

# Artificial Intelligence in Biodiversity Conservation: Bridging Traditional and Contemporary Method

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*Abstract- Gaps persist between existing knowledge and what is needed to tackle the biodiversity crisis. While preserving biodiversity is essential for ecological balance, traditional conservation methods face limitations, particularly in scalability and access to current data. This underscores the need for more robust forecasting tools to better understand ecological dynamics and inform effective strategies. With advancements in technology, artificial intelligence (AI) offers significant potential to bridge these gaps, though the areas of greatest impact remain uncertain. Recent advances in artificial intelligence (AI) hold transformative potential for modern conservation. Increasingly, AI tools such as machine learning and data analytics are being applied to species identification, habitat monitoring, and threat assessment with high precision. While most applications to date focus on tracking wildlife and modelling species distributions, AI is rapidly expanding into areas like phylogenetic analysis. AI processes images with greater consistency and efficiency than manual methods. It supports ecologists in monitoring air quality, assessing ecosystem changes, and tracking species distributions. Beyond enabling large-scale data collection and analysis, AI is advancing predictive modeling, offering transformative potential for ecology and environmental sciences—much like statistics reshaped these fields in the twentieth century. Its greatest untapped potential lies in addressing complex ecological questions that require integrating diverse data types images, video, text, audio, and DNA. Such advances could significantly expand biodiversity knowledge, from genes to ecosystems, and may prove critical for achieving the 2030 Global Biodiversity Framework targets.*

**Keywords:** AI, Biodiversity, Conservation, Contemporary Method

## I. INTRODUCTION

Biodiversity is the variety of life on Earth. It includes plants, animals, microorganisms, and the ecosystems they form. Healthy biodiversity is essential for human survival because it provides food, clean water, medicine, pollination, and climate regulation (Prakash, 2020). Yet biodiversity is declining at an alarming pace because of habitat loss, overexploitation, invasive species, pollution, and

climate change. Conservationists have long relied on traditional methods field surveys, expert observation, long-term monitoring, and community knowledge to understand and protect species and habitats. These methods are rigorous and proven, but they are also time-consuming, expensive, and limited in spatial and temporal coverage. So, there is need to make predicting methods that are more reliable and accurate. This will help us understand how ecosystems work and come up with better ways to protect them (Lhoumeau, *et al.*, 2025).

In the last decade, a wave of contemporary technologies has begun to transform this landscape. Among them, artificial intelligence (AI) stands out as a powerful set of tools for seeing patterns in large and messy datasets, spotting change in real time, and guiding decisions under uncertainty (Russel, 2016). Crucially, AI does not replace traditional conservation science; it extends and amplifies it. When we combine traditional conservation approaches with AI-driven analyses, we can bridge gaps in data, scale insights, and act faster and more precisely to prevent biodiversity loss (Fergus *et al.*, 2024).

The integration of AI into conservation practices provides several key benefits (Kwok, 2019). First, it enables continuous and non-invasive wildlife monitoring, reducing human disturbance in fragile habitats. Second, AI-powered analytics can rapidly process vast datasets, revealing patterns and trends that might otherwise go unnoticed. Finally, AI supports the detection of poaching activities, allowing for swift intervention and potentially preventing the illegal hunting of endangered species (Kammaing *et al.*, 2018).

This essay focuses at how AI and traditional methods of protecting biodiversity complement to each other. It shows when the two work together and when extra care is needed, as well as how to create human-

centered, morally sound processes that take into account local situations and knowledge systems.

Traditional Foundations or Traditional conservation methods:

Conservation is the process which is related to the use, preservation and proper management of the natural resources and their protection from destruction, misuse, decay, fire or waste. Traditional conservation methods have a long track record of success (Bruchac, 2014).). The traditional practices into biodiversity conservation represents a promising pathway toward sustainable environmental stewardship. They include:

1. **Field Surveys and Transects:** Scientists and trained volunteers conduct point counts for birds, pitfall traps for insects, camera trap setups for mammals, line transects for plants and herpetofauna, and snorkel or scuba surveys for coral reefs and fish. This yield standardized, comparable data across sites and years.
2. **Long-Term Ecological Monitoring:** Permanent plots, forest inventories, and repeated sampling reveal trends in species abundance, recruitment, mortality, and community composition. These datasets are gold standards for understanding change.
3. **Expert Taxonomy and Natural History:** Species identification, life history knowledge, and behavioral insights come from cumulative expertise. Accurate identification underpins any good dataset.
4. **Community-Based Monitoring and Indigenous Knowledge:** Indigenous communities play a vital role in biodiversity conservation, approaching it with an integrated and spiritual connection to nature. Recognizing and respecting their values and traditions is essential, as their presence significantly contributes to the preservation of biodiversity. Many communities possess detailed ecological knowledge of species distributions, migration timing, and resource dynamics. This knowledge is place-based and often spans generations.
5. **Conservation Planning and Policy:** Tools such as protected area design, environmental impact assessments, and recovery plans depend on robust field evidence and stakeholder processes.

Traditional methods bring ground truth, ecological context, and credibility. However, they can struggle

with scale (both space and time), costs, and the speed needed to respond to rapid change.

Contemporary Data Sources: How AI Amplifies Traditional Conservation:

Technological innovations are becoming vital in the conservation and restoration of biodiversity. They support the monitoring, protection, and recovery of ecosystems and species, enabling more effective and scalable conservation efforts. Below are some of the key tools and innovations driving this progress:

Image Recognition:

- I. **Camera Traps:** AI-powered camera traps are strategically deployed in wildlife habitats to capture images or videos triggered by motion or heat. The collected footage is analyzed using AI algorithms that identify and classify species, enabling researchers to monitor the presence, behavior, and population trends of endangered wildlife (Shorten and Khoshgoftaar, 2019).
- II. **Facial Recognition:** For species with unique markings or distinctive features, AI-based facial recognition technology can identify individual animals. This approach is especially valuable for tracking movements over time, studying social interactions, and assessing overall health (Trolliet et al., 2014).

Remote Sensing:

**Satellite Image Analysis:** Satellites (e.g., NASA's Landsat and ESA's Sentinel-2), drones, and airborne LiDAR (Light Detection and Ranging) provide high-resolution images of the forests, wetlands, grasslands, and reefs etc. to monitor changes in land cover, deforestation, habitat destruction, urban expansion, and other environmental changes (Sachan, *et al.*, 2023).

Drones equipped with cameras and sensors are increasingly used to survey vast landscapes, monitor wildlife, assess forest health, and track environmental changes. They are particularly valuable in providing real-time data from remote or inaccessible regions. LiDAR technology enables the creation of detailed 3D maps of ecosystems, such as forests, which help in evaluating vegetation structure, biomass, and biodiversity.

These tools not only support the identification of biodiversity hotspots but also play a crucial role in detecting illegal activities like poaching and deforestation.

**Robots:** They are increasingly being designed to support conservation tasks such as tree planting and the removal of invasive species. For instance, “seed-dropping drones” can disperse large numbers of seeds over vast areas, enabling faster and more efficient reforestation compared to human labor alone.

**Climate Monitoring:** AI processes satellite data to track climate variables like sea surface temperature, atmospheric conditions, and greenhouse gas concentrations (Sachan, *et al.*, 2023).

**Environmental DNA (eDNA):**

Environmental DNA or eDNA sampling is a method where DNA from rare and cryptic organisms (shed through skin, hair, waste, etc.) is collected from environmental samples like water, soil, or air. This approach enables scientists to monitor non-invasive biodiversity and identify species within a habitat without the need for direct observation. It is especially valuable for detecting elusive, rare, or endangered species. eDNA assays flag invasive carp, guiding nets and electrofishing teams to priority sites (Wilson, 2024).

eDNA promises wide detection across taxa but depends on reference databases to link DNA sequences to species. Traditional taxonomists are essential for voucher specimens, barcoding, and resolving cryptic species. AI can assist by clustering unknown sequences to flag likely new or misidentified taxa, but only taxonomic work can confirm them. This is a prime example of synergy: AI speeds the search; traditional science secures the truth.

**Artificial Intelligence (AI) and Machine Learning:**

**Species Identification:** AI and machine learning algorithms are employed to automatically identify species from images, videos, and sound recordings, including data from camera traps, acoustic sensors, and satellite imagery. These technologies can rapidly process large datasets, supporting wildlife monitoring, endangered species tracking, and ecosystem health assessment.

**Predictive Modeling:** AI-powered models are also used to forecast the effects of climate change, habitat loss, and other human activities on biodiversity. Such predictions provide valuable insights for more effective conservation planning and decision-making.

**Blockchain Technology:**

**Supply Chain Transparency:** Blockchain technology can be applied to build transparent supply chains that trace the origin of natural resources such as fish, timber, or agricultural products ensuring the sustainably protection of biodiversity friendly sources. This approach helps curb illegal wildlife trade and the unsustainable exploitation of natural resources.

**Conservation Funding:** Blockchain also offers innovative solutions for conservation financing by enabling decentralized and transparent donation systems that directly support conservation projects.

**Citizen Science and Mobile Apps:**

**Biodiversity Monitoring Apps:** Applications such as i-Naturalist, eBird, and Plant Snap enable citizens to contribute to biodiversity monitoring by recording and reporting species observations. The data collected through these platforms is crucial for tracking species distributions, migration patterns, and potential threats.

**Engaging Communities:** Mobile apps and online platforms also play an important role in raising awareness and involving communities in conservation initiatives. By facilitating crowdsourced data collection, they make it possible to monitor large areas more effectively.

**Smart Sensors and Internet of Things (IoT):**

**Wildlife Tracking Devices:** IoT-enabled sensors attached to wild animals can record their movements, behaviors, and interactions with the environment. Such data helps researchers study migration routes, habitat use, and threats like poaching.

**Acoustic Sensors:** Specialized microphones, including hydrophones for marine environments, are used to capture the sounds of birds, bats, amphibians, insects, and marine mammals, offering insights into species presence and activity. Acoustic sensors and AI detect frog choruses as indicators of wetland health.

**Smart Environmental Monitoring:** Sensors placed in ecosystems can measure key environmental parameters such as water quality, temperature, and pollution levels. These real-time measurements provide valuable data for assessing ecosystem health and guiding conservation actions.

**Telemetry and Bio-logging:** Devices such as GPS tags, accelerometers, and physiological sensors (e.g., temperature or heart-rate monitors) track animals across landscapes and seascapes, offering detailed information about movement, behavior, and health.

**Biotechnology:**

**Gene Editing (CRISPR):** Gene-editing tools such as CRISPR are being explored as a means to support endangered species by enhancing their resilience to diseases, climate change, and habitat loss. This technology is also being investigated for applications like de-extinction and restoring genetic diversity in vulnerable populations.

**Synthetic Biology:** Synthetic biology provides engineered solutions to aid ecosystem recovery. Examples include developing genetically modified organisms that can assist in environmental restoration, such as bacteria designed to clean up oil spills or absorb harmful toxins.

These innovations enhance the efficiency of monitoring, data collection, and intervention, allowing biodiversity conservation efforts to become more scalable and effective in addressing increasing environmental challenges.

**How AI to predictive distribution and early warning:** Species distribution models (SDMs) predict where species occur based on environmental variables; AI methods (e.g., gradient boosting, random forests, deep learning) can capture non-linearities and interactions. When updated with recent remote-sensing and climate data, these models forecast shifts in suitable habitat and identify climate refugia. They guide traditional surveys by pointing to “likely” areas for rare or invasive species.

Anomaly detection in satellite or acoustic data can flag unusual events forest clearing, illegal mining noise, chainsaw signatures, gunshots, or vessel activity in protected zones so rangers can respond. Traditional patrols provide verification and follow-up.

**Assessing Population Trends** By automating detection and applying hierarchical or Bayesian models, AI helps estimate abundance and occupancy with uncertainty, incorporating imperfect detection. Traditional statistical frameworks remain essential, but AI speeds data processing and reveals fine-scale patterns.

**Ecosystem Health and Soundscapes** Soundscape indices and unsupervised learning distill complex acoustic scenes into indicators of biodiversity. Combined with field data (point counts, vegetation plots), they produce holistic views of ecosystem condition.

**Restoration Prioritization:** Predictive models identify sites with the highest chance of long-term success based on soil, hydrology, and microclimate; restoration ecologists select species mixes and monitor outcomes.

**Environmental Impact Assessment (EIA):** AI can rapidly screen for sensitive habitats and species near proposed developments; field biologists conduct targeted surveys and propose mitigation.

**Adaptive Management:** Real-time alerts steer responses-closing fisheries when whales are detected, redirecting patrols to fresh incursions, or ramping up invasive species removal after early detection.

In each case, AI shortens the time from signal to decision, while human expertise ensures legitimacy and care.

**Building a Human-Centered AI-Conservation Workflow**

1. **Co-Define Objectives:** Start with clear conservation questions-Which species? What threats? What decisions will the results inform? Bring together scientists, rangers, community leaders, and policymakers.
2. **Design the Sampling Strategy:** Use established ecological methods (replication, controls, stratification) to plan sensor placement, transects, and survey timing. Avoid convenience sampling that introduces bias.
3. **Collect Multimodal Data:** Combine camera traps, acoustics, remote sensing, eDNA, and citizen science. Each modality covers different

detection gaps: nocturnal vs. diurnal, terrestrial vs. aquatic, cryptic vs. conspicuous.

4. **Curate and Label:** Set up quality-control pipelines. Use expert validation and active learning let the model suggest uncertain cases for humans to label—so scarce expert time improves model performance fastest.
5. **Model with Transparency:** Choose algorithms appropriate to the task (e.g., convolutional networks for images, recurrent or transformer models for audio sequences). Document training data, hyperparameters, and metrics (precision, recall, F1, calibration). Maintain version control and model cards.
6. **Integrate Uncertainty:** Report confidence intervals and false positive/negative rates. For sensitive decisions (e.g., enforcement actions), require human confirmation.
7. **Deploy for Action:** Connect outputs to patrol planning, restoration site selection, protected area zoning, or impact assessments. Keep interfaces simple—dashboards that show maps, trends, and alerts.
8. **Evaluate and Iterate:** Compare AI-guided outcomes to baselines. Did patrols find more snares? Did restoration plantings survive better? Use adaptive management loops to refine models and field strategies.
9. **Build Local Capacity:** Train local staff and students; create paid roles for community monitors; share data and authorship. Sustainability depends on rooted capacity, not only technology.
10. **Governance and Ethics:** Establish data agreements, privacy protections, and grievance mechanisms. Ensure the project complies with national laws and community norms.

#### Specific AI Techniques and Their Roles

- **Supervised Learning:** Species classification from images and audio, land-cover mapping, presence/absence prediction from eDNA metabarcoding reads.
- **Unsupervised and Self-Supervised Learning:** Clustering of soundscapes to detect community shifts without labeled data; representation learning for rare species where labels are scarce.
- **Active Learning:** The model flags uncertain cases (e.g., possible rare species) for expert review, accelerating improvement with minimal labeling effort.

- **Transfer Learning:** Fine-tuning models trained on large generic datasets (e.g., ImageNet, audio corpora) to specific local species, saving compute and data.
- **Anomaly Detection:** Identifying illegal logging acoustics, unexpected nocturnal activity near fence lines, or sudden changes in NDVI indicative of clearing.
- **Graph and Network Models:** Understanding metapopulation connectivity, wildlife corridor prioritization, and disease spread across contact networks.
- **Reinforcement Learning & Optimization:** Dynamic patrol routing, scheduling of surveys, or adaptive sampling where each new measurement informs the next best location.

Traditional statistics and experimental design remain the backbone—confidence, replication, and causal inference guard against spurious findings.

### III. CONCLUSION

AI is not a silver bullet for biodiversity loss. It is a set of tools powerful, fast, and scalable that can extend the reach of traditional conservation methods. The most effective projects begin with clear conservation questions, use robust ecological designs, and embed AI within human-centered workflows that respect ethics, equity, and local knowledge. When we bridge traditional and contemporary methods, we gain three vital capabilities: speed (from data to decision), scale (from plots to landscapes), and foresight (from trend to forecast).

The path ahead is not about replacing field biologists, taxonomists, or community stewards with algorithms. It is about equipping them: turning months of image sorting into minutes, turning patchy observations into continuous maps, turning alerts into timely patrols, and turning uncertainty into informed choices. If we invest in sound design, capacity building, and ethical governance, AI can help conservationists do what they have always done—protect life on Earth—only better, faster, and with more people meaningfully involved.

In short, bridging traditional and contemporary methods does not blur their identities; it braids them. Field craft and local wisdom anchor the work; sensors and models expand the view; policy and practice deliver impact. Together, they form a

resilient cord strong enough to pull biodiversity back from the brink.

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