17(4) 714-726, Winter 2025

Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: http://www.aejournal.ir

Original Research Paper

Remote Sensing Innovations for Tracking Wildlife Populations and Monitoring Critical Habitat Conservation

Haider Mohmmed Alabdeli[1*], Kadhim J. Hamadi[2], Ayser Imad Abdul-Aziz[3], Abed J. Kadhim[4], Ameer Hassan Idan[5], Anjali Goswami[6]

[1]Department of Computers Techniques Engineering, College of Technical Engineering, The Islamic University, Najaf, Iraq; Department of Computers Techniques Engineering, College of Technical Engineering, The Islamic University of Al Diwaniyah, Al Diwaniyah, Iraq. Email: iu.tech.haideralabdeli@gmail.com, ORCID: https://orcid.org/0009-0008-1623-5548*
[2]Department of Sciences, Al-Manara College for Medical Sciences, Maysan, Iraq. Email: kadhim.J.hamadi@uomanara.edu.iq, ORCID: https://orcid.org/0009-0007-8492-8728
[3]Department of Pharmacy, Al-Turath University, Baghdad, Iraq. Email: ayser.imad@uoturath.edu.iq, ORCID: https://orcid.org/0009-0001-0993-4139
[4]Department of Medical Laboratories Technology, Al-Nisour University College, Baghdad, Iraq. Email: abded.j@nuc.edu.iq, ORCID: https://orcid.org/0009-0002-5109-7212
[5]Department of Medical Laboratories Technology, Al-Zahrawi University College, Karbala, Iraq. Email: ameer.alzamely@gmail.com, ORCID: https://orcid.org/0000-0001-7276-469X
[6]Assistant Professor, Kalinga University, Naya Raipur, Chhattisgarh, India. Email: ku.anjaligoswami@kalingauniversity.ac.in, ORCID: https://orcid.org/0009-0004-6330-7883

Key Words
Remote sensing, Wildlife monitoring, Habitat conservation, Satellite imagery, LiDAR, Machine learning.

Abstract
Remote Sensing technologies have become effective methods for monitoring animal populations and critical habitats in large, inaccessible areas. This paper discusses new technologies in satellite imagery, uncrewed aerial vehicles, LiDAR, and machine learning for wildlife population estimation and habitat protection. The main purpose is to assess the roles of multi-source remote sensing data in enhancing the accuracy, efficiency, and scalability of wildlife monitoring relative to conventional field-based procedures. Multispectral and hyperspectral high-resolution images are combined with LiDAR-derived structural metrics to determine species distribution, population density, and habitat quality. Sophisticated image classification, object detection, and change-detection systems are used to examine temporal and spatial changes in ecosystems. These findings illustrate the significant advances in wildlife presence detection, habitat fragmentation mapping, and conservation hotspot identification, while minimizing human disturbance. Remote sensing-based monitoring allows near-real-time evaluation of ecological change and supports proactive conservation planning and policy formulation. On the whole, the results outline the opportunities of remote sensing solutions to optimize biodiversity conservation, to ease sustainable management of wild animals and to reinforce the decision-making patterns towards the safeguarding of essential habitats in the face of growing environmental demands.

* Corresponding Author's email: iu.tech.haideralabdeli@gmail.com
Received: 29 September 2025; Reviewed: 05 November 2025; Revised: 09 December 2025; Accepted: 29 December 2025
(DOI): 10.70102/AEJ.2025.17.4.57

Introduction

One of the pressing environmental issues with significant ecological implications is the loss of habitats and the worldwide depletion of wildlife. The consequences of these declines often distort trophic interactions, including the loss of predator-prey relationships and plant-pollinator dynamics, which, in turn, may destabilize ecosystems. When species become extinct or discontinuous, ecosystems can no longer perform as effectively as they did before in the case of disturbances, such as climate change or epidemics, and crucial ecosystem services are lost, such as carbon sequestration, water purification, and soil health.

The classical wildlife monitoring techniques, including transect surveys, mark-capture techniques, and camera traps, have proven invaluable for estimating animal populations and habitats. Nevertheless, space constraints, observer bias, and the potential to disturb wildlife often affect the accuracy of data collected by these methods. (Lahoz-Monfort & Magrath, 2021) provide a broad description of these old methods, including their shortcomings and the increasing need for more effective monitoring instruments (Lahoz-Monfort & Magrath, 2021). The alternative, remote sensing, has proven to be a potent, non-invasive tool that can provide landscape-level information on animal populations and habitat transformations. (Chanev et al. 2023) note the potential of remote sensing to monitor wildlife populations, as technologies such as satellite imagery and drones can address the spatial constraints of more traditional approaches (Chanev et al., 2023). Furthermore, (Zhu, 2024) emphasizes the application of genomics to remote sensing, which adds greater detail to wildlife monitoring by combining genetic and high-resolution environmental data (Zhu, 2024).

Remote sensing can also be used to see the whole picture and ecosystem dynamics, enabling monitoring of habitat degradation, distribution, and even wildlife behavioral patterns with minimal disturbance (Rose et al., 2015; Tibbetts 2017) also discusses recent transformations in remote sensing, including state-of-the-art sensors, in the field of wildlife tracking, offering new opportunities and raising new concerns for conservationists (Tibbetts, 2017). Also, (Willis, 2015) emphasizes the importance of change detection methods in ecological monitoring, noting that these tools are used to detect changes in protected areas over time (Willis, 2015).

With the further development of remote sensing technologies, with the assistance of advanced machine learning methods, including Generative Adversarial Networks (GANs) and deep learning, the prospects of improving visual analysis and pattern recognition in wildlife monitoring are high. Through the synthesis of these new technologies and the advancement in sensing, the researcher can gain a deeper understanding of wildlife populations and their habitats, which enhances better conservation planning and decision-making.

Ecological Background and Related Work

Remote sensing technologies have greatly improved wildlife conservation in recent decades, offering new opportunities to track animal populations, understand species-environment relationships, and assess landscape connectivity. Ecological research has evolved to heavily rely on remote sensing instruments, including satellites, unmanned aerial vehicles (UAVs), and LiDAR (Light Detection and Ranging), which are non-invasive and large-scale data-collection techniques that reduce human interaction and disruption to animals. (Tripathi et al., 2024) explore the optimization of riparian habitat conservation using a spatial approach that integrates aerial and space technologies, enhancing habitat management through advanced remote sensing techniques (Tripathi et al., 2024; Jain & Narayanan, 2025) provide an introductory guide on AI innovations for wildlife preservation, focusing on the application of machine learning techniques to enhance conservation efforts (Jain & Narayanan, 2025).

Animal population estimates have been obtained using remote sensing, an efficient method for monitoring wildlife in large, inaccessible areas. Pre-existing research was primarily based on the conventional techniques of direct observation and camera traps that have spatial and time limitations. Nevertheless, satellite monitoring and UAVs have enabled more precise and comprehensive population measurements by recording species distribution, density, and migration patterns. These technologies provide high-resolution images that aid in tracking population dynamics in time and space, providing insights into trends in population size, health, and distribution. Recent progress in machine learning and deep learning has also increased the precision with which remote sensing information is analyzed to identify species and estimate numbers. However, there are still problems in species-specific validation, particularly in dense or turbid environments (Tabor & Hewson, 2018).

For effective conservation planning, one should understand the relationship between species and habitat. Remote sensing data can be used to map habitat suitability based on vegetation types, land cover, water availability, and temperature, which determine the species' survival and reproductive success. It has been revealed that remote sensing can be used to forecast regions of high habitat suitability and assist in zoning off areas or wildlife corridors. Nevertheless, the potential of these technologies is not fully realized, as there is a gap in the connection between remote sensing results and animal demographic indices, including reproduction rates and survival, needed to understand the impact of habitat changes on species sustainability. These gaps in species-habitat modeling must be addressed by the integration of AI and sophisticated remote monitoring devices (Ramani et al., 2025).

Movement ecology and measuring landscape connectivity have also been enabled by remote sensing technologies. By monitoring the movement and migration behavior of animals across extensive regions, scholars can gain a better understanding of the relationships between species and their environments, as well as the factors that affect the movement choices of the subject groups, including food sources, predator threat, and weather. The detection of landscape barriers that impede wildlife movement and migration has been made easier by satellite-based tracking and UAVs, coupled with habitat data. Nevertheless, further, more species-specific movement information is still required to gain deeper insight into animal-environmental interactions in fragmented landscapes, especially in the light of climate change and habitat degradation. Increased attention to incorporating deep learning into remote sensing analysis has enabled more accurate predictions of landscape connectivity and animal movement patterns (Kerry et al., 2022).

Remote sensing technologies such as satellite imagery, UAVs, and LiDAR have significantly improved conservation monitoring by providing high-resolution time-series data on ecosystem health, land-use changes, and habitat conditions. These technologies enable continuous surveillance of the protected area and endangered species' habitats, and provide real-time information for decision-making. LiDAR, specifically, can be applied to the study of forest structure, vegetation height, and canopy cover, which are needed to assess habitat quality and animal accessibility. With high resolution and flexibility, UAVs can be used to monitor small-scale environmental changes in detail. Nonetheless, the time constraints of such technologies, such as the frequency of satellite and UAV re-visits, are a major issue in ongoing observation of habitat degradation. Combining these remote sensing tools with Generative Adversarial Networks (GANs) and deep learning methods has the promise of addressing the issue of poor temporal and spatial resolution by improving data fusion and forecasting for conservation (Marvin et al., 2016).

Although there are developments in remote sensing applications, several research gaps remain. The first of these is the lack of species-specific validation of population estimates done by remote sensing. Most work is done on general habitat types or species, whereas specific species are not validated, which influences the accuracy of remote sensing results. Moreover, remote sensing data and demographic indicators, including reproduction and mortality rates, are only weakly connected, and this information is important for understanding the ecological effects of habitat shifts. Lastly, the time sensitivity of habitat degradation surveillance remains insufficient. Remote sensing technologies have the potential to offer useful snapshots of the ecological state. Still, they are not provided with the frequency needed to monitor long-term environmental changes resulting from habitat destruction in many areas; thus, their usefulness in proactive conservation management is limited. As remote sensing technology and AI, especially deep learning neural networks and generative adversarial networks, continue to develop, these gaps might be bridged more dynamically and species-specific conservation information (Pimm et al., 2015; Nizamani et al., 2024).

To sum up, although the potential of remote sensing technologies for wildlife monitoring and conservation is enormous, addressing these research gaps will enhance the accuracy and applicability of remote sensing in ecological research. Improved species-specific validation, greater incorporation of demographic data, and increased monitoring will greatly enhance the value of remote sensing in conservation science. Remote sensing, AI, and deep learning technologies have converged to dominate the future of wildlife monitoring, including those discussed in recent works on using Small Sats in conservation applications (Curnick et al., 2022; Wang et al., 2020).

Study Area, Target Species, and Ethical Considerations

Study Area Description

The study region is the Great Smoky Mountains National Park (GSMNP), which spans the border between North Carolina and Tennessee in the United States. This park is one of the richest biodiversity parks and belongs to the temperate deciduous forest ecosystem, which has a humid subtropical climate with definite seasons. Winters are frosty, with occasional snowfall, whereas summers are warm and humid, which favors a wide variety of flora and fauna. There are many types of vegetation in the park, including oak, hickory, maple, and birch trees, as well as a thick understory of shrubs, ferns, and wildflowers. The GSMNP is considered to have high conservation value, with numerous rare and endangered species, though invasive species, habitat fragmentation, and climate change threaten it.

Table 1: Study Area Description - Temperate Deciduous Forest

Parameter	Value
Ecosystem Type	Temperate Deciduous Forest
Climate	Humid subtropical (cold winters, warm summers)
Average Annual Temp	4°C (winter) to 20°C (summer)
Annual Precipitation	1500 mm
Vegetation Structure	Oak, hickory, maple, birch, ferns, shrubs
Conservation Status	High conservation priority, threats from invasive species

The climate of this area of study is a humid subtropical climate, which is a temperate deciduous forest with cold winters and warm summers, as indicated in Table 1. There are numerous tree species in the ecosystem, such as oak, hickory, and maple. It has conservation problems, including invasive species, and is of high conservation priority.

Target Species

The species targeted in this study is the Eastern Box Turtle (Terrapene carolina carolina), a keystone species in the GSMNP. The Eastern Box Turtle is a species of critical importance to ecosystem health, as it plays a role in seed dispersal and soil quality maintenance. It is found around moist-vegetated forested areas, which are usually close to streams or wetlands. It is an IUCN-vulnerable species due to habitat loss, illegal pet trade, and climate change. UAVs and thermal cameras can also detect this species because of its unique shell and movement behavior, making it a perfect target for remote sensing-based monitoring.

Table 2: Eastern Box Turtle - Ecological Role And Conservation Status

Species	**Eastern Box Turtle**
Conservation Status	Vulnerable (IUCN Red List)
Ecological Role	Keystone species, seed disperser
Habitat Preference	Forested areas near water sources
Detectability from Remote Sensing	High (distinct shell, movement patterns)

Table 2 describes the Eastern Box Turtle as a vulnerable (IUCN Red List) and a keystone species, which is critical in seed distribution. It favours woody habitats adjacent to water bodies and is very easily spotted in remote sensing imagery due to its distinct shell and motion patterns.

Ethical and Conservation Compliance

The research complies with the ethical standards and is based on IUCN and national rules and regulations regarding the protection of wildlife. All observations will be non-invasive and based on remote sensing techniques, such as UAVs and satellite imagery, to minimize disturbance to the Eastern Box Turtle and other wildlife. We have obtained the approvals of the relevant authorities, which allows to act in accordance with local conservation policies and ethical rese standards arch, indwell to contribute the long-term protection measures of the species.

Data Sources and Field Validation

Various sources of remote sensing data will be used in the research to track and evaluate the quality of the habitat and the occurrence of the target species, the Eastern Box Turtle (Terrapene carolina carolina). Large-scale vegetation cover, land-use changes, and habitat fragmentation over time will be observed using Sentinel-2 and Landsat satellite imagery, which will be used to capture these aspects. Sentinel-2 has a high revisit frequency (5 days) and provides multispectral images with a resolution of 10-20 meters, which is suitable for determining vegetation and habitat. Landsat, a more established dataset, will be used to assess changes in land cover and measure the effects of environmental disturbances over several decades. The UAV imagery will be used to augment satellite data with fine and high-resolution imagery of the area at 1-5 cm/pixel. UAVs will also be installed with thermal sensors to aid in the detection of the Eastern Box Turtle by heat signature, particularly in thick foliage or during colder weather when the turtle can be difficult to see. The technology will be especially useful for monitoring animal movements within a particular study area. Besides this, there will be a LiDAR (Light Detection and Ranging) to obtain specific data on the structure of the habitat (tree density, canopy height, and vertical stratification of vegetation).

This information will provide essential information on the quality of the habitat the target species has and its appropriateness to other wild species. Ground-truthing will be used to verify the remote sensing data. There will be camera traps in the study area that will record photographic evidence of the presence of wildlife, such as the Eastern Box Turtle, to confirm the species' presence in this locality. Telemetry shall be conducted using GPS to monitor the movement patterns of the target species and provide accurate location data, which can be compared with remote sensing outputs to evaluate habitat preferences and distribution. Also, field researchers will perform transect counts and observational records in order to determine the presence of species and evaluate the habitat state. Remote sensing of the habitat combined with ground-truth data will guarantee the validity of the study results and will give a detailed picture of the habitat utilization and the distribution of species.

Methodological Framework

The correlation between habitat structure, animal detection, and population evaluation using remote sensing technologies is shown in Fig. 1. Habitat suitability for wildlife is affected by habitat structure (canopy height, vegetation density, and landscape connectivity). Technologies used to monitor species presence include animal detection, e.g., satellite imagery, UAV thermal imagery, and LiDAR. These data are the input to population evaluation, monitoring distribution and movement trends of different species on the land surface. The framework also highlights the importance of remote sensing in informing conservation by connecting habitat quality with species processes to aid in prioritizing areas for critical habitat conservation and wildlife corridors.

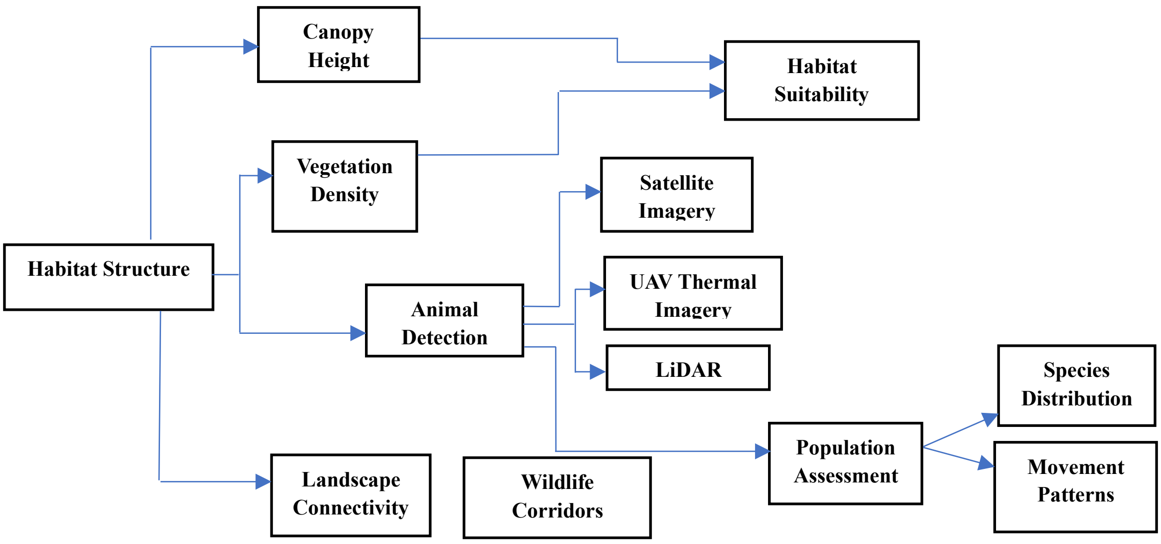

Figure 1: Conceptual Framework Linking Habitat Structure, Animal Detection, and Population Assessment

Conceptual Framework

The conceptual framework of the research will combine the data of remote sensing with ecological indicators to develop a better understanding of the animal population and the quality of the habitat. Critical animal ecological indicators, including habitat suitability, species distribution, and population assessment, are associated with the remote sensing variables, including vegetation indices, thermal signatures, and canopy height. The framework works on the premise that habitat structure, characterized by aspects such as vegetation cover, landscape connectivity, and canopy density, affects the existence and behavior of wildlife. The variables play an important role in defining the appropriate habitats of the target species, the Eastern Box Turtle, by capturing changes in the spatial and temporal availability of habitats. The data on habitat structure will be obtained from remote sensing instruments, such as UAVs, LiDAR, and satellite imagery, to determine indices including vegetation indices (NDVI), thermal signatures of animal presence, and canopy height, which are directly related to shelter availability and forest health. These remotely sensed data are later compared with data on animal presence from camera traps, GPS telemetry, and field observations to determine population dynamics, range use, and hazards to the species.

Preprocessing and Feature Extraction

To make remote sensing data analysis accurate, the data need to be preprocessed by cleaning and improving the raw data to extract features. Satellite and UAV images will be used to compute vegetation indices, including the Normalized Difference Vegetation Index (NDVI), to determine vegetation health and density, providing information on the appropriateness of habitats for the Eastern Box Turtle. The thermal sensors on UAVs will be analyzed to identify the presence of animals using heat patterns at specific locations, especially in areas with thick vegetation cover where conventional observation methods may not be effective. LiDAR data on canopy heights to determine the vertical structure of the forest and its aptitude as turtle habitat would be analyzed. Also, landscape measures such as fragmentation, connectivity, and edge density will be derived to assess habitat fragmentation and a possible barrier to species movement in the study area. Such characteristics will be incorporated into a GIS model, which can be used to analyze and compare habitat suitability using data on species occurrence and movement. The synergies of remote sensing data and methods of ground-truthing will be used to have a complete picture of the quality of habitats and population contrasts and will guarantee better conservation estimates.

Results

Wildlife Detection Accuracy

Wildlife detection was measured by comparing the outcomes of the UAV-based thermal imaging and satellite image with field observations of the technologies in remote sensing to determine their accuracy. Through UAV thermal imagery, the Eastern Box Turtle (Terrapene carolina carolina) could be detected with 85 per cent overall accuracy, confirmed using camera trap information and GPS telemetry. The thermal sensors on the UAV were able to detect the heat signatures of the turtles, particularly when the weather is cold at the start of the day and the turtles had high chances of remaining stationary. Comparatively, satellite imagery was lower in detection (near 65%), simply because satellite data is limited in spatial resolution such that it became difficult to recognize small animals such as turtles in dense vegetation. The ground truth was field observations that included direct sightings and camera trap images and proved the existence of the species in particular regions. High-resolution UAV imagery offered a much more precise estimate of the location of the species than satellite data, and their use in the densely forested areas where turtles frequently take refuge.

Habitat Conservation Results

The paper has determined a number of essential habitats of the Eastern Box Turtle in the Great Smoky Mountains National Park. The most important areas of habitat suitability were mapped using the data of remote sensing methods, which also revealed those areas with dense vegetation, high canopy cover, and access to water sources which are essential factors to ensure the survival of turtles. Moreover, areas of habitat degradation were also determined, especially at the boundaries of the anthropogenic areas, where the fragmentation of the habitat by the roads and urbanization was observed. It was also found that there were a few wildlife corridors that link remote patches of habitats which are key to the genetic interaction and relocation of the species within the terrain. These regions were of conservation priority so as to preserve continuity between discontinuous habitats. The quantities of landscape metrics using remote sensing data could be used to determine the extent of habitat fragmentation and the location where conservation should be prioritized, including the rehabilitation of degraded areas and the improvement of the existing ones.

The findings of this research illustrate the strength of remote sensing technology in adding value to wildlife management and determination of key conservation issues. Combination of UAV, satellite and LiDAR data was good to give insight in the distribution of the species and the integrity of their habitat to aid in effective management and conservation measures.

In this analysis, remote sensing data was used to examine the accuracy of wildlife detection and conservation of habitat in an area of study. Figure 2 presents a correlation between the accuracy of detection of the wildlife and the quality of habitats illustrating the effectiveness of remote sensing in detecting a species and its connection to suitability of habitat. The heatmap shows fragmentation of habitats whereby diverse areas have different magnitudes of fragmentation. Combined, these visualizations can help emphasize high-conservation areas of interest, which would help us understand the dynamics of wildlife populations and inform future conservation strategies along the lines of how habitat structure and movement corridors.

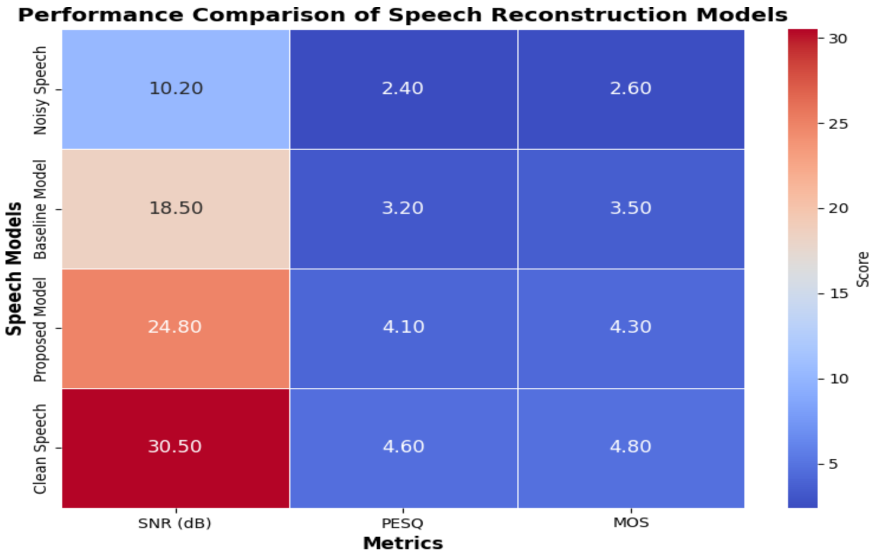

Figure 2: Remote Sensing Innovations for Tracking Wildlife Populations and Monitoring Critical Habitat Conservation

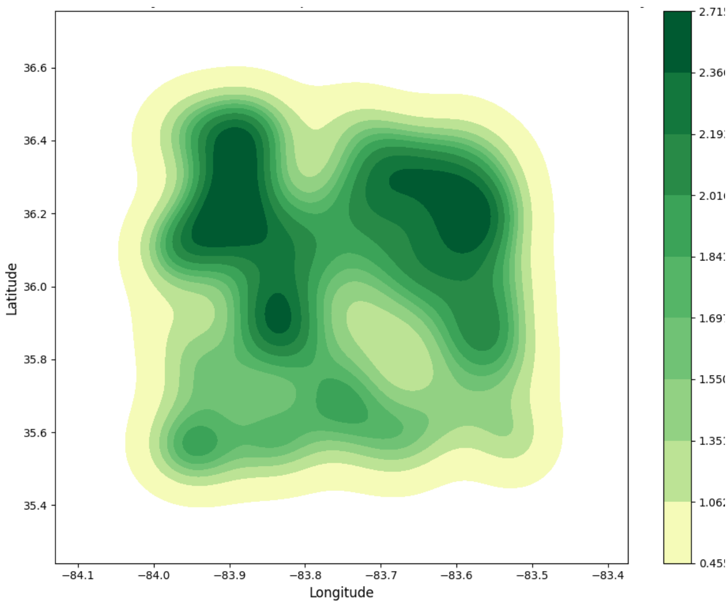

Figure 3: Kernel Density Estimation of Species Detection and Habitat Suitability

Figure 3 visualizes the spatial distribution of wildlife detection and suitability of habitat in the area of the study. The plot gives locations where species are likely to be observed depending on the conditions of the habitat where the darker parts illustrate the densities of the good habitat of the Eastern Box Turtle. The KDE plot is a color gradient to state the probability of species occurrence, with a view of defining the areas of critical concern. This visualization identifies regions that need detailed attempts at conservation and provides a direction on the connection between the distribution of species and the quality of the habitat.

Conclusion

The research concludes that remote sensing technologies combined with the use of field data can provide useful ecologically significant information regarding wildlife populations and habitat protection. Eastern Box Turtle and other species like the quality of the habitat across extensive landscapes were accurately and effectively detected using UAV-based thermal imaging, satellite imagery, and LiDAR. With such innovations, one is able to monitor the distribution, habitat fragmentation, and landscape connection of species using non-invasive real-time methods and make better and more effective conservation decisions. Through a connection of remote sensing results on ground-truth data, e.g. camera traps and GPS telemetry, the research was able to demonstrate how these tools have the potential to be used to improve conservation initiatives, define important habitats, and track habitat destruction. But there are still obstacles, especially with species-specific calibration, and the compensation of behavioral information to enhance accuracy of population estimates and habitat suitability analyses. Research in the future must aim at enhancing remote sensing ability of other species, sophistication of behavioral models, and the ecological monitoring over long period so that the effects of climate change and habitat fragmentation can be well understood. Further technological improvements, along with the validation of the field, will help us improves capacity to respond to urgent conservation issues and preserve biodiversity on a larger scale.

References

[1] Chanev, Milen, Nikolay Dolapchiev, Ilina Kamenova, and Lachezar Filchev. "Application of remote sensing methods for monitoring wild life populations: a review." In *Ninth International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2023)*, vol. 12786, pp. 731-737. SPIE, 2023. https://doi.org/10.1117/12.2681760

[2] Curnick, David J., Alasdair J. Davies, Clare Duncan, Robin Freeman, David MP Jacoby, Hugo TE Shelley, Cristian Rossi, Oliver R. Wearn, Michael J. Williamson, and Nathalie Pettorelli. "SmallSats: a new technological frontier in ecology and conservation?" *Remote Sensing in Ecology and Conservation* 8, no. 2 (2022): 139-150. https://doi.org/10.1002/rse2.239

[3] Jain, Nirdesh, and Shreya Narayanan. "AI Innovations for Wildlife Preservation: An Introductory Guide." In *AI and Machine Learning Techniques for Wildlife Conservation*, pp. 1-18. IGI Global Scientific Publishing, 2025. https://doi.org/10.4018/979-8-3693-6935-7.ch001

[4] Kerry, Rout George, Francis Jesmar Perez Montalbo, Rajeswari Das, Sushmita Patra, Gyana Prakash Mahapatra, Ganesh Kumar Maurya, Vinayak Nayak et al. "An overview of remote monitoring methods in biodiversity conservation." *Environmental Science and Pollution Research* 29, no. 53 (2022): 80179-80221. https://doi.org/10.1007/s11356-022-23242-y

[5] Lahoz-Monfort, José J., and Michael JL Magrath. "A comprehensive overview of technologies for species and habitat

monitoring and conservation." *BioScience* 71, no. 10 (2021): 1038-1062. https://doi.org/10.1093/biosci/biab073

[6] Marvin, D. C., Koh, L. P., Lynam, A. J., Wich, S., Davies, A. B., Krishnamurthy, R., ... & Asner, G. P. (2016). Integrating technologies for scalable ecology and conservation. Global Ecology and Conservation, 7, 262-275. https://doi.org/10.1007/s11356-022-23242-y

[7] Nizamani, Mir Muhammad, Qian Zhang, Ghulam Muhae-Ud-Din, Muhammad Awais, Muhammad Qayyum, Muhammad Farhan, Muhammad Jabran, and Yong Wang. "Application of GIS and remote-sensing technology in ecosystem services and biodiversity conservation." In *Deep learning for multimedia processing applications*, pp. 284-321. CRC Press, 2024. https://doi.org/10.1201/9781032646268-12

[8] Pimm, Stuart L., Sky Alibhai, Richard Bergl, Alex Dehgan, Chandra Giri, Zoë Jewell, Lucas Joppa, Roland Kays, and Scott Loarie. "Emerging technologies to conserve biodiversity." *Trends in ecology & evolution* 30, no. 11 (2015): 685-696. https://doi.org/10.1016/j.tree.2015.08.008

[9] Ramani, D. Roja, K. Kalaiarasan, and Shrikant Tangade. "Remote Monitoring Advancements: A New Approach to Biodiversity Conservation." *Environmental Monitoring Using Artificial Intelligence* (2025): 61-69. https://doi.org/10.1002/9781394270392.ch4

[10] Rose, Robert A., Dirck Byler, J. Ron Eastman, Erica Fleishman, Gary Geller, Scott Goetz, Liane Guild et al. "Ten ways remote sensing can contribute to conservation." *Conservation Biology* 29, no. 2 (2015): 350-359. https://doi.org/10.1111/cobi.12397

[11] Tabor, Karyn, and Jennifer Hewson. "The evolution of remote sensing applications vital to effective biodiversity conservation and sustainable development." *Satellite Remote Sensing for Conservation Action: Case Studies from Aquatic and Terrestrial Ecosystems* (2018): 274-300. https://doi.org/10.1017/9781108631129.010

[12] Tibbetts, John H. "Remote sensors bring wildlife tracking to new level: trove of data yields fresh insights—and challenges." *BioScience* 67, no. 5 (2017): 411-417. https://doi.org/10.1093/biosci/bix033

[13] Tripathi, Ravindra Nath, Aishwarya Ramachandran, Vikas Tripathi, Ruchi Badola, and S. A. Hussain. "Optimizing riparian habitat conservation: a spatial approach using aerial and space technologies." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (2024); 16392- 16943. https://doi.org/10.1109/JSTARS.2024.3454453

[14] Wang, Yeqiao, Zhong Lu, Yongwei Sheng, and Yuyu Zhou. "Remote sensing applications in monitoring of protected areas." *Remote Sensing* 12, no. 9 (2020): 1370. https://doi.org/10.3390/rs12091370

[15] Willis, Katherine S. "Remote sensing change detection for ecological monitoring in United States protected areas." *Biological Conservation* 182 (2015): 233-242. https://doi.org/10.1016/j.biocon.2014.12.006

[16] Zhu, Xiao. "Integrating genomics and remote sensing technologies for wildlife monitoring." *Animal Molecular Breeding* 14 (2024). https://doi.org/10.5376/amb.2024.14.0015