From Science to Software: Developing a product governance approach for environmental models

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Highlights

- Environmental models deployed as software at scale require governance across science, data, code, release management, user enablement, and security. This extends beyond core scientific rigour without replacing its essential relevance.
- A practical governance framework can be organised around governance domains, explicit trade-offs, and records that support accountability, learning and improvement.
- The Overseer case is presented as an illustrative account of how these ideas are being explored in Aotearoa New Zealand. It is not offered as evidence that the approach is complete or effective in every respect.
- An important corollary is that stewardship funding must extend beyond scientific research publication to include software development, quality assurance, documentation, support, and ongoing governance.

Keywords: auditability, accountability, decision support, information security, nutrient budgeting, transparency

Background

Environmental models support important decisions across spatial and temporal scales that measurement alone cannot cover; they necessarily simplify complex systems. Accuracy and precision must be assessed in terms of fitness-for-purpose, with assumptions and limitations understood (Ministry for the Environment (MfE) 2023).

These issues become more pressing when models move from voluntary decision support into assurance and regulatory settings. New Zealand guidance distinguishes between "softer" uses such as education, screening, or targeting investigations, and "harder" uses such as compliance decisions. As the consequences of use increase, so do expectations around corroboration, validation, version stability, and communication of change (MfE 2023; Parliamentary Commissioner for the Environment (PCE) 2024).

This paper follows the arc of: Concept → Framework → Practice Example.

Concept: Deploying an environmental model as software at scale expands model governance into *product governance*: scientific rigour applied across science, data, code, releases, user enablement, and security.

Framework: A practical product governance framework can be organised around three key elements: governance domains, explicit trade-offs, and records that support accountability, learning and improvement.

Practice Example: The Overseer science model and associated software product is presented as a worked example of how these ideas are being explored in the New Zealand context, including questions of science, software, regulation, transparency, and stewardship (PCE 2018; Science Advisory Panel (SAP) 2021; MfE and Ministry for Primary Industries (MPI) 2021; MfE 2024; PCE 2024).

The authors write from within Overseer Limited and therefore bring both practical knowledge and an institutional perspective to this conversation. The Overseer material is presented as an institutional self-assessment rather than an independent evaluation of governance effectiveness. Our purpose is to describe an approach currently being developed, make its assumptions and limitations visible, and invite scrutiny and improvement.

Concept: Product governance is broader than model governance

Users do not interact with an abstract scientific model; they interact with an evolving software product. That product includes the scientific model, embedded datasets, interfaces, workflows, reports, release practices, user guidance, support arrangements, and security controls. Changes in any of these elements can alter outputs, their interpretation, the consequences of using them, and trust. For that reason, governance must extend across the full chain from scientific principles, evidence and data, to code, release, security, and supported use. This is *product* governance.

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Established guidance supports this proposition. The U.S. National Research Council (NRC) treats model evaluation as a life-cycle activity, with credibility resting on peer review, documentation, uncertainty analysis, and intended use (NRC 2007). The U.S. Environmental Protection Agency (EPA) similarly covers specification, conceptualisation, implementation, evaluation, and application, emphasising transparency and communication (EPA 2009). New Zealand guidance adds that model evolution and explaining change require active governance (MfE 2023; PCE 2024).

Environmental models inform decisions rather than create certainty: verification and validation of natural-system models remain partial and conditional (Oreskes et al. 1994). Iterative development, stakeholder engagement, and critical review are therefore essential (Jakeman et al. 2006). Excess complexity can reduce transparency and increase governance risk when it exceeds decision needs (NRC 2007; Saltelli 2019). Trustworthiness thus depends on both scientific quality and disciplined translation into a fit-for-purpose mathematical model and workflows.

Scientific *software* adds a further layer of responsibility. Reliable computational results depend on version control, testing, reproducible workflows, and clear documentation (Wilson et al. 2014). In contemporary cloud environments, governance must also cover secure software development and information security, especially where platforms hold sensitive operational data (National Institute of Standards and Technology (NIST) 2022; International Organization for Standardization (ISO) 2022). Software quality and information security are just as vital as the trustworthiness of the science itself.

Governance covers both special projects to integrate key developments in the science and ongoing day-to-day governance to maintain a robust and secure service that continues to evolve in line with stakeholder needs, industry and government specifications, and institutional learning.

Framework: A system for product governance

A practical product governance framework for environmental models can be organised around three key questions. What domains must be governed? How are trade-offs made explicit? What records make governance visible and accountable, and facilitate ongoing learning and improvement?

Governance domains and records

At minimum, governance must cover the domains shown in . This grid provides a general framework that can be applied to any environmental model deployed as operational software.

Three points warrant emphasis. First, fitness is contextual: direct-compliance uses require stronger corroboration, boundaries, and change control than learning or screening uses (MfE 2023; PCE 2024). Second, data governance is as important as algorithm governance because changes to soil, climate, slope, or management datasets can alter results without changes to equations or logic. Third, governance includes user experience: weak guidance, training, or workflow design can undermine a technically sound model.

Explicit trade-offs

Governance does not eliminate trade-offs imposed by time, budget, expertise, and data; it handles them explicitly, proportionately, and accountably.

EPA's "graded approach" scales scrutiny to intended use, impact, uncertainty, and error consequences (EPA 2009); New Zealand guidance likewise stresses proportionality and active management as models evolve (MfE 2023). Prioritisation should weigh output impact, scale of use, unresolved scientific and operational risk, implementation effort, and cost. Cross-functional decisions bring scientific, software, operational, and user considerations together.

Decision risk is the risk that model error, uncertainty, or misuse causes a materially adverse decision. It comprises materiality (potential impact), decision criticality (proximity to a regulatory, assurance, or financial threshold and how determinative the output is), and error-cost asymmetry (relative consequences of false positives and negatives, or over- and under-estimation near a threshold). Rigour should increase with decision risk, not uncertainty alone: higher-risk uses require stronger corroboration, independent review, change-impact assessment, approval and release controls, communication of limitations, and monitoring; lower-risk exploration or screening may justify lighter controls if scope and boundaries remain explicit.

Similarly, model complexity should be proportionate to the fidelity required for the intended decision-support, compliance or assurance function, and the associated decision risk.

These considerations must be balanced against what can feasibly be maintained over time (NRC 2007; Saltelli 2019): unsustainable frameworks cannot govern effectively. Emerging tools such as AI may increasingly enable greater rigour and speed in this regard.

More on governance records

Governance records must support accountability, learning and improvement. The relevant records will differ by audience, but the principle is the same: stakeholders should have visibility into the governance framework, including how decisions are made and how learning is applied to improve systems over time; they

Table 1 Product governance framework for environmental science models.

Governance domain	Key question	Typical governance records
Fit-for-purpose, scope and decision risk	What decision is the model supporting, what is the associated decision risk in terms of materiality, criticality and error-cost asymmetry, and where does the use sit on the soft-to-hard spectrum?	Documented scope and limitations; qualitative decision-risk classification and rationale; guidance and control requirements aligned to the intended use context
Science model development	Is proposed change supported by evidence, peer review, and coherence with the wider system representation?	Technical reports; documented peer review; version rationale
Data stewardship	Are embedded datasets current, quality-assured, and traceable, and how might updates affect outputs?	Dataset provenance; quality assurance records; change notices
Software assurance and auditability	Are changes traceable, tested, reproducible, and recoverable?	Version control; automated tests; regression checks; build/release audit trails
Evaluation and performance	Do outputs correspond adequately to observations and benchmarks for the intended use?	Validation reports; performance metrics; model comparisons; uncertainty analyses
Release governance and change management	What changed, why did it change, and what does it mean for users?	Release notes; impact summaries; stakeholder notices
User enablement and interpretation	Do users have the guidance and capability needed to use outputs responsibly?	User documentation; training and certification; responsive support
Security and privacy	Are data protected within a disciplined risk-management framework?	Information security management system (ISMS) controls and records; independent certification (e.g., ISO 27001)

should also have opportunity to provide feedback and influence outcomes.

Scientists need model descriptions, equations, validation data, peer-review, sensitivity and uncertainty analyses, decision logs, assigned roles, and conflict-of-interest declarations. Government and industry need clear limitations, version change information, and implications for farm planning, assurance, or regulation. Users need workflow guidance, accessible help, and responsive support. Transparency requires both technical documentation and communication intelligible to those unable to inspect code or reconstruct modelling choices (NRC 2007; EPA 2009).

Interoperability extends governance into the wider digital ecosystem: version metadata, assumptions, and data definitions must accompany repurposed inputs and results to preserve traceability.

Practice Example: An evolving product-governance approach in the Overseer context[1]

Overseer is an example that helps make the governance problem tangible. OverseerFM is a cloud-based whole-farm nutrient management tool that combines farm-specific inputs with national soil, climate, and slope datasets to estimate nutrient budgets and greenhouse gas emissions (Overseer Limited 2025). It is used in decision support and has also intersected with assurance and regulatory compliance, which has brought questions of fitness-for-purpose, uncertainty, and governance into public view (PCE 2018; SAP 2021; MfE and MPI 2021; MfE 2024; MPI 2026).

This account marks one point in Overseer's governance journey. It describes strengthened practices without claiming sufficiency or consistent effectiveness and invites discussion rather than adoption without adaptation.

Governance of Overseer has evolved under sustained scrutiny of model architecture, transparency, uncertainty, regulatory fitness, and change consequences (PCE 2018; SAP 2021; MfE and MPI 2021). Those reviews remain active reference points for governance questions and evidence of progress.

Scope and use context

Overseer provides insights into long-term average farm nutrient cycles and losses. To enable decision support at scale, it uses readily available farm information and a steady-state rather than dynamic representation (Overseer Limited 2025). Dynamic models can answer more detailed research questions but demand substantially more configuration data than most New

[2]In this paper, *Overseer* refers to the overall modelling system, while i) *OverseerFM* denotes the primary farm-facing software platform, ii) *OverseerSci* refers to a research and evaluation environment, and iii) *Overseer Limited* is the organisation responsible for stewarding product governance.

Zealand farms hold. This trade-off matches the principle that model sophistication should fit the intended use (NRC 2007; Saltelli 2019): here, comparing long-term, steady-state outcomes of alternative management scenarios for a farm. It also accords with New Zealand guidance that whole-farm models generally serve as decision-support or one line of evidence, not the sole determinant of hard regulatory outcomes (MfE 2023; PCE 2024).

Guidance for practitioners is critical in this setting. Overseer materials for councils and rural professionals are targeted at addressing the fact that successful use depends not only on the design and quality of the scientific model, but also on the quality of the accompanying training and interpretation guidance (Freeman et al. 2016; MfE 2024).

Cross-functional governance and prioritisation

Overseer Limited's internal Product Governance Committee combines scientific, modelling, software, and business perspectives, and partners with specific external expertise to co-develop science, modelling, software and security. This reduces science-only or software-only decisions but cannot itself ensure effectiveness; governance must still test whether perspectives are independent and diverse, disagreements are resolved, and rationales are visible to affected stakeholders.

Table 2 shows a weighted rubric used to compare Overseer backlog items and clarify short- to medium-term sequencing. Its Overseer-specific[2] criteria are not generally applicable; the broader point is that impact, risk, and effort considerations are more visible and open to challenge than informal prioritisation. The composite score supports, but does not replace, judgement. Its value depends on sound assessments and weights and on reviewing its effectiveness over time.

Scoring sequences the agreed backlog over the short to medium term; a complementary strategic horizon selects longer-term workstreams according to stakeholder priorities and funding, decision-risk considerations, relevant research programmes into which the team seeks visibility and input, regulatory and industry shifts, and enabling technologies such as AI.

In this rubric, "Urgency" may overlap other criteria but usefully elevates work driven by practical deadlines or other timing constraints.

The inclusion of business considerations in the rubric makes explicit a potential tension within product governance. Financial sustainability may affect the ability to maintain the product, but commercial considerations should not override minimum requirements relating to scientific integrity, legal obligations, information security, or high-consequence decision uses.

In summary, this rubric has proven useful for a small, tight-knit team like Overseer but is not expected to translate well as-is to larger organisations.

Work prioritisation sequences candidates; decision-risk classification sets minimum governance rigour. High-risk work therefore requires escalation, review, validation, approval, and communication, in collaboration with relevant external stakeholders and experts, regardless of its prioritisation score.

This work prioritisation approach is also consistent with principles-based governance, in which boards and governing bodies define decision frameworks and constraints while delegating judgement within them (Carver 2006), improving accountability and adaptability without prescribing rigid rules.

Evidence trail, evaluation, and managed change

Overseer's evidence trail spans model descriptions, redevelopment evaluations, validation studies, and versioned releases with communication (Overseer Limited 2025; MPI 2023; Tavernet 2023a; Overseer Limited 2026a; 2026d). Because release does not end governance, a live product needs continuing stewardship and explanations of each change's rationale and consequences (MfE 2023; PCE 2024).

Whole-farm nutrient-loss validation is difficult because "true" losses can only be measured imperfectly, so confidence relies on multiple evidence lines. Redevelopment studies compared modelled nitrate loss with lysimeter observations using standard performance metrics and examined sensitivity and uncertainty (MPI 2023; Tavernet 2023a; Tavernet 2023b; Moriasi et al. 2015). They add evidence without fully resolving dataset representativeness, structural uncertainty, transferability, or fitness for specific uses; governance must continually investigate and disclose evidence, limitations, uncertainty, and disagreement.

Changes to science and implementation require tightly managed quality assurance: in Overseer, impact analysis spans more than 170,000 farm analyses, and materially changed results are checked for sensibility. Validation datasets test for degraded predictive accuracy, alongside software regression testing.

OverseerSci packages the science model for independent dataset runs, parameter-change interrogation, and comparisons across farm scenarios or science-model versions, supporting research and release-cycle evaluation (Overseer Limited 2026e).

[3]In Table 2, criteria that would elevate work prioritisation with increasing assessment level (e.g., Strategic Alignment) incur an incrementally positive score with each level. Conversely, criteria that would lower work prioritisation (e.g., Implementation External Cost) incur an incrementally negative score with each level. The individual scores are then summed for the overall priority score.

Table 2 Example: prioritisation rubric being tested in the Overseer case.

Criterion	Assessment Level
Strategic Alignment	Low, Medium, High
Potential Impact on Farm-scale Modelled Result	Low, Medium, High
Potential Scale of Impact	Few, Many
Risk to Model/Software Confidence if Unaddressed	Low, Medium, High
Risk to Revenue if Unaddressed	Low, Medium, High
Urgency	Low, Medium, High
Implementation External Cost	Low, Medium, High
Implementation Internal Effort	Low, Medium, High

Such tools strengthen governance by enabling custodians to test, compare, and interrogate model behaviour as science and user features evolve, rather than investing only in the production platform.

Transparency for different audiences

Transparency is audience-specific: scientists need technical descriptions, equations, and evaluation evidence by suitably credentialled authors; government and industry need limitations, assumptions, and version implications; users need workflow guidance and timely support. Overseer's model descriptions, release notices, and AI-assisted knowledge base reflect this layered documentation increasingly common in cloud model products (Overseer Limited 2025; 2026c; 2026d).

Proprietary software or IP can reduce external visibility and complicate trust (NRC 2007). Published descriptions, peer review, evaluation reports, and release communications mitigate but cannot remove this constraint. A continuing question is whether Overseer's assurance material gives each audience enough visibility, especially for higher-consequence uses, and what further external access or review is warranted.

Security as part of product governance

For farm-data platforms, information security is a core part of governance: data must be protected, managed, and made available within a disciplined control environment. Overseer's ISO/IEC 27001:2022 alignment and attention to secure cloud development reflect this (ISO 2022; NIST 2022; Overseer Limited 2026b). Any digital environmental-model platform handling sensitive operational data requires security assurance within its governance framework.

Future work

The Overseer experience also demonstrates that product governance must be treated as an ongoing process.

Integration of te Tiriti o Waitangi and te ao Māori perspectives remains underdeveloped. New Zealand guidance treats it as integral to legitimate, responsible modelling (MfE 2023; PCE 2024), and any mature governance framework in Aotearoa must address it more fully. Experience with the Contaminant Loss Risk Index Tool also shows that this nuanced issue has no one-size-fits-all solution (MfE 2025, p. 29).

Like any governance system, the approach described here will require ongoing evaluation and refinement. Priorities include continuing external engagement, broadening the perspectives that inform governance, and improving how model limitations, uncertainty, and version changes are communicated to different audiences. This ongoing learning is integral to maintaining governance that remains proportionate to changing uses, risks, and stakeholder expectations.

The framework, processes, and records describe an evolving direction, not a complete or consistently applied system. Progress requires sustained investment in capability, time, operational discipline, external engagement, and scrutiny. We offer this account to invite further discussion and contribution.

Conclusion

Environmental models deployed as software require *product governance*. We structure it around governance domains, explicit trade-offs, and visible records; the Overseer example applies these through cross-functional decisions, evidence trails, managed releases, audience-specific transparency, research and validation tools, and security assurance. Rigour should match decision risk assessed through materiality, criticality, and error-cost asymmetry.

Beyond Overseer, publishing science is not the endpoint of stewardship. Models supporting decisions at scale require funded and governed science translation, software development, quality assurance, documentation, training, support, and security. Product governance cannot remove uncertainty or disagreement, but can expose assumptions, trade-offs, evidence, and change pathways; its ability to enable informed, transparent, accountable use remains open to evaluation.

Both the proposed framework and the implementation practices described here should be regarded as

provisional. Their value will depend on how they are tested, challenged, and adapted through experience, external scrutiny, and engagement with those affected by model use.

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