial scales to determine habitat patches that have a disproportionately higher influence on connectivity.

ii) Conservation plans and actions are best implemented at the administrative levels that are responsible for executing forest management plans. In India, forest patches are managed at the level of administrative units known as taluks or tehsils (sub-districts). Having identified habitat patches that are crucial for connectivity within conservation landscapes, we have now demarcated taluks where habitat restoration can be done to facilitate connectivity for the species. In the landscape(s) where we plan to continue this work, specifically in the Western Ghats, our aim is to adopt a taluk-focused approach to guide wildlife managers in identifying locations for habitat restoration and advocating for wildlife-friendly land-use practices.

iii) We would like to work towards validating the results of our connectivity study and intend to do this through a combination of approaches such as molecular techniques and camera-trapping. These approaches can provide evidence of gene flow (and consequently individual movement) between sites in the conservation landscape and utilisation of study areas as 'functional corridors' for movement between sites, respectively.

iv) An often-overlooked component of connectivity studies is the potential increase in human-wildlife conflict arising from increased interface in shared spaces. Early mitigation of retaliatory killings and indirect poaching of dholes will be key to ensuring that connectivity areas have the continued support of local stakeholders, and these areas retain their functionality. Given the historic persecution of dholes and the current negative attitudes they face from local communities in northeast India, we would like to determine 'hotspots' of conflict, and work with local

communities and the regional Forest Department to: (i) initiate outreach and awareness campaigns to reduce negative attitudes towards dholes, (ii) provide locally feasible measures for reduction of livestock depredation (iii) provide information on what compensatory measures would be most effective in instances of livestock depredation, and (iv) providing academic support to local Forest Departments to institute management plans that focus on targeted actions to conserve dholes.

6. How do you plan to share the results of your work with others?

- We are glad to report that we have already presented this work at the Student Conference for Conservation Science, Bangalore, in November 2020. The presentation was titled 'Unlock 1.0: Linking Populations and Landscapes for Dhole Connectivity Conservation in India'.
- We published the results from our countrywide connectivity assessment in an international peer-reviewed journal, *Journal of Applied Ecology* (Rodrigues, R.G., Srivathsa, A., & Vasudev, D. (2022). Dog in the matrix: envisioning countrywide connectivity conservation for an endangered carnivore. *Journal of Applied Ecology*, 59, 223–237).
- We also tried to widen our reach and communication among the public and stakeholders through publishing popular articles in notable online platforms–
- Conservation India (<https://www.conservationindia.org/articles/mind-the-gap-connectivity-conservation-for-dholes-in-india>).
- DownToEarth (<https://www.downtoearth.org.in/blog/wildlife-biodiversity/let-s-talk-sh-t-a-carnivore-biologist-s-toolkit-101-75952>).
- The Applied Ecologist (<https://appliedecologistsblog.com/2021/10/21/connect-the-dogs-a-framework-to-inform-countrywide-connectivity-conservation-of-indias-wild-dogs/>); and
- The Wire Science (<https://science.thewire.in/environment/wildlife-connectivity-gati-shakti/>).
- We prepared outreach material for the Kerala Forest Department (in English and the regional language, Malayalam) highlighting the importance of dholes and their populations. The posters were distributed for display at every range office of Wayanad Wildlife Sanctuary in Kerala State, Western Ghats.
- Our methods and results are freely available to potential collaborators and research groups for replication and implementation in other regions. The results will also be disseminated to forest departments within other dhole-range states.

- The broader findings will be shared with the IUCN Dhole Working Group, IUCN SSC Canid Specialist Group and the IUCN Connectivity Conservation Specialist Group. We will work towards: (i) presenting at scientific conferences such as the Rufford regional conference, and (ii) writing more popular articles in print and web-based platforms targeted at members of the civil society, with the intent of highlighting management interventions required to ensure dhole survival and garnering public support for conserving the species.

7. Looking ahead, what do you feel are the important next steps?

Based on the results of our analyses, we believe that the following measures would help strengthen and secure dhole conservation in India:

(i) Conducting field surveys to assess functional connectivity within dhole conservation landscapes using approaches like camera-trapping, GPS collaring and molecular techniques.

(ii) Ensuring early mitigation of dhole–human conflict through reduction of negative attitudes towards dholes and the implementation of compensation-based schemes for appropriately compensating livestock depredation events.

(iii) Developing a conservation breeding programme for dholes with the intention of planning a metapopulation based approach for the reintroduction and management of individuals or packs in regions that were historically part of the dhole range or, for demographically supplementing populations that have low survivability rates.

(iv) Developing a cost-effective, reliable and robust method for the accurate estimation of dhole populations. This would enable long-term conservation monitoring of dholes across different landscapes and would supplement the monitoring of connectivity between dhole populations.

(v) Coordination of a long-term conservation monitoring programme to obtain critical information on population dynamics of dholes.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

Yes, the Rufford Foundation logo was used on a presentation of the project given at SCCS, Bangalore 2020, acknowledged in the aforementioned journal article, and in the outreach, posters distributed in Kerala. Going forward, the logo will be prominently displayed on all future presentations or media articles based on the results of this project. Additionally, all publications further arising from the project will acknowledge The Rufford Foundation.

9. Provide a full list of all the members of your team and their role in the project.

Dr. Arjun Srivathsa is a member of the IUCN Canid Specialist Group and Dhole Working Group. His incisive inputs and knowledge of dhole ecology ensured that we had access to and used the most recent information on the species, and that the analyses were done with a focus on species biology. He was also instrumental in the development of the project and its successful execution.

Dr. Divya Vasudev is a member of the IUCN Connectivity Conservation Specialist Group. Dr Vasudev has expertise in developing and conducting connectivity assessments for endangered taxa. She was awarded a Rufford Small Grant in 2012 to support a project titled "Identifying Drivers of Primate Occupancy Patterns in a Fragmented Landscape of Garo Hills, India, for Efficient Conservation Planning". She played a significant role in the development of the project, providing guidance for executing analyses of connectivity at different scales.

Ms. Sushma Sharma worked as a Project Assistant for The Dhole Project. She is trained in quantitative statistical modelling, and analysis of remotely sensed and geospatial data. She assisted with extracting and analysing remotely sensed variables of interest and the geospatial data, and in running analysis for mapping countrywide connectivity in India.

Dr. Uma Ramakrishnan is a molecular ecologist specialising in population genetics and genomics of endangered species. She provided insights and discussions on laboratory techniques and analysis of whole-genome sequenced data. She also provided logistical and financial support for the laboratory work and allied components of the project.

Mr. Puspa Lal Sharma worked with the PI during field work in Arunachal Pradesh. Mr. Sharma was a key resource person, providing assistance with local logistics, building contacts, and other activities in Arunachal Pradesh.

10. Any other comments?

I am very grateful to The Rufford Foundation for supporting this project and thank the grant administrators and Trustees for being extremely supportive and cordial throughout the project. I would also like to especially thank Ms Jane Raymond and Mr Simon Mickleburgh.

I would like to thank a number of people who provided support and advice for this project that include C. Sheth, K. Teegalapalli, A.D. Roy, A. Datta, A. Aiyadurai, A. Kamdar, S. Dalvi, S. Sawant, U. Srinivasan, N. Velho, P. Singh, M. Matthew, R. Pandit, M. Janaki, K. Medi, S. Valsan, C. Ri, T. Tapi, B. Bhatt, A. Kumar, B. Taja, B. Tajak, T. Kabak, S. Nijhawan, J. Pulu, A. Meston, J. Meston, R. Meston, D. Ganguly, A. Khan, M. Natesh, V. Paynter, M.M. Chawla, B. Joshi, A. Wilkinson, Wild Canids–India Project team, NCBS–IT team and WCS–India.