ARBOREAL CAPITAL

Research Note 007

The Hundred-Year Problem

Applying the gomboc engineering framework to design a conservation protocol that outlives its creators—and every institution that exists today.

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1. Every Conservation Mechanism in History Has an Expiration Date

The National Park Service is 110 years old. It depends on annual congressional appropriation. The Nature Conservancy is 75 and depends on donations. The Endangered Species Act is 52 and depends on political will. Every one of these mechanisms is a human institution, and human institutions fail in predictable ways: leadership succession introduces drift, funding dependencies create fragility, regulatory capture redirects purpose, cultural evolution erodes founding intent, and key-person risk concentrates institutional knowledge in individuals who eventually leave, lose interest, or die.

These are not criticisms of the people who built these institutions. They are descriptions of the default. The Pyramids at Giza survive, but the priesthood that gave them meaning does not. Roman roads still cross Europe, but the legions that maintained them dissolved sixteen centuries ago. The question is not whether human institutions can protect forests for a decade or two. They can. The question is whether any mechanism exists that could protect a tree for a hundred years—across changes of government, economic collapse, cultural upheaval, technological disruption, and the retirement, death, or disinterest of every person currently involved.

This is the hundred-year problem. It is not a funding problem, though funding matters. It is not a governance problem, though governance matters. It is a durability problem: can we design a conservation mechanism whose protective force is a property of its structure rather than of the people operating it?

The author recently proposed a framework for reasoning about this class of problem. Gomboc engineering (Hart, 2026) draws on the mathematical gömböc—a convex solid with exactly one stable equilibrium that self-rights through shape alone, requiring no internal weighting—to define five formal properties of systems that return to their intended operating state after any perturbation without human intervention. This paper applies that framework to Arboreal Capital and asks: does this protocol have the shape to survive a century?

Key Reframe:

> The hundred-year problem is not “how do we keep people caring for a hundred years.” It is “how do we design a mechanism that works whether or not anyone cares.”

2. Coins and Ledgers: Two Kinds of Durability

A Roman denarius minted in 200 AD still exists. You can hold it in your hand. Silver does not rot. The coin survives because physics requires nothing of its continued existence. This is passive durability: the object persists because no force acts to destroy it and no process is required to maintain it. But the denarius has not functioned as money in seventeen centuries. It is durable and dead.

A number recorded on a distributed ledger is the inverse. It is physically fragile: it requires electricity, network consensus, and the continued operation of the internet. Yet it is actively durable. It is maintained by millions of participants simultaneously, across every jurisdiction, without centralized permission. The denarius survived because nobody could destroy it. The ledger entry survives because everyone would have to stop maintaining it at the same time.

For conservation, passive durability is insufficient. A tree is not a painting stored in a vault. It needs active, ongoing defense against chainsaws, fires, developers, drought, and policy changes. You need a mechanism that keeps working, keeps incentivizing, keeps defending, decade after decade, without a pilot. The question for Arboreal Capital is not “will the data survive” but “will the mechanism keep running.”

> **Design Principle:**
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> Passive durability preserves objects. Active durability preserves functions. Conservation requires the latter: a mechanism that keeps generating protective behavior indefinitely, not a record that sits inert on a shelf.

3. The Gomboc Test Applied

Gomboc engineering defines five properties that constitute a self-righting system (Hart, 2026). A system satisfying all five returns to its intended operating state after arbitrary perturbation through the geometry of its incentive structure alone. We evaluate Arboreal Capital against each.

3.1 Single Stable Equilibrium

The intended equilibrium state of Arboreal Capital is: distributed token holders, verified living trees, and self-funding verification infrastructure sustained by endowment yield and holder activity. This is the configuration where the mechanism functions as designed—where self-interested behavior by participants produces conservation as a metabolic byproduct (Research Note 006).

The “exactly one” constraint requires that no alternative stable configuration exists that the system could settle into. The primary candidate for a second stable equilibrium—extreme concentration by a single entity—is addressed in Section 4. We will argue that the physical distribution of old-growth trees creates a two-sided cost structure that makes concentration structurally inferior to distribution, regardless of the concentrating entity’s strategy.

3.2 Endogenous Restoring Forces

When the system drifts from equilibrium, does it generate its own corrective forces? Three mechanisms suggest yes.

The death-freeze. When a tree dies, its token is permanently frozen—rendered non-transferable at the smart contract level (Research Note 002). This contracts supply automatically, without any governance vote or administrative action. Supply contraction increases scarcity of remaining tokens, which strengthens the economic incentive to protect surviving trees. The restoring force is generated by the protocol’s own mechanics, not by a committee deciding to act.

The verification tax. Holders who cannot personally verify their trees pay a tax; holders who verify are exempt (Research Note 005). This creates continuous pressure toward local holding patterns and active monitoring. If verification activity declines—because holders become complacent or disengaged—the tax accumulates, funding third-party verification and creating an economic incentive for new participants to enter and verify. The system self-corrects for insufficient monitoring without anyone directing it to.

The immutable endowment. The principal contract has no withdrawal function—the function is architecturally absent, not merely restricted by access control (Research Note 006). Yield from the principal flows to verification infrastructure through a mutable allocation contract. The principal cannot be raided, redirected, or defunded because the mechanism to do so does not exist in the code. The legal significance of this design was reinforced by *Van Loon v. Department of the Treasury* (5th Cir. 2024), in which the court held that immutable smart contracts are not property under IEEPA precisely because they cannot be owned, controlled, or altered. The endowment generates restoring force the way gravity generates it: continuously, without decision.

3.3 Participant Independence

The gomboc property requires that the restoring force be a property of the system’s structure, not its participants. Replace every participant and the equilibrium should persist.

For Arboreal Capital, this translates to: if the founder, the development team, every current holder, and every current verifier vanished tomorrow, would the mechanism still function? The immutable principal contract would still generate yield. The death-freeze would still execute on confirmed tree deaths. The verification tax would still accrue on unverified tokens. New participants, discovering the protocol for the first time, would encounter the same incentive structure and the same equilibrium dynamics as the original participants. The mechanism does not remember who built it. It does not need to.

3.4 Single Unstable Equilibrium

The null state—no tokens minted, no value, no activity—is the single unstable equilibrium. It is technically stable in the trivial sense that nothing happens when nobody participates. But the moment anyone mints a single tree and creates any value, the system tips toward the functional equilibrium. The death-freeze engages. The verification incentives activate. The endowment begins generating yield. The null state is a knife-edge, not a basin.

3.5 Constructive Deflation Under Stress

This is the property that distinguishes gomboc engineering from generic robust design. When something bad happens, does the perturbation itself strengthen the restoring force?

For Arboreal Capital, the answer centers on tree death. Trees die. Wildfires consume entire regions. Droughts kill stands that survived centuries. Disease outbreaks devastate species. Each death freezes a token, permanently removing it from circulation. Supply contracts. The remaining tokens—referencing trees that are still alive—become scarcer. Scarcity concentrates economic value on survivors. The incentive to protect the remaining trees intensifies precisely because the system just lost some.

This is not the same as antifragility (Taleb, 2012). The system does not benefit from tree death—it loses real assets. But the incentive structure tightens under loss. The mechanism gets more protective of what remains, not less. A wildfire that kills a thousand trees makes the remaining ninety-nine thousand more fiercely defended. The perturbation strengthens the restoring force.

> **Design Principle:**
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> Stress tightens the system rather than loosening it. The mechanism that damages the underlying asset base is the same mechanism that strengthens the incentive to defend what remains.

4. Concentration and the Two-Sided Cost of Physics

Every system that channels economic value confronts the concentration problem. Wealthy participants bring capital that the system needs, but concentrated holdings create systemic fragility—a single point of failure that, if it collapses, can take the entire mechanism with it. This tension is as old as institutional design itself, and the conventional response is governance: rules, limits, committees empowered to intervene. These are weeble solutions. They work until the committee is captured, the rules are amended, or the enforcer disappears.

Arboreal Capital’s anti-concentration mechanism does not depend on governance. It depends on a physical fact that no wallet structure can circumvent: the trees are living organisms distributed across a planet with regional weather, fire regimes, and disease vectors. This creates a two-sided cost structure for large holders that makes concentration a structurally inferior strategy regardless of approach.

4.1 Side One: The Verification Cost of Geographic Spread

The verification tax (Research Note 005) exempts holders who personally verify their trees. Personal verification requires physical proximity—visiting the tree, submitting geotagged evidence of its continued existence. A holder with five trees in their home region can verify them all by walking through the forest a few times a year. Cost: effectively zero.

A holder with ten thousand trees across forty countries cannot personally visit them all. The trees the holder cannot visit incur the verification tax. The holder can outsource verification—paying local agents to visit and submit evidence—but this cost scales with the geographic spread of the portfolio. Crucially, this cost cannot be avoided by splitting holdings across multiple wallets. The trees are still in Patagonia regardless of which wallet holds their tokens. Somebody still has to physically go there. The anti-concentration force is rooted in physical reality, not in on-chain identity. The holder’s body can only be in one place at a time.

The system does not prevent large holders from outsourcing verification. It welcomes it. A whale paying local agents to verify trees in remote forests is funding exactly the ground-truth conservation workforce the protocol needs. The emergent verification industry—people paid to visit and monitor trees—is the Stolpejakt model from Research Note 005: secondary economic activity that the protocol incentivizes without building. The cost to the whale is real and scales with portfolio size. The benefit to the system is conservation infrastructure funded by concentrated capital.

4.2 Side Two: The Catastrophic Risk of Geographic Clustering

The natural response to verification cost pressure is geographic clustering: accumulate trees in a single region where verification is cheap. Buy every old-growth tree in northern British Columbia and verify them all from one base. Verification cost: minimal.

But geographic clustering is catastrophic risk clustering. A single wildfire season, a single pine beetle outbreak, a single prolonged drought can freeze a massive portion of a geographically concentrated portfolio. The death-freeze is permanent. There is no recovery, no insurance claim, no governance vote to reverse it. The tokens are gone. The same physical reality that makes clustered verification cheap makes clustered loss probable on long timescales.

The whale faces a dilemma with no resolution. Diversify geographically and pay verification costs that scale with spread. Cluster geographically and accept catastrophic risk that scales with concentration. There is no portfolio configuration that avoids both. The mechanism does not need to prevent whales from accumulating. It needs concentration to be a structurally inferior strategy. And it is—not because of rules, but because of the physical properties of the underlying assets.

Key Insight:

> The anti-concentration force is not a penalty on wealth. It is a structural property arising from the fact that old-growth trees are living organisms distributed across a planet with regional climate risk. Large holders benefit from this structure: the mechanism that prevents any single entity from concentrating enough to introduce systemic fragility is the same mechanism that protects every participant's position from systemic collapse. The cost of geographic verification at scale flows directly into conservation infrastructure, reinforcing the system that all participants depend on.

5. The Kill Scenarios

The gomboc test is a framework, not a guarantee. Any honest application must enumerate the specific perturbations that could move the system away from equilibrium and trace whether the restoring forces actually operate. We examine six scenarios.

5.1 Ethereum Dies

The protocol is deployed on Ethereum (initially Base L2, with the immutable principal on L1). Ethereum is twelve years old. No blockchain has survived twenty. Building a hundred-year system on twelve-year-old infrastructure is a legitimate concern.

The answer requires distinguishing the invariant layer from the adaptive layer. The invariant is the *data*: the mapping of GPS coordinates to token IDs, ownership records, alive/dead status, and endowment principal. The adaptive layer is the *chain*: the specific infrastructure executing the smart contracts. If Ethereum fails, the data must migrate. The endowment yield must resume on a new substrate.

Migration requires community action—a bounded human coordination event, not a continuous dependency. The economic incentive to perform the migration is endogenous: holders with positions on a dying chain want the mechanism to continue functioning. As long as the tokens reference value, someone has a financial reason to fund and execute the migration. The system depends on *some* chain existing. It does not depend on *this* chain existing. Once migration completes, the system is back in its gomboc configuration on new infrastructure. The weeble moment is real but bounded and self-motivating.

5.2 A Major Government Bans Crypto

The token references coordinates, not land. It confers no property rights, no legal claim, and no jurisdictional authority (Research Note 001). A government that bans cryptocurrency trading within its borders does not affect the trees. It does not affect the contract. It affects only holders within that jurisdiction, who may need to transfer tokens to wallets in permissive jurisdictions. The protocol is permissionless by design—it does not know or care where its participants are located.

Geographic regulatory risk is structurally diversified. The trees are distributed across every continent. Holders are distributed across every jurisdiction. No single government action can disable the mechanism. A ban in one country creates opportunity for participants in another. The system redistributes around regulatory obstacles the way water flows around rocks.

5.3 Satellite Verification Becomes Unavailable

The three-layer verification architecture (Research Note 005) is designed for exactly this scenario. Satellite monitoring is the first layer, but not the only one. Ground truth networks—holders visiting trees, submitting geotagged photographs—operate independently of satellite infrastructure. The alive-until-proven-dead default means that a gap in satellite coverage does not trigger mass token freezes. It increases detection lag, but the vast majority of old-growth trees in any given year are alive. When satellite access resumes, the system catches up.

More fundamentally, satellite technology is a current implementation choice, not a protocol dependency. The verification architecture requires *some* form of remote sensing, not specifically satellites. Drone networks, aerial surveys, LiDAR, or technologies that do not yet exist could substitute. The mutable allocation contract can redirect endowment yield to whatever verification technology is available. The invariant is the *requirement* for verification. The method is adaptive.

5.4 Coordinated False Death Attack

An adversary attempts to falsely declare thousands of trees dead, freezing tokens and destroying value. The arbitration architecture (Research Note 004) addresses this: death declarations require evidence, disputed declarations go to decentralized arbitration, and false reporters forfeit their stake. No party profits from a death ruling. The incentive structure of the dispute resolution system mirrors the core protocol: the path of least resistance leads to accurate reporting.

The constructive deflation property also limits the damage. Even if an attacker successfully freezes some tokens, the supply contraction increases the economic incentive to protect and accurately verify the rest. The attack partially funds its own remedy.

5.5 Token Price Collapses for a Decade

This is the scenario that kills fee-funded mechanisms. Research Note 006 addressed this through the biome value floor—the fundamental value of old-growth ecosystem services is denominated in physics, not in token price, providing holder retention during market downturns.

The gomboc framework adds a structural argument. The immutable endowment principal continues generating yield regardless of token price. The yield allocation contract continues funding verification. The death-freeze continues executing. The core mechanism does not depend on the token’s trading price to function. A decade-long bear market degrades the system—fewer holders means less ground-truth verification, less liquidity means less price discovery—but it does not kill it. The mechanism degrades proportionally, not catastrophically. When conditions change, the mechanism is still running. It waited.

5.6 The Original Team Disappears

This is the gomboc test in its purest form. The founder retires. The development team dissolves. Nobody associated with the original project remains.

The immutable principal has no admin key. The death-freeze is coded into the ERC-721 transfer function. The verification tax accrues automatically. The yield allocation contract distributes to whitelisted verification contracts. None of these require a founder to approve, a board to vote, or a team to maintain. The adaptive layer—which verification contracts receive funding, how allocation percentages are set—requires governance by token holders. But the invariant layer—the principal, the death-freeze, the token-to-coordinate mapping—runs on code that does not know who wrote it.

This is the specific property that no traditional conservation mechanism possesses. The National Park Service depends on its staff. The Nature Conservancy depends on its board. Every land trust, every easement, every protected area designation depends on specific humans in specific roles making specific decisions. Arboreal Capital is designed so that the disappearance of its creator is a non-event for the mechanism. The trees do not know who Mitch Hart is. They do not need to.

Key Insight:

> Six scenarios. In each, the mechanism either generates an endogenous restoring force or degrades gracefully rather than failing catastrophically. The weeble characteristics are bounded and concentrated in the adaptive layer, while the invariant layer runs without human input. This is not permanence. It is the longest-duration self-correction architecture available for conservation.

6. Gomboc Erosion: The Real Threat

The kill scenarios above are dramatic but tractable. The subtler and more dangerous threat is what the gomboc framework identifies as *gomboc erosion* (Hart, 2026): the gradual, organic, often well-intentioned accumulation of human dependencies around a system that was designed not to have them.

Bitcoin is the cautionary tale. At the protocol layer, Bitcoin's gomboc properties were remarkably strong at launch. The creator vanished. The difficulty adjustment is a near-perfect endogenous restoring force. Every miner and node operator is interchangeable. But the ecosystem that grew around the protocol—mining pools, ETFs, political endorsements, institutional custody—gradually reintroduced the human dependencies the protocol was designed to eliminate. The code did not change. The weight inside the shape changed.

For Arboreal Capital, the erosion vectors to anticipate include: a dominant verification provider becoming a single point of failure, a large institutional holder whose participation becomes load-bearing for market stability, a regulatory framework that the protocol begins to depend on for legitimacy, or a governance culture that concentrates decision-making in a small group of active participants. None of these would break the protocol. Each would add weight inside the shape.

The defense is architectural. The immutable principal cannot be captured because it cannot be controlled. The death-freeze cannot be suspended because no suspension function exists. The token-to-coordinate mapping cannot be altered because the mapping is the token. These invariants are structural resistance to erosion: surfaces of the shape that cannot accumulate weight because there is nothing for weight to attach to. The design strategy is to keep the adaptive layer as thin as possible and the invariant layer as thick as possible, so that the surfaces exposed to erosion govern the least critical functions.

Design Principle:

> The hundred-year threat is not a dramatic failure. It is the slow, invisible accumulation of human dependencies around a system that was designed to operate without them. The defense is an invariant layer so thick that the surfaces exposed to erosion cannot reach the mechanism's core.

7. Phase-Dependent Weeble Characteristics

The preceding analysis identifies several points where Arboreal Capital exhibits weeble characteristics—where the system depends on human action rather than structural geometry. An honest assessment reveals something that the gomboc framework makes legible: these characteristics are not permanent deficiencies. They are phase-dependent. Each has an exit condition after which the system's self-righting properties engage at that failure mode and do not disengage.

Chain dependency. The protocol currently depends on Ethereum. If Ethereum fails, holders must coordinate a migration—a weeble event. But the migration only needs to happen once per chain failure. After migration, the system operates on new infrastructure with its gomboc properties intact. The economic incentive to perform the migration is endogenous: holders want the mechanism to continue functioning. The weeble moment is bounded, self-motivating, and non-recurring.

Concentration risk. In the early phase, before the holder base reaches sufficient scale and geographic distribution, whale accumulation is a real risk. As the system grows, the two-sided cost structure described in Section 4 makes concentration structurally inferior. The exit condition is sufficient scale and diversity of participation. After that, concentration is an unstable state the system naturally corrects away from.

Bootstrap. Before the first mint, the system is inert. The gomboc shape exists—the equilibrium is defined, the restoring forces are coded—but nothing has entered the system to activate them. The null state is the single unstable equilibrium: technically stable, but the smallest perturbation tips the system toward function. The bootstrap problem is not a mechanism design problem. It is a marketing problem. And once the first perturbation occurs—one mint, one holder, one unit of value—the gomboc properties engage. The shape was always there. It was waiting for something to land on it.

Key Insight:

> The weeble characteristics of the protocol are not permanent. They are conditions of early-phase operation, each with a defined exit condition. Chain dependency exits after migration. Concentration risk exits after sufficient scale. Bootstrap exits after the first perturbation. The trajectory is from weeble to gomboc, and the transitions are one-directional: once the system passes an exit condition, it does not re-enter the weeble state at that failure mode—unless gomboc erosion reintroduces human dependencies over time, which is the threat Section 6 addresses.

8. What Remains Open

This paper applies the gomboc framework to Arboreal Capital and finds that the protocol approaches the gomboc property with bounded, phase-dependent weeble characteristics. The honest open questions:

Formal verification. The physical gömböc was conjectured in 1995 and proven in 2006. The gomboc property for social systems may not admit mathematical proof in the same sense. Whether the framework can move from engineering judgment to formal verification—through agent-based modeling, game-theoretic analysis, or dynamical systems theory—is an open research question.

Concentration modeling. The two-sided cost argument in Section 4 is structurally sound but unmodeled. Agent-based simulation could test whether the geographic verification cost and regional death risk are sufficient to make concentration an unstable equilibrium under realistic assumptions about whale behavior, verification outsourcing costs, and regional climate risk profiles.

Erosion measurement. If gomboc erosion is the central long-term threat, the system would benefit from a metric that quantifies it: some measure of how much of the system’s behavior depends on specific participants versus structural incentives. Defining and tracking such a metric is an open problem.

9. Conclusion

The hundred-year problem is the hardest question Arboreal Capital faces. Not because the mechanism is weak, but because a hundred years is longer than any cryptocurrency has existed, longer than most conservation organizations have survived, and longer than many nations have maintained their current form of government.

The gomboc framework provides a way to reason about this problem that is neither naive optimism nor defeatist pessimism. It asks a precise question: does the system have exactly one place it ends up, and does it get there through structure rather than through the continued attention of specific humans?

Arboreal Capital’s answer is: mostly yes, with bounded weeble characteristics that are phase-dependent and self-resolving. The invariant layer—immutable principal, death-freeze, coordinate mapping—runs without human input. The endowment generates yield without human decision. The supply contracts automatically when trees die. The incentive to protect surviving trees strengthens under stress. The physical distribution of trees creates a two-sided cost structure that makes concentration structurally inferior without requiring governance intervention. These are properties of the mechanism’s architecture, not promises by its designer.

The trees that exist today have already survived 250 years of human expansion. They survived the Industrial Revolution, two world wars, the invention of the chainsaw, and the explosive growth of global timber markets. They did this without any financial protection whatsoever. The proposition of Arboreal Capital is that adding a self-righting economic mechanism—one designed to outlive its creator—gives them a better chance at the next 250.

A process engineer’s highest achievement is designing a system that works while they sleep. The gomboc property is the formalization of that ambition: a mechanism that works while everyone sleeps, forever, because the shape of the thing leaves it nowhere else to go.

Design Principle:

> The mechanism funds itself or it does not exist. The mechanism rights itself or it eventually falls. The mechanism outlives its creator or it was not worth creating. These are not aspirations. They are engineering requirements.

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