INTERNATIONAL PARTHENIUM NEWS

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Editorial

First, we'd like to share the good news to all our newsletter readers, all back issues of the parthenium weed newsletter are now back on the APWSS website: http://apwss.org.in/APWSS_Working_Group__Newsletter.aspx

As a member and the only survived working group in APWSS, we apologize for the inconveniences during the past few years and hope our working group would thrive through the support of the society and everyone who reads this newsletter. Please also support *Weeds* - Journal of the Asian-Pacific Weed Science Society (2652-533X - online), which publishes two issues per year. All submissions on biology, ecology and management of weeds are welcome from both members and non-members.

Please keep sharing your articles and enjoy this issue!

Runping Mao
Steve Adkins

Parthenium Perspectives

Use of aerial imaging in weed management and growth stage identification - The case for parthenium weed.

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Our research group has in the past 5 years been trialling the use of unmanned aerial vehicles (UAV) carrying cameras to capture images of weeds at the landscape-scale level, such as that of parthenium weed in pastures and grazing lands and along riparian corridors (Figure 1). While the imagery capture (*via*. the UAV) exercise was successful, the challenges were in developing artificial intelligence (AI) protocols through deep learning algorithms to enable automated identification of the weed and the classification of its various growth stages. Our initial attempts using the readily available software program YOLO (You Only Look Once), and by developing Python codes for object recognition and classification (undertaken by data engineering) of field-captured aerial images of the weed, only resulted in low identification accuracy (35%; see Costello *et al*. 2022). The mapping and detection of the weed was made difficult by the varying nature of the infested landscapes (e.g., uneven terrain and varying cloud/light intensity). To overcome these teething challenges, we proposed a novel method to detect and map parthenium weed in a series of simulated pastoral environments by using a Red-Green-Blue (RGB) and/or a hyperspectral imagery system aided by AI neural networks. Two datasets (one with RGB and one using multispectral cameras) were collected in a control environment using a series of parthenium weed and naturally co-occurring, non-parthenium (monocot) communities. The RGB images were processed with a YOLOv4 Convolutional Neural Network (CNN)

Figure 1 A pasture field infested with parthenium weed in central Queensland, Australia. The drone for image capture is operated by the person in the extreme left of the photograph, while the other three researchers (Osunkoya, O; Shi, B; and Perrett, C) are within the survey plots-marking and tagging individual parthenium plants (flowering ones are white/cream in colours) for other ecological work.

implementation, achieving an overall accuracy of 95% for detection, and 86% for classification of flowering and non-flowering stages of the weed. It is worthwhile noting that machine learning discrimination of growth stages of the focal weed has rarely been reported, but the work reported herein indicates that it is achievable. We also explored the importance of spectral signatures captured via. hyperspectral cameras as a potential discriminatory trait amongst the species tested, especially for discriminating parthenium weed from other co-occurring pasture plants. Our ordination of the hyperspectral signature data suggested that the wavelengths responsible for major differentiation of parthenium weed from co-occurring control plants (grasses and sedges) are mainly in the blue (400-500 nm) and the infrared (> 900 nm) ranges.

The main difference between our work (undertaken in a control environment and which gave a high accuracy for detection of 95%) and the previous attempts (in pastoral fields, which gave a low accuracy of detection of 35%) is the quality of the data collected. A notable shortcoming is that the previous field attempts used data involving the ground sampling distance (GSD; that is the distance between centre points of each sample taken of the ground) – and these were far greater than what was used in the control environments. This amplified and complicated by the fact the nature of the field: that is a more heterogeneous environment of fast changing atmospheric condition (especially solar illumination, cloud, and shadow), with significant variation in terrain (slope and aspect) and soil quality. Hence field image data captured via. UAV can be less reliable and more challenging for model training. This highlights the importance of data quality, specifically the GSD of the images.

Despite these field challenges, the reported work in Costello *et al*. (2022) provides strong evidence that parthenium weed can potentially be detected in both RGB and hyperspectral imagery using machine learning methods in a real pastoral environment. Because the simulated environment used in this study was developed to imitate natural/human-made landscapes as closely as possible, our findings suggest that with further work and refinements, these methods might be applicable to field environments.

For scalability of our findings to the field, improvements need to be made to the use of UAV and the deployment of high specification (e.g., HS/MS) cameras that can achieve low ground sampling distances (GSDs) while maintaining flight heights. This will allow for a more efficient, high resolution spatial image capture. A good detector (i.e., a camera and/or laser scanner mounted on a UAV) must be optimised to capture and relay field data. The ultimate performance of this detector also depends on the capability of the available computer system to receive, store, retrieve and transmit data collected to other devices. Thus, in future applications, computer systems specifically designed for object detection and AI should be used. Image and data augmentation (the process of artificially creating more data from the images captured) techniques for generation of training data could be optimised as this may also improve performance. Better image annotation techniques, such as Semantic Segmentation, should be used because in natural fields, established parthenium weed and co-occurring plants present a much more complicated scenario that can make bounding box annotations inefficient and limit performance. Lastly and overall, with further improvement in image processing (e.g., using Mask/faster R-CNN) and ML protocols (e.g., transitioning from YOLOv4 [the version available in the course of this work] to more recent YOLOv7 or even YOLO-Representation, the findings reported herein have the potential for extension and application in real-world pastoral and cropping environments. This will ultimately lead to better detection and management of weeds and revolutionize how people deal with the ever-growing problem of invasive alien species.

Figure 2 Another shot from the drone imagery.

Read more:

Costello, B.; Osunkoya, O.O.; Sandino, J.; Marinic, W.; Trotter, P.; Shi, B.; Gonzalez, F.; Dhileepan, K. (2022), Detection of Parthenium Weed (*Parthenium hysterophorus* L.) and Its Growth Stages Using Artificial Intelligence. Agriculture vol 12, 12, 1838. **https://doi.org/10.3390/agriculture12111838**

The further spread of parthenium weed in Bhutan – A report from a recent field visit to Eastern Bhutan

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Parthenium hysterophorus L., commonly referred to as parthenium weed, is an invasive alien species that is rapidly spreading and posing significant ecological and agricultural concerns in Bhutan. Initially documented in 1992 across 17 Districts (Parker, 1992), the weed has since proliferated to an additional two Districts, marking its presence in 19 out of 20 Districts in Bhutan (Dorji *et al.*, 2021). A 3-week long field visit was undertaken by Sangay Dorji and Steve Adkins from March 30 to April 20 to eastern Bhutan to observe the extent of the parthenium weed invasion in that part of Bhutan, to train scientists to conduct farmers' survey work and to evaluate parthenium weed modelling predictions. This report encapsulates the findings and experiences from this recent field visit to Bhutan.

Before embarking on the journey to the east, four scientists were trained on the identification of parthenium weed, questionnaire comprehension, and in conducting farmers' surveys. They already had experience in conducting farmers' surveys and a further 2-day training activity was enough for them to undertake the task. The first day was spent on parthenium weed identification using the University of Queensland (UQ) parthenium weed identification kit, comprehension of the UQ-developed farmers questionnaire, and how to conduct a farmers' survey. The second day was spent in the field for actual identification of parthenium weed so that they did not confuse with other similar-looking plants.

After completing the training activities, the journey to the east started on April 2. The expedition covered the Districts of Trashigang, Trashiyangtse, Lhuentse, and Mongar, spanning approximately 3,421 km through mountains passes and valleys. The elevations ranged from 600 to over 3,600 m above sea level and covered sub-tropical to temperate climates. The four Districts are major producers of maize and rice in the east and also constitute the largest regions by population and area. In addition to cereal crops, farmers also cultivate legumes and potatoes. Rainfed and dryland agriculture are the dominant forms of agriculture practices in these four Districts.

Figure 1 Left: Training of four scientists on parthenium weed identification, use of the survey questionnaire, and conducting farmers surveys. Right: Field training on the parthenium weed identification so that the scientists were not confused with other similar-looking plants.

We began our field visits first from Trashigang District. In Trashigang, we travelled to a small town called Radhi, which is about 30 km away from the District town where the highest rice cultivation is undertaken and known as the rice bowl of the east in Bhutan. Along the way, we viewed many parthenium weed infestations – new and those observed in an

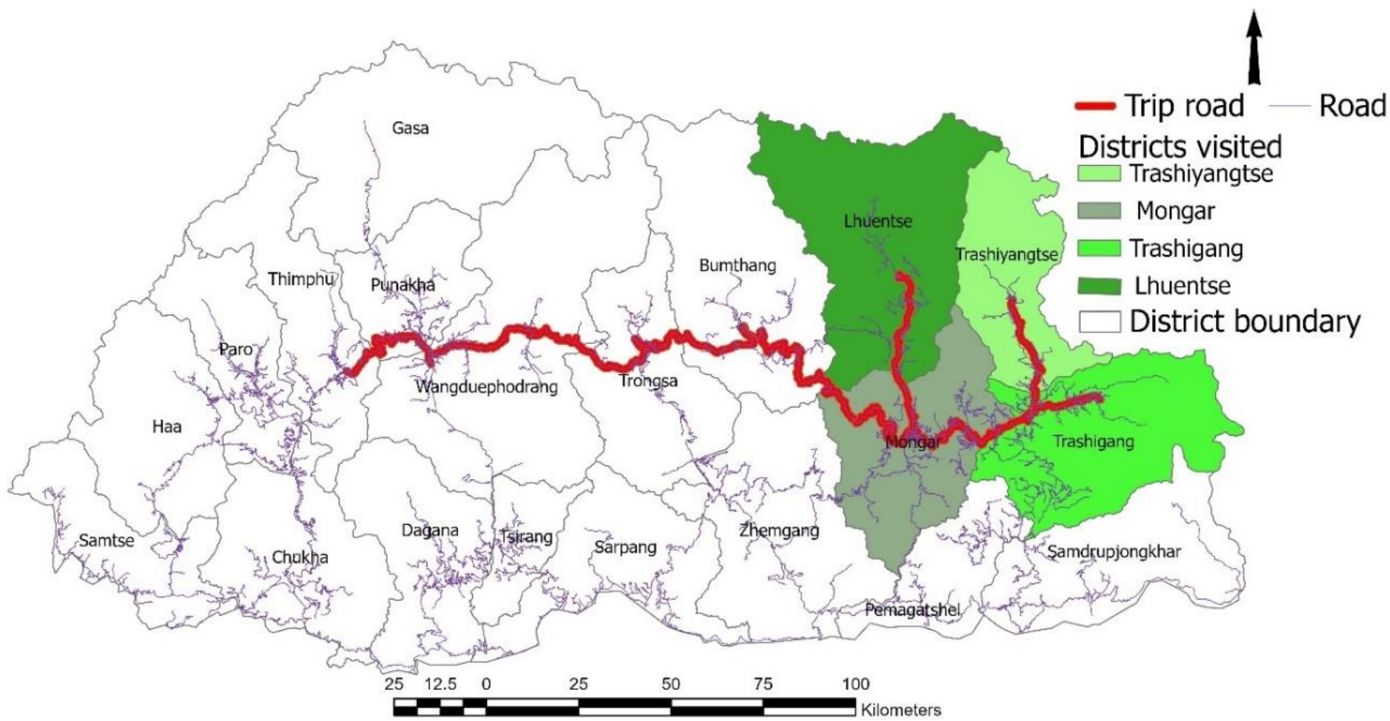

Figure 2 Map of Bhutan showing the four Districts (coloured) surveyed and the national highways traveled along (red).

earlier survey undertaken in the previous year. Many plants were still in their rosette stage as it was early springtime. In Radhi, there were plenty of plants in full bloom. We drove further from the town, about 5 km, and reached a village called Jonla. There we saw more roadside plants and stopped to interact with farmers.

However, farmers had travelled that day to attend an important community event but luckily, some had already returned to their village. We approached them and enquired, "Have you seen this plant in your fields or around here?" presenting them with a roadside collected specimen. Farmers responded, "No, we have not seen the plant". What is it and why is it important?" asked one of the farmers. Despite its proximity, the farmers were unaware of its existence or the threats it posed to them. We took this opportunity to create awareness and educate them on the detrimental impacts of parthenium on health, crop production, and livestock. After hearing this from us, farmers were keen on spreading the word and committed to vigilant management practices to curb its spread.

Figure 3 Creating awareness and educating farmers on the detrimental impacts of parthenium weed on health, crop production, and livestock in Jonla village, Trashigang. Left: Showing sample to the farmers and families. Right: Explaining using parthenium weed identification kit before handing copies over to them.

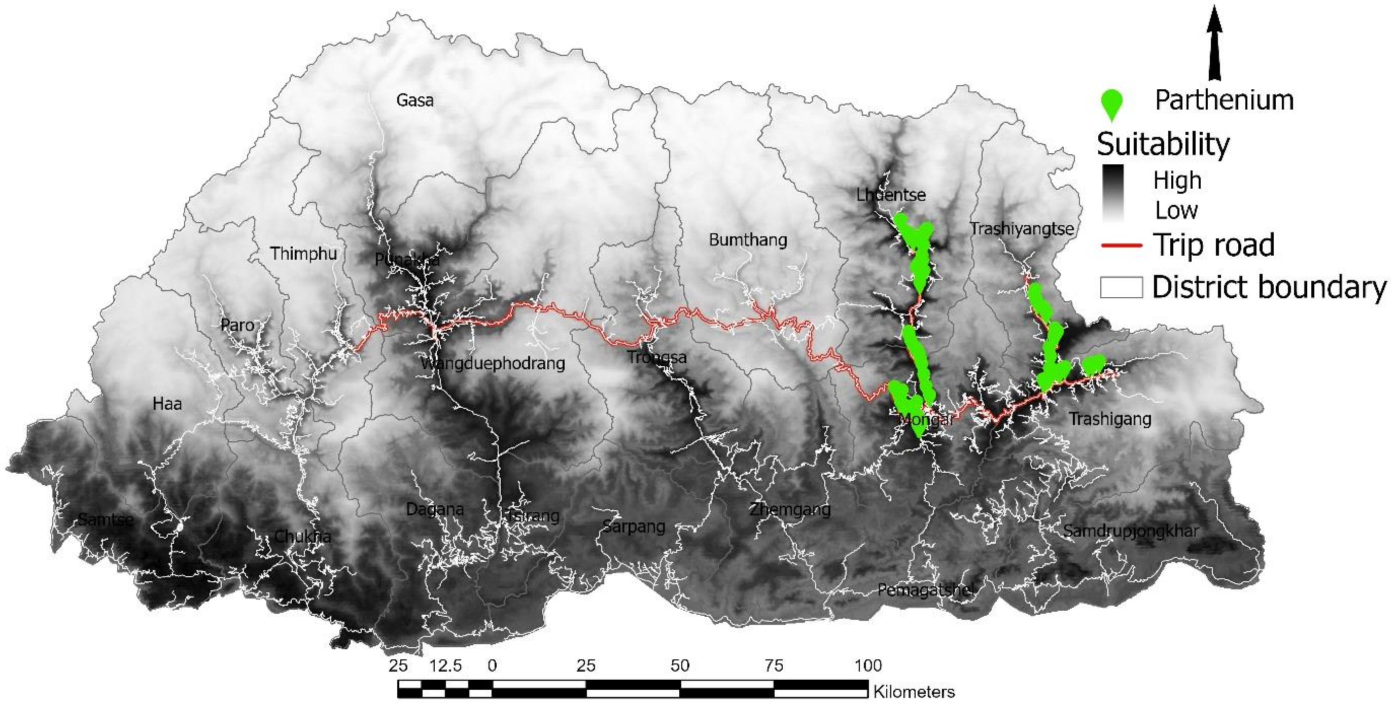

Figure 4 Prediction of land suitability for parthenium weed taken from the parthenium weed distribution model undertaken for Bhutan. High suitability areas are shown by a darker colour while the low suitability areas are shown by a lighter colour. The green points are locations of parthenium weed observed during field visits. The map was prepared in ArcGIS Pro 8.2.0 while the suitability modelling was implemented in R version 4.3.1.

Our next destination was Trashiyangtse District. While we viewed numerous parthenium weed infestations along the roadside, they disappeared after the town of Buyang, a place about 12 km away from the town of Trashiyangtse. We went further than Trashiyangtse town to Bumdeling village, about 10 km north, and could not detect any further populations. The parthenium weed distribution modelling undertaken using the downscaled general circulation models of Bhutan showed very low suitability in the township of Trashiyangtse and further north.

After Trashiyangtse, we moved to Lhuentse District, a region where Sangay had worked in his earlier life as a District Agriculture Officer for about 3.5 years (2006 to 2009). Parthenium weed was detected along the national highways and farm roads at that earlier time but has since spread further into inner villages by 2024. We also met with the scientists undertaking the survey in Lhuentse as well as with further farmers. As with the farmers at Radhi in Trashigang, a farmer in Gangzur had also not seen the weed despite being on the edge of his property. We have made him aware and educated him concerning the negative impacts of parthenium weed and the need to remove it before the weed spread further and enters into his crops.

Figure 5 Interaction with the scientists undertaking the survey and the farmer. Educating the farmer about parthenium weed identification and the negative impacts of parthenium weed and the need to control it.



Figure 6 Parthenium weed infestation at Gyelpozhing town in Mongar District. The place is one of the heavily infested regions in Mongar and locals there were aware of its negative impacts on them. Locals avoided the plant, especially during flowering as it interfered with their breathing.

The field trip concluded in Mongar, particularly in Gyelpozhing town, where parthenium weed infestations were severe. Discussions with locals revealed an acute awareness of the weed's health hazards, with complaints of skin irritation and respiratory issues during its flowering stage. "When it flowers, I can hardly breathe near it," a local resident described.

As we continued our journey to our night stop at Trogon Villa in Yongkola, we visited a nearby maize field in Thrinangbi village. In the crop we noticed parthenium weed plants invading from the roadside verge further confirming the weed's encroachment into agricultural lands. At the Trogon Villa, we also visited adjacent fields, which was previously planted to vegetables. There we saw the field completely overrun by parthenium weed. Such sightings were a first-time observation in such settings in Bhutan.

During our field visits, we commonly saw the winter rust on the lower parts of many parthenium weed plants but the attack was not sufficiently strong enough to inhibit the growth of the plant or to kill it.


Figure 7 Left: Parthenium weed was detected in a maize field at Thrinangbi village in Mongar. Right: Heavy infestation of previously planted vegetable field by parthenium weed at Trogon Villa, Yongkola.

Most interesting, we came across a parthenium weed plant with an abnormal growth. The whole plant looked pale green and its inflorescences appeared like "broccoli". The peduncles were slender and abnormally long and the flowers were not form well. The flowers did not appear to turn white as the plant developed and appeared to turn brown and prematurely die. Only a few capitula showed fully maturity, and upon crushing, produced unhealthy-looking achenes. There were also an unusual production of tiny flower heads, with long pedicels, from the terminal panicles.

Figure 8 Left: Winter rust on the leaves. Right: Winter rust on the stem.

Such growth of parthenium weed is not commonly reported in the literature, and is presumably due to virus or phytoplasma attack It may be worth further investigation this disease for the possible development of a new control and management approach for this serious invasive alien weed.

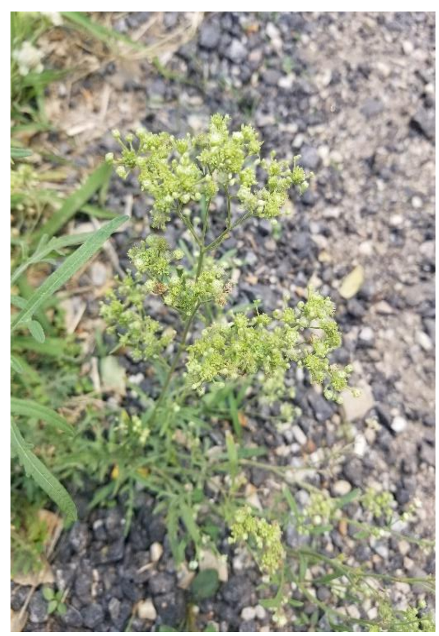

Figure 9 A parthenium weed plant found with abnormal growth. The whole plant was pale greenish and appeared to have a "broccoli"-like appearance. Flowers did not seem to turn white and produce seeds. There were unusual productions of tiny flower heads or capitula with long pedicels from the terminal panicles.

To conclude, the field visits to eastern Bhutan proved to be immensely fruitful, yielding a wealth of insights into the infestation of parthenium weed in eastern Bhutan. Our journey into the east has shed light on new dynamics of parthenium weed invasion in the country. We discovered that despite farmers' proximity to the weed, many were unaware of its presence and the potential threats it posed. This lack of awareness underscored the critical need for extensive educational outreach. Our interactions with local farmers not only increased their awareness of parthenium weed but also empowered them to disseminate their knowledge gained, thereby strengthening community response to combating this invasive species. Additionally, our observations in the field supported in the 'ground-truthing' of parthenium weed distribution models in Bhutan, the work currently being undertaken by Sangay for his doctoral studies. We also noted a rising trend in the number of parthenium weed infestations which is growing year by year. The farmers' survey conducted in the four Districts will further augment the field visits, validate the models, and assist in formulating effective management strategies in Bhutan.

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Update on parthenium weed distribution in South Korea

Parthenium weed is expanding its range in South Korea, as reported in a recent publication found on the database of koreascholar.com. In 2022, the Korean Ministry of Environment designated *Parthenium hysterophorus* as an ecosystem-disturbing plant. In the paper abstract, the authors wrote: *in Korea, it only grows in some areas of Tongyeong and Changwon, Gyeongsangnam Province*. Last time news was reported from Korea, the weed was only found at the Port in Masan, and in Changwon but it was reported as spreading (Parthenium Weed Newsletter No. 7, Jan 2013). Thus, a decade later, the weed has spread to more regions from its initial entry point.

An additional publication, predicting its future occurrence in South Korea, has also been published. In this publication, the authors suggest climate change would increase the habitat suitability of parthenium weed, from the current low suitability to a moderate to very high suitability, especially in the southern region of the country.

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Upcoming Conferences on Weed Science

23rd Australasian Weeds Conference

Dates: 25-28 August 2024
Venue: Brisbane, AUSTRALIA
Website: https://caws.org.nz/upcoming-awc-2/

9th International Weed Science Congress (IWSC)

Dates: 1-5 December, 2024
Venue: Jerusalem, ISRAEL
Website: https://www.iwsc2024.com/

2nd International Conference on Biological Control

Dates: 25-28 February, 2025
Venue: Bengaluru, INDIA
Website: https://icbc2025.eventsdashboard.in/

Fourth International Workshop of the IOBC Global Working Group on Biological Control and Management of Parthenium Weed

Dates: 2-5 March, 2025
Venue: Barisal, Patuakhali, and Dhaka, BANGLADESH
Please see the First announcement flyer for details!

Recent Publications

Adhikari, P., Lee, Y. H., Poudel, A., Lee, G., Hong, S. H., & Park, Y. S. (2023). Predicting the impact of climate change on the habitat distribution of *Parthenium hysterophorus* around the world and in South Korea. *Biology*, 12(1), 84.

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