

DAVIS EXPEDITION FUND

REPORT ON EXPEDITION / PROJECT

Expedition/Project Title: Impact of woody encroachment on grassland ecosystems of Bhutan

Travel Dates: 27 June – 21 September 2025

Location: Bhutan (Sarpang, Wangdue Phodrang, Haa)

Group Members: Tshering Dorji, Dewash Rai, Sonam Phuntsho (but see Section).

Aims:

- i. Collect of ground-truthing data for encroached sites and rapid ecological information of sites
- ii. Collect leaf, wood....
- iii. Pretesting of questionnaire of 30 respondents will be done to collect social data,

Photography consent form attached: Yes
(please refer to your award letter) No

Outcome (a minimum of 500 words):-

PART A - QUICK SUMMARY

Table 1. Achievement summary of the fieldwork

Activity	Measurable outcomes	Contribution to the Aims and overall goal of the PhD
Ground truthing of encroached sites	50 sites; rapid ecological information of the site (focussing on woody plants) also collected	Aim 1; use Remote Sensing to see assess spatiotemporal patterns of encroachment
Establish sampling sites and collect functional traits	50 sites sampled using GGG protocol; plant structural, physiological and generation traits collected from 928 individuals	Aim 2; define traits and strategies associated with encroachers and non-encroachers
Collect herbarium samples	120 numbers; transferred to UK	
Collect soil samples	57 samples (3 depths x 19 sites)	
Prescreening survey	Carried out for 30 individuals	Findings from this will be used the findings of which will be used identifying gaps and improvement of questionnaire.

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PART B – DETAILED REPORT

1. Background

The encroachment of woody plants into grassland ecosystems is emerging as one of the major threats to its ability to support biodiversity, livelihoods and ecosystem functions (Zhao et al., 2020). Occurring across multiple biomes, they have profound influence on biodiversity (Wieczorkowski & Lehmann, 2022), soil (Zhou et al., 2017), and livelihoods (Lett & Knapp, 2003). Along with changes in elevated on the earth's atmospheric CO₂ levels, these processes have been linked to changes in herbivory, fire regimes and management practices (Archer et al., 2017) which often operate at the regional scales. Thus, understanding local context and their influence on the landscape provides a key towards addressing the issues related to woody encroachment.

Despite evidence of woody encroachment causing a potential regime to shift its grassland ecosystems (Brandt et al., 2013), current understanding on the dynamics of woody encroachment in the Himalayan region remains poor. Here we use Bhutan as a model to understand this phenomenon where an estimated 20% of the rangeland is lost to woody encroachment (Chophyel, 2009). The country's geography and the elevational gradient support unique grassland ecosystems (Noltie, 2000), enabling the study of woody encroachment across various socioecological contexts. Given the multifaceted drivers and impacts of woody encroachment (Archer et al., 2017), and with the aim of providing a multi-perspective view of encroachment in Bhutan, My PhD research will take an interdisciplinary approach to quantify encroachment dynamics over space and time across Bhutan, determine ecological impacts and collaborate with local communities across Bhutan to document both their perceptions of encroachment and its impacts on livelihoods

It was against this backdrop, a fieldwork to Bhutan was conducted in summer 2025 to collect information critical towards delivering the objectives of the PhD. This would be the first of the two major fieldworks planned for the PhD, where I aimed to:

- i. Collect of ground-truthing data for remote sensing and carry out rapid ecological surveys of the sites
- i. Collect plant functional traits of woody plants
- ii. Carry out preliminary screening to inform the social data collection methods

2. Outcomes

2.1 Ecology and ground-truthing data

Sites for ground-truthing and ecological survey were selected along a gradient of woody encroachment, ranging from open to a closed-canopy system, to substitute space-for-time. At each site, we used the Global Grassy Group protocol to systematically characterize the ecological condition, ecological condition, vegetation types, woody cover were collected as well as the dominant species.

Ground-truthing data was collected from 50 GGG sites across Sarpang, Wangdue Phodrang and Haa districts of Bhutan. Together, these represents three distinct eco-floristic zones, encompassing subtropical, temperate and alpine grasslands in Bhutan. This includes 19 sites in subtropical, 15 in temperate and 16 in alpine (Figure 1; Table 2). The data will be used to as a training dataset to improve models to detect changes in land cover due to woody encroachment relevant to Bhutanese grasslands.

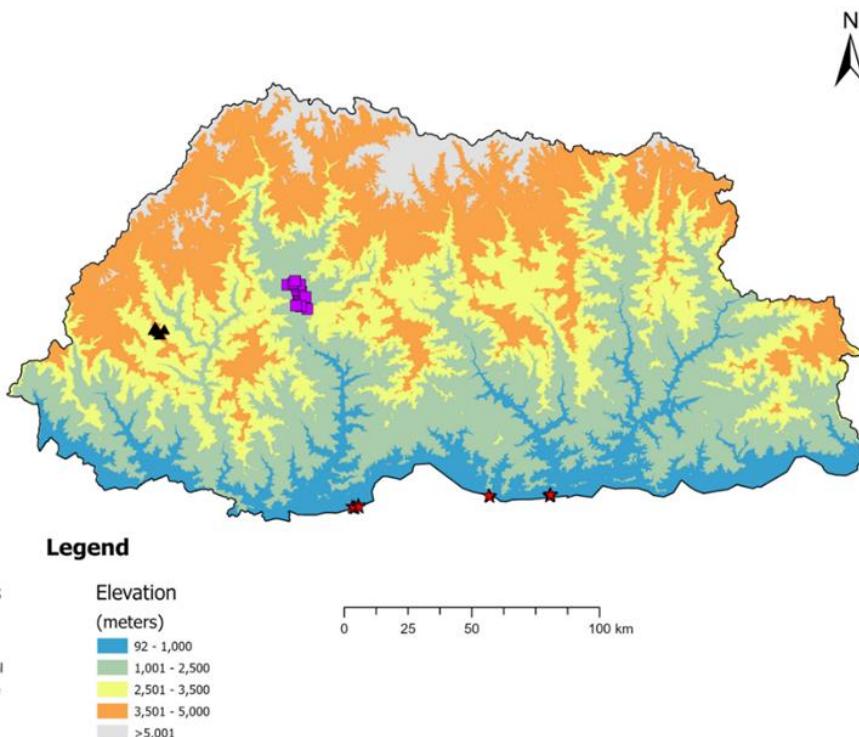


Figure 1. Study sites spread across different regions and altitudinal zones in Bhutan

We recorded a total of a total of 92 species of woody plants in the form with the highest rerecorded species in temperate (40), followed by subtropical (31) and alpine (23). Species richness of woody plants showed variation across a gradient of encroachment and between different altitudinal zones. Reference samples amounting to 120 herbarium specimens were collected to be housed in National Herbarium, Serbithang (THIM), and the Royal Botanic Garden, Edinburgh (E). In addition, soil samples were collected from 19 subtropical sites to carry out soil nutrient analysis. All samples were transferred after executing a Material Transfer Agreement and producing all relevant export and import permits.

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Table 2. Summary of the ecological survey and ground-truthing work

	Subtropical	Temperate	Alpine
Number of sites	19	15	16
Elevation (masl)	<300	1200-1500	>3800
Woody species recorded	31	40	23
Dominant woody	<i>Leea, Bombax, Dillenia, Lagerstroemia, Clerodendron</i>	<i>Pinus roxburghii, Searsia paniculata, Berberis aristata</i>	<i>Rhododendron lepidotum and Berberis angulosa</i>
Dominant herbs	<i>Saccharum, Themeda, Digitaria</i>	<i>Cymbopogon, Chrysopogon, Eriophorum,</i>	<i>Agrostis, Calamagrostis, Carex, Stipa</i>
Invasive species	<i>Chromolaena odorata, Lantana camara, Sida acuta, Mimosa pudica</i>	<i>Chromolaena odorata, Sida acuta, Mimosa pudica</i>	N/A

2.2 Collection of plant functional traits

We collected plant functional traits for woody plants occurring across all 50 GGG sites in the three regions. This includes traits related to plant structure (height, diameter, crown diameter), leaf (leaf thickness, leaf dry matter content, specific leaf area, leaf nitrogen and leaf phosphorous content), wood (stem-specific density), and regeneration (maximum recruit density). Plot-level abundance data obtained from the ecological survey will be used to classify individual species into encroachers and non-encroachers based on a priori classification. The classification will be used to assess if plant traits of woody species influence encroachment success and explain patterns of distribution across different sites.

In total, plant functional trait data was collected for 928 individuals. We recorded growth form, plant height, stem diameter, crown diameter, resprouting evidence and recruit density in the field. Leaf samples were collected from sun-exposed, mature and undamaged individuals (Cornelissen et al., 2003) and wrapped in moist tissue paper, sealed in a plastic bag and stored in cool box. We then measured its fresh weight, leaf thickness and made scans of leaves. Leaves were then dried at 70°C for 48 hours and weighed again.

Wood samples were collected to calculate the stem specific density (Pérez-Harguindeguy et al., 2013). Samples were collected from a healthy stem were collected, and its fresh volume measured using water displacement method. Then the samples were weighed again after drying in the oven at 105 °C for 24 hours. The stem specific density is obtained from the ratio of the dry mass and fresh volume. The samples were collected and processed at the laboratory at National Biodiversity Center in Bhutan and were transferred to UK for further analysis.

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Figure 2. a-c: Different sites sampled across Bhutan including alpine (a), temperate (b) and subtropical (c) grasslands; d-f collection of functional traits showing setting up of GGG plot (d), measurement of height (e), collection of leaf and wood samples (f), weighing and scanning of leaf samples (g)

2.3 Pre-screening survey

As a preliminary assessment to inform the community perception survey to be carried out in 2026, a pre-screening survey was carried out for 30 individuals involving government officials, NGOs and local communities. This was done using informal discussion and open-ended questions designed to identify potential respondents, and guide design of questionnaires. The preparatory work helped identify relevant themes that needed to be addressed in the upcoming social survey. Respondents shared their perceptions relation to grassland ecology, vegetation change and the need for understanding land management.

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3. Further work

- The ground-truthed data will be used as a training dataset to improve models to detect changes in land cover due to woody encroachment relevant to Bhutanese grasslands. This component will feed into the larger objective (Chapter) of developing a comprehensive synthesis of the state of Bhutan's grassland ecosystems and identifying the different degradations along different ecofloristic zones.
- Plant and soil samples collected during the fieldwork will be analysed for C, N and P content at the Crew Laboratory in Kings Building. In addition, soil samples will be used to conduct germination experiments at the RBGE to provide more insights on regeneration potential and role of edaphic conditions in woody plant establishment.
- Voucher samples collected will be identified and deposited at E and THIM. Samples will be photographed and used to aid in identification in the upcoming field work.
- Building on the insights from the pre-screening survey, questionnaire will be developed to conduct survey and focus group discussions on Bhutan 2026. Further fieldwork is planned for 2026 to collect data for Chapter 3 and 4, focussing on the ecological impacts, and social perceptions to woody encroachment.

4. Project team and collaboration

The project comprised of myself and two permanent members who were involved in all three regions. Depending on the areas we were working on, we involved local partners from the forestry and livestock departments, and members from the local community. Not only did this enable us to take advantage of local knowledge and gain widespread insights, but it also helped reduce expenses on travel and food. This work builds on the excellent cooperation we have been able to foster from our previous projects. Bhutan's low population and compact bureaucracy enabled swift and efficient communication making collaboration very easy. This was evidenced by the high level of official and unofficial support the project received throughout, ranging from administrative approvals to logistical help.

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5. Expense details

The fieldwork incurred a total expenditure of £8028.3 against the allotted budget £7370. The additional expense will be covered from the RTSG fund of the E4 DTP. We were able to make significant savings from our per diems, thanks largely to the strong support received from our field collaborators. Despite making huge savings on accommodation cost through camping in tents and guest houses, we record a slight discrepancy expense against this category in the actual expense £318.9 instead of the proposed £50. This was because finding appropriate campsites in places like Sarpang and Wangdue Phodrang was not feasible. This deviation notwithstanding, we were still able to keep the overall accommodation cost under 4% of the total expenses due to the logistical support rendered by our local partners. This savings allowed us to reallocate for laboratory analysis of samples (300 leaf and 50 soil samples) for nitrogen and phosphorus content.

Table 3. Details of expenditure against each category and comparison with proposed amount

Category	Proposed	Amount (£)	Remarks
Per diem	4485	2253.6	Per government rate
Analysis	600	2222.5	Analysis of 300 leaf samples and 50 soil samples
Flight	1500	1422.9	Return tickets
Transportation	1100	1097.8	Hired vehicle
Food	600	569.7	Mostly self-catered
Accommodation	50	318.9	
Equipment	185	143.0	Includes stationeries, first aid kits, etc

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6. Equipment borrowed or purchased for this project

Field equipment critical for this project were sourced from various partners (Table 4). Those purchased from Davis are securely stored in Bhutan to be used again in the next fieldwork season.

Table 4. Sources of equipment and facilities used during the project

Items	Quantity	Sources
Measuring tape (5m)	2	Davis Expedition Fund
Stationeries	Assorted	Davis Expedition Fund
Ziploc bags	100	Davis Expedition Fund
Secateur	1	Davis Expedition Fund
Newspaper	20 kg	Davis Expedition Fund
Gas cylinder and stove		Davis Expedition Fund
Batteries	10 pairs	Davis Expedition Fund
Storage boxes	3	Davis Expedition Fund
Cooking utensils		Davis Expedition Fund
First aid kit	2 sets	Davis Expedition Fund; Royal Botanic Garden Edinburgh (RBGE)
Envelopes	Assorted	Davis Expedition Fund; RBGE
Measuring tape (>50m)	2	Department of Forests and Park Services (DoFPS)
Compass	1	DoFPS
Clinometer	1	DoFPS
Machete	1	DoFPS
Pool vehicle support		DoFPS; Department of Livestock (DoL)
Cool box	3	DoL; National Biodiversity Center (NBC)
Ice pack gels	15	DoL; NBC
Weighing scale	2	NBC
Plant press	3	NBC
Tents	2	NBC
Drying oven	1	NBC
Camera	1	RBGE
Silica gel	1 kg	RBGE
Scanner	1	RBGE (Caroline Lehmann)
Calliper	1	RBGE (Caroline Lehmann)
Micrometer	1	RBGE (Susan Eshelman)
GPS	1	Personal
Guidebooks		Personal
Saw	1	Personal

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7. Conclusion

Although it was previously proposed to complete the fieldwork in 10 weeks, this had to be extended by another three weeks because of poor access to some field sites due to monsoon. That said, this has been a very successful fieldwork season with all the primary aims achieved. Ecological surveys, ground-truthing and collection of plant functional traits were achieved in all regions. Similarly, the groundwork for future fieldwork has been laid with sampling sites identified and geolocated, and prescreening insights available to formulate context-driven and appropriate questionnaires.

8. Acknowledgement

We are deeply thankful to the Davis Expedition Fund for the funding support. We thank our local partners in Bhutan (Department of Forests and Park Services, Department of Livestock, RBGE and ICIMOD) for their support. (see Table 4). Thank you also to many wonderful people who has helped in the smooth transfer of samples from Bhutan to the UK. Thank you to the wonderful people at FunkyBio research group and RBGE for all their help. Most importantly, we thank all the field guides who contributed with their time, effort and knowledge to this work.

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9. References

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