PREDICTION MARKETS FOR NATURE-RELATED RISK

A Mechanism for Outcome-Based Validation and Forward-Looking Governance

CONTENTS

ABSTRACT

From Method to Outcome - A Market-Based Infrastructure for Nature-Related Risk Validation

Nature-related risks, including biodiversity loss, ecosystem degradation and disruption of ecosystem services, pose significant and accelerating threats to financial systems.[1] While frameworks like the Taskforce on Nature-related Financial Disclosures (TNFD) and the Science Based Targets Network (SBTN) provide clear guidance on what to measure, persistent uncertainty surrounds how to measure these elements credibly and comparably. This paper introduces prediction markets as a novel, outcome-oriented mechanism to validate nature-related forecasts under real-world conditions.

Prediction markets are platforms where participants trade contracts tied to the likelihood of specific future events, with market prices reflecting the collective probability estimate of an outcome. We show how these markets can aggregate distributed data, AI-driven models, Indigenous and local observations, in-situ and remote sensing imagery, to generate dynamic, probabilistic forecasts of nature-related outcomes, defined as measurable changes in the state of natural assets such as ecosystems, species populations, or water quality.

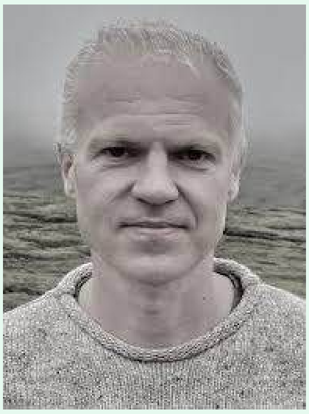
Because contracts are tied to independently verifiable results, prediction markets introduce falsifiability - the ability to test and disprove inaccurate forecasts. This allows for empirical validation of assumptions and shifts nature-related assessment from static disclosure to performance-based accountability.

These markets can in principle reward predictive accuracy rather than methodological orthodoxy, enabling adaptive refinement of indicators, target-setting pathways and credit issuance protocols. Drawing on analogues from climate-linked insurance and biodiversity finance, we demonstrate how prediction markets can complement standardised disclosure regimes by testing assumptions, pricing delivery risk and enhancing decision-usefulness.

Through real-world use cases, system design schematics and projections of market scale, we propose a dual-track infrastructure for nature-related risk assessment, combining protocol-based metrics with incentive-aligned outcome validation. This framework supports a more inclusive, transparent and empirically grounded approach to nature-related risk governance. Where protocols offer structure, prediction markets introduce consequence, enabling claims about nature to be tested, priced and refined under real-world conditions.

[1] Dasgupta Review, 2021

FOREWORD



Mark Roulston

Senior Research Fellow at Lancaster University Management School

Mark Roulston is the Director of Operations of the CRUCIAL initiative that uses prediction markets to forecast climate-related risks.

In addition to climate change, other nature-related risks — such as the degradation of ecosystems and the loss of biodiversity — are now acknowledged to have potential impacts for society and, by extension, the financial system. It is now recognised that there is a need to evaluate these risks and the effectiveness of measures to mitigate them. Because the appreciation of the threat posed by nature-related risks is relatively recent, we are not constrained by legacy methods when it comes to evaluating them. Instead, we have an opportunity to adopt more innovative approaches to assessing this category of risks. Prediction markets are one such approach.

Prediction markets use incentive-compatible mechanisms, similar to those found in betting markets, to aggregate distributed knowledge and expectations of many participants. However, unlike conventional gambling, participants in a prediction market do not necessarily have to pay to take part. Prediction markets can be sponsored by organisations that either want a forecast based on collective knowledge or who want to fund such a forecast as a public good. In this sense, prediction markets can be more like inducement prizes — like the X-Prizes — for the prediction of nature-related risks. The market mechanism means that these prizes do not have to be "winner-takes-all" but can be allocated in proportion to the contributions participants make to the accuracy of the collective forecasts. With prediction markets, users of forecasts are not forced to pick a single forecast provider, which they must sometimes do in the absence of meaningful track records, and instead can benefit from the collective expertise of all the participants. The market mechanism holds the participants accountable and compensates them for accuracy.

The CRUCIAL initiative, based at Lancaster University and funded by the SCOR Foundation for Science, is validating prediction markets for climate-related risks.[2] Prediction markets, with expert participants, for metrics linked to physical climate — such as hurricane activity and seasonal temperatures and rainfall — can produce calibrated probabilistic forecasts.[3] This whitepaper describes how a similar approach could be applied to produce collective forecasts of nature-related risks. This approach offers a scalable way of harnessing distributed knowledge and incentivizing accuracy in nature-related forecasting. The approach rewards forecasters for results rather than methods, and in particular rewards the provision of information which is both accurate and novel, encouraging innovation. Only with accurate forecasts is it possible to know which policies to mitigate nature-based risks are likely to be effective.

[2] www.crucialab.net
[3] Roulston, M., & Kaivanto, K. (2024). Can expert prediction markets forecast climate-related risks? Bulletin of the American Meteorological Society, 105(10), E1898-E1914.

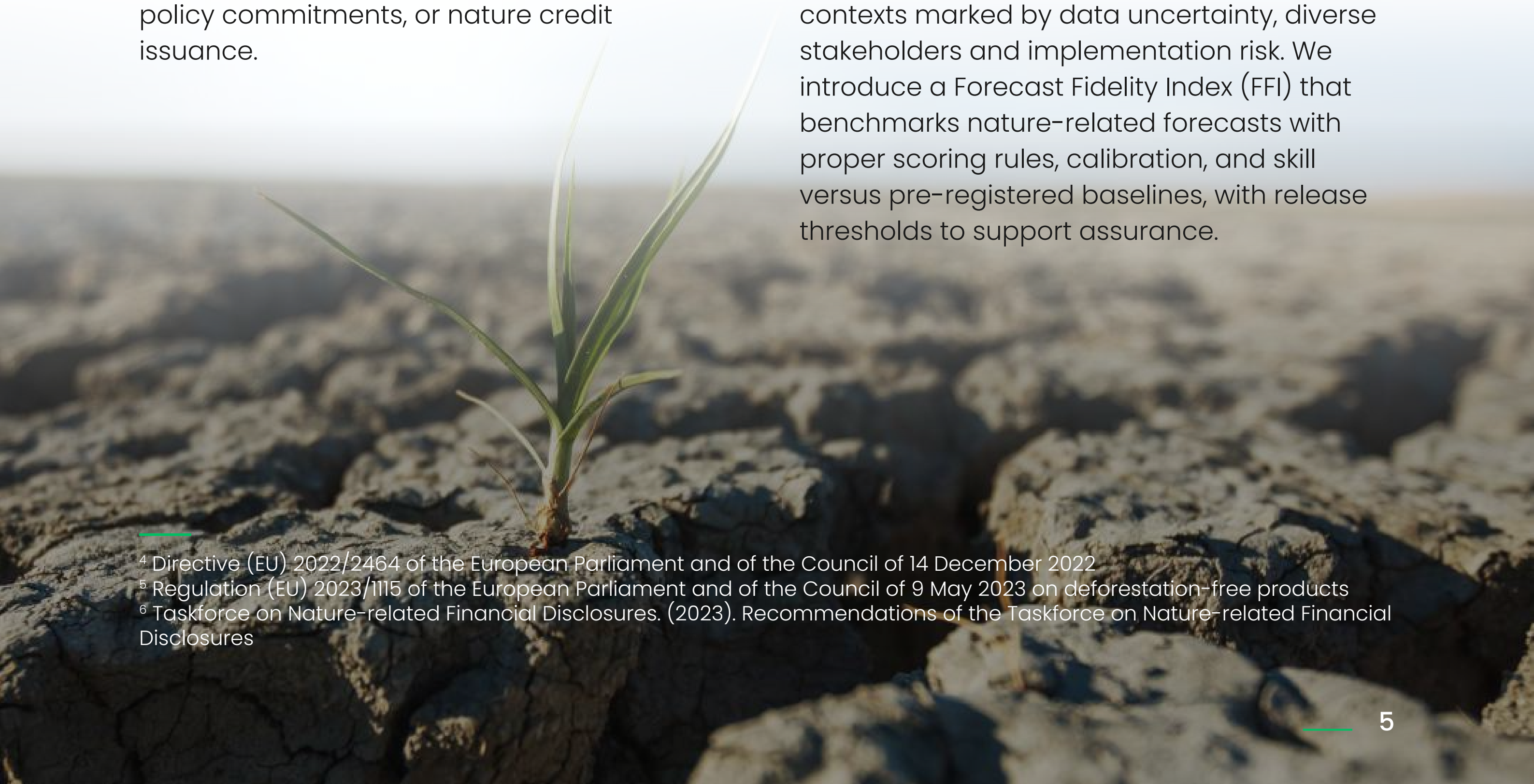
INTRODUCTION

The assessment of nature-related dependencies, impacts, risks and opportunities has gained momentum through emerging regulations like the EU's Corporate Sustainability Reporting Directive[4] (CSRD), European Union Deforestation Regulation[5] (EUDR) and the development of voluntary initiatives like the Taskforce on Nature-related Financial Disclosures[6] (TNFD) and Science Based Targets Network (SBTN). These developments, regulatory and voluntary, mark a shift toward recognising the financial relevance of ecosystem degradation and the need for more decision-useful information to guide investment, policy, disclosure and performance at all levels.

This paper proposes a complementary infrastructure using prediction markets to generate transparent, falsifiable and incentive-aligned forecasts across a range of nature-related outcomes. While current frameworks focus on what to measure and how to measure it, prediction markets shift attention to whether those outcomes are likely to materialise. They offer a practical tool for forecasting progress, validating mitigation plans, comparing interventions and informing decisions, whether for financial portfolios, policy commitments, or nature credit issuance.

By linking forecasts to clearly defined nature-related indicators, prediction markets can serve a wide range of users: financial institutions seeking insight into risk-adjusted returns; governments evaluating progress on biodiversity targets or National Biodiversity Strategies and Action Plans (NBSAPs); corporates under scrutiny for environmental performance; and local knowledge holders and technical experts who can be rewarded for their data contributions and methodological precision.

Rather than supplanting existing initiatives, this architecture enables regulators, investors, conservationists and communities to track collective expectations and dynamically price ecological delivery risk. Contracts tied to nature-related indicators, like species abundance, forest cover, or water quality, could enable institutions, regulators, conservationists and communities to observe collective expectations around progress in real-time. For investors, lenders, insurers and regulators, this shift to outcome-based validation is not just technical, it is material. What matters is not only what is disclosed, but whether ecological outcomes actually occur. The approach is particularly suited to contexts marked by data uncertainty, diverse stakeholders and implementation risk. We introduce a Forecast Fidelity Index (FFI) that benchmarks nature-related forecasts with proper scoring rules, calibration, and skill versus pre-registered baselines, with release thresholds to support assurance.



[4] Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022
[5] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 9 May 2023 on deforestation-free products
[6] Taskforce on Nature-related Financial Disclosures. (2023). Recommendations of the Taskforce on Nature-related Financial Disclosures

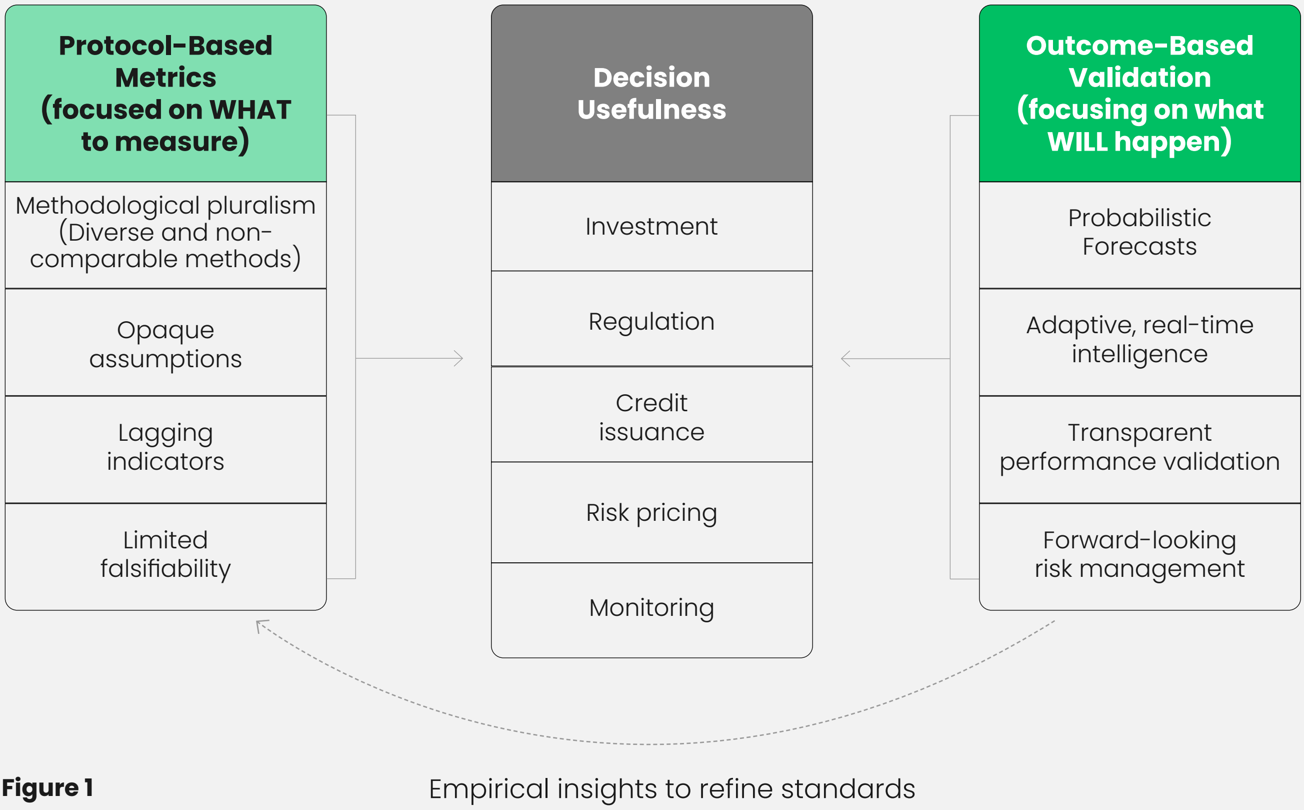


Figure 1

Figure 1: *This diagram illustrates how protocol-based metrics (focused on what to measure) and prediction markets (focused on what will happen) can jointly support decision-useful insights across investment, regulation, credit issuance, risk pricing and monitoring. Outcome-based validation feeds empirical insights back into standard-setting processes, enabling adaptive refinement.*

The sections that follow introduce the limitations of current frameworks, explain the mechanics of prediction markets and explore how this infrastructure could be applied in the nature context. It concludes by considering governance, design principles and the potential for pilot implementation.

What are Prediction Markets?

Prediction markets are platforms for trading contracts that yield payoffs contingent on the occurrence of specific future events. Each contract reflects a binary or probabilistic outcome and its trading price reveals the market's aggregated belief about the likelihood of that outcome.[7] For example, a contract that pays $1 if species richness increases by 20% by 2030 might trade at $0.65, signalling a 65% probability estimate according to market participants.

[7] Wolfers, J. & Zitzewitz, E. (2004). Prediction Markets. NBER Working Paper No. 10504.
[8] Abramowicz, M. (2004). Information Markets, Administrative Decision making and Predictive Cost-Benefit Analysis. University of Chicago Law Review, 71(3), 933–1020.
[9] Hsu, S. (2011). A Prediction Market for Climate Outcomes. University of Colorado Law Review, 83, 179

The mechanism offers a rigorous alternative to consensus-based or model-driven forecasts. It enables participants, including domain experts, data analysts and informed stakeholders, to act on their information by trading contracts linked to verifiable outcomes.[8] As new evidence emerges, market prices update to reflect revised expectations, producing dynamic, real-time forecasts. These forecasts are directly falsifiable and continuously refined.[9] Unlike conventional disclosures, which typically describe past actions or future intentions, based on internal assumptions, prediction markets produce probabilistic, externally verifiable forecasts about specific future outcomes. They reward accuracy over authority and allow for post hoc validation of expectations against observable results. For example, In forecasting reproducibility across 103 findings, prediction markets were correct 73% of the time vs 66% for expert surveys; both correlated with outcomes ($r=0.58$ markets; $r=0.56$ surveys). The accuracy gap was not statistically significant, but markets had lower mean absolute error (0.384 vs 0.423, $p<0.001$).[10]

A well-documented real-world application is the Iowa Electronic Markets (IEM), which has operated since 1988 to forecast U.S. election outcomes.[11] Contracts linked to vote shares and victory margins are traded by participants using real money. Across multiple election cycles, IEM forecasts have often outperformed major polling averages and statistical models in predicting both winners and vote distributions, offering strong evidence of their reliability in aggregating dispersed information.

[10] Gordon et al. (2021), PLOS ONE, doi:10.1371/journal.pone.0248780.
[11] University of Iowa Tippie College of Business. Iowa Electronic Markets. http://tippie.uiowa.edu/iem

To illustrate the relevance for nature-related risk, consider a hypothetical contract that pays $1 if pollinator abundance in a designated agricultural zone returns to a defined baseline by 2028. Such a contract could be priced and traded based on field survey data, satellite indicators and local interventions. If it trades at $0.42, the implied market belief is that there is a 42% chance of ecological restoration success. This market-generated signal could reveal gaps in monitoring, policy implementation, or stakeholder coordination, serving both as an early warning and a validation mechanism.

Prediction markets are particularly well-suited to nature and climate domains, where uncertainty is structural, baseline data are inconsistent and current frameworks often conflate disclosure with insight.[12] Properly designed, they can provide independent, adaptive and incentive-aligned assessments of nature-related targets, supporting decision-making, accountability and resource allocation.

Illustrative Nature Prediction Market

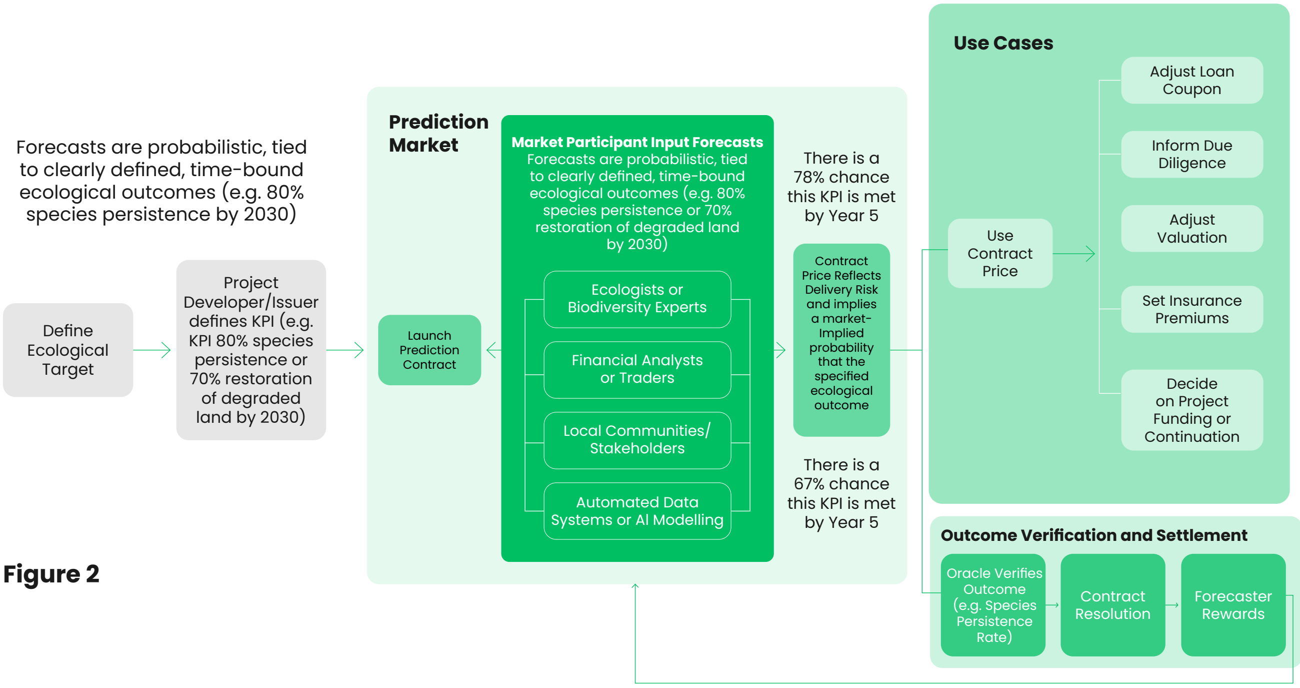


Figure 2

The Measurement Challenge in Nature-Related Assessment and Disclosure

Nature-related frameworks like TNFD and SBTN guide both internal assessment and disclosure. TNFD's LEAP framework[13] and SBTN's stepwise target-setting method[14] emphasise comprehensive dependency and impact analysis. However, the operationalisation of these frameworks reveals a deeper methodological challenge. Metrics like land use change, water risk, or ecosystem service dependence are often assessed using divergent data sources and assumptions, resulting in fragmented, inconsistent outputs.[15]

[12] Hsu, S. (2014). Climate Change Regulation and Prediction Markets. Regulation, 37(2), 26–33
[13] Taskforce on Nature-related Financial Disclosures (TNFD). (2023). The TNFD Recommendations and Guidance: Version 1.0. Appendix 3 Taskforce on Nature-related Financial Disclosures
[14] Science Based Targets Network. (2023). Technical Guidance for Setting Science-Based Targets for Nature: Initial Guidance for Business
[15] TNFD (2023). Beta Framework v0.4: Summary of Pilot Testing Results. Taskforce on Nature-related Financial Disclosures

This methodological heterogeneity undermines comparability, hampers target setting and complicates investment analysis. For example, during TNFD's pilot testing, participating companies noted significant difficulties in aligning geospatial data on ecosystem impacts with corporate disclosures, particularly in supply chains spanning multiple jurisdictions. Similarly, SBTN's initial implementation phase revealed that while many companies were willing to adopt targets, the lack of harmonised spatial and reference conditions limited their ability to translate ambition into measurable outcomes. These examples illustrate the operational challenges that arise from methodological diversity and underscore the need for mechanisms that can help adjudicate and validate competing approaches in real-world contexts. For example, while TNFD recommends disclosing exposure to ecosystem dependencies like pollination and water quality, there remains no standardised method for quantifying these services at the site level. Companies adopt a range of proxies, like land-use classifications, supplier questionnaires, or external biodiversity indices, resulting in inconsistent outputs and limited comparability.[16] SBTN's guidance on impact assessments similarly allows for flexibility in spatial resolution and ecosystem classification, which complicates target benchmarking across peers or portfolios. Without a common evidentiary baseline, disclosures become less decision-useful and less auditable.

In this context, prediction markets offer a novel solution. Rather than attempting to harmonise all inputs, prediction markets shift attention to outcomes. They enable diverse perspectives - scientific, community-based, or data-driven - to be reflected in probabilistic forecasts of future states.[17] This enables institutional users to navigate uncertainty, not by picking one metric or model, but by assessing the collective signal that emerges from informed participants.

[16] Taskforce on Nature-related Financial Disclosures (TNFD). (2023). Recommendations of the Taskforce on Nature-related Financial Disclosures. September 2023
[17] Arrow, K. J., Forsythe, R., Gorham, M., Hahn, R., Hanson, R., Ledyard, J. O., Levmore, S., ... & Zitzewitz, E. (2008). The promise of prediction markets. Science, 320(5878), 877–878

Markets as Adaptive Inference Systems

Prediction markets operate as decentralised mechanisms for updating beliefs in response to new information. Their structure reflects the logic of Bayesian inference, though not in a formalised or centralised sense.[18] As new evidence becomes available (whether from satellite imagery, ecological field data, policy developments, or community observations) participants revise their expectations and prices shift accordingly. This creates a real-time, evolving estimate of the likelihood of specified outcomes.

Such adaptive updating is particularly relevant in nature-related contexts, where ecological systems are dynamic, non-linear and often characterised by feedback loops and tipping points.[19] Prediction markets do not reduce the inherent complexity of these systems, but they help translate uncertainty into probabilistic signals that reflect the best available synthesis of knowledge at a given moment.

This synthesis arises from the interaction of diverse evidence streams. Markets can implicitly integrate quantitative datasets, qualitative insights from local monitoring and structured scientific or regulatory forecasts, each weighted through the behaviour of participants acting on their own information and confidence. The result is not a deterministic forecast, but a probabilistic consensus that updates as conditions evolve.

For example, if updated satellite data shows declining canopy cover in a restoration area and this is echoed in local field observations or shifts in enforcement policy, traders may adjust their positions. These changes, aggregated through market mechanisms, produce a transparent and continually updating signal of ecological expectation.

The strength of this approach lies in its ability to absorb evidence continuously, without waiting for scheduled reports or consensus-driven updates. In doing so, prediction markets offer a decentralised inference engine. One that adapts as the system does, providing institutional actors with a live readout of nature-related risk and opportunity.

[18] Hanson, R. (2003). Combinatorial information market design. Information Systems Frontiers, 5(1), 107–119
[19] Dietz, S., & Stern, N. (2008). Why economic analysis supports strong action on climate change: a response to the Stern Review's critics. Review of Environmental Economics and Policy, 2(1), 94–113

Rewarding Accuracy - Market Incentives for Methodological Performance

A central premise of this paper is that predictive accuracy, rather than methodological conformity, should drive credibility in nature-related assessment. In a prediction market, participants are rewarded or penalised based on the realised outcome of a forecast, not on whether they followed a prescribed model or framework.[20] This introduces a mechanism for remunerating data providers, forecasters and methodology developers based on real-world performance. Approaches that consistently yield accurate forecasts are more likely to attract capital, trust and influence, while less reliable methods are naturally de-emphasised over time.

While disclosures report past actions and forward-looking intentions, prediction markets infer. Their purpose is not to declare commitments but to assess, in probabilistic terms, whether nature-related outcomes are likely to materialise. This makes them a complement to, not a substitute for, disclosure systems and a mechanism for testing, challenging and refining expectations under uncertainty.

In investment and lending contexts, this mechanism can directly inform allocation decisions. Methodologies with a demonstrated track record of forecasting nature-related outcomes (like habitat recovery, species persistence, or policy implementation) are more likely to underpin robust environmental claims and therefore support the credibility of instruments like biodiversity credits or nature-based solutions. Likewise, in regulatory or certification settings, data streams or analytical tools that are validated through prediction market outcomes may be more favourably considered by standard-setters or policy actors when evaluating disclosure quality or project eligibility.

This stands in contrast to many current sustainability disclosure and nature assessment frameworks, where methodological credibility is often based on expert consensus, theoretical robustness, or institutional endorsement, rather than on predictive performance. For example, frameworks like TNFD or SBTN provide much-needed guidance on what to measure and how to structure disclosures or targets, but they are not designed to systematically test which approaches perform best in practice. Similarly, crediting platforms like Verra[21] or Plan Vivo[22] rely primarily on ex-ante validation, protocol adherence and periodic auditing, rather than on continuous, market-based validation of actual outcomes.

By linking credibility and compensation to forecast performance, prediction markets introduce an evidence-driven selection mechanism. This could support the emergence of reputational markets for models, data providers and verification approaches, where credibility accrues through demonstrated accuracy rather than through hierarchical certification or peer consensus.[23]

For instance, if a biodiversity credit verification method consistently aligns with realised nature-related outcomes in prediction markets, it may emerge as a preferred standard in voluntary markets or outcome-based financing. Conversely, methods with poor predictive performance may gradually fall out of favour, without requiring formal delisting or top-down enforcement. In this way, prediction markets function as a decentralised quality filter, rewarding what works in practice and continuously refining the landscape of decision-useful methods. By creating financial and reputational consequences for inaccurate forecasts, prediction markets reward reliability in a way that current frameworks, designed for structure rather than selection, often cannot.

[20] Hanson, R. (2003). Combinatorial information market design. Information Systems Frontiers, 5(1), 107–119
[21] Verra. 2024.SD VISta Nature Framework v1.0. Verra
[22] Plan Vivo (2022). Standard for Community and Ecosystem Projects v5.0.
[23] See Arrow et al. (2008), The Promise of Prediction Markets, previously cited

Use Cases in Target Setting, Monitoring and Risk Pricing

The following use cases were selected to illustrate the versatility of prediction markets across different types of nature-related financial decision-making. The first focuses on corporate target setting and project-level nature-related outcomes, while the second addresses systemic financial risk pricing linked to ecosystem decline and regulatory exposure. Together, they demonstrate how prediction markets can support both micro-level performance monitoring and macro-level scenario planning.

CASE STUDY 1

AGROFORESTRY RESTORATION IN THE CERRADO[24]

A food company with soy-linked supply chain exposure sets a target to restore 15,000 hectares of degraded pastureland in Brazil's Cerrado biome through agroforestry. In the absence of prediction markets, the company would typically rely on internal methodologies or third-party consultants to define reference conditions, model carbon sequestration potential and monitor biodiversity uplift. However, these methods often differ in their assumptions, spatial resolution and data transparency. For instance, projections of soil carbon accumulation may rely on generalised biome-wide factors, while species recovery rates are extrapolated from limited pilot sites, making it difficult to assess whether targets are realistic or being met across heterogeneous landscapes.

Prediction markets offer an adaptive alternative. Contracts could be launched to forecast the likelihood of achieving specific nature-related outcomes, like net gains in soil organic carbon, increases in native species richness, or compliance with biome-specific restoration thresholds under Brazil's Forest Code. These markets would integrate remote sensing data, on-the-ground ecological monitoring and expert forecasts, producing dynamic probability estimates of outcome achievement. These evolving forecasts allow the company to iteratively refine its expectations and timelines and to identify which restoration practices are most likely to succeed under local conditions.

Importantly, contributors whose forecasts prove accurate (whether scientists, cooperatives, or AI-informed models) are rewarded, creating a standing incentive for knowledge sharing and methodological innovation. Over time, the prediction market surfaces which approaches, data types, or indicators are empirically predictive, creating a decentralised performance feedback loop that complements traditional monitoring systems and enhances decision-usefulness for corporate sustainability teams.

Table 1: Comparison of Traditional and Prediction Market Approaches – Cerrado Agroforestry

Challenge / Activity	Traditional Approach	With Prediction Market
Target Definition	Based on internal assumptions or consultant models	Market contracts tied to specific, measurable nature outcomes (e.g. soil carbon gain, species richness recovery)
Data Sources	Limited field trials, consultant models, biome-wide averages	Integrated: remote sensing, field data, local monitoring, and AI-driven models
Assumption Transparency	Often opaque or model-dependent	Forecast prices reflect collective, real-time beliefs and are continuously updated
Spatial Specificity	Biome-wide or extrapolated data may miss local variation	Localised forecasts grounded in site-specific inputs
Uncertainty Handling	Treated qualitatively or ignored	Expressed probabilistically; forecasts reflect changing risk and confidence
Incentives for Methodological Improvement	Limited feedback or reward for improved methodologies	Accurate contributors (e.g. scientists, cooperatives) are rewarded based on performance
Learning and Adaptation	Static reporting, limited iterative learning	Adaptive feedback loop enables dynamic refinement of expectations, practices, and targets
Decision-Usefulness for Corporate Teams	Reports may lack comparability, timeliness, or actionability	Live probability signals help prioritise interventions, adjust timelines, and validate restoration performance

[24] This example is illustrative, but reflects common challenges and methodologies observed in Cerrado-linked restoration projects. See CDP Forests (2023); Soft Commodities Forum (2022); SBTN Initial Guidance (2023)

CASE STUDY 2

LENDING EXPOSURE TO COASTAL ECOSYSTEM RISK

A European bank with lending exposure to shrimp aquaculture operations in Southeast Asia seeks to assess and price the risk of mangrove degradation and regulatory tightening. In the absence of prediction markets, the bank typically relies on ESG risk ratings, regional biodiversity indices, or consultant-produced heat maps to inform due diligence. However, these tools often operate at the national or basin level, lack spatial precision and are updated infrequently. For instance, a biodiversity risk rating may flag country-level pressures but fail to capture mangrove loss in the immediate vicinity of a production facility or informal land conversion adjacent to a protected area.

Moreover, conventional risk models embedded in loan assessment may assume static reference conditions, slow policy change, or simplified hazard exposure pathways, rendering them poorly suited to detect dynamic risks like emergent legislation on land use zoning, enforcement variability, or climate-linked habitat tipping points.

Prediction markets provide a forward-looking complement. Contracts could be launched to forecast discrete outcomes like "Will mangrove cover within 5 km of Facility X decline by more than 10% by 2028?" or "Will Province Y introduce a moratorium on new aquaculture licenses by 2026?" These contracts would integrate satellite imagery, land use alerts, regulatory consultations and local civil society inputs. As forecasts evolve, the bank receives continuously updated, probabilistic estimates of ecosystem and policy risks relevant to specific lending decisions.

These forecasts can inform dynamic loan pricing, provisioning strategies and portfolio risk assessments, particularly in sectors exposed to nature-based regulatory tightening or reputational risk. Forecasters may include local NGOs, coastal ecologists, geospatial analysts and legal observers, each incentivised to contribute accurate, timely insights. In this way, prediction markets transform risk analysis from a static screening tool into a live, adaptive capability, supporting more granular, transparent and responsive decision-making in nature-exposed credit portfolios.

Table 2: Comparison of Traditional and Prediction Market Approaches – Lending Exposure to Coastal Ecosystem Risk

Lending control area	Traditional approach	Prediction-market–enabled approach
Site eligibility & tenure/titling	Borrower attests to land/sea tenure; legal opinion; static KYC/ESG screens	Eligibility contingent on p(outcome) for "no unresolved tenure/titling disputes in AOI" ≥ threshold (e.g. 80%) at signing and at each draw; market resolves on cadastral updates and adjudication events; automatic margin step-up if p(dispute) rises.
Zoning & permitting compliance	Check current zoning, EIAs, permits; annual certifications	Covenant ties pricing to p(non-compliance with coastal zoning/MPA rules) derived from markets informed by gazette updates and enforcement bulletins; automatic draw stop if p(non-compliance) exceeds trigger (e.g. 30% for >30 days).
Policy & moratoria risk	"Qualitative watchlists for new moratoria (e.g. mangrove clearing, reef extraction)"	"Embedded market on p(policy moratorium affecting project class within 12 months); coupon ratchets +50 - 150 bps when probability crosses tiers; optional MAC clause if market settles to 'moratorium enacted'."
Enforcement variability	Country/region risk ratings; reviewer judgement	Market on p(enforcement shortfall in AOI) (e.g., patrol coverage, prosecution rate) drives collateral haircuts; haircuts widen as p(shortfall) rises; reset quarterly.
Near-shore water quality (sediment/turbidity)	Occasional lab tests or contractor self-reporting	Outcome contract on NTU turbidity or TSS mg/L medians vs baseline in defined polygons and seasons; if market-implied p(exceeding threshold) >40%, pricing step-up; if settlement confirms exceedance, cash sweep to remediation reserve.
Habitat condition (mangroves/seagrass/coral)	One-off ESIAs; infrequent remote-sensing reviews	Markets on p(net habitat loss > X ha) and p(coral bleaching index > Y) by period; loan-to-value and DSCR covenants tighten as probabilities rise; reversal (step-down) if probabilities fall and settle to 'no loss/bleaching'.
Runoff & buffer compliance	Paper buffers (e.g. 50 - 100 m) in management plans	Market on p(buffer breach within AOI) using geofenced alerts; breach probability >25% triggers independent audit and temporary draw suspension.
Community grievance & FPIC	Grievance logs reviewed annually; lender calls with sponsor	Market on p(material unresolved grievance > 90 days); if >20%, coupon adds +25 bps and triggers mandatory mediation; settlement to "grievance resolved" unlocks reversal.
Biodiversity credit/offset integrity	Accept registry-issued credits; desk review	Market on p(project achieves credited outcomes by T+N); issuance/acceptance gated by p(outcome) ≥ threshold; discount rate applied to credits when p(shortfall) high; settlement determines clawback or make- good.
Transition & physical risk stress testing	Scenario narratives; spreadsheet overlays	Scenario grid where coupon/margin is a function of p(event) surfaces (storm surge, bleaching, moratoria); automated monthly repricing via market odds; stress ECL computed from probability-weighted outcomes.
Monitoring & reporting frequency	Quarterly/annual ESG reports; static KPIs	Rolling dashboards streaming market probabilities; early-warning signals (Δp over 30/90 days) trigger site inspections; thresholds and look-back windows codified in loan agreement.
Incentives for nature-positive actions	Sustainability-linked loan (SLL) KPIs (e.g., generic) with step-ups/downs	SLL KPIs redefined as outcome-probability targets (e.g., reduce p(net habitat loss) by ≥15% YoY); verified by market settlement; balanced step-up/down (25–100 bps) tied to probability tiers rather than self-reported inputs.
Collateral & valuation	Static collateral haircuts; environmental adjustments ad hoc	Dynamic haircuts linked to p(impairment from environmental breach); if probability >35% for 60 days, haircut widens (e.g., +10 - 20%) until settlement resolves to 'no breach'.
Default & cure mechanics	ESG breaches treated as covenant violations with broad cure periods	Specific probability-triggered cure: if any of {p(non-compliance), p(habitat loss), p(moratorium)} > threshold for X days, borrower must post additional reserve or deliver remedial actions; cure verified by downward shift and/or favourable settlement.

In both cases, prediction markets enable participation from a wide range of contributors - scientists, local NGOs, data providers, community groups and institutional analysts - each incentivised to submit forecasts or evidence that improve predictive accuracy. Contracts are resolved by outcome oracles, which rely on agreed-upon nature-related indicators (e.g. satellite-verified canopy change or official policy enactment dates) to determine contract outcomes. To ensure fairness and liquidity, markets employ proper scoring rules (like the Brier score) and automated market makers that continuously update contract prices in response to participant inputs. This structure promotes transparency, continuous learning and decentralised accountability in nature-related decision-making. Taken together, these examples motivate a standard for benchmarking predictive performance.

FORECAST FIDELITY INDEX – BENCHMARKING PREDICTIVE ACCURACY

We propose a Forecast Fidelity Index (FFI) as a transparent benchmark of predictive performance across indicators, methods, and contributors. Prediction markets surface valuable information about ecological outcomes, but usefulness depends on the quality of indicators, models, and data. Some metrics (e.g., habitat-condition indices, species return rates) yield timely, decision-relevant signals; others may lag or mis-specify local dynamics. The FFI provides a rigorous way to compare what works in practice.

The FFI applies proper scoring rules at the contract level and reports Skill relative to a declared baseline for cross-market comparability. Binary and categorical contracts use the Brier score; continuous targets (e.g. NDVI, canopy cover %) use the Continuous Ranked Probability Score (CRPS); the logarithmic score (log loss) is optionally reported where tail probabilities materially affect risk. Skill is defined in Equation 1 and computed on the same sample for the model and the baseline. Baselines are set ex ante by indicator and region (e.g. climatology for event rates; persistence/no-change for state variables; or a current approved method). Unless noted, results are computed against the default baselines in Table 3 (Appendix 2). Results are published by forecast horizon (0 - 6 m, 6 - 24 m, >24 m) and may be summarised as a Cumulative Fidelity Score (CFS), a horizon-weighted average with documented weights; unweighted means are also published for transparency.

Equation 1

$$\text{Skill} = 1 - \frac{\text{S model}}{\text{S baseline}}$$

where S (·) is the chosen proper scoring rule (Brier by default), S(M) is the model score, and S(B) is the baseline score, computed on the same set of resolved contracts.

Example: if S(M)=0.18 and S(B) = 0.24, then Skill =1-(0.18/0.24) = 0.25 (25% improvement).

Beyond accuracy, the FFI reports calibration (reliability diagrams and Brier decomposition) and 95% confidence intervals estimated via a block bootstrap over resolved markets. Official scores are published only once minimum thresholds for market liquidity, participant count, and number of resolved markets are met. Conflicts of interest are flagged and governed (see Considerations and Challenges). Detailed bootstrap settings - block length, number of resamples, and horizon stratification - are provided in Appendix 2. In practice, these reporting principles are delivered through a prototype dashboard (Figure 3), which enables filtering by region, indicator, horizon and contributor and provides visual comparisons of performance and calibration across time horizons, contributors and indicators.

Figure 3: The mock-up shows filters for region, indicator and contributor, and summarises predictive accuracy across contributors and time horizons, with visual indicators of calibration and market coverage.

Prototype dashboard of Forecast Fidelity Index results

The mock-up shows filters for region, indicator and contributor, and summarises predictive accuracy across contributors and time horizons, with visual indicators of calibration and market coverage.

Rather than prescribing methodological consensus, the FFI rewards empirical accuracy under real-world conditions. It gives decision-makers in finance, regulation and conservation a standard to assess credibility and to manage delivery risk. It highlights which indicators and methods consistently predict observed outcomes verified by oracles, helping to refine biodiversity credits and KPIs. The FFI attributes performance to methods, institutions and contributor cohorts (for example, Indigenous peoples and local communities, academic teams, or commercial providers). This allows fair comparison of Indigenous knowledge, machine-learning models, and field protocols on difficulty-adjusted, horizon-specific terms. It also reports scores on TNFD-relevant indicators and horizons, complementing LEAP-style assessment with an outcome-validation layer.

A practical next step is to pilot the FFI in a live prediction market linked to a biodiversity intervention (for example, mangrove restoration or species reintroduction), with pre-declared baselines, oracle definitions and horizon buckets. This would enable structured comparison of TNFD-relevant indicators, revealing their relative forecastability and decision-usefulness.

Prediction Markets and Biodiversity Credit Integrity

The emergence of biodiversity credit markets presents both a financial opportunity and a credibility challenge. Existing platforms like Plan Vivo and Verra (see earlier references 21, 22) as well as national schemes like Australia's Nature Repair Market[25] aim to quantify and monetise measurable ecological uplift. However, critics highlight concerns around weak baselines, unverifiable persistence and variable additionality.[26,27]

Prediction markets offer a complementary mechanism to enhance transparency and accountability. Forecast contracts tied to long-term biodiversity outcomes - for example, "Will 80% of this habitat sustain target species five years postintervention?" - can serve as a real-time barometer of credit integrity. This model reduces reliance on static audits or ex-post certifications and instead creates an adaptive pricing signal for credit quality. Registries can gate issuance on a marketimplied probability that the credited outcome will be verified by T+N (the verification horizon) exceeding a threshold θ (the issuance threshold; e.g. 0.75). Insurance premia and buyer discounts are then adjusted in tiers to that probability surface, with stepup/step-down clauses triggered by sustained shifts over a defined look-back window.

Prediction contracts could be tied to nature-related KPIs relevant to credit issuance, like canopy recovery, species richness, or ecosystem functionality. As field data and satellite inputs inform market pricing over time, stakeholders, including credit buyers, insurers and outcome funders, can monitor delivery risk in real-time. This enables dynamic premium adjustment, reputational filtering and risk transfer tools like performance-linked insurance or credit enhancement mechanisms.[28]

By integrating prediction markets into biodiversity credit infrastructure, the market can shift from retrospective trust models to forward-looking outcome verification. Despite growing interest, biodiversity credits currently lack fungibility and an active secondary market, issues raised prominently during COP16 in Cali.[29] The highly site-specific and non-replicable nature of nature-related outcomes makes these instruments inherently difficult to standardise.[30] As a result, credit valuation is opaque, liquidity is limited and buyers face significant due diligence burdens.

Prediction markets do not eliminate non-fungibility, but they can price project-level delivery risk more transparently and consistently. By assigning forward-looking probability scores to nature-related KPIs, like habitat persistence or species return, prediction markets help establish a market consensus on quality and reliability. This enables more informed comparisons across diverse projects, improves capital allocation and lays the foundation for more robust secondary trading mechanisms. This will be critical to building buyer confidence, scaling supply and ensuring that financial instruments reflect real ecological progress.

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[25] Australian Government. (2023). Nature Repair Act 2023 (Cth). (In force, administered by DCCEEW.)
[26] Maron, M., et al. (2022). Global no net loss of natural ecosystems: A policy perspective. Nature Ecology & Evolution
[27] Seddon, N., et al. (2021). Getting the message right on nature-based solutions to climate change. Global Change Biology
[28] CreditNature (2023). Operationalising nature performance in credit markets
[29] Earth Negotiations Bulletin (2024). COP16 Summary: Key Outcomes and Policy Challenges for Nature Finance
[30] Lankoski, J., & Ollikainen, M. (2013). Agri-environmental externalities: A framework for designing targeted policies. OECD

Complementing a Nature Measurement Protocol

There is growing interest across the scientific community, companies, financial institutions, standard-setters and governments in developing a more consistent approach to nature-related measurement, often described as a Nature Measurement Protocol. A unified framework to define what should be measured in assessing nature-related impacts, dependencies, risks and opportunities. While no such protocol currently exists and formal development is still at an exploratory stage, the rationale for greater consistency and comparability is widely acknowledged. Momentum is visible in ongoing technical consultations and alignment efforts led by initiatives like the TNFD, SBTN and the Accountability Framework Initiative, among others.

The objective of a Nature Measurement Protocol would be analogous to that of the Greenhouse Gas (GHG) Protocol in climate reporting. Namely to create a common reference point that enables more transparent, interoperable and decision-relevant disclosures. Such a protocol would likely provide guidance on the selection of nature-related indicators, data sources, units of measurement and spatial or temporal boundaries. It could also support alignment across asset classes and jurisdictions, helping institutions comply with emerging regulatory expectations while improving investor and stakeholder confidence.

However, standardisation alone does not resolve the deeper issue of how to determine which methods or models actually work in practice. Protocols can define acceptable inputs and minimum data requirements, but they do not adjudicate between competing approaches when multiple, equally compliant methods yield different predictions. Nor can they fully account for the ecological heterogeneity, feedback loops and localised knowledge systems that shape environmental outcomes on the ground.

This is where prediction markets offer a valuable, decentralised complement. By attaching financial stakes to probabilistic forecasts of nature performance (e.g. species return, habitat persistence, restoration success), these markets allow for real-world testing of methodological validity. Forecast accuracy becomes an observable outcome, rather than a theoretical assumption. Over time, the collective intelligence embedded in market prices reveals which approaches perform best under varying ecological, social and regulatory conditions.

Together, a Nature Measurement Protocol and prediction-based validation could form a dual architecture for robust, adaptive and scalable nature-related assessment. A protocol would provide a shared language for what should be measured whereas prediction markets would generate feedback on how well different methods perform in delivering measurable nature-related outcomes. This combination not only enhances trust and transparency, but also supports continuous learning, ensuring that nature-related disclosures and investments remain responsive to complex and dynamic systems.

Complementarity with TNFD - An Outcome-Validation Layer

Prediction markets and the FFI complement TNFD's principles-based how, aligning with the LEAP process (Locate, Evaluate, Assess, Prepare to respond and report) to provide an outcome-validation layer alongside input and process metrics. TNFD provides both the what and a principles-based how through LEAP, sector guidance, and a metrics architecture spanning dependencies, impact drivers (pressures) and impacts, and changes in the state of nature and ecosystem services. Our proposal is not a substitute, rather it adds a validation mechanism. By aggregating and scoring forecasts on TNFD-relevant indicators, prediction markets and the FFI help prioritise indicators, calibrate assumptions, and compare methods on real-world performance across horizons. This strengthens materiality judgements, supports assurance, and improves comparability without prescribing a single methodology. In short, TNFD guides assessment and disclosure; prediction markets evidence which implementations perform best under uncertainty.

Considerations and Challenges

While prediction markets offer a compelling tool for nature-related risk assessment, their implementation raises important regulatory, governance and ethical considerations. In many jurisdictions, particularly in the United States and the European Union, the use of real-money prediction markets is subject to stringent regulation.[31] Legal questions related to licensing, market classification and oversight must be addressed to ensure compliance with securities, derivatives and gambling laws. In some cases, regulatory sandboxes or nonprofit governance structures may be required to pilot nature-related applications without triggering enforcement risk.

There is also a potential risk of market manipulation or conflict of interest, especially in thinly traded or high-stakes contracts. For instance, project developers or credit issuers may have incentives to bet on the success of their own interventions, distorting incentives and undermining trust. Clear governance rules, like participant exclusions, role separation, transparent oracles and independent third-party auditing, will be essential to preserve integrity.

Ethical design principles must also guide implementation. Prediction markets related to ecosystems should actively include Indigenous Peoples and Local Communities (IPLCs) as knowledge contributors and potential beneficiaries, while ensuring that data sovereignty and free, prior and informed consent (FPIC) are respected. In addition, prediction market outcomes must be treated as informational inputs, not as substitutes for democratic deliberation, policy accountability, or scientific judgement. They offer a means of aggregating probabilistic insights, not issuing binding decisions.

By anticipating these challenges and embedding robust safeguards and accountability mechanisms into market design, prediction markets can evolve into legitimate and trusted components of the nature finance infrastructure, supporting more transparent, adaptive and evidence-based environmental decision-making.

[31] Real-money prediction markets fall under the oversight of securities or derivatives regulators in the U.S. and EU. In the US, the Commodity Futures Trading Commission (CFTC) regulates markets offering contracts for future events and has historically restricted commercial prediction markets outside academic or nonprofit exemptions (see: CFTC [2022], Order Prohibiting Kalshi's Political Event Contracts). In the EU, prediction markets trigger regulation under the Markets in Financial Instruments Directive (MiFID II) or be treated as gambling instruments, depending on structure and national implementation (see: Schilling, C. [2019], Prediction Markets and the EU Legal Framework, European Journal of Risk Regulation).

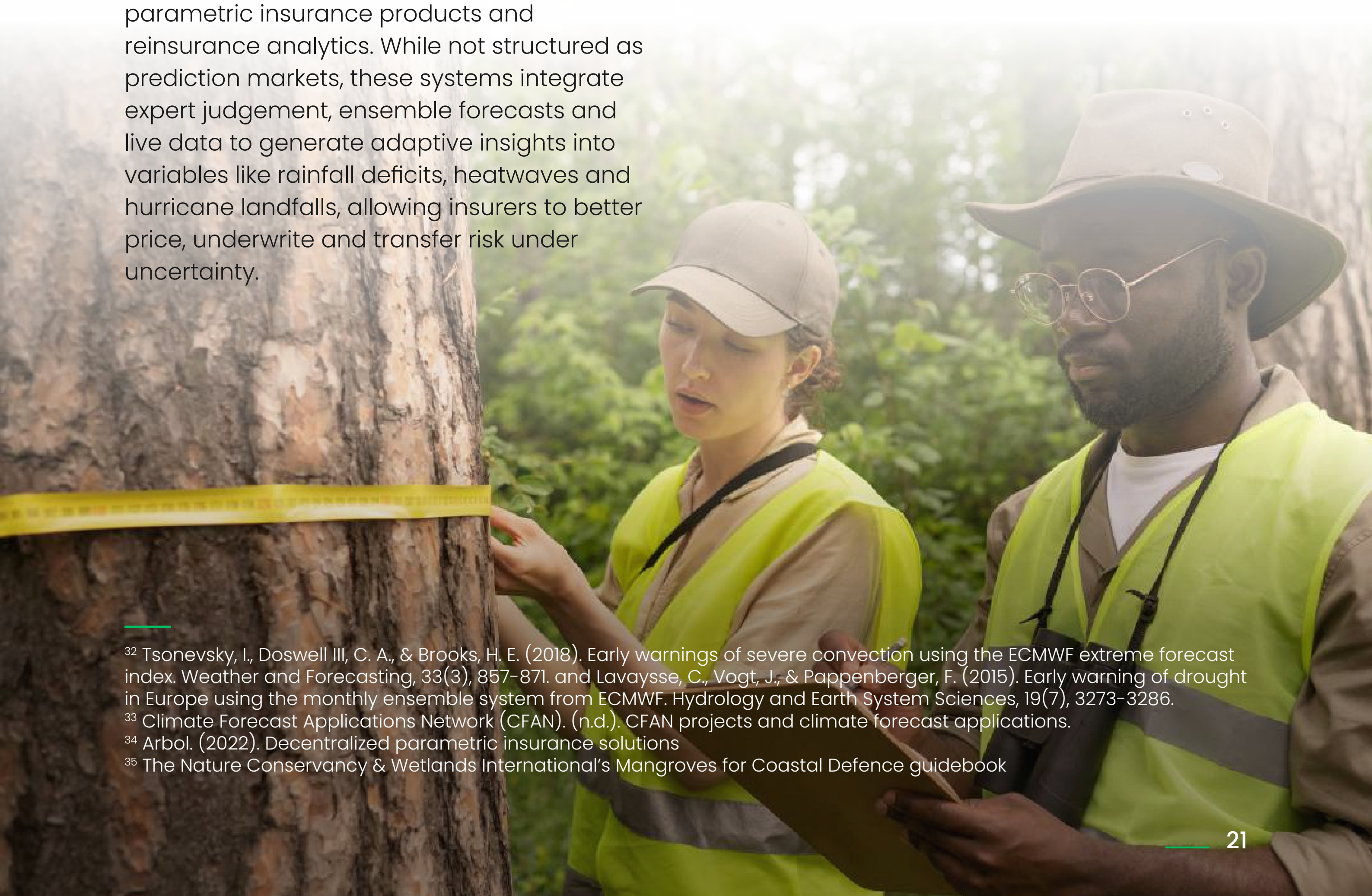
Insurance Innovation and Climate Prediction Markets

The insurance and reinsurance sectors have long relied on deterministic models and actuarial baselines to assess climate and catastrophe risk. However, the growing volatility of climate systems, driven by tipping points, compound events and socioecological feedbacks, has exposed the limitations of static modelling approaches. In response, leading insurers and risk modellers are increasingly exploring climate prediction markets and other probabilistic tools to enhance the granularity, responsiveness and accuracy of their assessments.

Research shows that ensemble-based earlywarning methods provide skilful operational forecasts for high-impact events, including severe convection and drought.[32] Platforms like the Climate Forecast Applications Network (CFAN)[33] and Arbol[34] have applied probabilistic forecasting and data-driven modelling in real-world contexts, including agricultural risk management, parametric insurance products and reinsurance analytics. While not structured as prediction markets, these systems integrate expert judgement, ensemble forecasts and live data to generate adaptive insights into variables like rainfall deficits, heatwaves and hurricane landfalls, allowing insurers to better price, underwrite and transfer risk under uncertainty.

These innovations provide a credible precedent for applying prediction markets to nature-related risks. If insurers can use real-time, decentralised forecasting to manage financial exposure to drought and flood, similar architectures could be adapted to monitor ecosystem degradation, species loss, or the performance risk of nature-based solutions. Furthermore, prediction markets may enhance the credibility of emerging nature-linked insurance instruments, like parametric products tied to mangrove integrity, forest cover, or soil health, by linking payouts to verifiable or forecasted nature-related indicators.[35]

This evolving practice underscores the operational feasibility and financial utility of embedding probabilistic tools into instruments underpinned by natural capital. It also demonstrates that risk-bearing institutions are already moving toward outcome-responsive forecasting systems, paving the way for nature prediction markets to become a viable component of broader nature-finance infrastructure.



[32] Tsonevsky, I., Doswell III, C. A., & Brooks, H. E. (2018). Early warnings of severe convection using the ECMWF extreme forecast index. Weather and Forecasting, 33(3), 857-871. and Lavaysse, C., Vogt, J., & Pappenberger, F. (2015). Early warning of drought in Europe using the monthly ensemble system from ECMWF. Hydrology and Earth System Sciences, 19(7), 3273-3286.
[33] Climate Forecast Applications Network (CFAN). (n.d.). CFAN projects and climate forecast applications.
[34] Arbol. (2022). Decentralized parametric insurance solutions
[35] The Nature Conservancy & Wetlands International's Mangroves for Coastal Defence guidebook

EMPIRICAL SIGNALS

EARLY EVIDENCE FROM ECOLOGICAL PREDICTION MARKETS AND ANALOGOUS SYSTEMS

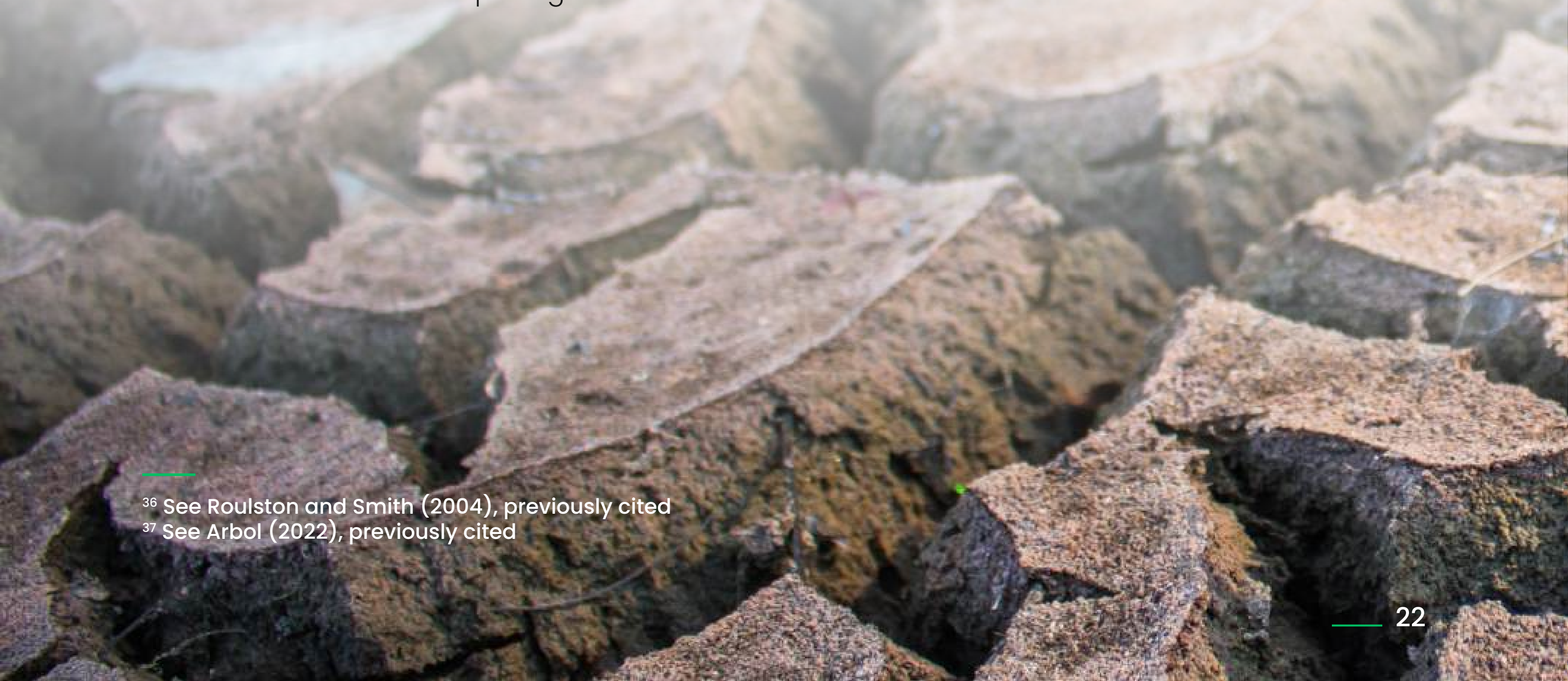
While nature-related prediction markets are still nascent, several empirical and analogue sources suggest their feasibility and comparative value in forecasting ecological or policy-relevant outcomes.

1 ENSEMBLE FORECASTING IN CLIMATE APPLICATIONS (PUBLISHED EVIDENCE)

Roulston et al. (2004)[36] demonstrated that ensemble-based probabilistic forecasts outperform traditional deterministic models in predicting extreme weather events like tropical cyclones. These systems, evaluated using Brier scores and other proper scoring rules, were more accurate and better calibrated, especially under high uncertainty. While this research focused on climate rather than ecosystems, it underscores the inferential power of distributed probabilistic reasoning.

2 PARAMETRIC FORECASTING IN CLIMATE INSURANCE (COMMERCIAL ANALOGUE)

Arbol[37], a blockchain-enabled insurance platform, prices parametric products based on forecasted environmental variables (e.g. rainfall, temperature). Although the platform does not run open prediction markets, its use of real-time, probabilistic inputs in contract pricing mirrors core elements of nature-related prediction systems. Internal reporting (2022, unpublished) from pilot programmes in East Africa indicated up to 18% reduction in loss ratios compared to traditional actuarial pricing.



[36] See Roulston and Smith (2004), previously cited
[37] See Arbol (2022), previously cited

3 CROWDFORESTS SIMULATION – BIODIVERSITY RECOVERY (EXPERIMENTAL EVIDENCE)

Between 2020 and 2022, a small-scale simulation titled CrowdForests, developed in partnership with a South American university, tested a prototype prediction market to forecast NDVI changes following reforestation efforts in Amazonia. Participants including ecologists, students and NGO stakeholders forecasted canopy recovery over an 18-month period. The market-derived probability distributions correlated more strongly with satellite-observed NDVI outcomes (R^2 = 0.71) than any individual baseline model (R^2 range: 0.33–0.56).[38] While unpublished, the pilot illustrates how collective forecasting can track biodiversity outcomes in spatially complex ecosystems.

4 SUPER FORECASTING AND NATURE-POLICY INTERFACES (CONCEPTUAL ANALOGUE)

The Good Judgment Project has demonstrated that trained forecasters can consistently generate accurate, well-calibrated predictions in complex domains, including environmental regulation and international policy. While not focused on biophysical metrics, these modules have achieved performance metrics like AUC scores of 0.85 in forecasting environmental policy outcomes, suggesting translatability to nature-policy interfaces.[39]

[38] CrowdForests (2022). Pilot data summary from reforestation forecasting simulation.
[39] Tetlock, P., Mellers, B., & Scoblic, J. P. (2014). Forecasting tournaments: Tools for increasing transparency and improving the quality of debate. Current Directions in Psychological Science, 23(4), 290–295.

Community Empowerment and Localised Data Contribution

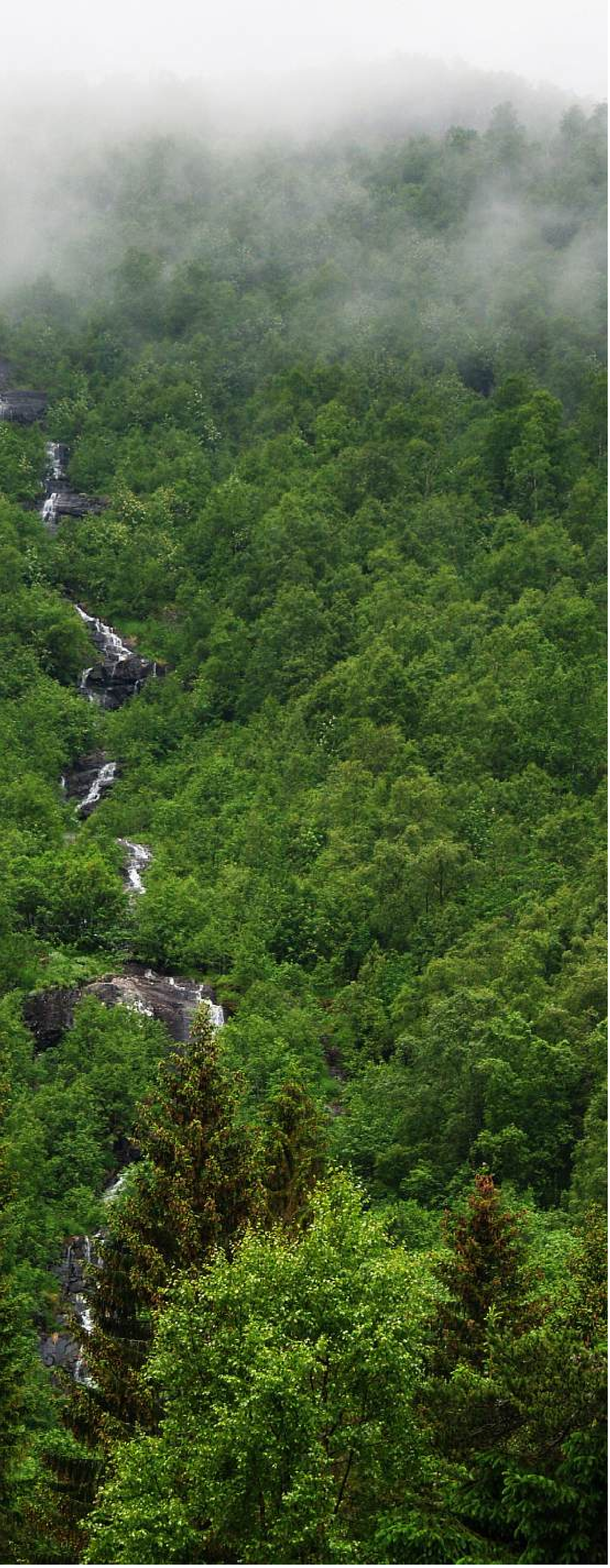
Prediction markets offer a powerful mechanism for empowering Indigenous Peoples, local communities (IPLCs) and smallholders, who are often the primary stewards of biodiversity-rich landscapes. These groups frequently possess rich ecological knowledge and are best positioned to provide hyperlocal, real-time observations on habitat quality, species presence, land use change and climate impacts.[40] Yet, their participation in conventional environmental monitoring systems is often limited by lack of formal recognition, data ownership rights, or compensation.[41]

Prediction markets invert this dynamic. By enabling individuals and community institutions to contribute actionable insights and forecast outcomes relevant to their landscapes, these markets offer new pathways for equitable participation and benefit sharing. For instance, a smallholder cooperative observing seasonal changes in pollinator activity or shifts in stream turbidity could input forecasts tied to relevant ecosystem service outcomes or biodiversity credits.

When these forecasts prove accurate, communities can be directly remunerated—either through monetary rewards, digital tokens, or performance-linked grants. Importantly, this model supports trust building between local actors and institutional users by creating transparent, verifiable feedback loops that validate experiential knowledge. Furthermore, it respects community autonomy by allowing data provision to occur on voluntary, contract-specific terms rather than through extractive data-sharing frameworks.

To ensure legitimacy, market operators must adopt protocols for informed consent, data sovereignty and culturally appropriate contract framing.[42] Co-designing market categories and verification methods with IPLCs ensures relevance and strengthens accountability. In doing so, prediction markets can not only improve nature-related risk assessment, but also support a more inclusive, pluralistic model of environmental governance.

[40] Berkes, F. (2012). Sacred Ecology (3rd ed.). Routledge
[41] Global Indigenous Data Alliance (2020). CARE Principles for Indigenous Data Governance
[42] Carroll, S. R., et al. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data governance. Scientific Data, 8, 108. https://doi.org/10.1038/s41597-021-00892-0



Recent frameworks like the CARE Principles for Indigenous Data Governance and guidelines from the Global Indigenous Data Alliance (GIDA) highlight the importance of data sovereignty, consent and co-management.[43] Prediction markets, when appropriately designed, can operationalise these principles by treating IPLCs not merely as data sources, but as co-creators of value. Markets structured to allow voluntary participation and fair compensation offer a pathway to reverse extractive patterns of ecological data collection.[44]
These systems can also formalise and monetise the contributions of IPLCs and smallholders in a transparent way. For example, a community observing seasonal pollinator activity or monitoring forest edge encroachment can feed their observations into forecast contracts. If these forecasts are validated, communities can be compensated through performance-based payments, digital tokens, or access to enhanced financial services. This creates a feedback loop of validation and trust where experiential knowledge is rewarded, recognised and integrated into institutional decision-making.

To ensure legitimacy and trustworthiness, prediction markets must embed culturally appropriate consent mechanisms, clear benefit-sharing arrangements and community-led governance. Co-designing contract structures and outcome metrics ensures that markets align with local priorities and avoid commodifying knowledge without consent. In this way, prediction markets can contribute not only to improved nature-related forecasting, but also to inclusive governance, knowledge pluralism and environmental justice.

[43] Global Indigenous Data Alliance (GIDA). (2019). CARE Principles for Indigenous Data Governance. Available at: https://www.gida-global.org/care
[44] Jonas, H., Makagon, J., & Shrumm, H. (2018). A framework for assessing equity in the context of area-based conservation. International Union for Conservation of Nature (IUCN)

The Role of Artificial Intelligence in Enabling Predictive Ecology

Artificial intelligence (AI) plays a critical role in enhancing the functionality, scalability and credibility of prediction markets for nature-related risk. Given that ecological data is often unstructured, spatially heterogeneous and incomplete, AI offers tools for both data extraction and inference, helping to generate and validate the probabilistic forecasts that underpin these markets.

A primary application of AI is in remote sensing interpretation. Machine learning algorithms now routinely analyse satellite and drone imagery to detect land cover changes, classify habitat types and estimate indicators like forest biomass, NDVI, or water quality.[45] These AI-derived data streams serve as high-frequency, high-resolution inputs into prediction markets, enabling contract prices to reflect real-time environmental change.

Another important domain is nature-related forecasting. AI methods like deep learning, ensemble modelling and hybrid simulation are increasingly used to model biodiversity responses to land-use change, restoration interventions, or pollution events.[46] These modelled outcomes can be used as priors or dynamic inputs in prediction markets, synthesising scientific expectations with locally observed evidence.

AI also plays a growing role in natural language processing (NLP). NLP systems can monitor regulatory updates, policy announcements and scientific publications to extract signals relevant to specific prediction contracts. For example, the early release of a biodiversity bill or conservation funding programme could be parsed, summarised and integrated into relevant market forecasts.[47]

Beyond data extraction, AI can support market operations and integrity. Techniques like reinforcement learning can optimise automated market maker parameters, while AI-based anomaly detection can flag manipulative behaviour or identify confidence deficits in forecast distributions.[48] In this sense, AI becomes both a content contributor and a governance layer.

However, integrating AI into predictive ecological systems requires transparency and accountability. Black-box models pose interpretability risks, particularly when used in high-stakes financial or conservation contexts. The adoption of explainable AI (XAI) and open model auditing protocols can help ensure that forecasts remain interpretable, traceable and scientifically defensible.[49]

In sum, AI technologies act as foundational enablers of nature-related prediction markets. They help address signal sparsity, temporal volatility and ecosystem complexity, three core limitations of traditional monitoring and modelling systems. When responsibly integrated, AI and prediction markets offer a scalable, adaptive infrastructure for forward-looking ecological risk intelligence.

[45] Gorelick, N., et al. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote Sensing of Environment, 202, 18–27
[46] Reichstein, M., et al. (2019). Deep learning and process understanding for data-driven Earth system science. Nature, 566(7743), 195–204
[47] Dellarocas, C., & Zervas, G. (2021). Extracting signals from unstructured text for market predictions. MIT Sloan Research Paper
[48] Othman, A., et al. (2013). Practical automated market making via machine learning. ACM Conference on Electronic Commerce
[49] Carvalho, D. V., Pereira, E. M., & Cardoso, J. S. (2019). Machine learning interpretability: A survey on methods and metrics. Electronics, 8(8), 832

EXAMPLE 1

INDIGENOUS FIRE MANAGEMENT IN NORTHERN AUSTRALIA[50]

Indigenous ranger groups in Northern Australia, like those involved in the West Arnhem Land Fire Abatement (WALFA) project, have long practiced traditional mosaic burning techniques to reduce wildfire risk and maintain biodiversity. These practices have measurable impacts on greenhouse gas emissions and are already recognised in accredited carbon methodologies under Australia's Emissions Reduction Fund.

A nature-linked prediction market contract could ask: "Will savannah fire emissions in Region X fall below the 10-year baseline average by the end of the dry season?" Indigenous ranger teams contribute real-time observations on burn timing, wind conditions and vegetation response. When accurate, these insights help recalibrate market expectations and enhance forecast reliability.

When community-generated data aligns with successful contract outcomes, ranger groups could be compensated through performance-based conservation funding or tokenised participation mechanisms. This reinforces the value of Indigenous ecological knowledge and creates direct financial incentives for sustained landscape stewardship.

[50] Russell-Smith, J., et al. (2013). Managing fire regimes in north Australian savannas: applying Aboriginal approaches to contemporary global problems. Frontiers in Ecology and the Environment, 11(s1), e55–e63

EXAMPLE 2

SMALLHOLDER AGROFORESTRY IN THE CONGO BASIN[51]

Smallholder farmers in the Congo Basin increasingly practice cocoa-agroforestry systems that contribute to biodiversity conservation, soil health and carbon storage. However, these efforts are often invisible to conventional monitoring and crediting systems, due to their small scale, spatial dispersion and limited access to formal reporting channels.

A prediction market contract could be designed around a forecast like: "Will canopy cover in Project Y's agroforestry plots exceed 70% by 2027?" Farmers and cooperative members contribute ground-truth data, like planting density, tree survival and intercropping regimes, which are compared with satellite observations and field audits to inform contract pricing.

Participants whose inputs help generate accurate forecasts, i.e. where projected outcomes align with verified ecological change, can be compensated via ecosystem service payments, green lending access, or digital reward systems. This builds trust in market mechanisms and creates feedback loops that valorise smallholder stewardship.

[51] Vaast, P., & Somarriba, E. (2014). Trade-offs and synergies between agroforestry and biodiversity conservation. Agroforestry Systems, 88(6), 947–962. Cocoa & Forests Initiative (2023). Progress Reports from Côte d'Ivoire and Ghana.

Market Scale and Strategic Potential

The viability of nature-related prediction markets depends not only on technical design and governance, but also on their potential scale and strategic relevance. Early analysis suggests that such markets could reach meaningful volumes by aligning with existing and emerging use cases across climate finance, corporate sustainability and conservation-linked investment.

1 CORPORATE TARGET VALIDATION AND ESG MONITORING

Over 5,000 companies currently report nature-related data through CDP and several hundred are aligning with frameworks like the TNFD and the SBTN.[52] If even a modest fraction of these companies (e.g. 5 - 10%) were to adopt prediction markets for scenario testing, restoration monitoring, or KPI-linked forecasting, a market worth \$50m to \$250m † annually could emerge, assuming annual contract volumes of \$10,000 to \$50,000 per company.[53] This aligns with the growing demand for outcome verification tools that support both compliance and internal decision-making.

2 NATURE AND CARBON CREDIT VERIFICATION

The voluntary carbon market exceeded \$2bn in 2022, with biodiversity credit platforms like Plan Vivo and Verra's Biodiversity Credit Standard beginning to monetise ecosystem service outcomes.[54] Prediction markets could provide decentralised, real-time validation of credit integrity, particularly in the context of outcome-based issuance or risk-linked payout triggers. If applied to just 10% of high-volume carbon and biodiversity projects, this could support \$100m or more in forecasting contracts annually.[55]

3 INSURANCE-LINKED SECURITIES AND CATASTROPHE BONDS

The global market for catastrophe bonds and insurance-linked securities (ILS) surpassed \$100bn in 2023.[56] Natural hazard-linked products, like Mexico's FONDEN or Caribbean Catastrophe Risk Insurance Facility (CCRIF), already rely on parametric indices tied to precipitation, cyclone intensity, or coral reef cover. Prediction markets could enhance the pricing of such instruments or serve as real-time indicators of payout triggers. Even a minor foothold (0.05 - 0.1% of market activity) could result in \$25m to \$75m in contracts annually.

[52] CDP (2023). Nature data reporting trends
[53] Author extrapolation based on adoption rates in early ESG analytics markets (e.g. ISS, Sustainalytics) and TNFD corporate pilot data
[54] Ecosystem Marketplace (2023). Voluntary Carbon Market Insights: Mid-Year Update. Verra (2023). Biodiversity Credit Standard
[55] Estimate assumes market use by ~10% of verified projects with average contract sizes of \$100k+
[56] Aon (2023). Insurance-Linked Securities Market Update Q4 2023

SOVEREIGN NATURE-LINKED DEBT INSTRUMENTS

Debt-for-nature swaps and sustainability-linked sovereign bonds increasingly incorporate environmental KPIs linked to debt relief or coupon adjustments. Ecuador's 2023 Galápagos deal ($1.6bn) and Belize's 2021 blue bond restructuring ($364m) are prominent examples.[57] Prediction markets could serve as low-cost, independent validation mechanisms for such instruments, especially for sovereign issuers with limited monitoring capacity. A 1% adoption across this market segment could yield $10m to $30m annually, with potential for multilateral scale-up via development banks.

In aggregate, these channels, spanning corporate reporting, voluntary markets, insurance and sovereign debt, suggest that nature-related prediction markets could plausibly support $250m to $500m in annual transaction volume within a decade. As interoperability, regulatory clarity and stakeholder trust increase, this could scale into the billions. This outlook justifies early investment in protocol development, governance design and inclusive participation infrastructure.

[57] Inter-American Development Bank (2023). Nature-Linked Sovereign Financing Landscape. The Nature Conservancy (2023). Blue Bonds Progress Report

† All market-size figures in this section are order-of-magnitude and assumption-dependent (uptake, pricing, enabling policy, MRV quality, risk capacity) they are illustrative, not forecasts.

Sustaining Critical Data Infrastructure through Prediction Markets

Reliable biodiversity assessment depends on access to foundational global datasets, like the IUCN Red List of Threatened Species, the World Database on Protected Areas (WDPA), the Key Biodiversity Areas (KBA) dataset and the Global Biodiversity Information Facility (GBIF). These platforms provide essential taxonomic, spatial and ecological data that underpin conservation planning, environmental impact assessments and nature-related financial disclosures.[58] However, despite their central role, many of these systems are underfunded, donor-dependent, or maintained by academic or NGO consortia with limited long-term financing.

Prediction markets could provide a novel mechanism to help sustain these biodiversity data infrastructures. Markets depend on authoritative reference data to define, benchmark and verify nature-related outcomes. These foundational datasets act as baseline layers for contract specification and resolution, especially in markets forecasting habitat status, species trends, or conservation policy effectiveness.

For example, an oracle may rely on the Red List status of a species, or KBA boundaries, to validate whether a conservation target has been met. Integrated Biodiversity Assessment Tool (IBAT) as an integrated data delivery platform, operationalises these datasets for institutional users. Market operators, traders and asset managers benefit directly from their continued availability and enhancement.

By allocating a share of transaction fees, oracle licensing charges, or contract resolution costs to data providers, prediction markets could help monetise and redirect value to the systems that support naturerelated forecasting. This is similar to how decentralised digital infrastructure projects fund core developers or open-source toolkits through protocol revenue.

This model follows the logic of ecosystem services: just as natural ecosystems support economic activity, biodiversity data infrastructures support nature-informed finance. Embedding funding flows into market architecture could offer a scalable, incentivealigned approach to maintaining the global biodiversity data commons.

[58] IUCN (2022). Strategic funding needs for the Red List and supporting datasets. GBIF (2023). Annual report: Enabling open biodiversity data at scale. Hardisty, A. R., et al. (2013). BioVeL: Biodiversity virtual e-laboratory. Biodiversity Informatics, 8, 93–99. Costello, M. J., et al. (2014). Biodiversity data should be published, cited, and peer reviewed. Trends in Ecology & Evolution, 29(8), 454–461. UNEP-WCMC (2021). IBAT: Delivering global biodiversity datasets to business and finance.

CONCLUSION

Prediction markets offer a viable and underexplored mechanism for addressing the ambiguity, fragmentation and dynamism inherent in nature-related risk. Their value lies in enabling diverse models and data sources to compete on the basis of forecasting accuracy, rather than methodological consensus, rewarding empirical performance and improving decision relevance over time.

By aggregating decentralised knowledge, updating forecasts in real-time and validating performance through observable outcomes, prediction markets introduce a novel form of accountability and consequence into nature-related assessment. This would complement emerging protocol-based efforts, like those led by TNFD and SBTN, which define what should be measured but cannot adjudicate which methods perform best under real-world conditions.

Crucially, protocol-based measurement and prediction-based validation are not substitutes, but complements. Together, they can form a dual-track architecture: one that sets the rules for disclosure and comparability and another that continuously tests, refines and validates those rules through evidence. This dual approach supports a more adaptive, pluralistic and performance-driven model of nature-related governance.

As corporates, financial institutions and governments increasingly commit to nature-related targets, the need for tools that bridge intention with observed outcomes is growing. Embedding prediction markets into this landscape offers not only a means of tracking ecological risk with greater agility, but also a scalable, incentive-compatible way to strengthen the credibility of the entire nature finance system.

APPENDICES

APPENDIX 1

Methods and System Design - System Architecture for Nature-Related Prediction Markets.

Contracts define verifiable environmental outcomes. Diverse data inputs inform a market engine where participants forecast likelihoods. Outcomes are resolved by independent oracles and used to allocate rewards based on predictive accuracy. Outputs may inform and validate protocol-based frameworks (e.g. TNFD, SBTN).

Overview of Prediction Market Architecture for Nature Risk

This section outlines the theoretical design and functional architecture of a nature-related prediction market system, adapted for practical implementation across diverse ecological contexts.

1. Contract Design

Prediction markets are structured around discrete contracts linked to verifiable environmental outcomes. These may be binary (e.g., "Will mangrove cover in Region X increase by 10% by 2027?"), continuous (e.g. "What will be the average NDVI index of Region Y in 2026?"), or conditional (e.g. "If Policy Z is passed, will species abundance in Area A increase by 2030?"). Contracts are designed through a participatory process involving ecologists, data providers and community stakeholders.

2. Outcome Verification and Oracles

An independent verification system, referred to as an oracle, resolves contract outcomes. These oracles may include remote-sensing data, ground-truth surveys, or published government datasets. Criteria for verification must be pre-specified and transparent. Dispute resolution protocols and governance boards are recommended.

3 Market Mechanism

Prediction markets operate via an automated market maker, like a logarithmic market scoring rule (LMSR), which continuously updates contract prices based on the trades of participants. These contracts typically follow a defined workflow that includes: (1) contract formulation based on a verifiable ecological outcome; (2) data aggregation from remote sensing, community observations and scientific models; (3) active trading by informed participants including scientists, local actors and financial analysts; (4) resolution by a third-party oracle using agreed data sources; and (5) reward allocation to participants based on forecast accuracy.

4. Data Contribution and Participant Inclusion

Market participants include scientific experts, Indigenous Peoples and local communities, financial analysts and data scientists. Contributions may be made directly through trades or indirectly through shared data and methodologies. Incentives are distributed based on forecast performance.

5. **Incentive Structure and Remuneration**

   Participants whose forecasts improve market accuracy, measured via proper scoring rules (e.g. Brier score) are rewarded. These rewards may be monetary, token-based, or reputation-linked. Special mechanisms may be introduced to reward verified high-quality data provision from under-represented communities.

6. **Integration with Protocol Frameworks**

   Prediction markets complement rather than replace protocol-based systems (e.g. TNFD, SBTN). They serve as adaptive overlays to test assumptions, evaluate scenario pathways and validate the empirical relevance of indicators. Feedback loops can be embedded to refine protocol metrics based on market-informed outcomes.

7. **Ethical and Regulatory Design**

   The system must adhere to international ethical standards. Key elements include informed consent from data providers, community governance roles, compliance with local and global financial regulations and protocols for data sovereignty and cultural sensitivity.

Appendix 2

Forecast Fidelity Index – Methodological Specification

This appendix provides the technical detail underpinning the Forecast Fidelity Index (FFI). It is intended as a methodological anchor to support the main text.

Purpose

The FFI benchmarks predictive performance across contributors, methods, and indicators in nature-related prediction markets. It does so by applying established probabilistic scoring rules and reporting skill relative to declared baselines, with results released under minimum data sufficiency and governance standards.

Scoring Rules

- **Brier Score:** Used for binary and categorical outcomes; measures mean squared error between predicted probabilities and actual outcomes (lower is better).
- **Continuous Ranked Probability Score (CRPS):** Used for continuous outcomes (e.g. NDVI, canopy cover); measures the distance between the predicted cumulative distribution and the observed outcome (lower is better).
- **Logarithmic Score (optional):** Applied where tail probabilities materially affect risk; penalises overconfidence in low-probability events.

Skill Scores

Results are expressed as skill relative to a baseline:

$$\text{Skill} = 1 - \frac{S\ \text{model}}{S\ \text{baseline}}$$

Results are expressed as Skill relative to a declared baseline (see equation 1, main text). Skill >0 indicates improvement over baseline; Skill = 0 parity; Skill <0 under-performance. Raw scores are retained for transparency. Baselines are declared ex ante, locked and version-controlled. Defaults include:

- **Event rates -** climatology (long-term average frequency)
- **State variables -** persistence/no-change
- **Policy outcomes -** historical enactment frequency

Illustrative Table - Baseline Types and Examples

Indicator type	Default baseline	Example application
Event rates	Climatology (long-term average frequency)	Annual probability of wildfire in Cerrado region
State variables	Persistence / no-change	NDVI vegetation index in mangrove restoration plots
Policy outcomes	Historical enactment frequency	Share of proposed local coastal ordinances enacted

Aggregation

Market-level scores are reported by forecast horizon (e.g., 0–6 m, 6–24 m, >24 m). Aggregated results may be presented as a Cumulative Fidelity Score (CFS), a horizon-weighted mean of skill scores. Documented weights are applied to counter short-term bias, with unweighted means also published.

Calibration and Uncertainty

Forecast calibration is reported using reliability diagrams and Brier decomposition. Confidence intervals are estimated using block bootstraps, a resampling method appropriate for dependent data. Minimum sample sizes are required before official publication.

Worked Example - Binary Market

- **Forecast:** 70% chance of mangrove survival after 12 months
- **Outcome:** Survival occurs (coded as 1)
- **Brier Score =** (0.70 – 1)^2 = 0.09
- **Baseline climatology =** 50% survival - Baseline Brier = (0.50 – 1)^2 = 0.25
- **Skill =** 1 – (0.09 / 0.25) = 0.64 (64% improvement over baseline)

Release Criteria

- Minimum number of resolved markets per indicator-region-horizon cell
- Minimum liquidity and participation thresholds
- Explicit flagging of provisional results until thresholds are met

Attribution

Performance is attributed to methods, institutions, and contributor cohorts (e.g. Indigenous peoples and local communities, academic teams, commercial providers). Identity verification (KYC for individuals; signed model cards for institutional models) is required. Method changes mid-market are recorded to preserve attribution integrity.

Governance and Assurance

The FFI forms part of the wider governance system (see Appendix 3 - Governance Framework for Nature-Related Prediction Markets). Baselines and scoring protocols are subject to independent review. Results are designed to be assurable in line with emerging regulatory requirements (CSRD, TNFD) and can support auditor scrutiny of nature-related disclosures.

Next Steps

Pilot testing of the FFI is proposed in live biodiversity-linked prediction markets, with pre-declared baselines and oracle definitions. These pilots will inform refinement of scoring protocols, weighting schemes, and assurance pathways.

APPENDIX 3

Recommendations

- **Establish pilot markets for high-priority nature risks -** Launch regionally focused prediction markets targeting biodiversity loss, deforestation, or freshwater ecosystem degradation. Pilots should involve diverse stakeholders, including scientific experts, local communities and institutional investors and be governed through transparent, verifiable oracles to evaluate outcomes.
- **Conduct comparative research on predictive accuracy -** Undertake empirical studies comparing prediction market performance with existing nature-related models and benchmarks. This research should explore accuracy over time, responsiveness to new data and the reliability of predictions across ecosystems, geographies and risk domains.
- **Explore regulatory and disclosure alignment pathways -** Engage with regulators, standard-setting bodies and market initiatives to assess how prediction markets might be integrated into or inform nature-related financial disclosures. Pilot applications could include market-derived probability thresholds that inform materiality assessments or scenario testing.
- **Support reward systems that compensate data and methodology providers based on predictive success -** Develop infrastructure that enables attribution of market-informed success to contributing methods or datasets. Establish funding, token-based, or reputational reward mechanisms that encourage ongoing data provision, methodological refinement and participation in market validation.
- **Ensure integration of outcome-based tools alongside protocol-based frameworks to validate and refine methodologies in practice -** Formalise feedback loops between prediction markets and emerging nature measurement protocols. Encourage the use of prediction markets to test assumptions embedded in target-setting tools and to improve the calibration of protocol-approved indicators over time.

APPENDIX 4

Governance Framework for Nature-Related Prediction Markets

Robust governance is essential to ensure the credibility, fairness and legal defensibility of nature-related prediction markets. The following framework outlines core governance components across oracle operation, dispute resolution and integrity safeguards, drawing from best practices in prediction markets, environmental data verification and decentralised governance systems.

1. Oracle Governance - Ensuring Outcome Integrity

- **Independent Verification -** Outcomes are resolved by third-party entities ("oracles") using pre-agreed, transparent data sources (e.g. remote sensing datasets, field surveys, national statistics).
- **Multi-source Validation -** Oracles must triangulate at least two independent data sources per contract to minimise single-point failure or data bias.
- **Accreditation Standards -** Oracles must meet eligibility criteria including transparency of methods, historical reliability and conflict-of-interest declarations. Accreditation bodies may include multilateral institutions, scientific consortia, or TNFD-aligned assurance providers.
- **Version Control -** Oracles must publicly log version histories of datasets or algorithms used, ensuring traceability and reproducibility of outcome decisions.

2. Dispute Resolution: Managing Conflicts and Contestation

- **Challenge Window -** All market outcomes are subject to a pre-defined challenge window (e.g. 30 days) during which participants can contest resolution via evidence submission.
- **Governance Tribunal -** An independent panel of technical experts, community representatives and legal advisors adjudicates disputed outcomes, following structured criteria and transparency norms.
- **Appeal Mechanism -** A second-tier appeal mechanism can be established for high-stakes or precedent-setting disputes, with binding arbitration protocols.

3. Integrity Safeguards - Preventing Manipulation and Conflicts of Interest

- **Conflict Controls -** Project developers, credit issuers, or contract sponsors must adhere to strict limits or exclusions on trading in related contracts to avoid perverse incentives.
- **Audit Trails -** All market transactions, outcome resolutions and data updates are logged immutably, ideally using distributed ledger technology (DLT) for verifiability.
- **Anomaly Detection -** Automated systems using machine learning flag abnormal trading patterns, data anomalies, or suspected collusion for human review.
- **Transparency Dashboards -** Public dashboards display market parameters, contract terms, oracle methodologies and conflict-of-interest declarations for all active actors.
- **Ethical Review Board -** Markets impacting Indigenous Peoples and Local Communities (IPLCs) must be subject to ethical review procedures aligned with CARE Principles, including free, prior and informed consent (FPIC) and benefit-sharing arrangements.

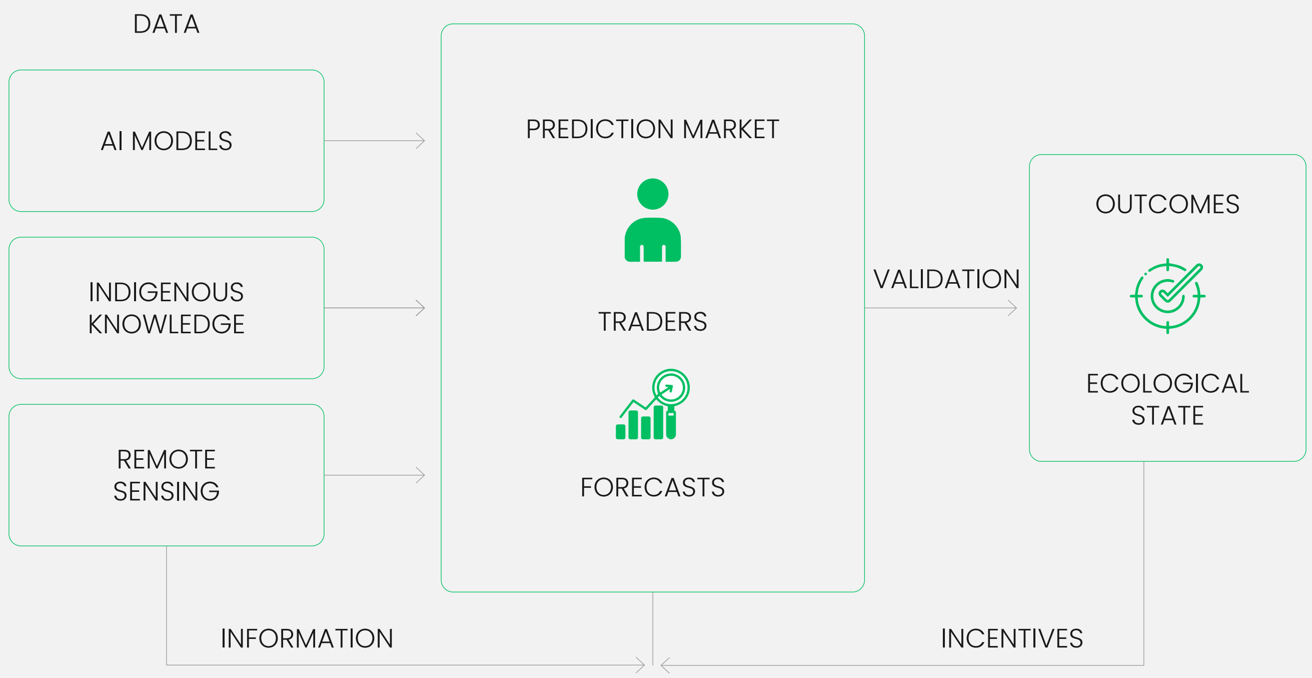
Institutional Options

Governance functions may be housed within:

- Independent Foundations (e.g. akin to the Linux Foundation or Climate Disclosure Standards Board)
- Multi-Stakeholder Coalitions involving data custodians, community organisations and financial users
- RegTech Providers offering compliant market infrastructure under regulatory sandboxes

APPENDIX 5

System Architecture of Nature-Related Prediction Markets



APPENDIX 6

Glossary of Key Terms

Adaptive Governance

A governance approach that is flexible, iterative and responsive to feedback, particularly effective in managing complex, uncertain and evolving systems. Prediction markets support adaptive governance by enabling real-time forecasting, collective learning and post hoc validation of expectations.

Bayesian Updating

The process of revising probability estimates as new evidence becomes available. Prediction markets exhibit collective Bayesian updating as informed participants adjust their trades in response to evolving data and expectations.

Financed Impact Drivers

Activities or pressures (e.g. land use change, water abstraction, pollution) resulting from the business operations financed by a financial institution. These are a key focus for assessing nature-related risks and opportunities in portfolio-level analysis.

Financed Nature-Related Risk

The exposure of financial institutions to environmental degradation or ecosystem disruption through their lending, investment, or underwriting activities. This includes physical, transition and reputational risks.

Framework-Aligned Metrics

Standardised indicators used to assess nature-related dependencies, impacts and risks, typically developed or endorsed by frameworks such as the TNFD or SBTN. These are often input, or condition-focused and support consistency and comparability in corporate and financial disclosures.

Materiality (Nature-Related)

The extent to which nature-related dependencies, impacts, risks, or opportunities affect, or are likely to affect, an organisation's financial condition, performance, or decision-making. This includes both financial materiality (nature's impact on the organisation) and impact materiality (the organisation's impact on nature). Prediction markets may help operationalise both by revealing expected nature-related outcomes and their significance to stakeholders.

Nature KPIs (Key Performance Indicators)

Quantifiable indicators tied to specific nature-related targets, used to track nature performance and accountability. Examples include canopy cover, species richness, soil carbon content, or water quality. Prediction markets may anchor contracts to these KPIs to assess progress against defined outcomes.

Nature Measurement Protocol

A standardised framework for determining how nature-related metrics should be measured, reported and disclosed, analogous in purpose to the Greenhouse Gas (GHG) Protocol. These protocols aim to ensure consistency and comparability across entities and reporting periods but typically do not address the validation of nature performance or the likelihood of target achievement.

Oracle

A mechanism, either institutional or technical, that provides authoritative information used to verify whether a predicted outcome has occurred. In the context of prediction markets, oracles are essential for resolving contracts based on independently sourced, trustworthy data.

Outcome oracles are a specific type of oracle used to validate nature-related predictions against pre-agreed environmental indicators or thresholds. They ensure transparent settlement and are critical to maintaining credibility and trust in nature-related forecasting markets.

Outcome-Based Validation

A method of assessing credibility based on whether predicted outcomes actually occur, rather than relying solely on methodological soundness. Central to prediction markets, it shifts focus from inputs to observable, falsifiable results. This approach is particularly suited to managing outcome uncertainty, common in ecological systems, by expressing forecasts in probabilistic terms and allowing for adaptive updating as new information emerges.

Proper Scoring Rule

A mathematical method for evaluating the accuracy of probabilistic forecasts. Proper scoring rules assign higher scores when predicted probabilities align closely with actual outcomes, thereby incentivising honest forecasting. They are integral to prediction markets, as they allow for objective comparison of forecast performance and encourage truthful, well-calibrated probability estimates.

The Brier Score is a commonly used proper scoring rule. It is calculated as the mean squared difference between the predicted probabilities and the actual binary outcomes. Lower Brier Scores indicate higher accuracy.

Formula:

$$BS = \frac{1}{N} \sum_{t=1}^{N} (f_t - o_t)^2$$

Where:

- N = the number of items you are calculating a Brier score for
- ft is the forecast probability (i.e. 25% chance)
- ot is the outcome (1 if it happened, 0 if it didn't)

Verification Baseline

A pre-defined ecological condition or threshold used to determine whether a predicted outcome has occurred (e.g. canopy cover, species abundance). It enables objective contract resolution by providing a reference point for outcome verification.

CONTACT

james@scoutmac.com

ABOUT THE AUTHORS

James d'Ath

James d'Ath has over 30 years' experience in capital markets across asset management, research, product development and ESG strategy. He founded the sustainable finance advisory firm ScoutMac and has worked with UNEP FI, Global Canopy and the World Economic Forum on sustainable finance, deforestation finance, biodiversity metrics and environmental risk management.

Gareth Thomas

Gareth Thomas PhD MRSB is CEO of the National Biodiversity Network Trust, leading the UK's biodiversity data infrastructure. Formerly Head of Research Innovation at the Natural History Museum, he created the Biodiversity Intactness Index commercial model. He is also a Trustee of Chester Zoo and a recognised international speaker on biodiversity finance.