

Irreversible Foreclosure and the Allocation of Justificatory Burden in Governance beyond Epistemic Reach

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Abstract

Governance of the relations between human activity and the wider natural and cosmic field operates under a scale relation that the governance of human affairs has generally been spared. The field within which the relations obtain substantially exceeds both the portion of it that becomes representable to any governing party and the portion of it that any governing party can modify. Existing responses to this relation are largely prohibitive in form. The epistemic tradition running from Hayek through Scott to Luhmann derives restraint from the limits of knowledge; the precautionary tradition derives it from the possibility of serious harm under uncertainty. This paper proposes a criterion that is procedural in form and narrow in trigger. Where a proposed intervention would irreversibly foreclose the generative capacity of trajectories other than the intervener's own, the burden of justification lies with the intervener; below that threshold, competing claims remain plural and are settled by ordinary political and legal means. The criterion is defended by an asymmetry argument, which generalises the quasi-option value of Arrow, Fisher and Henry from a resource to a relational capacity, and it is distinguished from the precautionary principle by two features: its trigger is irreversibility where the precautionary trigger is uncertainty, and its consequence is a dischargeable burden where the strong precautionary consequence is a bar. The paper then states the difficulty that bears most heavily against it. A sequence of individually reversible actions may accumulate to an irreversible foreclosure while every step carries a warrant, and the early-warning literature has itself established that certain classes of transition afford no detectable approach. The consequence drawn is that option preservation operates as the primary rule and that the governing rule is a function of the dynamical state of the system. Two matters are recorded as unsettled and are named as the subject of a companion paper: the authority competent to determine that a system has entered a critical state, and the distribution of the observational capacity on which any such determination depends.

Keywords: irreversibility; option value; precaution; environmental governance; orbital sustainability; generative relational governance.

Draft. This is a working draft. It is circulated for comment, and its arguments, formulations, and open questions are subject to revision. Correction and criticism are welcome at huangwanhong@serendip.ngo.

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Use of generative artificial intelligence. Generative AI assistants (Anthropic’s Claude, OpenAI’s ChatGPT, and Google’s Gemini) were used extensively in preparing this manuscript: for literature survey, for drafting prose from the author’s specifications, for adversarial review of the argument, and for consistency and citation auditing and typesetting. The paper contains two computed figures and one comparative table. The figures report numerical results from models stated in the text, the scripts producing them accompany the source, and no empirical dataset is used; the arguments the figures support are stated in their captions and are established discursively in the sections that carry them. Formulations and objections arose in the course of that exchange as well as from the author. Every claim, argument, and citation was reviewed and decided by the author, who is responsible for the content and for any errors. Bibliographic details are to be verified against the primary sources before reliance.

Suggested citation: Wanhong Huang, *Irreversible Foreclosure and the Allocation of Justificatory Burden in Governance beyond Epistemic Reach*, working draft, 2026.

1 Introduction

This section states the governance problem the paper addresses, exhibits a difficulty shared by the two families of response that presently occupy the ground, states the criterion the paper proposes in their place, and sets out the order of the argument. The method throughout is analytical. The paper derives a criterion from a structural asymmetry, tests it against the case that bears most heavily against it, and records what it leaves unsettled.

Governance has ordinarily been theorised for fields whose participants can be addressed. Parties to a dispute can be summoned, states can be signatories, firms can be licensed, and citizens can be represented. The relations between human activity and the wider natural and cosmic field lack this property throughout. A migration corridor, an atmospheric composition, a night sky and an orbital shell are altered by human activity and answer none of it.

The absence of address is a familiar observation and is by itself of limited consequence, since a governing party may constrain its own conduct toward what cannot answer. A second feature carries more weight. Let $\mathcal{R}_{\text{onto}}$ denote the relational field within which human activity proceeds, $\mathcal{R}_{\text{epi}}$ the portion of that field which becomes representable to a governing party, and $\mathcal{R}_{\text{op}}$ the portion the same party can modify by deliberate action. The governance of human affairs has ordinarily proceeded under conditions where $\mathcal{R}_{\text{epi}}$ and $\mathcal{R}_{\text{op}}$ approach $\mathcal{R}_{\text{onto}}$ closely enough for the difference to be treated as a margin of error. A legislature can in principle survey the population it governs and can in principle reach it. The field this paper considers satisfies

$$\mathcal{R}_{\text{epi}} \subsetneq \mathcal{R}_{\text{onto}}, \quad \mathcal{R}_{\text{op}} \subsetneq \mathcal{R}_{\text{onto}}, \quad (1)$$

with both containments proper by a wide margin and with the further property that neither of $\mathcal{R}_{\text{epi}}$ and $\mathcal{R}_{\text{op}}$ contains the other. A governing party may therefore hold the capacity to alter relations whose wider consequences remain outside its representation. The condition is structural and follows from the situatedness of any symbolic system relative to the field it describes. It is distinct from a shortfall in current instruments, and improvements in observation shift the boundary while leaving the containment in place.

The scale relation of equation (1) is the ground on which the paper works, and two families of response presently occupy it, each deriving a prohibitive conclusion from a premise the present paper accepts.

The first derives restraint from the limits of knowledge. Hayek's account of dispersed and tacit knowledge, Scott's account of the damage done when a governing party imposes legibility on a field whose operation depends on local practical knowledge, and Luhmann's account of the impossibility of steering an operationally closed system all conclude that a governing party should withdraw, decentralise, or confine itself to irritation of a system it cannot direct. The conclusion presupposes a substantive dynamical claim: that the field, left unforced, continues to generate. Where the presupposition holds, the conclusion follows and is valuable. It fails in a class of cases central to the present subject. An orbital shell above a threshold density of fragments proceeds toward cascading collision whether or not any party

acts, and the fragments already present will remain for centuries at the altitudes that matter. Withdrawal in such a case abandons the field.

The second derives restraint from the prospect of serious harm under uncertainty. The precautionary principle in its stronger formulations shifts the burden of justification onto the party proposing an activity whenever the activity might cause serious or irreversible damage and the science remains incomplete. Sunstein's objection to this family is decisive against the strong form and is worth stating precisely, since the present paper must survive it. Risks attend every course of action available to a governing party, including the course of forbidding an activity. A principle triggered by the presence of uncertainty therefore speaks against every option in the choice set at once, and it can guide conduct only by being weakened until the trigger seldom fires.

Both families are therefore keyed to a feature that is either universally present, in the case of uncertainty, or contingently absent, in the case of the field's capacity to recover unaided. What both lack is a trigger stated over a property that some interventions possess and others lack.

Against that shared limitation, the criterion this paper defends is procedural in form and narrow in trigger.

Criterion 1.1 (Allocation of justificatory burden). Where a proposed intervention would irreversibly foreclose the generative capacity of trajectories other than the intervener's own, the burden of justification lies with the intervener. Below that threshold, competing claims remain plural and fall to be settled by ordinary political and legal means.

Three features of this formulation carry the argument and are established in Sections 4 to 6.

The first feature is the trigger: the criterion fires on irreversibility, which is a dynamical property of a proposed foreclosure and not a measure of the value of what is foreclosed. This is what permits the criterion to operate within a framework whose other terms are generative, since a criterion stated in the same currency as the goods it ranks cannot select among them without circularity. The point applies with particular force to the framework within which this paper is written, where generativity is the primitive and where a criterion keyed to generativity alone would license every generative expansion, including the resort, the constellation and the industrial corridor.

The second feature is the consequence: the criterion allocates a burden and imposes no bar. A burden is discharged by argument, and an intervener who shows that the foreclosure is warranted proceeds. This is the feature that answers the paralysis objection, since a burden falling on one side of a question leaves the question decidable.

The third feature is the silence about value: the criterion settles which party must persuade and settles nothing about which claim should prevail. Pluralism about the competing claims survives intact below the threshold and survives intact above it, where the criterion determines the order of argument and leaves its outcome open.

One observation about the present state of international law bears on the paper's ambition and is developed in Section 10. Between May 2024 and July 2025, three international tribunals

delivered advisory opinions bearing on obligations owed in respect of the climate and marine environments. The opinion delivered by the Inter-American Court of Human Rights in July 2025 holds that the prohibition of anthropogenic conduct capable of irreversibly affecting the interdependence and balance of the common ecosystem constitutes a peremptory norm. The formulation is keyed to irreversibility and carries no accompanying account of why irreversibility should occupy that position. The present paper supplies an argument for a criterion that an emerging body of doctrine has begun to assert.

Against these grounds for confidence, the criterion faces a difficulty that arises from the dynamics of the systems it governs, and Sections 7 to 9 are given to it.

Foreclosure is frequently produced by accumulation. Each launch into a congested orbit is individually reversible in the sense that the object can be deorbited, each individually justified, and each individually negligible in its contribution to the density above which cascading proceeds. A criterion triggered by the irreversibility of a proposed intervention will therefore find no intervention to which it applies until the accumulated state has passed the threshold, at which point the foreclosure has occurred. A natural repair is to trigger the criterion on proximity to the threshold in place of on the intervention, and the scientific literature on early warning supplies candidate indicators. That literature has itself established the limits of the repair. Transitions induced by the rate at which a control parameter changes involve no loss of stability of an equilibrium and afford no critical slowing, and transitions induced by noise may occur with no advance signature at all.

The consequence the paper draws is stated in Sections 8 and 9 and is stronger than a caution. Since detection is structurally insufficient, option preservation operates as the primary rule and the governing rule becomes a function of the dynamical state of the system, in the form $\pi = \pi(X_t)$. Two questions raised by that form are recorded as unsettled: the authority competent to determine the state, and the distribution of the observational capacity on which such a determination rests. They are the subject of a companion paper and are recorded in Section 13 as limits of the present paper.

The order of the argument is as follows. Sections 2 and 3 fix the object: Section 2 states the scope of the account, the restrictions it accepts and the positions it declines. Section 3 sets out the prior formulations of restraint under uncertainty and identifies the claim each owns.

Sections 4 to 6 establish the criterion. Section 4 develops the scale relation of equation (1) and derives the epistemic and operational partiality from it. Section 5 states the asymmetry between foreclosure and deferral and generalises the quasi-option value argument from a resource to a relational capacity. Section 6 states and defends Criterion 1.1 and distinguishes it from the precautionary principle along the two axes of trigger and consequence.

Sections 7 to 9 state the difficulty. Section 7 sets out the accumulation problem. Section 8 sets out the detection limits established within the early-warning literature. Section 9 derives the state-dependence of the governing rule.

Sections 10 and 11 treat two settings. Section 10 examines the standing of an irreversibility criterion in the advisory opinions of 2024 and 2025. Section 11 treats the institutional accounting of restraint, where the product of a successful intervention is an absence.

Sections 12 and 13 close. Section 12 argues the positions the paper declines. Section 13 states its limits in three classes and names the questions carried to the companion paper.

2 Scope of the Account and the Restrictions It Accepts

This section fixes the object of the account, states four restrictions that confine it, names the resources imported from elsewhere, identifies the settings in which the criterion is examined, and states four positions the paper declines. The purpose of stating the declinations within the scope, before any of them is argued, is to prevent the criterion from being read as an answer to questions it makes no attempt to reach. Its role in the paper is boundary-fixing: every later section argues within the scope stated in this section and assumes nothing outside it. The section is arranged as follows: §2.1 fixes the object, §2.2 states the four restrictions, §2.3 names the imported resources, §2.4 identifies the two settings of Sections 10 and 11, and §2.5 announces the four positions declined, whose arguments Section 12 supplies.

2.1 The Object of the Account

The object is a proposed intervention by a human party into a relational field of which that party is a member. Three features of this specification carry weight.

The intervention is proposed and therefore prospective. The account addresses the allocation of argumentative burden at the point of decision and addresses the assessment of completed conduct only derivatively.

The party is a member of the field it acts within. The account therefore declines the formulation under which humanity governs nature and adopts the formulation under which a human party governs its own trajectory with respect to a field it belongs to. Writing τ_H for that trajectory and $\mathcal{R}_N$ for the wider field, the object of governance is $\text{Govern}_H(\tau_H \mid \mathcal{R}_N)$. This formulation follows from the scale relation of equation (1): a party whose operational reach falls properly within the field cannot command the field, and an account that concedes the first while asserting the second is inconsistent.

The field contains trajectories that generate. The term is used in the sense fixed by the framework of generative relational being, where a trajectory generates when the relations it participates in produce structures the trajectory did not contain. Nothing in the argument requires that such trajectories be subjects, hold interests, or possess intrinsic value, and Section 12 declines each of these commitments explicitly.

2.2 Restrictions Accepted by the Account

The account is restricted in four respects, each of which narrows what the criterion of Section 6 may be taken to settle.

The first restriction is that the account concerns foreclosure and remains silent about production. A criterion for the allocation of burden where a capacity is destroyed supplies no criterion for the allocation of benefit where a capacity is created.

The second restriction is that the account concerns generative capacity and remains silent about states. The distinction is developed in Section 6 and is the distinction between the persistence of an entity and the persistence of its capacity to continue becoming. A deer that survives the loss of its migration corridor illustrates the difference, and a framework keyed to states records the first while missing the second.

The third restriction is that the account allocates burden and settles no question of justice. A party that discharges the burden may still act wrongly, and a party that fails to discharge it may still hold the better claim on grounds the criterion does not reach.

The fourth restriction is that the account concerns structure and remains silent about magnitude. The criterion sorts interventions by whether the foreclosure they would produce admits reversal and supplies no scale along which foreclosures are ranked once the threshold is passed.

2.3 Resources Imported

Four resources are imported from established literatures, and each is credited at the point where the argument uses it.

The first, the economics of irreversibility under prospective learning supplies the formal core of the asymmetry argument, in the quasi-option value of Arrow and Fisher and of Henry. The present paper's contribution is the generalisation of the argument from an asset to a relational capacity; the argument itself belongs to its authors.

The second, the account of responsibility owed to a counterparty incapable of reciprocity, is taken from Jonas, whose priority in this matter is complete and whose conclusion the present paper narrows.

The third, the classification of critical transitions into those induced by bifurcation, by noise and by rate, is taken from the dynamical systems literature and is used in Section 8 to establish a limit on detection.

The fourth, the analysis of deliberate non-decision as an exercise of power, is taken from Bachrach and Baratz and is used in Section 12 against a position the account might otherwise be read as holding.

2.4 Settings Examined

Two settings are examined in Sections 10 and 11, chosen for lying at opposite ends of the difficulty the account faces.

The first is the treatment of irreversibility in the advisory opinions delivered by international tribunals in 2024 and 2025. The setting is favourable to the account, since the criterion appears there in the highest register available to international law. It is examined for what the doctrine asserts without argument.

The second is the institutional accounting of restraint, where a successful intervention yields an absence. The setting is unfavourable to the account, since the criterion recommends conduct whose product cannot be exhibited. It is examined for what follows about the

provision of restraint under ordinary institutional incentives.

2.5 The Positions Declined

Four positions are declined in the present subsection, and the argument for each declination is given in Section 12, after the results on which it depends have been established.

The first declination is of intrinsic value. The criterion operates over the reversibility of foreclosures and is available to a party holding any view about the standing of what is foreclosed, so the question of that standing is left with the parties who hold views on it.

The second is of a ranking of competing claims. A criterion allocating burden determines the order of argument and leaves the outcome of the argument open, and the silence about outcomes is deliberate.

The third is of a maximand. A quantity defined over preserved possibility and offered for maximisation would range over trajectories and would therefore aggregate, and aggregation permits the compensation that a burden stated per foreclosure exists to withhold, so the account keeps to the per-foreclosure burden.

The fourth is of institutional machinery. Machinery specified from outside is administered by the party whose intervention is at issue, and the specification supplies that party with a determinate account of what compliance consists in. The predictable result is an arrangement complete in every specified feature under which the burden is discharged by the production of documents. The cost of this declination is stated in Section 13: a criterion specifying no machinery gives a party seeking to comply little to build.

3 Prior Formulations of Restraint under Uncertainty

This section sets out the formulations of restraint already available and states for each the claim it owns. The purpose is twofold. The first is to concede priority where priority is owed, and the debts are substantial. The second is to establish, in Claim 3.1, that a class of cases survives every formulation surveyed, and that the criterion of Section 6 is required for that class. The order proceeds from the formulations grounded in the limits of knowledge, through those grounded in the prospect of harm, to those grounded in the structure of choice under irreversibility, and closes with the treatments of restraint available in political theory. The formulation nearest to the criterion this paper defends is the safe minimum standard of conservation, treated at §3.3, and the differences separating the two are stated there at length. Its role in the paper is twofold: it concedes priority to the formulations that own the ground, and it establishes in Claim 3.1 the residual class of cases for which the criterion of Section 6 is required, which is the class the remainder of the paper addresses. The section is arranged as follows: §3.1 treats restraint derived from the dispersal of knowledge, §3.2 restraint derived from the prospect of harm, §3.3 the safe minimum standard of conservation, §3.4 the value of deferral under irreversibility, §3.5 responsibility owed to a non-reciprocating counterparty, §3.6 formal statements of option preservation, §3.7 adaptive and polycentric treatments, §3.8 deliberate non-action in political theory, and §3.9 states Claim 3.1.

3.1 Restraint Derived from the Dispersal of Knowledge

The most developed account of restraint under epistemic limitation is owed to Hayek [9], who argues that the knowledge relevant to economic coordination exists in dispersed, local and partly tacit form, that no central party can assemble it, and that coordination is therefore accomplished by a price system operating without any party holding the whole. The claim owned is that a governing party's ignorance is structural and survives every improvement in its instruments.

Scott [22] establishes a further claim, and it is the one that bears most directly on the present subject. Schemes to improve a complex field fail characteristically when a governing party imposes a simplified legibility on that field in order to administer it, and in so doing destroys the local practical knowledge on which the field's operation depended. The claim owned is that the demand for legibility is itself an intervention, and that a field rendered legible has already been altered.

Luhmann [16] argues that a functionally differentiated society consists of operationally closed systems, each processing its environment through its own distinctions, and that no system steers another. The claim owned is that steering in the cybernetic sense is unavailable across system boundaries, so that a governing party may irritate a field and cannot direct it.

Two further contributions belong to this family. Rittel and Webber [20] establish that a class of planning problems admits no definitive formulation, no stopping rule and no test of correctness, so that solutions are assessed as better or worse and never as true or false. Funtowicz and Ravetz [5] establish that where facts are uncertain, values in dispute, stakes high and decisions urgent, the warrant for a scientific claim must be established by an extended community of peers.

The family shares a conclusion and a limit. The conclusion is prohibitive: a governing party should decentralise, withdraw, or confine itself to the local and the revisable. The limit is that the conclusion presupposes that a field released from direction proceeds acceptably, and the presupposition is a substantive claim about dynamics that the family does not defend and that fails in the cases treated in Section 7.

3.2 Restraint Derived from the Prospect of Serious Harm

The precautionary principle exists in formulations of differing strength. Principle 15 of the Rio Declaration states the weak form, under which the absence of full scientific certainty affords no ground for postponing cost-effective measures against serious or irreversible damage. The Wingspread Statement of 1998 states a strong form, under which the proponent of an activity carries the burden of proof where the activity raises threats of harm even where causal relations remain unestablished. The German *Vorsorgeprinzip* supplies the doctrinal ancestor of both. The claim owned by the family is that incomplete knowledge affords no warrant for inaction where the prospective harm is serious.

Sunstein [25] states the objection that governs the assessment of the strong form. Risks attend every option in a choice set, including the option of prohibiting an activity, so a

principle triggered by the presence of a risk under uncertainty speaks against every option at once and yields no guidance. Sunstein's own proposal narrows the principle to catastrophic outcomes and joins it to cost-benefit analysis. Gardiner [6] defends a narrower core, restricting the principle to circumstances satisfying the conditions under which a maximin rule is rationally required, and the defence establishes that the incoherence objection reaches the unrestricted form and leaves a restricted form standing.

The present paper accepts the objection and adopts a restriction of a different kind. The restriction proposed in this paper operates on the trigger and leaves the strength of the consequence reduced, where Gardiner's operates on the conditions of application and leaves the consequence at full strength.

3.3 The Safe Minimum Standard of Conservation

The formulation nearest to the criterion this paper defends is older than the precautionary family and is owed to resource economics.

Ciriacy-Wantrup [36] introduced the safe minimum standard of conservation expressly to bring uncertainty together with irreversibility into the appraisal of projects bearing on the natural environment, proposing a level below which a stock should not be permitted to fall. Bishop [35] supplied the formulation the literature has used since, under which the standard is adopted, and the irreversible loss thereby avoided, unless the social costs of adopting it are unacceptably large. Norton and Toman [38] later proposed a two-tiered arrangement in which a calculus of costs and benefits gives way to a conservationist mode as considerations of irreversibility and of intergenerational justice increase in weight.

The claim owned by this family is the one the present paper contests least. A presumption against irreversible loss, defeasible by sufficient countervailing reason, is stated there, it is stated with irreversibility as its trigger, and it is stated three decades before the precautionary formulations of §3.2 acquired their present form. The present paper claims no priority for the presumption and claims priority for none of its parts.

Three differences separate Criterion 6.1 from the safe minimum standard, and the first carries the separation.

The defeater of the safe minimum standard is an aggregate. Unacceptability of social cost is assessed over the parties affected, so the standard yields to a sufficient sum of countervailing interests, and a foreclosure of one capacity is thereby traded against enlargements of others. Section 12 establishes formally that any quantity defined over the preserved capacity of a field takes a single value for a field containing many trajectories, therefore aggregates, and therefore licenses exactly this substitution. Criterion 6.1 is stated per foreclosure and withholds it, so that reasons offered under the criterion are reasons bearing on the foreclosure at issue and never a sum computed across the field.

The safe minimum standard sets a level and requires that the level be specifiable in advance. A minimum population, a minimum flow, a minimum area: each is a quantity fixed before the standard operates. Criterion 6.1 sets no level and allocates an argumentative burden, and §4.3 establishes why a criterion conditioned on a prior specification is unavailable

where enlarging the represented sub-field is itself an intervention.

A second difference is that the standard is stated over development decisions. A party proposing to develop bears the standard and a party proposing to defer bears nothing, and §5.5 establishes that a formulation so stated releases the party whose foreclosure is produced by delay.

The two-tiered arrangement of Norton and Toman stands nearer to the present construction than the standard itself, since it makes the mode of reasoning depend on the degree of irreversibility at issue. The difference is that a two-tiered arrangement switches the decision procedure at the threshold, so that a party above the threshold reasons differently from a party below it, where Criterion 6.1 switches the allocation of the burden of justification and leaves the procedure by which the question is settled unchanged.

3.4 The Value of Deferral under Irreversibility and Prospective Learning

The formal core of the present paper's argument is owed to a result in environmental economics, and the value category on which that result operates was supplied a few years earlier. Krutilla [37] established that an unspoiled natural environment carries value to parties who neither presently use it nor may ever use it, distinguishing the value attaching to the retention of a future possibility of use from the value attaching to use itself. The claim owned is that retention has a value statable in the terms of the decision, and the present paper's argument is constructed so as to require no such statement, for the reason given at §5.3.

Arrow and Fisher [1] and Henry [10] established independently in 1974 that where a development decision is irreversible and where information bearing on its desirability is expected to arrive, the expected value of preserving the undeveloped option exceeds the value computed by ignoring the prospect of learning. Hanemann [7] subsequently formalised the surplus as quasi-option value and identified it as the value of the information that preservation makes usable.

The claim owned is precise and the priority is complete. Under irreversibility together with prospective learning, a rational party biases its choice toward the reversible option, and the bias follows from the structure of the decision without any appeal to the value of what would be developed.

Two features of the result bound its reach and open the space the present paper occupies. The result is stated for an asset whose value is expressible in the units of the decision, and the estimation of quasi-option value has proved difficult where such units are unavailable. The result is stated for a party choosing on its own account, and the allocation of burden between parties lies beyond it.

3.5 Responsibility Owed to a Counterparty Incapable of Reciprocation

Jonas [12] established the question of what is owed to a counterparty that cannot claim, negotiate, or reciprocate, and did so for a technological civilisation whose reach extends

beyond the horizon within which its consequences can be assessed. Three elements of the account are owed to him without qualification: the asymmetry of the responsibility relation, where the party bearing the duty holds all the power and the party protected holds none; the heuristic of fear, under which the imaginative representation of what is at stake precedes and enables its valuation; and the priority accorded to the adverse prognosis over the favourable one where the stakes admit no recovery.

The present paper narrows Jonas's conclusion in one respect and extends it in another. It narrows the conclusion by declining the general imperative and substituting a criterion that fires on a determinate structural property. It extends the counterparty class beyond future humanity, to which Jonas's argument is principally addressed, to contemporaneous trajectories that generate and do not speak.

Parfit [18] established the non-identity problem, under which a policy affecting which persons come to exist cannot straightforwardly wrong those persons by comparison with an alternative under which they would not have existed. Brown Weiss [4] established intergenerational equity as a doctrine of international law, resting on a planetary trust held by each generation for its successors. Both are addressed to the temporal case and neither reaches the contemporaneous case that Claim 3.1 identifies.

3.6 Formal Statements of Option Preservation

A formal treatment of option preservation independent of the economics literature is available in the work of Klyubin, Polani and Nehaniv [14], who define empowerment as the channel capacity between an agent's actions and the states of the world subsequently available to it, and propose its maximisation as an objective that is specified without reference to any particular goal. The claim owned is that the preservation of future options admits a quantitative, goal-independent formulation.

The formulation is used in the present paper as evidence that option preservation is well defined, and it is declined as a governing rule for the reason given in Section 12: an objective function defined over preserved possibility ranges over trajectories and therefore aggregates.

3.7 Adaptive and Polycentric Treatments of Institutional Design

A large institutional literature treats governance under ecological uncertainty. Holling [11] established resilience as the persistence of a system's relationships under disturbance, distinguishing it from stability near an equilibrium. Walker and colleagues [26] subsequently distinguished resilience, adaptability and transformability, and the distinction is used in Section 6, since a system may hold high resilience by having become rigid. Ostrom [17] established that commons are governed successfully by users under identifiable institutional conditions, and the polycentric extension of that work supplies the standard argument against reliance on a single global authority. Young [27] established the problem of fit, under which institutions fail where their spatial and temporal boundaries diverge from those of the ecosystems they govern.

The family owns the design of institutions that learn. A criterion determining which foreclosures a learning institution should decline to perform lies outside what the family supplies, and that space is the one Section 6 occupies.

3.8 Treatments of Deliberate Non-Action in Political Theory

Political theory has treated deliberate non-action principally as an exercise of power. Bachrach and Baratz [3] established non-decision as the second face of power, under which a party controls outcomes by confining the agenda to matters innocuous to it. The result bears against the present paper and is treated in Section 12, since a criterion recommending that certain possibilities remain unrealised will be exercised by whichever party the unrealised state favours.

Treatments of restraint as an achievement are comparatively scarce. Levitsky and Ziblatt [15] identify forbearance, the restrained exercise of a legal power, as a norm on which constitutional systems depend, and the treatment is confined to relations among political competitors. The Daoist tradition supplies the most developed account of non-forcing as a governing posture, and Slingerland [23] establishes that the tradition has been over-read as a technique of government at the expense of its status as an ideal of action. The present paper draws on that tradition as a dialogue partner and declines to found the criterion upon it, for the reason given in Section 7: non-forcing presupposes that the field recovers when released, and the presupposition fails precisely where foreclosure is irreversible.

3.9 The Class Surviving the Surveyed Formulations

Claim 3.1 (Residue of the surveyed formulations). The formulations surveyed locate the ground of restraint in the structural dispersal of knowledge, in the prospect of serious harm under scientific uncertainty, in a presumption against irreversible loss defeasible by an aggregate of countervailing cost, in the value of information under irreversibility where an asset is priced, in a duty owed to a temporally distant counterparty, in the maintenance of institutional adaptive capacity, or in the control of an agenda. Where the relevant knowledge is adequate, where no scientific uncertainty attends the outcome, where no level can be specified in advance for the capacity at issue, where no asset is priced, where the affected trajectory is contemporaneous and neither human nor a bearer of interests, and where the adaptive capacity of every institution concerned remains undiminished, an intervention may still irreversibly foreclose the capacity of that trajectory to continue generating. The safe minimum standard reaches such a case and yields to a sufficient sum of countervailing interests, and no formulation surveyed allocates the burden of justification per foreclosure.

The class is populated and its members are ordinary. A migration corridor crossed by a development corridor is the standard instance, and it exhibits the residue against the safe minimum standard as well as against the rest. No population level is specifiable for the capacity the corridor supplies, since what the corridor supplies is a route and not a stock; and where a level is nonetheless fixed, the standard yields on a showing that the development's

benefits exceed the cost of foregoing it, which is the aggregate the present criterion withholds. The outcome carries no scientific uncertainty, since the effect of severing a corridor on the population that used it is well established. No asset is priced, since the corridor has no market and its occupants make no claims. The affected population is contemporaneous with the party developing, so no appeal to future generations is available. Every institution involved may hold ample capacity to learn from the outcome, and the capacity is of no use, since the corridor cannot be reconstituted once the land use has changed.

The remainder of the paper is addressed to that residual class, and Section 4 begins by establishing the structural premise on which a criterion for it must rest.

4 The Scale Relation between the Relational Field and the Capacities of a Governing Party

This section establishes the structural premise on which the remainder of the argument rests. It states the containments introduced at equation (1), derives the epistemic and operational partiality of a governing party from a property of the field together with a property of any party situated within it, identifies the regime in which the two partialities stand in their most consequential relation, and states what the premise withholds. Its role in the paper is to supply the structural premise: the partiality derived in this section is what Sections 5 and 6 use to construct a criterion that operates without a common measure over what it protects. The section is arranged as follows: §4.1 states the containments and their terms, §4.2 derives partiality from situatedness, §4.3 states the cost attaching to enlargement of the represented sub-field, §4.4 treats the regime in which reach exceeds representation, and §4.5 states the exclusions. The method is analytical, and the section makes no empirical claim about the magnitude of any containment in any particular case.

4.1 The Containments and Their Terms

Let $\mathcal{R}_{\text{onto}}$ denote the relational field within which a governing party acts, understood as the totality of relations obtaining among the trajectories present, together with their dynamics. Let $\mathcal{R}_{\text{epi}}$ denote the sub-field that becomes representable to that party, in the sense that the party can form and revise a description of it. Let $\mathcal{R}_{\text{op}}$ denote the sub-field the party can modify by deliberate action.

Three relations hold for the governance of human activity within the wider natural and cosmic field.

Premise 4.1 (Scale relation). $\mathcal{R}_{\text{epi}} \subsetneq \mathcal{R}_{\text{onto}}$ and $\mathcal{R}_{\text{op}} \subsetneq \mathcal{R}_{\text{onto}}$, with each containment proper. Further, $\mathcal{R}_{\text{op}} \not\subseteq \mathcal{R}_{\text{epi}}$ and $\mathcal{R}_{\text{epi}} \not\subseteq \mathcal{R}_{\text{op}}$.

The first two clauses state that a governing party represents a portion of the field and reaches a portion of it. The third states that the two portions cross: a party may hold the capacity to alter relations it cannot represent, and may represent relations it cannot alter.

4.2 The Derivation of Partiality from Situatedness

The containments of Premise 4.1 admit two readings, and the difference between them determines what the premise can support.

Under the first reading, the containments record a shortfall in the instruments presently available. Better sensors, longer records and improved models would enlarge $\mathcal{R}_{\text{epi}}$ toward $\mathcal{R}_{\text{onto}}$, and the containment would close in the limit. On this reading the premise is a statement about the current condition of science, and what it supports is a programme of investment in place of a criterion of conduct.

Under the second reading, which the paper adopts, the containments follow from the situatedness of any representing party within the field it represents. A representation is generated by a system that occupies a position in the field, operates through a finite set of distinctions, and admits into its descriptions those features its distinctions register. The field contains relations that no such system registers, and it contains them for every such system, since the property responsible is the finitude and positionality of the representing system and not the coarseness of any particular set of distinctions. Improvements in instruments therefore move the boundary of $\mathcal{R}_{\text{epi}}$ and leave the containment in force.

The second reading carries a commitment that requires care in its statement. It asserts a property of the relation between a field and the systems that describe it, and it asserts nothing about the field considered by itself. A claim that the field is intrinsically unknowable would convert a limitation of every situated describer into a positive attribute of what is described, and the conversion is unavailable, since the evidence for the limitation is evidence about describers. The premise is accordingly perspectival in its ground and structural in its force. It holds for every party and for every state of the instruments, and it attributes nothing to the field beyond the excess it exhibits relative to any description of it.

4.3 The Cost Attaching to Enlargement of the Represented Sub-Field

A governing party seeking to enlarge $\mathcal{R}_{\text{epi}}$ acts upon the field in doing so, and Scott [22] established the consequence. A field is rendered administrable by the imposition of categories under which its elements become countable, comparable and assignable, and the imposition characteristically displaces the local practical knowledge through which the field had been operating. The enlargement of the represented sub-field is therefore an intervention with its own effects, and a governing party that pursues representational completeness as a precondition of acting has already acted.

Two consequences follow for the present argument. The first is that a criterion conditioned on the completeness of the party's representation would license an unbounded programme of measurement, and the programme would alter what it measured. The second is that a criterion must be statable on the information a party holds at the point of decision. Criterion 1.1 is so statable, since irreversibility of a proposed foreclosure is a property of the proposal and of the field's dynamics under it, and its assessment requires no survey of the field entire.

4.4 The Regime in Which Reach Exceeds Representation

The third clause of Premise 4.1 admits two orderings of the crossing sub-fields, and they carry different pathologies.

Where $\mathcal{R}_{\text{epi}}$ substantially exceeds $\mathcal{R}_{\text{op}}$, a governing party understands more of the field than it can alter. The characteristic failure is impotence, and the party observes a deterioration it lacks the means to arrest. The failure is severe and it is legible: the party can say what is happening and can say that it cannot act.

Where $\mathcal{R}_{\text{op}}$ substantially exceeds $\mathcal{R}_{\text{epi}}$, a governing party alters more of the field than it represents. The characteristic failure is the production of consequences the party holds no description of, and the failure is illegible in a specific and important sense: the party has no representation under which the consequence appears, so the absence of an observed effect carries no evidential weight. This is the regime in which a technological capacity outruns the understanding of what it operates on, and it is the regime that Premise 4.1 identifies as governing the present subject.

The asymmetry between the two orderings is what makes the scale relation a premise for a criterion in place of an occasion for humility. A party in the first regime requires capacity. A party in the second requires a rule statable without the representation it lacks.

4.5 Exclusions from the Scale Premise

Three matters lie outside Premise 4.1 and are stated in the present subsection so that Sections 5 to 9 are not read as resting on them.

The premise is qualitative. It asserts that the containments are proper, their properness stands ungraded by any quantity, and the argument of Section 5 uses no such quantity.

Nor does the premise carry a claim about the field's disposition. Nothing in it asserts that the field is self-maintaining, self-repairing, or adaptive. Those are positive claims about dynamics, they are true of some sub-fields and false of others, and Section 7 turns on a case where they are false.

The premise carries, finally, no prohibition. A party may act within a field it represents partially, and the whole of ordinary human life consists in doing so. What the premise establishes is that a criterion for such action cannot be conditioned on the party first holding an adequate representation of what it acts upon.

5 The Asymmetry between Foreclosure and Deferral

This section supplies the argument on which Criterion 1.1 rests. It states the asymmetry informally, reconstructs the formal result that establishes it for a priced asset, generalises that result from an asset to a generative capacity, and then establishes the bound within which the asymmetry holds. The bound is the section's principal contribution and it operates against the criterion: deferral carries its own foreclosure where the field drifts while a party defers, and above a determinate drift rate the presumption in favour of deferral is defeated. Its role in

the paper is load-bearing: Criterion 6.1 rests on the asymmetry established in this section, and the bound established at §5.4 supplies the limit that Section 13 carries forward. The section is arranged as follows: §5.1 states the asymmetry informally, §5.2 reconstructs the classical result for a priced asset, §5.3 generalises it to a generative capacity in Claim 5.1, §5.4 establishes the drift bound in Proposition 5.2, §5.5 states the consequence for the criterion, and §5.6 states the exclusions. The method is analytical for the generalisation and formal for the bound, which is stated as Proposition 5.2 and verified numerically.

5.1 Informal Statement of the Asymmetry

Two courses are available to a party contemplating an intervention that would foreclose a capacity held by another trajectory. It may proceed, and it may defer.

Proceeding and deferring stand in an asymmetric relation with respect to what each leaves available. A party that defers retains the capacity to proceed later, and the interval of deferral is an interval during which information bearing on the wisdom of proceeding may arrive. A party that proceeds, where the foreclosure is irreversible, retains no capacity to restore what the intervention destroyed, and information arriving after the intervention bears on a choice that is closed.

The asymmetry is a property of the structure of the decision. It appeals to no valuation of what would be foreclosed, and it holds whatever the party's view of the relative merits of the two outcomes.

5.2 The Result Established for a Priced Asset

Arrow and Fisher [1] and Henry [10] established the asymmetry formally for a development decision concerning an asset whose alternative uses are valued in common units. Where development is irreversible and where information bearing on the relative value of the two uses is expected to arrive, the expected value of the development option computed under the prospect of learning falls below the value computed by ignoring that prospect, and the difference is a positive quantity attaching to preservation. Hanemann [7] identified the quantity as the value of the information that preservation renders usable.

Two features of the classical statement bound its application, and both were noted in Section 3. The result is stated for an asset priced in the units of the decision, and the estimation of the surplus has proved difficult where such units are unavailable. The result is stated for a single party choosing on its own account, and it therefore yields a recommendation to that party and no allocation of burden between parties.

5.3 The Generalisation from an Asset to a Generative Capacity

The generalisation this paper requires replaces the priced asset with the capacity of a trajectory to continue generating, and it replaces the party's own valuation with the allocation of an argumentative burden.

Claim 5.1 (Generalised asymmetry). Let an intervention foreclose the capacity of a trajectory

to continue generating, and let the foreclosure admit no reversal. Then the asymmetry of §5.1 obtains with respect to that capacity, and it obtains without any valuation of the capacity being available.

The argument for Claim 5.1 turns on what the classical result uses. The formal content of quasi-option value is the observation that an irreversible act removes a branch of a decision tree that a reversible act preserves, together with the observation that information arriving later has value only where a branch remains open for it to bear upon. Neither observation refers to the price of what occupies the removed branch. Pricing enters the classical treatment because that treatment computes a magnitude, and the present argument computes no magnitude. It concludes that one option preserves a structure the other destroys, which is a comparison of the two courses and not a valuation of either.

The consequence is the feature identified in Section 1 as carrying the criterion. A framework whose primitive is generativity cannot select among generative expansions by appeal to generativity, since every candidate exhibits it. The asymmetry supplies a selector stated over the structure of the decision, and a criterion resting on it is therefore available inside such a framework without circularity.

5.4 The Bound on the Asymmetry Set by Drift during Deferral

The classical treatment reconstructed at §5.2 holds the field fixed during the interval of deferral. Where the field drifts, deferral acquires a cost of its own, and the cost is of the same kind as the one deferral was adopted to avoid. A transition may be reached by the passage of time under an unchanged policy, and the capacity a party deferred in order to preserve may be foreclosed while the party defers.

Consider a party choosing at $t = 0$ between intervening and deferring, with a signal arriving at $t = 1$ that reveals whether the field's continued generation or the intervention's product carries the greater value. Write V_Q for the value realised by intervening, V_P for the value realised by leaving the field intact, p for the probability that the signal favours the field, and r for the fraction of the preserved capacity destroyed by drift during the interval of deferral. Intervening at $t = 0$ commits the party. Deferring preserves the choice and admits the drift. The expected values are

$$\text{EV}(A) = V_Q, \quad \text{EV}(D) = p V_P (1 - r) + (1 - p) V_Q, \quad (2)$$

and the option value of deferral is $\text{OV}(r) = \text{EV}(D) - \text{EV}(A)$.

Proposition 5.2 (Directional bound). Let $V_P > V_Q$ and $0 < p \leq 1$. Then (i) $\text{OV}(0) > 0$, so deferral is preferred where the field does not drift; (ii) OV is strictly decreasing in r ; and (iii) there exists $r^* = 1 - V_Q/V_P$ in $(0, 1)$ with $\text{OV}(r^*) = 0$, so that for $r > r^*$ intervening is strictly preferred to deferring even though intervening is the irreversible act.

The three clauses are verified over the parameter ranges stated, and Figure 1 displays the option value against the drift rate at four learning probabilities.

One feature of the root deserves record, since it runs against an expectation the classical

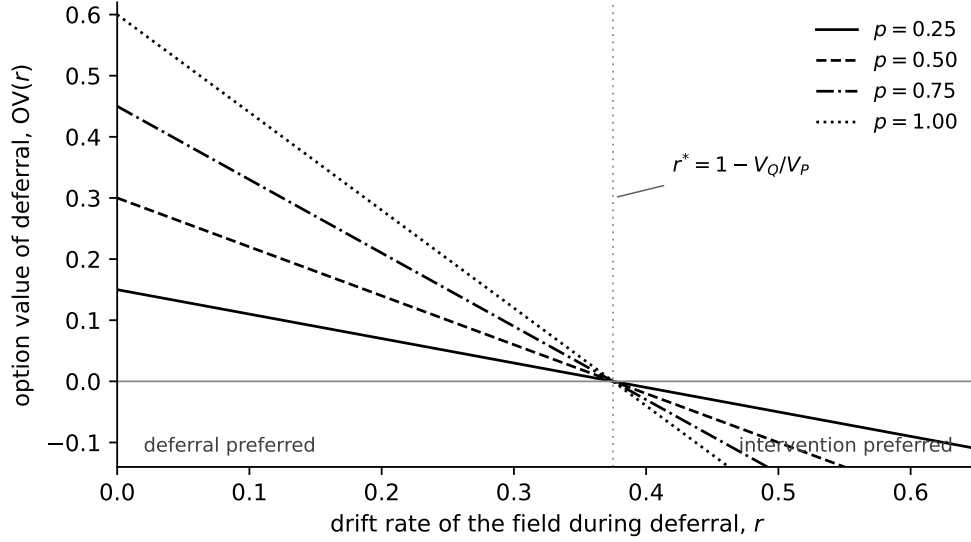


Figure 1: Option value of deferral against the drift rate of the field during the interval of deferral, at four values of the learning probability p , for $V_P = 1.6$ and $V_Q = 1.0$. The option value is positive at low drift rates and changes sign at $r^* = 1 - V_Q/V_P$. The location of the root is fixed by the ratio of the valuations and is independent of p ; the magnitude of the option value depends on p .

result invites. The bound r^* depends on the ratio V_Q/V_P alone and stands independent of the learning probability p . A party that expects to learn a great deal by deferring therefore gains a larger option value at every drift rate below the bound, and gains no extension of the bound itself. The prospect of learning governs how much deferral is worth and settles nothing about how long the field will wait.

5.5 The Consequence for the Statement of the Criterion

Proposition 5.2 requires that the criterion be stated over foreclosure and not over intervention.

A criterion attaching the burden of justification to intervention alone would treat deferral as the position requiring no argument, and Proposition 5.2 establishes that the treatment is unavailable where $r > r^*$. The energy transition supplies the standing instance. A party deferring a transition defers an intervention, and the field drifts during the deferral toward a state in which the capacity that transition would have preserved has been foreclosed. Under a criterion stated over intervention, the deferring party carries no burden. Under a criterion stated over foreclosure, the burden falls upon it, since its course forecloses irreversibly and the alternative course does not.

Criterion 1.1 is accordingly stated over the foreclosure a course would produce, and it is indifferent to whether the course consists in acting or in declining to act. The companion paper on the four operations reaches the same case from the other side, excluding deferred transition from the operation of withholding on the ground that a withholding performed in a drifting field retains nothing. This is the respect in which it departs most sharply from the traditions surveyed in Section 3, each of which attaches its presumption to the party proposing to act.

5.6 Exclusions from the Asymmetry Argument

Three matters lie outside the argument of this section, concerning respectively the determination the argument presupposes, the standing of its construction, and the ordering it yields.

The first is that the argument begins where a determination of irreversibility has been made and establishes what follows from it; the making of the determination is a separate task, and Section 13 records the determination itself as an unresolved difficulty.

The second is that the two-period construction of §5.4 is an existence argument and no model of any actual decision. Its role is to establish that the bound exists and that the sign of the option value can change, and it supports no estimate of r^* in any case.

The third is that the argument establishes an ordering of two courses, the ranking of the states they lead to lying outside it. A party whose course carries the burden may discharge it, and Section 6 states what discharging it consists in.

6 The Condition on the Allocation of Justificatory Burden

This section states the criterion in full, fixes the sense of each of its terms, establishes what discharges the burden it allocates, and distinguishes it from the precautionary principle along the two axes of trigger and consequence. It closes by establishing that the criterion allocates per foreclosure and admits no aggregation, and by stating what it leaves to ordinary political settlement. Its role in the paper is central: the criterion stated in this section is the paper's thesis, and every section after it either tests the criterion against a difficulty or examines it in a setting. The section is arranged as follows: §6.1 states the criterion and fixes its terms, §6.2 states the content of the burden and its discharge, §6.3 establishes the per-foreclosure property, §6.4 distinguishes the criterion from the precautionary principle along the axes of trigger and consequence, and §6.5 states what remains settled by ordinary means. The method is analytical throughout, and the comparison of §6.4 is displayed in Table 1.

6.1 The Criterion and the Sense of Its Terms

Criterion 6.1 (Allocation of justificatory burden). Where a course available to a party would irreversibly foreclose the capacity of a trajectory other than that party's own to continue generating, the burden of justification for adopting that course lies with the party adopting it. Where no course available to the party would produce such a foreclosure, competing claims among the available courses remain plural and fall to be settled by ordinary political and legal means.

Four terms carry the criterion, and each is fixed here in the sense the later sections use.

A *course* includes acting and declining to act. This follows from Proposition 5.2 and is the respect in which Criterion 6.1 departs from every formulation surveyed in Section 3. A party that defers adopts a course, and where the field drifts during deferral the course may foreclose.

Foreclosure concerns capacity in place of state. The distinction is the one Walker and

colleagues [26] draw within the resilience literature between the persistence of a system and its adaptability, and it is the distinction between a population that survives and a population that retains the relational conditions under which it continues to produce new arrangements. A herd that persists in a fragment with its migration corridor severed exhibits the first and has lost the second. A criterion keyed to states records the survival and misses the foreclosure.

Irreversibility is relative to available means and to a horizon fixed by the trajectories concerned. A foreclosure is irreversible where no course available to any party returns the field to a condition in which the foreclosed capacity operates, within a period that the affected trajectories can traverse. Two consequences follow from this relativity and both are accepted. Irreversibility is a factual matter admitting dispute, and it stands as a claim about available means in place of a metaphysical attribute of an act. And a foreclosure may be irreversible at one horizon and reversible at another, so the horizon must be stated whenever the criterion is applied. Section 13 records the determination of irreversibility as the criterion's principal unresolved difficulty.

The reversibility of an *act* is distinct from the reversibility of the *foreclosure* it produces, and conflating the two defeats the criterion. A satellite may be deorbited, which reverses the act. Where its fragmentation has already raised the debris density above the value at which collision becomes self-sustaining, the foreclosure stands. Section 7 turns on this distinction.

6.2 The Content of the Burden and Its Discharge

The burden allocated by Criterion 6.1 is argumentative. A party bearing it is required to state the foreclosure its course would produce, to state the horizon at which the foreclosure is claimed to be irreversible, and to give reasons sufficient to warrant proceeding in the face of it. A party that gives such reasons proceeds.

Three features of this construction carry weight, concerning respectively the discharge of the burden, its bearer, and the question it leaves open.

The first is that the burden so stated is dischargeable, and this is the feature that answers the paralysis objection recorded in §3.2. Sunstein's argument establishes that a principle speaking against every option in a choice set yields no guidance. A burden allocated to one side of a question leaves the question decidable, and it remains decidable where the burden falls on every available course, since the party then compares the reasons offered for each.

The second is that it falls on a determinate party and is therefore addressable. This distinguishes the criterion from a general injunction toward caution, which no party in particular is charged with satisfying and which is accordingly satisfied by no party in particular.

The third is that its concern is the order of argument, so that the outcome it leaves open is the whole of the substantive question. A party may bear the burden, discharge it, proceed, and be wrong. The criterion records nothing about that case, and §6.5 states why the silence is deliberate.

Table 1: Trigger and consequence across the formulations that allocate an argumentative burden, together with the party charged and the act that discharges the charge.

Formulation	Condition triggering the allocation	Consequence for the party charged	Party charged	Act discharging the charge
Rio Declaration, Principle 15	Serious or irreversible damage under incomplete certainty	Removal of a ground for postponing measures	The party invoking uncertainty	Demonstration that measures lack cost-effectiveness
Wingspread formulation	Threat of harm, causation unestablished	Proof of safety required before proceeding	The proponent of the activity	Demonstration of safety
Gardiner, core principle	Conditions under which maximin is rationally required	Selection of the maximin option	The decision maker	Showing the conditions fail
Arrow, Fisher and Henry	Irreversibility with prospective learning	Positive value attaching to deferral	The party choosing on its own account	Computation showing the surplus outweighed
Criterion 6.1	Irreversible foreclosure of another trajectory's generative capacity	Argumentative burden, the course remaining available	The party adopting the course, whether that course is action or deferral	Reasons warranting the foreclosure at the stated horizon

6.3 The Per-Foreclosure Property

Criterion 6.1 is stated over a single foreclosure affecting a single trajectory, and the statement admits no summation over trajectories.

An arrangement satisfying the criterion for many trajectories and failing it for one has failed it. No surplus of preserved capacity held elsewhere in the field repairs the failure, and no quantity of foreclosures avoided offsets a foreclosure produced.

The property is the reason Section 12 declines an objective function defined over preserved possibility. A function of that form ranges over trajectories and therefore aggregates, and aggregation licenses precisely the offsetting that a per-foreclosure statement withholds. The point holds under every substitution of the maximand, including maximands defined over the property Criterion 6.1 itself names, and the formal argument is given at §12.3.

6.4 The Axes Separating the Criterion from the Precautionary Principle

Criterion 6.1 and the precautionary principle share a device, the allocation of an argumentative burden to a proposing party, and they differ along two axes. Table 1 sets out the comparison across the formulations surveyed in Section 3.

The first axis concerns the trigger. The precautionary formulations fire on uncertainty conjoined with the prospect of serious harm, and Criterion 6.1 fires on irreversible foreclosure. The trigger of Criterion 6.1 is narrower in two respects. An intervention attended by

deep uncertainty whose foreclosures admit reversal falls outside it, and the precautionary formulations catch such interventions and should release them. An intervention whose foreclosure is certain falls squarely within it, and the precautionary formulations release such interventions, since the uncertainty condition fails where the outcome is known. The migration corridor of §3.9 is an instance of the second kind, and it is the instance that motivates the criterion.

The second axis concerns the consequence. The Wingspread formulation requires a demonstration of safety and thereby operates as a bar, since a demonstration of safety is generally unavailable. Criterion 6.1 requires reasons and thereby operates as an allocation. A party holding sufficient reasons proceeds under Criterion 6.1 and is stopped under the Wingspread formulation.

The two departures run in opposite directions, and the pairing is what permits the criterion to reach the cases the precautionary formulations miss while releasing the cases they wrongly catch.

6.5 The Settlement Left to Ordinary Means

Criterion 6.1 determines which party argues and determines nothing about which party should prevail. This silence is a commitment and admits statement in three parts.

Below the threshold, where no available course forecloses irreversibly, the criterion is inert. Competing claims about land, energy, orbit and sky remain plural, they are frequently incommensurable, and they fall to be settled by the political and legal processes available for settling them. The criterion adds nothing to those processes and subtracts nothing from them.

Above the threshold, the criterion allocates the burden and leaves the argument to be conducted. A party bearing the burden may hold reasons that a community accepts, and the foreclosure then proceeds with warrant. The criterion is compatible with the destruction of a great deal.

The commitment to plurality therefore stands as the position the criterion is constructed to protect, in place of a residue left where the criterion runs out, since a criterion that ranked claims would require a common measure over the trajectories in the field, and Premise 4.1 establishes that no party holds a representation adequate to construct one.

The unavailability of such a measure is the sense in which a field is called heterogeneous throughout this paper, and the sense requires statement, since a variety of kinds within a field is a property of a description in place of a property of the field. A field is heterogeneous with respect to a party when no common measure over its participants is available to that party, in the sense that the party holds no scale on which a foreclosure of one participant's capacity and an enlargement of another's may be compared. The statement is relational in the manner of §4.2, where the containment of the represented sub-field is derived from the situation of the representing party in place of from an attribute of what is represented, and the companion synoptic paper treats the point at length.

7 The Composition of Individually Warranted Courses

This section states the difficulty that bears most heavily against Criterion 6.1 and establishes its extent. The difficulty is that the criterion fails to be closed under composition: a sequence of courses on none of which the criterion fires may compose into exactly the foreclosure the criterion exists to allocate a burden for. The section states the failure, establishes it formally in Proposition 7.1, establishes in Proposition 7.2 that the two attribution rules available for such sequences are defective in complementary ways, and sets out the three repairs available. The repairs are assessed in Sections 8 and 9. Its role in the paper is adversarial: the difficulty stated in this section is the strongest the paper knows against its own criterion, and the two sections following assess the repairs this section sets out. The section is arranged as follows: §7.1 states the form of the difficulty, §7.2 establishes the failure of composition in Proposition 7.1, §7.3 establishes the shared defect of the attribution rules in Proposition 7.2, §7.4 sets out the three repairs, and §7.5 states the scope and residue of the result. The method is formal, and both propositions are verified over the stated parameter ranges.

7.1 The Form of the Difficulty

Criterion 6.1 is stated over a course available to a party and fires where that course would irreversibly foreclose. A party assessing its own course consults the state of the field and the effect of its course upon that state. Where the effect is small and the field is far from any condition in which small effects matter, the criterion is silent and the party proceeds without burden.

Foreclosure in the systems at issue is characteristically produced by many such courses. Each launch into a congested shell is small against the population already present. Each is reversible as an act, since the object placed can be removed. Each is undertaken by a party for which the criterion is silent, and each party is correct that the criterion is silent.

The failure is therefore structural and admits no repair by the exercise of greater care by any party. Every party may apply Criterion 6.1 correctly and the foreclosure occurs.

7.2 The Failure of Composition

Consider a shell carrying n objects, in which collisions generate K fragments each and occur at a rate proportional to n^2 , while natural removal takes a fixed fraction β of the population per period. The population evolves as

$$n_{t+1} = n_t + K\alpha n_t^2 - \beta n_t, \quad (3)$$

which is self-clearing below and self-amplifying above the critical population

$$n_{\text{crit}} = \frac{\beta}{K\alpha}. \quad (4)$$

Let N parties each place a quantity u of objects into a shell carrying n_0 initially, with $n_0 < n_{\text{crit}}$.

Proposition 7.1 (Failure of composition). There exist n_0 , u and N with $n_0 + u < n_{\text{crit}}$ and $n_0 + Nu > n_{\text{crit}}$. For such parameters, (i) the placement of any single party leaves the shell in a self-clearing condition, so Criterion 6.1 fires on no party's course; and (ii) the composition of the N placements leaves the shell in a self-amplifying condition, and the fragments generated thereafter are irreversible in the sense of §6.1. Criterion 6.1 is accordingly not closed under composition.

The verification uses $\alpha = 1.47 \times 10^{-6}$, $\beta = 4 \times 10^{-2}$, $K = 8$, $n_{\text{crit}} = 3400$, $n_0 = 3000$, $u = 120$ and $N = 6$. A single placement carries the shell to 3120, from which iteration of equation (3) drives the population to a negligible remainder. The six placements together carry the shell to 3720, from which the same iteration grows without bound.

Two features of Proposition 7.1 deserve emphasis. The result requires no error by any party, and it requires no party to hold information it lacks. Each party's assessment is correct, and the assessments compose into a false conclusion about the sequence.

7.3 The Defect Shared by the Available Attribution Rules

A natural response holds that the criterion should fire on whichever course carries the field across the threshold. A second holds that the burden should be divided among the parties by their marginal contributions. Proposition 7.2 establishes that each response carries a defect, and that the defects are of different kinds.

Proposition 7.2 (Defects of the attribution rules). Under the construction of Proposition 7.1, (i) the party whose placement carries the shell across n_{crit} is determined by the ordering of the sequence, and under permutation of the sequence every party occupies that position in some ordering, while the terminal state is invariant under permutation; and (ii) the Shapley value of each party in the crossing equals $1/N$, so a rule allocating by marginal contribution assigns each party a share falling toward zero as N grows, while the foreclosure it allocates remains total.

Clause (i) is verified exhaustively over all 720 orderings of the six parties, in each of which the crossing occurs at the fourth placement and the party occupying that position differs. Clause (ii) is verified by direct computation of the Shapley value over the same orderings.

The two clauses jointly characterise the difficulty. A rule of but-for causation is available and selects its party by an accident of sequence, so that identical conduct is charged or released according to the order in which the parties happened to act. A rule of marginal contribution is available and is invariant under permutation, and it purchases that invariance by assigning each party a vanishing share of a loss that does not vanish. A field in which many parties act therefore admits no attribution rule that is both invariant under the ordering and proportionate to the loss.

The result is the reason Criterion 6.1 is stated as a burden of justification and no scheme of liability. A burden falls at the point of decision and is discharged by argument. A liability falls after the event and requires an attribution, and Proposition 7.2 establishes that the attribution is unavailable in the form the case requires.

7.4 The Repairs Available

Three repairs are available to a criterion facing this difficulty, and Sections 8 and 9 examine the first and the third, the second being carried to Section 13.

The first conditions the criterion on the proximity of the field to a threshold in place of on the effect of a single course. A party contemplating a placement into a shell near n_{crit} would bear the burden that a party contemplating the same placement into an empty shell would not. The repair requires that proximity be ascertainable, and Section 8 establishes the limits of that requirement.

The second aggregates the parties into a single governing party competent to assess the sequence. The repair converts the many-party case into the one-party case for which Criterion 6.1 was stated, and it presupposes an authority the field ordinarily lacks. Where the shell crosses several jurisdictions and the parties answer to different states, the aggregation is the whole of the governance problem in place of a repair to the criterion.

The third makes the criterion itself a function of the state of the field, so that the burden a given course carries varies with the condition the field is in when the course is adopted. Section 9 develops this repair and states its cost, which is considerable.

7.5 Scope and Residue of the Composition Result

The section's result concerns composition alone, and the criterion's application to the single-party case stands untouched by it, where it operates as Section 6 states.

The construction of §7.2 is an existence argument. It establishes that parameters exist for which composition fails, and it supports no claim about the frequency of such parameters in any actual shell, watershed or airshed. The orbital instance is used because its dynamics are documented and its threshold behaviour was described early [13], and the argument would proceed identically on any system exhibiting a self-amplifying regime above a critical value.

The section leaves open whether the first repair is available, and Section 8 addresses that question directly.

8 The Reach of Statistical Warning and the Repair Conditioned on It

This section assesses the first of the three repairs set out in §7.4, under which Criterion 6.1 is conditioned on the proximity of the field to a threshold in place of on the effect of a single course. The repair requires that proximity be ascertainable in advance. The section states what the scientific literature establishes about that requirement, establishes in Proposition 8.1 that a class of transitions lies outside what the established indicators can register, distinguishes detection from the availability of a response, and draws the consequence for the standing of Criterion 6.1. Its role in the paper is eliminative: the section closes off the first repair, and its negative result is what forces the state-dependence of Section 9. The section is arranged as follows: §8.1 states the requirement the repair imposes, §8.2 sets out the established indicators, §8.3 establishes the class of transitions outside their reach, §8.4 treats the interval between

detection and response, §8.5 states the consequence for Criterion 6.1, and §8.6 states the exclusions. The method is formal for Proposition 8.1 and expository for the remainder, and the section claims no result in dynamical systems theory that the cited literature has not established.

8.1 The Requirement Imposed by the Repair

Under the repair, a party contemplating a course consults the condition of the field. Where the field stands far from any threshold, the party proceeds without burden. Where the field stands near one, the party bears the burden that Criterion 6.1 allocates, since its course would then contribute to a foreclosure that the field's own dynamics would carry to completion.

The repair addresses Proposition 7.1 directly. The composition failure arises because each party assesses its own course against a field treated as fixed, and the repair replaces that assessment with an assessment of the field. Where the repair is available it is decisive, and the question is the extent of its availability.

8.2 The Established Indicators and the Transitions They Register

Scheffer and colleagues [21] established that a system approaching a fold bifurcation exhibits generic statistical signatures in advance of the transition. As the system nears the point at which the equilibrium it occupies loses stability, the rate at which perturbations decay falls toward zero. The consequence, termed critical slowing down, is that the system recovers more slowly from disturbance, its variance rises, and the autocorrelation of its fluctuations rises toward unity. These quantities are computable from a time series of the state without any model of the system's dynamics.

The claim owned by this literature is precise and it is substantial. Where a transition proceeds by the loss of stability of an occupied equilibrium, and where a time series of adequate length and resolution is available, the approach to that transition is in principle detectable from the series alone.

8.3 The Class of Transitions Outside the Indicators' Reach

The premise of the indicator results surveyed at §8.2 is that an equilibrium loses stability. Ashwin and colleagues [2] established that transitions occur in three ways, of which the loss of stability of an equilibrium is one. A transition may be induced by a bifurcation, in which the occupied equilibrium ceases to exist or ceases to be stable. It may be induced by noise, in which a fluctuation carries the system out of a basin whose equilibrium remains stable throughout. It may be induced by rate, in which a moving equilibrium remains stable throughout while the system fails to track it.

The third class is the one that bears on the present argument, and Proposition 8.1 establishes its properties in a system exhibiting them.

Consider

$$\dot{x} = (x + \lambda(t))^2 - 1 + \sigma \xi(t), \quad (5)$$

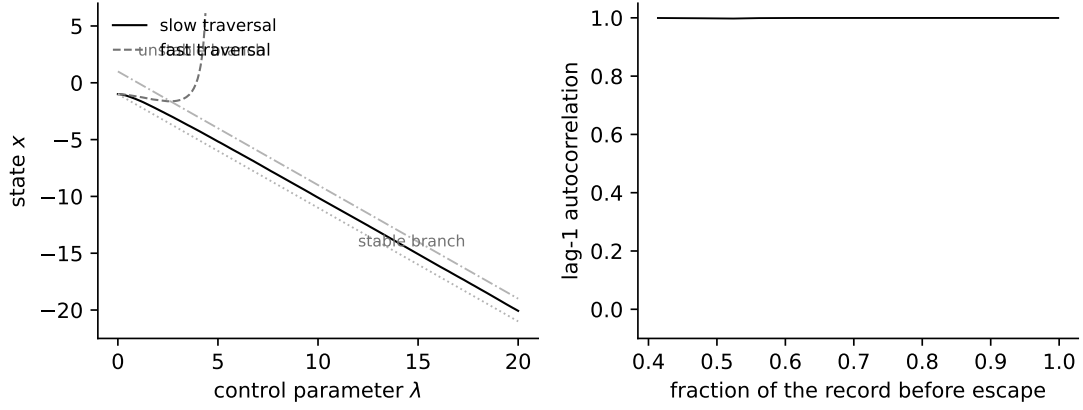


Figure 2: Left: traversals of the system of equation (5) over $\lambda \in [0, 20]$ at rates 1 and 3, against the stable branch $x = -\lambda - 1$ and the unstable branch $x = -\lambda + 1$. The slow traversal tracks the stable branch; the fast traversal lags, meets the descending unstable branch, and escapes. Right: lag-one autocorrelation of the detrended fast record over the interval preceding escape, showing no material rise.

whose equilibria lie at $x = -\lambda - 1$, which is stable, and $x = -\lambda + 1$, which is unstable. Both branches translate downward as λ increases, and a trajectory occupying the stable branch must follow it.

Proposition 8.1 (Absence of statistical warning under rate-induced transition). For the system of equation (5) traversing a fixed interval of λ , (i) a traversal at a low rate leaves the trajectory tracking the stable branch while a traversal at a higher rate carries the trajectory across the unstable branch and away without bound, so the outcome is determined by the rate and the interval traversed is identical; (ii) the restoring rate at the stable branch equals $|\partial f / \partial x| = 2$ at every value of λ , so no slowing occurs at any point of either traversal; and (iii) the lag-one autocorrelation of the detrended record exhibits no material rise over the interval preceding the escape.

The verification traverses $\lambda \in [0, 20]$ at rates 1 and 3 with $\sigma = 10^{-2}$. The slow traversal terminates on the stable branch. The fast traversal escapes at $t \approx 1.46$. The mean lag-one autocorrelation over the first half of the pre-escape record stands at 0.9990 and over the second half at 0.9996, a change of +0.0006. Figure 2 displays both traversals against the two branches, together with the autocorrelation of the fast record.

Two further results in the literature bear on the same question. Hastings and Wysham [8] established that regime shifts occur in ecological systems with no advance warning of the kind the indicators register. Rietkerk and colleagues [19] report that the indicators are ambiguous in application, in that a loss of resilience can be produced by mechanisms that generate no tipping and a tipping can occur without the indicators preceding it.

8.4 The Interval between Detection and the Availability of a Response

A second limitation attaches to the repair and is independent of the first. Detection of an approach establishes that the field stands near a threshold; whether a course remains available that would carry it away is a separate question, and the interval between the two is where the

repair fails.

The indicators register the approach through the decay of the restoring rate, and the decay is the same quantity that governs the system's response to a corrective intervention. A field whose recovery from disturbance has slowed sufficiently for the slowing to be measurable is a field whose recovery from a corrective course has slowed by the same amount. The interval in which the approach is legible is therefore an interval in which correction is correspondingly slow, and the property that makes the warning available is the property that reduces what the warning is worth.

8.5 The Consequence for the Standing of Criterion 6.1

The repair of §8.1 is available for one of the three classes of transition and is unavailable for the other two, and it is attended in the class where it is available by the interval problem of §8.4.

The consequence is stated as follows. A governance rule conditioned on the detection of an approach to a threshold is a rule that operates in a proper subset of the cases in which foreclosure occurs, and the complement of that subset contains cases in which the foreclosure is total. Option preservation accordingly stands as the primary rule, and the detection of approach stands as a supplement available where the class of transition permits it.

This is a stronger position than the one available to a framework that treats detection as the principal instrument and option preservation as a fallback for cases where monitoring is absent. Under the present argument, option preservation is required by the structure of the problem, and improvements in monitoring narrow the class of cases in which it operates alone without removing that class.

8.6 Exclusions from the Assessment of Statistical Warning

Three matters lie outside the argument, concerning respectively the literature the section draws on, the classification it presupposes, and the repair it does not reach.

The first is that the early-warning literature stands untouched by the section: its results hold within their stated premise. Proposition 8.1 exhibits a system outside that premise, and the premise is stated by the literature itself.

The second is that the section supplies no method for determining, in advance, which class a given transition belongs to. That determination would require the model of the dynamics whose absence motivated the indicators, and the difficulty is recorded in Section 13.

The third is that the second repair of §7.4, under which the parties are aggregated into a single governing party, lies outside the section's assessment. Section 9 develops the third repair, and the second is carried to Section 13 as a matter left open.

9 The State-Dependence of the Governing Rule and Its Cost

This section develops the third repair set out in §7.4, under which the burden a course carries varies with the condition of the field at the time the course is adopted. It establishes in Claim 9.1 that the repair is forced by the results of Sections 7 and 8, states the form the resulting rule takes, and then states the cost, which is that a rule of this form shares its structure with the state of exception. Three constraints are proposed that bear on the resemblance, and the defect of each is stated. The section closes by naming the two questions the paper carries to a companion paper. Its role in the paper is to state the position the argument reaches and its price: the rule of equation (6) is what the composition and detection results force, and the questions it raises are the ones the companion paper takes as its object. The section is arranged as follows: §9.1 establishes the necessity of the repair in Claim 9.1, §9.2 states the form of the resulting rule, §9.3 establishes its structural resemblance to the exception, §9.4 states the constraints bearing on the resemblance, §9.5 states the questions carried forward, and §9.6 states the standing of the rule. The method is analytical, and the section keeps to the declination of institutional design recorded at §2.5.

9.1 The Repair and Its Necessity

Criterion 6.1 as stated in Section 6 is invariant in form. The burden it allocates attaches to a course by virtue of what that course would foreclose, and the allocation is the same whatever condition the field is in.

Claim 9.1 (Necessity of state-dependence). A criterion invariant in form is inadequate to the composition case. Proposition 7.1 establishes that a sequence of courses on none of which an invariant criterion fires may compose into an irreversible foreclosure. Proposition 8.1 establishes that the approach to such a foreclosure affords no statistical warning for a class of transitions. A criterion adequate to the composition case must therefore attach a burden to courses on which an invariant criterion is silent, and the ground for attaching it can lie only in the condition of the field, since the courses themselves are by hypothesis indistinguishable from courses that carry no burden.

The claim establishes the form of the repair; its administration is a further matter. What follows from it is that the governing rule takes the form

$$\pi = \pi(X_t), \tag{6}$$

in which X_t denotes the condition of the field at the time of decision and π the allocation of burden that Criterion 6.1 performs.

9.2 The Form of the Resulting Rule

Equation (6) carries a substantive commitment, and the commitment runs against the form that normative principles ordinarily take. A principle is ordinarily stated so as to hold across circumstances, and its generality is among the properties that recommend it. Equation (6)

states that the correct allocation of burden for a given course depends on where the field stands, so that identical courses adopted by identical parties carry different burdens according to the condition of the field at the time.

The commitment admits statement without any partition of the state space into named regimes. Where the field stands far from any condition in which the composition of ordinary courses forecloses, π reduces to Criterion 6.1 as stated in Section 6, and courses carrying no foreclosure of their own carry no burden. As the field approaches such a condition, π extends the burden to courses whose individual contribution is small, on the ground that the composition of such courses is what the field's condition makes consequential. The extension is continuous in principle and it is the whole of what equation (6) asserts.

9.3 The Structural Resemblance to the Exception

A rule whose content depends on an authority's determination that the governed system has entered a particular condition shares its structure with the state of exception, and the resemblance is exact in the respect that matters. Schmitt's account [33] locates sovereignty in the competence to decide that the ordinary situation has lapsed. Agamben's account [32] establishes that arrangements of this form tend toward permanence, since the authority competent to declare the exception is ordinarily the authority competent to determine that it continues. Wainwright and Mann [31] state the climate-specific form, in which a planetary authority acquires the competence to declare emergency and thereby to determine which parties are spared.

The resemblance is a cost the paper accepts and states. A framework that arrives at equation (6) by the route of Claim 9.1 has arrived at the structure of the exception by argument, and it holds no ground for treating the arrival as accidental.

Three questions follow and the paper answers none of them. Which party determines X_t . On what evidence, given the results of Section 8. What returns the field to the ordinary condition, and who determines that it has returned.

9.4 Constraints Bearing on the Resemblance

Three constraints distinguish equation (6) from the exception in its classical form. Each is stated with the defect that limits it, since a constraint offered without its defect would misrepresent the strength of the position.

The first concerns the direction in which the determination operates. A declaration of exception in the classical form enlarges the permissions of the declaring authority. A determination that the field stands near a threshold, under equation (6), contracts the permissions of every party including the declaring one, since it extends the burden of justification to courses that previously carried none. The incentive to declare is accordingly reversed.

The defect is substantial. Contraction bears unequally on parties differently placed. A party whose capacity is already deployed loses little by a determination that freezes

further deployment, and a party that has yet to deploy loses the whole of its prospect. A determination made under equation (6) therefore confers an advantage on incumbency, and the advantage is available to an incumbent party as a reason for making the determination. The reversal of incentive is thus partial, and it fails precisely where the distribution of prior use is unequal.

The second concerns termination. The classical exception carries no internal condition for its own ending, and the authority that declares it determines when it has ended. Equation (6) is keyed to a state variable, and the condition for its relaxation is stated in the same terms as the condition for its extension: the burden contracts as X_t leaves the region in which composition is consequential.

The defect is that the condition is only as available as the observation of X_t , and Section 8 established that the observation is unavailable for a class of transitions and attended by the interval problem where it is available. A termination condition that cannot be evaluated operates as no termination condition.

The third concerns what the determination transfers. A declaration of exception transfers competence, in that the declaring authority acquires powers it did not previously hold. A determination under equation (6) transfers no competence and alters the distribution of argumentative burden among parties whose competences are unchanged. The parties that decided before the determination decide after it, under a different allocation of who must persuade.

The defect is that the distinction holds only where the burden is genuinely dischargeable. A burden that no party can discharge in practice operates as a prohibition, and a prohibition administered by a party competent to determine when it applies is a competence in all but name. The dischargeability of the burden is accordingly load-bearing for the whole distinction, and Section 11 gives a reason for doubting it in institutional settings.

9.5 The Questions Carried Forward

Two questions raised by equation (6) lie outside this paper and are the subject of a companion paper.

The first concerns the authority competent to determine X_t . The three constraints of §9.4 bear on what such an authority may do and settle nothing about which party it should be, how it is constituted, or how a determination it makes is contested by a party the determination disadvantages.

The second concerns the distribution of the capacity to observe X_t . The determination requires observation, observation requires instruments and records, and both are distributed unequally among the parties whose conduct the determination governs. A rule keyed to a state that some parties can observe and others cannot allocates argumentative burden by an allocation of instruments, and the second allocation is prior to and independent of the first. This is a question of justice in its own right and it is not treated in this paper.

9.6 Standing of the State-Dependent Rule after the Difficulty of Composition

The section establishes that state-dependence is forced by the earlier results, that it carries the structure of the exception, and that three constraints bear on the resemblance while leaving it substantially in place.

The institutional form such a rule should take is a further question, and answering it would require answers to the two questions of §9.5, which are the subject of the companion paper.

The position the paper occupies at the close of the difficulty stated across Sections 7 to 9 is accordingly this. Criterion 6.1 stands for the single-party case argued in Sections 4 to 6. It fails to compose. The repair that composition requires carries a cost the paper states and does not discharge, and the statement of that cost is the paper's contribution to the question of what governance under equation (6) would have to answer for.

10 The Standing of an Irreversibility Trigger in Recent International Adjudication

This section examines a body of doctrine that has adopted an irreversibility trigger without supplying an argument for it, and reads that doctrine against Criterion 6.1. The purpose is threefold: to establish that the criterion the paper defends has independent support in the practice of international tribunals, to identify three respects in which the doctrinal formulation departs from Criterion 6.1, and to establish that the class identified in Claim 3.1 survives the doctrine unaddressed. The paper claims no expertise in public international law, and treats the opinions as evidence about the shape of an emerging norm in place of authority for any proposition of law. Its role in the paper is to examine the first of the two settings announced at §2.4, and its finding is that an emerging body of doctrine asserts the criterion's trigger without supplying the argument that Section 5 supplies. The section is arranged as follows: §10.1 sets out the opinions and their holdings, §10.2 identifies the argument the doctrine omits, §10.3 states the departures of the doctrinal formulation from the criterion, §10.4 treats the distribution of the contested ground, and §10.5 states the standing of the reading.

10.1 The Opinions and Their Holdings

Three advisory opinions delivered between May 2024 and July 2025 bear on the obligations of states with respect to the climate and marine environments.

The International Tribunal for the Law of the Sea [30] held in May 2024, on a request from a commission of small island states, that anthropogenic greenhouse gas emissions constitute pollution of the marine environment under the Law of the Sea Convention, and that states carry obligations of due diligence to prevent, reduce and control them.

The Inter-American Court of Human Rights [28] adopted Advisory Opinion OC-32/25 in May 2025, on a request submitted by Chile and Colombia, and published it in July of that year. The Court recognised a right to a healthy climate, recognised nature as a subject of rights, and held that the peremptory prohibition of anthropogenic conduct that may irreversibly affect the interdependence and vital balance of the common ecosystem that makes life possible for species constitutes a norm of *jus cogens*. This last holding carried by four votes to three, with

the President of the Court among the dissenters.

The International Court of Justice [29] delivered its opinion on the obligations of states in respect of climate change in July 2025, unanimously among fifteen judges, on a request from the General Assembly initiated by Vanuatu. The Court held that the climate treaties impose binding obligations, that the temperature limit of one and a half degrees is the agreed primary goal and binding as such, that the discretion of states in formulating nationally determined contributions is bounded by an obligation of due diligence, and that failure to comply may engage state responsibility.

10.2 The Argument the Doctrine Omits

The formulation adopted by the Inter-American Court is keyed to irreversibility. Conduct that may irreversibly affect the vital balance is prohibited peremptorily, and conduct that affects it reversibly is governed by the ordinary obligations the same opinion sets out.

The opinion supplies grounds for the elevation of the prohibition to peremptory status, resting on the necessity of the norm for the effectiveness of obligations already codified, on general principles, and on a growing consensus. It supplies no argument for the selection of irreversibility as the property that distinguishes the prohibited conduct from conduct governed ordinarily. The selection is treated as evident.

Section 5 supplies the missing argument. Irreversible foreclosure removes a branch of the decision that reversible foreclosure preserves, and information arriving later has value only where a branch remains open for it to bear upon. The argument holds without any valuation of what occupies the removed branch, which is the property that permits it to operate where the affected trajectories are heterogeneous and no common measure over them is available. A tribunal reasoning about a common ecosystem containing species, atmospheric processes and human populations is in exactly that position.

10.3 Departures of the Doctrinal Formulation from the Criterion

Criterion 6.1 and the doctrinal formulation differ in three respects, and the differences are informative in both directions.

The first departure concerns the consequence: the doctrine states a prohibition where Criterion 6.1 allocates a burden. A peremptory norm admits no derogation, and the conduct it reaches is barred. This is the structure of the Wingspread formulation examined at §3.2, and it inherits that formulation's exposure to the objection recorded there. The exposure is aggravated by the modal term: conduct that *may* irreversibly affect the vital balance reintroduces uncertainty into the trigger, and a great deal of ordinary industrial activity satisfies a condition so stated. A norm of this breadth must be narrowed at the point of application, and the principles governing the narrowing are unstated. Criterion 6.1 addresses the same conduct by allocating a burden that a party may discharge, and the narrowing is thereby performed in the open by the reasons offered.

The second concerns the object: the doctrine is stated over a planetary aggregate where

Criterion 6.1 is stated per trajectory. The protected object is the interdependence and vital balance of the common ecosystem that makes life possible for species, and conduct reaches the threshold by bearing on that balance. A development corridor severing a migration corridor bears on the vital balance of the common ecosystem in no measurable degree. The class identified in Claim 3.1 accordingly survives the opinions untouched, and the survival is the paper's principal reason for stating the criterion per trajectory.

The third concerns the courses reached: the doctrine is stated over conduct where Criterion 6.1 is stated over courses including deferral. The Inter-American formulation reaches anthropogenic conduct, and §5.5 established that a formulation so stated releases the party whose foreclosure is produced by delay. The opinion of the International Court is the partial exception, since an obligation of due diligence in the formulation of contributions reaches a state that does too little as well as one that does too much, and the holding that the temperature limit binds gives that obligation a determinate content. The delay-side case is thus reached by the climate doctrine through a route the paper's argument reaches directly.

10.4 The Distribution of the Contested Ground

One feature of the Inter-American opinion bears on the paper's construction and is recorded here.

The holding divided the Court four to three, and the division concerned the elevation of the prohibition to peremptory status. The identification of irreversibility as the property marking the gravest class of environmental conduct attracted no comparable disagreement, and it appears across all three opinions and across the separate declarations.

The division therefore falls along the second of the two axes distinguished at §6.4. The trigger commands assent; the consequence attached to it divides. This is the distribution the paper's construction predicts, since a trigger stated over a structural property of a foreclosure is assessable by parties disagreeing about the value of what is foreclosed, while a consequence that bars conduct requires agreement about how much the foreclosure matters. The companion paper on the determination of system state reaches the same separation from the position of a party disadvantaged by a determination, finding that the contest such a party can conduct concerns the consequence and never the trigger, so that an arrangement collapsing the two forecloses the only contest available to it. A formulation retaining the trigger and weakening the consequence occupies the ground the tribunals agree on and vacates the ground they divide over.

10.5 Standing of the Doctrinal Reading

The section establishes that an irreversibility trigger has been adopted in the highest register available to international law, that the adoption proceeded without an argument for the trigger, and that the argument of Section 5 supplies one.

It establishes no proposition of law. The reading offered in this section is a reading of published holdings by a paper in political philosophy, the doctrine is recent and contested,

and the elevation to peremptory status is the subject of live scholarly dispute that the paper takes no position in.

It establishes that the doctrine leaves the class of Claim 3.1 unaddressed, and the remainder of the paper is addressed to that class. Section 11 turns to the difficulty that the class faces in institutional settings, which is of a different kind from the compositional and detection difficulties treated in Sections 7 to 9.

11 The Invisibility of Restraint in Institutional Accounting

This section examines the setting identified in §2.4 as unfavourable to the account. Criterion 6.1 recommends a course whose product is an absence, and institutions account for absences poorly. The section states the form of the difficulty, establishes in Claim 11.1 that the evidential asymmetry between the two sides of the burden operates in one direction, draws the consequence for the third constraint of §9.4, and establishes that the framework faces failure in two opposite directions whose occurrence depends on the institutional setting. Its role in the paper is to examine the second setting announced at §2.4, the one least favourable to the account, and to record without resolving the difficulty that institutional accounting poses for a criterion whose product is an absence. The section is arranged as follows: §11.1 states the form of the difficulty, §11.2 establishes the direction of the evidential asymmetry in Claim 11.1, §11.3 states the consequence for the dischargeability of the burden, §11.4 states the two-sided bearing of deliberate non-decision, and §11.5 states the exclusions. The method is analytical, and the section stops at the record of the difficulty, for the reason given in §11.5.

11.1 The Form of the Difficulty

A party that discharges the burden allocated by Criterion 6.1 proceeds, and the product of its course is exhibitable. A road exists, a constellation delivers service, a facility employs. A party that declines to proceed produces a state of affairs in which the road is absent, the orbital region is unoccupied, and the corridor remains traversable. The second party has performed the whole of what the criterion recommends and holds nothing to display.

The difficulty is familiar in another domain. Rose [34] established that a preventive measure operating across a population yields little discernible benefit to any member of it, so that the measure is undervalued by each while the aggregate effect is substantial. The structure of the present difficulty is related and the asymmetry is sharper, since the beneficiary of a foreclosure avoided is a trajectory that renders no account of the benefit and that would have rendered none of the loss.

11.2 The Direction of the Evidential Asymmetry

Claim 11.1 (Asymmetric evidence in the discharge of the burden). Where the burden allocated by Criterion 6.1 is contested, the reasons offered for proceeding are supported by evidence of a kind that can be produced, and the reasons offered against proceeding are

supported by evidence of a kind that cannot. The contest is therefore asymmetric in its evidential structure, and the asymmetry operates in the same direction on every occasion of its application.

The argument for Claim 11.1 runs as follows. The reasons for proceeding concern a state of affairs the course would bring about, and comparable courses have been carried out elsewhere, so their products are available for inspection and their magnitudes are estimable from the record. The reasons against proceeding concern the continued operation of a capacity, and the evidence for what that capacity would have produced is evidence about a course of events that the successful discharge of the burden prevents. Where the burden is discharged against preservation, the foreclosure occurs and its consequences enter the record. Where the burden is discharged in favour of preservation, the field continues and nothing enters the record that identifies the continuation as an achievement.

The consequence is that the evidence available to the two sides diverges over time in a single direction. A difficulty of the same form arises in the companion papers by other routes. The paper on the determination of system state finds that the record supporting a determination is held by the party the determination favours; the paper on the four operations finds that a withheld possibility and a possibility no scheme addressed present the same configuration. In each the object at issue cannot be verified from the field by the party that would need to verify it, and the companion paper constituting the problem class states the common form. Each foreclosure carried out contributes a case to the record from which the effects of foreclosure may be estimated, and thereby improves the epistemic position of the party proposing the next one. Each foreclosure avoided contributes nothing.

11.3 The Consequence for the Dischargeability of the Burden

Section 9 established that the third constraint distinguishing $\pi(X_t)$ from the state of exception holds only where the burden is genuinely dischargeable, and recorded that this section would give grounds for doubting it. The grounds are of an unexpected kind.

The worry stated in §9.4 was that a burden no party can discharge operates as a prohibition, and that a prohibition administered by the party competent to determine when it applies is a competence in all but name. Claim 11.1 establishes a difficulty running in the opposite direction. Where the evidential contest is asymmetric in the manner described, the burden is discharged on most occasions of its application, since the party bearing it holds the producible evidence and the party opposing holds a projection. A burden discharged on most occasions of its application is a formality, and a formality performed before proceeding is what an institution seeking to comply will build.

The framework therefore faces failure in two directions. In a setting where the determination of X_t is controlled by a party with an interest in restricting others, the burden hardens toward prohibition and the arrangement acquires the structure Section 9 described. In a setting where the burden is contested through ordinary institutional procedures under the evidential asymmetry of Claim 11.1, the burden softens toward formality and the criterion ceases to allocate anything. Which failure obtains is determined by the setting, and the

criterion by itself selects neither.

11.4 The Bearing of Deliberate Non-Decision in Both Directions

Bachrach and Baratz [3] established that a party may control outcomes by confining an agenda, and §3.8 recorded that the result bears against the present paper. With Claim 11.1 stated, the bearing admits precise statement, and it is two-sided.

A criterion recommending that certain possibilities remain unrealised may be exercised by whichever party the unrealised state favours, and the exercise is available to a party opposing a development for reasons unconnected with any foreclosure. This is the reading of the criterion as a device of obstruction.

The same result operates in the opposite direction, and the second operation is the one the invisibility of restraint makes available. A foreclosure that proceeds by accumulation raises no occasion on which any party's course is contested, and Proposition 7.1 established why: each course is individually unremarkable. A party favoured by the accumulation therefore requires no agenda control, since the accumulation raises no item to be kept off an agenda. Non-decision in this setting operates without any party deciding, and the absence of a contested occasion is what makes the second face of power effective and invisible at once.

11.5 Exclusions from the Institutional Assessment

The section records the difficulty and stops at the record; the stopping point is a consequence of the declination recorded at §2.5.

A remedy for the asymmetry of Claim 11.1 would require that reasons be recorded at the point of decision, that the projection offered against proceeding be preserved, and that the record be consulted when comparable decisions arise. This is machinery, it would be specified from outside, and it would be administered by the party whose course is at issue. Section 12 argues that machinery so specified is satisfied by the production of documents, and the argument applies to this machinery as much as to any other.

The section accordingly records a difficulty that stands unresolved, and it identifies the point at which the paper's refusal of institutional design carries its highest cost. A criterion that allocates a burden which institutional settings will predictably render nominal has stated something true about the structure of the decision and supplied nothing that alters the decision. Whether the gap between the two can be closed without importing the machinery the paper declines is left open, and Section 13 records it among the questions carried forward.

12 Positions Declined and the Arguments for Declining Them

This section argues the four declinations announced at §2.5. Each is argued in the same form: the position is stated at the strength its proponents would give it, the ground for declining it is derived from a result established in Sections 4 to 9, and the cost of the declination is stated. The purpose of arguing them in this section, in place of at the point of their announcement in §2.5, is that each argument depends on those results. Its role in the paper is to discharge

the four announcements of §2.5 with arguments, so that each declination stands on a stated result in place of on preference. The section is arranged as follows: §12.1 declines intrinsic value, §12.2 declines a ranking over claims, §12.3 declines a maximand, and §12.4 declines institutional machinery. The method is analytical.

12.1 The Declination of Intrinsic Value

The position declined holds that the trajectories the criterion protects possess value in themselves, and that the ground for restraint lies in that value. The position is held in developed forms across environmental ethics, and Leopold's formulation of a biotic community owed direct moral consideration is its most influential statement.

The ground for declining it is derived from §5.3. The asymmetry argument establishes a comparison between two courses and computes no magnitude, and it proceeds without any valuation of what occupies the foreclosed branch. A criterion resting on that argument is accordingly available to a party holding any view about the standing of what is foreclosed, including the view that it holds no standing at all. Adopting a commitment to intrinsic value would narrow the criterion's availability while adding nothing to its derivation.

The cost is that an account of why the foreclosed capacity matters must come from elsewhere. The criterion establishes who argues and leaves the substance of the argument to be supplied by whatever the parties hold, which §6.5 states as a commitment.

12.2 The Declination of a Ranking over Claims

The position declined holds that a governance framework should determine which of two competing claims prevails, and that a framework declining to do so has left the substantive question untouched.

The ground for declining it is derived from Premise 4.1. A ranking over the claims of trajectories in a field heterogeneous in the sense of §6.5 requires a common measure over those trajectories, the construction of such a measure requires a representation of the field adequate to compare its members, and Premise 4.1 establishes that no party holds one. A framework asserting a ranking under these conditions asserts a comparison it holds no warrant for, and the assertion would be made by the party best placed to construct the measure, which is ordinarily the party with the greatest interest in the outcome.

The cost is the one the objection identifies. The criterion is silent at exactly the point where a party seeking guidance most wants a determination, and it offers that party the allocation of a burden where the party asked for an answer.

12.3 The Declination of a Maximand

The position declined holds that preserved possibility admits quantification, that the framework should therefore direct parties to maximise it, and that the empowerment formulation of §3.6 shows the quantification to be available.

The ground for declining it is derived from §6.3 and is formal. Let Φ be any quantity

defined over the preserved capacity of the trajectories in a field, and let a governing rule direct that Φ be maximised. Since Φ takes a single value for a field containing many trajectories, Φ aggregates over them. Aggregation permits substitution: a course foreclosing the capacity of one trajectory and enlarging that of two others raises Φ and is therefore recommended by the rule. Criterion 6.1 is stated per foreclosure and withholds exactly this substitution. A rule maximising Φ accordingly contradicts the criterion it was introduced to serve.

The argument holds under every substitution of the maximand, and it holds in particular where Φ is defined over the property Criterion 6.1 itself names. The companion paper on the four operations inherits the argument as a constraint on the doctrine it finds absent, since a doctrine of withholding requires a measure of what a performance preserved and a measure of that form is a Φ of exactly this kind. A rule directing that irreversible foreclosures be minimised in number recommends one irreversible foreclosure in place of two, and the criterion refuses that trade.

A second and weaker ground is recorded separately so the first is taken as sufficient on its own. A party maximising a measurable proxy for preserved possibility will preserve what the proxy registers, and §4.3 established that the enlargement of what is registered is itself an intervention.

The cost is that the comparison of two arrangements each of which forecloses falls outside the criterion. A party required to choose between two such arrangements holds a burden on both courses and no instrument for weighing them, and §6.5 leaves that weighing to ordinary means.

12.4 The Declination of Institutional Machinery

The position declined holds that a criterion allocating a burden should specify the procedure by which the burden is raised, heard and determined, and that a criterion specifying none is inapplicable.

The ground for declining it has two parts. The first is that machinery specified from outside is administered by the party whose course is at issue, and the specification supplies that party with a determinate account of what compliance consists in. The predictable result is an arrangement complete in every specified feature under which the burden is discharged by the production of documents. The second part is derived from §11.3, which established that the burden is exposed to softening into formality through the evidential asymmetry of Claim 11.1. Machinery would supply the form that softening takes.

The cost is the highest the paper pays and it was named at §11.5. A party seeking to comply with Criterion 6.1 is given a criterion and no instrument, and the gap between holding a true account of the structure of a decision and altering that decision is left open.

13 The Limits of the Account and the Questions Carried Forward

This section states the limits of the account in three classes, records the objections it leaves unanswered, and fixes the division of labour between this paper and its companion. The

classes are the limits internal to the criterion, the limits of the two applications examined in Sections 10 and 11, and the standing objections that bear on the account as a whole. The section closes by stating what the companion paper owns. Its role in the paper is closing: it states what the account has not established, so that the criterion is carried forward at its warranted strength and no further. The section is arranged as follows: §13.1 states the limits internal to the criterion, §13.2 the limits of the two applications, §13.3 the standing objections left unanswered, and §13.4 the division of labour with the companion paper.

13.1 Limits Internal to the Criterion

Three limits attach to Criterion 6.1 itself, and each concerns a determination the criterion requires and does not supply.

The first is that the determination of whether a proposed foreclosure is irreversible stands outside the criterion, and §5.6 recorded the boundary. The determination requires a judgement about the dynamics of a field that Premise 4.1 establishes to be represented partially, and §8.6 established that the classification of a transition into the three kinds requires the model whose absence motivated the statistical indicators. The criterion therefore fires on a property whose instantiation is contestable in the cases where it matters most, and a party wishing to avoid the burden may contest the determination in place of discharging it. This is the criterion's principal internal defect.

The second is that the horizon relative to which irreversibility is assessed is left to be stated at the point of application, and its selection is governed by whatever principle the applying party brings. A party selecting a short horizon finds few foreclosures irreversible, and §6.1 requires only that the horizon be stated.

The third is that the criterion individuates capacities loosely. A course ordinarily forecloses several capacities of several trajectories at once, some irreversibly and some not, and a fully specified version of the criterion would quantify over them and state how a mixed case is treated. The present statement treats the mixed case by the per-foreclosure property of §6.3, under which the presence of one irreversible foreclosure allocates the burden, and the treatment is coarse.

13.2 Limits of the Two Applications

Both settings, the adjudicative and the institutional, are treated analytically and neither supports an empirical claim.

The reading of the advisory opinions in Section 10 is a reading of published holdings by a paper in political philosophy. The doctrine is recent, the elevation to preemptory status carried by four votes to three and is the subject of live scholarly dispute, and nothing in Section 10 establishes a proposition of law.

The treatment of institutional accounting in Section 11 rests on Claim 11.1, which is argued and unverified. The claim concerns the direction of an evidential asymmetry and is testable against the record of decisions in which preservation was contested. No such test is conducted

in this paper.

The account has exhibited only cases in which the criterion allocates a burden, and it has exhibited no worked case in which a party bears the burden and discharges it. It has therefore not shown that the burden is dischargeable at reasonable cost in any actual setting, and §11.3 gives a reason for doubting that it is. This is recorded as a defect in the presentation.

13.3 Standing Objections the Account Leaves Unanswered

Three objections bear on the account as a whole, and the paper records each without answering it.

The first is the two-directional failure established at §11.3. The criterion hardens toward prohibition in one class of institutional setting and softens toward formality in another, and the criterion by itself selects neither. An account of which settings produce which failure would require the institutional analysis the paper declines.

The second concerns the second repair of §7.4, under which the parties in a composition case are aggregated into a single governing party competent to assess the sequence. The paper set the repair aside on the ground that the aggregation presupposes an authority the field ordinarily lacks. The setting aside is a deferral. Where such an authority exists, the repair is available and is preferable to the state-dependence of Section 9, since it converts the many-party case into the one-party case for which the criterion was stated. The conditions under which the aggregation is achievable are a governance question the paper does not treat.

The third concerns the incumbency advantage established at §9.4. A determination that the field stands near a threshold contracts the permissions of every party and bears unequally on parties differently placed, so that a party whose capacity is already deployed is advantaged by the determination. Criterion 6.1 holds no resources for correcting this, since a correction would require a judgement about the prior distribution of use, which is a question of distributive justice and lies outside a criterion stated over the structure of foreclosure.

13.4 The Division of Labour with the Companion Paper

Two questions raised by equation (6) are the subject of a companion paper and are stated in this subsection so that the boundary between the two papers is fixed.

The first concerns the authority competent to determine the state X_t . The three constraints of §9.4 bear on what such an authority may do and settle nothing about which party it should be, how it is constituted, how a determination it makes is contested by a party the determination disadvantages, and what terminates a determination where the observation supporting it is unavailable. The companion paper treats these questions and treats the incumbency advantage of §9.4 with them, since the two are connected: an authority determining the state is ordinarily a party holding prior use.

The second concerns the distribution of the capacity to observe X_t . A rule keyed to a state that some parties observe and others cannot allocates argumentative burden by a prior allocation of instruments and records, and that prior allocation is a question of justice standing

independent of the criterion. The companion paper treats it under that description.

The present paper accordingly stands as follows. Criterion 6.1 is derived for the single-party case by the asymmetry argument of Section 5, distinguished from the precautionary principle along the two axes of §6.4, and found to fail composition by Proposition 7.1. The statistical repair is found partial by Proposition 8.1 and by the interval argument of §8.4. The state-dependent repair is found necessary by Claim 9.1 and found to carry the structure of the exception. The account of that structure, and of the party competent to administer it, is what the paper carries forward.

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