Mapping Urban Biodiversity Hotspots Using Remote Sensing and Citizen Science for Effective Conservation Planning

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Abstract. Biodiversity (BD) information underpins conservation studies and guides conservation choices in tackling BD loss. Such information often needs analysis and compilation before use, which surpasses the time constraints of expert scientists. Scientists enlist, educate, and assist a network of Citizen Science (CS) to collect this data via internet platforms. This text outlines three CS initiatives funded by the Arkansas Natural Heritage Commission to transcribe and georeference historical herbarium samples and document contemporary BD via iNaturalist (i-N) in two ecologically rich and rapidly growing counties. Data obtained via CS will be included in a County Natural Heritage Inventory (CNHI) report, with a detailed list of species associated with voucher samples and documentation of uncommon populations of plants. Since the inception of the CNHI initiative, CS has written down 9000 and georeferenced 2500 sample data. i-N investigations have reported 130 uncommon plant communities across 40 taxa. This CNHI indicate will identify the most vital taxa, ecosystems, and places for preservation efforts in the region and will provide guidance to conservation participants at regional, state, and federal scales as they undertake land acquisition, restoration of ecology, handling of natural resources, expansion and growth organizing, and the environment reviews.

1 Introduction

The fast decline of Biodiversity (BD) [1] is a complex challenge in conservation, necessitating creative methods to promptly catalog populations of rare species and regions of significant conservation significance to ensure preservation before populations are diminished and taxa face extinction. BD is diminishing before its documentation, with around 40% of plant species at risk of extinction, and just 12% of all plant taxa evaluated according to Red List criteria [2]. To address the significant challenges of plant preservation in the twenty-first century, the research suggests several focal areas, including vital details on plant diversity, distribution, and plenty, in particular for organisms of conservation issue; the necessity for the collection of data on BD to ensure accessibility and utility; and the promotion of connections among creatures, plants, and puts to enhance local understanding and reestablish the relationship between individuals and nature [9]. The aggregation of BD data facilitates conservation efforts to combat the urgent issue of accelerated BD decline [4]. In contrast, historical and contemporary BD records offer essential temporal and spatial insights for stakeholders acquiring land, planning to restore ecosystems, conducting environmental assessments, and other practical conservation initiatives [6]. Options other than using these historical and contemporary BD data include extensive, unfeasible field inventory initiatives, given the restricted funds [3]. Conservation research is sometimes laborious and expensive, necessitating proactive protection of uncommon species and high conservation value places to mitigate extinction danger [8]. Comprehending BD loss necessitates decades of detailed data over a regional scope, and acquiring long-term monitoring information essential for assessing the state of conservation needs more time than is typically accessible to professional researchers and resource managers. Citizen Science (CS) [13] has substantially advanced conservation and BD studies, with multidisciplinary teams from academia, government, and natural history museums supporting CS initiatives using electronic devices [10]. In a sample of 390 projects from the inaugural quantitative examination of CS information for BD studies, the involvement of 1.4 million individuals was projected to yield an in-kind contribution valued at USD 2.8 billion, representing a substantial labor input for CS initiatives at a comparatively low expense for project planners. Nature galleries facilitate CS by promoting education and conservation initiatives [12]. For centuries, these institutions have collaborated with amateur scientists to document BD, offering assistance in knowledge dissemination regarding recognition and field methods, access to equipment and reference groups, and curating for the membership of collected samples [14]. CS gets scientific information, including taxon proof of identity, by reporting sightings on iNaturalist (i-N) while helping with BD studies [5]. Regional BD research necessitates the analysis of thousands of historical and

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contemporary BD data. Numerous online platforms enable CS to contribute to processing this data into publicly accessible, standardized datasets [16]. This research outlines the establishment and maintenance of a CS network aimed at enhancing the availability of verified BD data from two ecologically rich and swiftly growing counties, using three web platforms:

(1) Recording herbarium samples via Notes from Nature, (2) georeferencing the herbarium the sample communities utilizing Collaboration Georeferencing (CoGe) [11], and (3) recording extant taxon existence as well as distribution using Naturalist, emphasizing the identification of previously unrecorded groups of tracked taxa, groups of indicator species, and county documents. The information collected by CS will be collated and incorporated into national BD databases to identify priority places for preservation and highlight these locations for funding and ecological control.

2 Determining The Geographic Component for the Urban Category

The last stage in formulating an urban categorization system is to choose a fundamental geographic unit for investigation. The geographical unit must be selected according to the scale at which users want to use the categorization scheme and the scale at which relevant information is accessible within the research region. The geographical unit is delineated by ecosystem-based limits (e.g., sub watersheds or environmental areas), territorial limits (e.g., municipalities or regions), demographic limits, or manufactured grids that partition a study space into uniformly sized cells. Determining the geographical region requires considering the future relevance and functionality of the categorization [7]. An artificial grid is less beneficial for those preserving urban areas, whereas jurisdiction and demographic borders are more recognizable and readily utilized by decision-makers.

To reconcile the trade-offs among the resolution of available databases, the necessity for the findings to apply to city and county-level organizing and handling of conservation, and to mitigate computational constraints, the research selected the Census Block Groups (BG) as the fundamental categorization unit. A BG is a geographic subdivision between the Statistical Results and the Enumeration Block in size. It denotes a collection of Census Building blocks, often analogous to cities. BGs are usually delineated by highways, vegetation, or governmental borders, frequently corresponding to neighborhood boundaries acknowledged by local inhabitants. Typically, biophysical parameters (including microclimate and altitude), socioeconomic status, construction of housing type, and landscape exhibit considerable homogeneity within a biogeographical region. BGs are accessible in the Geographic Information System (GIS) format [15]. Numerous other nations possess similar census divisions. BGs have been extensively used in urban landscape categorization research as a suitable unit for quantifying variability across expansive metropolitan regions. In the research region, there were 6000 BGs, varying in size from 0.04 km² to 24.43 km², with a mean dimension of 0.62 km².

2.1 Species Frequency Information Generated by CS

Due to the expansion of CS initiatives, there is growing accessibility to species distribution information for metropolitan regions. Specific CS systems or initiatives concentrate on a singular taxon, whilst others include a variety of organism categories. Typically, species-specific data provided by CS are freely available to the public, and several programs facilitate straightforward web access for downloading and using this data. The World BD Data Facility is a comprehensive data storage facility, enabling users to obtain BD information gathered from many sources, such as museum specimen collections and CS data, via a singular interface.

The research used Naturalist sightings as the source of species-specific data. The Naturalist has achieved significant popularity in Los Angeles County owing to a succession of continuous CS initiatives overseen by the Natural History Museum. The i-N collection comprises species-specific information for various taxa, making it suitable for diversity evaluations. The research utilized 6000 reports (2300 species) of species-level, i-N data encompassing diverse taxa (e.g., birds, bugs, plants, vertebrates, animals, gastropods, arachnids, fungi, etc.) recorded to evaluate the patterns of BD within the study area. i-N data is accessible via a data exporting tool. i-N defines research-grade sightings as those with a photographic voucher, specific place, date, and community-validated identification, excluding grown or captive species. Based on the study inquiries, users choose to include grown or captive creatures, since they might be vital elements of the plant and animal life in some urban environments. This material is available for purchase on i-N. This case research focuses on natural BD; hence, the research excluded farmed or captive creatures. The research obtained data on the origin of the above species from the state's Department of Fish & Wildlife, the Bird Records Group, and i-N. The research categorized 900 species as indigenous to California and 450 as non-native. Nine hundred ninety organisms, primarily insects, were devoid of provenance data.

3 Framework for Preservation of BD and Monitoring

The Artificial Intelligence (AI)-Driven System for BD Preservation and Maintenance (Fig. 1) offers a systematic methodology for incorporating AI technology into conservation initiatives via five hierarchical tiers, converting data into implementable results. The AI Techniques & Tools Layer is the foundational technology directing the structure. Current developments influenced the research in implementing AI methods across several fields while constructing this hierarchical structure. The study identified key principles for the proper deployment of AI in intricate social systems, including data standards, ethical issues, and the essential equilibrium between automated and human monitoring. These fundamental values guided the strategy for using AI in BD conservation, namely in guaranteeing fair access to technologies and upholding openness in decisions made. The Data Management Level integrates five essential data streams Remote Monitoring, Climate Sensors, Acoustic Tracking, CS, and Historical Records to guarantee complete BD indicators across various scales. The Evaluation & Modeling Layer utilizes sophisticated methods like Species Recognition, Habitat Suitability Simulation, Environmental Service Assessment, Risk Evaluation, and Forecasting to derive insights into ecological processes and the number of species.

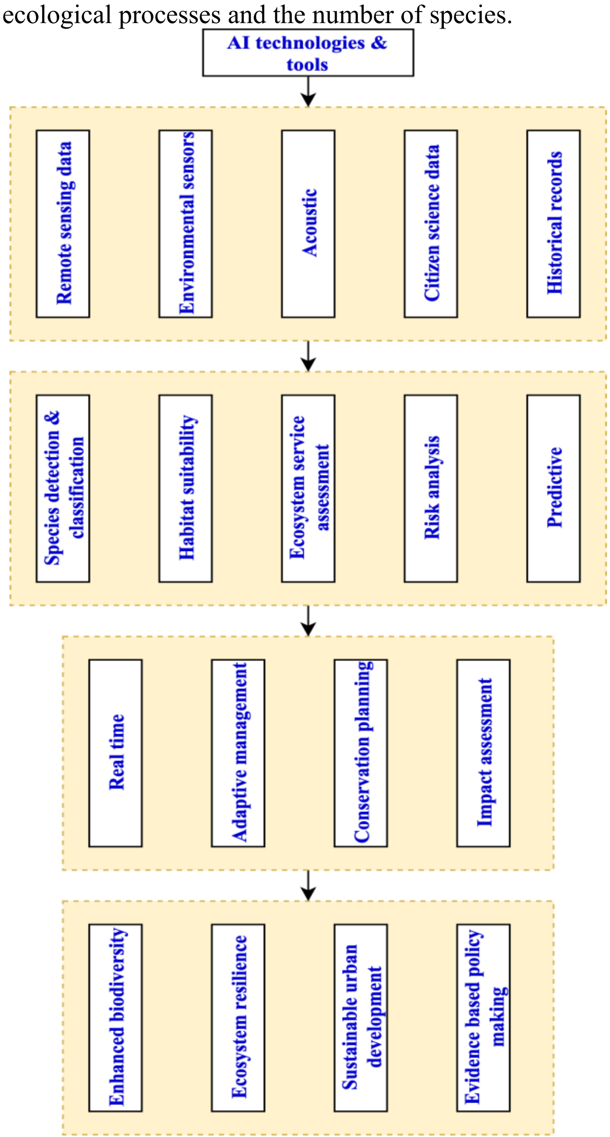

Fig. 1. Workflow of the AI-based mapping of BD mapping using CS.

Insights derived from analysis are executed in the Execution & Surveillance Layer via Real-time Tracking, Adaptive Administration, Conservation Planning, and Impact Evaluation, connecting analysis and action for data-driven, pragmatic conservation. The Outcomes Layer emphasizes four goals: Improved BD, Environmental Resilience, Healthy Urban Growth, and Evidence-based Decision Making.

The structure operates as a cohesive system, characterized by a sequential data flow and feedback cycles that provide ongoing strategy improvement. This systematic method guarantees that AI is efficiently used to tackle BD issues while offering explicit routes for execution and assessment. This document is an operational manual for conservation managers and an intellectual framework for academics, highlighting AI's pivotal role in attaining goals for preservation and healthy management of ecosystems.

4 Discussions

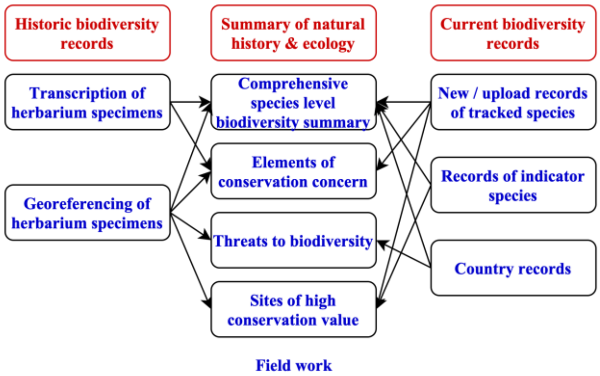

Fig. 2. CNHI workflow and Climate Sensors.

The County Natural Heritage Inventory (CNHI) study has five parts, with the contributions of CS detailed in four (Fig. 2). CS writes historic BD data on Notes from Nature before their georeferencing in CoGe. The written record of the herbarium samples alone contributes to the detailed taxon-level BD assessment (an annotated county species list). It offers additional details about the ecosystems, places, and collecting dates for conservation-sensitive components. Through georeferencing these documents, the research acquired geospatial data to pinpoint areas of significant preservation importance characterized by rare and/or indicator species and detect existing or imminent threats to BD. The existing BD data (i-N sightings) contribute to each of the four reporting parts, supplemented with recent findings of invasive species as county recordings to identify emerging threats to BD.

5 Conclusion

The Natural Heritage Program statistics serve as a crucial instrument for directing conservation efforts to tackle the complex issue of accelerated BD loss and to inform conservation choices in the area via five primary methods: (1) directing the procurement of critical conservation areas, (2) supplying data for ecological assessments and impact evaluations, (3) pinpointing specific locations within designated areas to circumvent during infrastructure development and recreational enhancements (including roads, parking facilities, and biking trails), (4) putting first particular sites, on both public and private properties, for repair and administration initiatives such as noxious species eradication and controlled burns, and (5) determining habitats for vulnerable species of preservation interest that require mitigation strategies such as preservation transplanting for ex-situ preservation. The diversity in their rare species conservation plan. During the next few years of the CNHI project, CS will persist in gathering and analyzing BD information. The ANHC will use this data to determine each county's most critical preservation sites and collaborate with conservation organizations to preserve, safeguard, and oversee these locations moving forward.

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