Regen Network Economics Technical Paper

An Ecological Market-Commons, Secured by Proof-of-Stake

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The state is a tree, agriculture its roots, population its trunk, arts and commerce its leaves. From the roots come the vivifying sap drawn up by multitudinous fibres from the soil. The leaves, the most brilliant part of the tree, are the least enduring. A storm may destroy them. But the sap will soon renew them if the roots maintain their vigour. If, however, some unfriendly insect attack the roots, then in vain do we wait for the sun and the dew to reanimate the withered trunk. To the roots must the remedy go, to let them expand and recover. If not, the tree will perish.

- Marquis de Mirabeau (physiocrat), 1751

Abstract

This paper will outline the use case of our token, starting from the context of ecological markets and agriculture. We will explore why blockchain is an appropriate solution, and why our Proof-of-Stake architecture and token design provide a suitable framework for overcoming the coordination challenges that are currently undermining market and non-market attempts to manage the common resource base of ecosystems as a public good. After this introduction we will detail our current token design, as well as list important topics for research and development for our project and the space more generally. We will argue that a commons-based framework is optimal for understanding both the design and operation of a blockchain as well as the management of ecosystems. We will review pilots that catalog the different actors and how they interact with our blockchain and token, and illustrate our token economy in a formal economic model. We intend for this paper to clearly illustrate the role of bringing together a group of potentially adversarial stakeholders to generate the public goods of verified information about ecological state, and the regeneration of agro-ecosystems to revitalize the carbon cycle and increase land steward profitability. This paper focuses exclusively on the protocol Proof-of-Stake token mechanics—not the smart contract enabled tokenization layer that will be built to represent, steward and exchange ecological value.

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1 Introduction

The aim of Regen Network is to imbue the economy with ecological sentience. The model of production of ecological knowledge—what and how we know about what is happening in a given ecosystem—is the foundation for achieving this aim. Therefore, a community dedicated to maintaining a decentralized open ledger of ecological health information to serve as the basis for conditional agreements between parties is an essential building block for a new phase of the global economy that accounts for ecological health and invests in ecological regeneration as the cornerstone of healthy business and governance. This paper outlines the economics and governance of the community that will maintain this open ecological ledger. On top of this ledger, a new economy of ecological value will be built. We will explore the economics of this application layer in subsequent papers. The "Regen" in Regen Network is short for regeneration. But what does this mean? When we use the term, we're drawing on the work of business development consultant and educator Carol Sanford. We refer to regeneration as actions that increase the capacity, viability, and vitality of both the agent and system being acted within or upon. As these concepts can be elusive, it may be useful to ground our working definition in the sphere of regenerative agriculture. As defined by our sister enterprise, Terra Genesis International, regenerative agriculture is a system of farming principles and practices that enhance ecological health [Ter19]. This could be contrasted with conventional agriculture, which degrades ecological health. Public good outcomes of Regenerative Agriculture include carbon sequestration, clean water and biodiversity. Private good outcomes include increased economic prosperity for land stewards and other network participants.

Financial capital is often created by liquidating ecological and social capital (for more on this subject see [Sza19a]). For example, the vast majority of palm oil plantations are sited on clearcut rainforest. Timber is often harvested using clearcuts, and fisheries extract so many fish that the populations crash. All this is driven by short-term profit. While it is clear that these processes create some form of value (especially financial capital), it is also clear that there is something important that has been lost along the way, and that the true wealth of the system is undermined. As these losses keep adding up, we find ourselves in a state of both societal and ecosystems collapse. If we want to address ecological degradation systemically, we need to intervene somewhere in the economic process. Regen Network aims to reinvent the economics of agriculture, and land use more broadly by bringing ecological state information to agreements and contracts to ensure rational choice and more efficiently price externalities. Beyond rational choice and pricing externalities, ubiquitous access to high quality ecological information will have an enormous impact on the quality of the relationship between the human economy and the greater than human living world.

Near real-time access to high-fidelity ecological state information is now possible. This capacity has not been a common part of the human experience since the poorly-understood and nearly-forgotten evolutionary arc of small bands of

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hunter-gatherer Homo sapiens. Early humans and intact cultural traditions maintained (and sometimes still maintain) intimate individual and cultural connections to landscapes and ecosystems. We can now regenerate that missing capacity to attune our human economy with the health of the ecosystems that support us. Regen Network is making this leap possible.

How can we ground these grand aims in a tooling that brings these ethics into an actionable sphere? Recent developments in blockchain architecture—such as Byzantine-Fault-Tolerant Proof-of-Stake consensus algorithms—have enabled a new form of decentralized governance in a data commons. To build on this foundation, we introduce a community staking model to even further decentralize decision making and align it more deeply with the community of users. Built on the Cosmos SDK, Regen Network is one of the first of a third generation of blockchains that leverages the governance mechanisms and data provisions for real world commons management.

2 Assumptions

This paper is written with a certain set of assumptions:

- The environment is being drastically and negatively impacted by the human economy.
- We must act quickly and solve key coordination issues related to environmental degradation, climate change, extinction and pollutants.
- Blockchain is a social and technical tool that can offer a solution to solving trust and coordination issues.
- Due to its massive environmental footprint, Proof-of-Work is not an option for an endeavor serious about ecological concerns.
- Sovereignty of a blockchain is a tool that gives a community the ability to generate the social conditions needed to solve coordination issues.
- The appropriate scale of governance to achieve optimal coordination is as local as possible, yet there is also the need for an open global ledger of ecosystem health to refer to. Our planet is a singular, interconnected whole, and needs an open source of ecological truth for agreements about ecosystem health.

With those assumptions enumerated, we dig into the domain of ecosystem regeneration, for which our token model is designed.

3 Why Proof-of-Stake?

What is the economic value Regen Network is generating? How is it generated? These are two pivotal questions to understand. In order to answer them

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successfully we must first understand the role of information in environmental decision making. Let us look at a hypothetical example.

A farmer continually degrades the health of their soil in order to optimize for short-term yield increase and stability. Commodity buyers and the food businesses that rely on this product have short-term access to stable and cheap produce, but the long-term effect is a sharp increase in price, or even complete lack of availability due to the inability of the soil to continue supporting yields. In addition to this impact, there are corollary impacts such as costs to downstream farms and cities, as well as to the farmer and eaters of the food themselves in the form of malnutrition and bioaccumulation of toxins. In this case, the cost over time of the short-term market decision is enormous. Why then does such a poor state of affairs endure? We argue that one of the key factors is the lack of distribution of good information. However, it is not enough to say that ignorance is equally distributed. It is more accurate to describe access to information as disparate, in which the only companies that are truly profiting from current conditions hold near-perfect information regarding the costs being externalized onto the other stakeholders of the system, and yet continue to optimize business for extraction. This is made possible by the massive discrepancy in access to information, and the systematic occlusion of the information that is available in order to maintain conditions whereby firms who profit from this situation can continue to profit instead of evolving their business model and offerings in a way that provides a non-degenerative, non-extractive form of value exchange.

Good information: What is it? How do you generate it? How do you maintain it?

Given the above scenario, it seems clear that access to high quality information—in this case, about ecological state—that is accessible to all parties participating in the production of economic value from an agricultural commodity is essential to realign the economics to agribusiness to incorporate ecosystem health. The short and long-term economic outlook improves for all parties when market agreements can take into account this information and base pricing accordingly.

How do we create the conditions to provide ubiquitous access to high quality ecological state information? This is a complex question, and given this is an outline of the economics, and not the science of the Regen Network vision, we will focus on the crypto-economic underpinnings of our approach. For further information on the scientific approach to verifying ecological state information, please refer to our whitepaper, science paper, and documentation about the Regen Oracle Protocol. The crypto-economic underpinnings of an ecological health ledger is fairly simple to outline to someone with an understanding of blockchain in particular, and distributed cryptographically-secure state machines more generally. The essence of this value proposition is a distributed database with a shared directory that is censorship resistant, which refers to a heterogeneous but interoperable network of ecological data and ecological model storage.

What is the value of such a system? There are different ways to look at that: we might claim that the value of the information is equal to the economic value generated by having access to that information (a value driven approach).

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We might value this as the cost to upkeep the durable and censorship resistant nature of the network plus the cost of the collection of the data (a cost approach). We might calculate the value of this network by understanding the revenue potential dependent on the network (which can be considered a type of public infrastructure). At the end of the day, the market will value this according to some mix of the above approaches.

The maintenance of such a network requires a globally distributed network of highly competent validators to run the Proof-of-Stake apparatus. For those not familiar with this new role in the crypto-economic landscape, you might think of these stakeholders as artisan data centers operating with the security of a bank, and the uptime needs of a cloud provider, at a much smaller scale. A huge amount of value may be stored and protected on the computers run by a validator. Censorship resistance, durability and shared state of the network is directly dependent on the competence of this community. As such, this community is a key stakeholder to be compensated for their labors, and the first layer of token economics in Regen Network are designed specifically to compensate competent validator operation and punish incompetence or bad actors in the community that provides this key service.

Of course, the value derived by these operators depends on the value of the staking token itself on the open market, which should be directly related to the utility derived by users of the permissionless public network providing ecological state information and tools to execute agreements about ecological state and manage and exchange ecological assets.

4 Ecosystem Service Markets and Agreements

Current ecosystem service markets such as carbon offset markets (voluntary and compliance), are deeply flawed. We feel strongly that the foundation upon which ecosystem service markets—as well as non-market agreements between stakeholders to govern ecological commons in a sustainable, and if possible, regenerative way—will depend on in infrastructure of trust that we refer to as an ecological knowledge commons.

The layers of technology that generate security, durability and integrity around data, compute functions and algorithms are the foundation for a trusted monitoring and verification system of ecological state. This trusted monitoring and verification system in turn is the foundation of any agreement between parties about ecological state. Agreements about ecological state are the foundation for the inclusion of ecological health into our financial system—an important aim of Regen Network.

Currently, ecological health is not held on the balance sheet of any entity, private or governmental. This means that financial decisions are blind to their ecological impacts. This is starting to change in small ways; there is a global payments for ecological services market. A conservative estimate puts the global market size in 2016 at $36 billion annually [SBC+18]. One example of this would be the Natural Resource Conservation Service (a branch of the United States

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Department of Agriculture) paying farmers to plant riparian buffers around streams that pass through their farms to improve the health of their waters.

We would like to build on these shifts in societal perception of farmers and others interacting with natural systems. Rather than viewing farmers simply as food producers, we would like to elevate their societal status to that of land stewards. Agricultural use is the primary way (by land area) that humans interact with land, representing 37% of land globally [wor19]. Currently, the vast majority of this activity is degenerative, but it doesn‘t need to be this way. We do this through two fundamental instruments: Ecological State Protocols (ESPs) and Ecological Agreements. ESPs are algorithms that, primarily utilizing remote-sensing data, determine the change in state of a specific facet of ecological health. An example of this would be a soil carbon ESP, which would track the change in soil carbon in a given piece of land over a given period of time. Ecological Agreements are smart contracts tied to the outcomes of Ecological State Protocols. For example, a rancher has demonstrated via a soil carbon ESP that they‘ve sequestered one hundred tons of CO2 over the past year in their ranch land. A carbon market, utilizing an Ecological Agreement, could pay them automatically when this carbon sequestration is verified.

4.1 What does it take to make regeneration happen on the ground?

An appropriately designed token will reinforce on-the-ground regenerative activities. In practical terms, this means that the operations of Regen Network should promote higher levels of investment in natural capital, accelerate the implementation of regenerative projects, and elevate the standing of land stewards who are working to achieve these ideals. Our token design will be judged by its effectiveness to create real world impacts.

Several reports published over the last decade have examined the need for increased investment in the environment and natural systems [Ens16] [Ter18]. Some of the key impediments, at least from the perspective of those with the means to invest, are that the benefits are unclear, or that small, fragmented projects are simply not investable in a scalable way. These observations point to an important element of Regen Network‘s place in the global earth repair movement: the centrality of knowledge in regeneration efforts. If investors and politicians know that their actions have a positive impact, if resource users know how their choices impact natural systems, and if land stewards know their efforts will be recognized accordingly, then we have a foundation upon which we may enact real change.

As we have noted elsewhere, knowledge production systems can help inform land stewards, investors, resource users, and the broader body politic of the total impacts of human decision making on ecosystems [Bir18]. Knowledge production involves much more than simply reporting data from sensors and satellites; it is the generation of higher-level awareness of intertwined ecological and social systems.

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In a sense, every Ecological State Protocol and Ecological Agreement that uses ESPs includes its own knowledge production system: what information do we need? How do we go about obtaining it? How do we evaluate the quality of that information? How do we ensure accuracy and truth-telling? We believe the embodiment of that knowledge in the concept of ESPs—the methods, techniques, and know-how—can be a source of great value.

We are proposing that Regen Network is a platform to make Ecological Agreements easy to craft, meaningful in their impacts, enforceable, and worthy of trust. It follows that there are two important roles for a token in our ecosystem:

1. to ensure the parties in an agreement can independently establish the validity of actions that are recorded on Regen Ledger,

2. to provide appropriate governance tools for the participation of all stakeholder groups in upgrading rules and standards as conditions evolve.

This is made possible by the Proof-of-Stake model provided by our use of the Tendermint consensus engine. Our design further allows the bonding of services, such as trusted computation, that can be examined, even audited, by other participants for accuracy and reliability.

5 Token Design

5.1 Economic Model

Regen Network's ecological ledger and contracting platform build on the Cosmos SDK (for more background on this choice of tech stack, see [Lan19b]. Despite the opportunity created by the large and growing market for ecosystem service payments and transactions about ecological health and the imperative to stabilize ecological systems in order to regenerate a degraded planetary carbon cycle, there is no other domain-specific blockchain being developed for ecological applications.

There are other projects that are building smart contract dApps on top of other chains. This will create governance and incentive issues that will ultimately affect their ability to generate the dual public good outcomes of trusted ecological information and coordination of ecological regeneration outcomes.

We propose the need for coherence between:

1. The governance of the blockchain

2. The goals of the application users and

3. The aims of the community.

Using a generic public blockchain does not create this alignment. Therefore, Regen Network is building Regen Ledger to create the first blockchain dedicated to ecological claims.

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Regen Ledger is a Tendermint-core-based Proof-of-Stake blockchain with bonded validators, which provide network security and durability. This creates the foundation for a new asset class of public goods: durable information about ecological state and an ecological agreement framework.

We hypothesize that it will be more efficient to coordinate ecosystem health-related, domain specific activities such as carbon markets, and tokenization of living and natural capital assets on an integrated and sovereign zone. That being said, Regen Network is designed with the ability to interoperate with and support ecological application zones with unique validator pools as the need arises.

5.2 Staking Token

Regen Network's token design is heavily influenced by that of the Cosmos ATOM, adapted to ensure utility for ecological data and outcome markets [Agg17]. Regen Network will be governed as a public blockchain by token holders following the model outlined and implemented by Cosmos. We will be upgrading the model to focus on the utility and sovereignty for the domain of ecological claims.

Key adaptations include:

- Modification of slashing to reflect graduated sanctions theory developed by Elenor Ostrom
- Community Stake—35 million $REGEN locked token pool for non-token holding users such as:
  - Land stewards
  - Scientists
  - Developers

5.3 Key Stakeholders

- **Validators**: Cosmos Network validators who chose to also validate Regen Ledger, and perhaps other validators who chose to run Regen Ledger. Validators must be staked in the system. Validators host secure compute infrastructure that ensures the shared state of the Regen Network Virtual Machine through the PoS mechanisms of the Cosmos SDK.
- **Delegators**: People who delegate or bond $REGEN to other network participants in order to earn a fraction of the fees generated through the economic activity of the network. We will follow the Cosmos model and make upgrades reflecting the wisdom learned from the Cosmos experiment. As of now, we assume a three-week unbonding period.
- **Oracles**: Computers that are writing information to the ledger about ecological state (different function from Validators, although an entity might choose to do both).

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- **Data Providers**: Agents (people/machines) providing information into an algorithm or as an attestation on the network. Includes the spectrum from sensors and satellite information to third party verification and human observation.
- **Land Stewards**: Agents with addresses tied to land parcels. Land stewards are active in managing land. This may include individuals, communities, legal entities or DAOs.
- **ESP Curators**: Companies like RND, TGI, TK Design Labs, and Applied GeoSolutions. May assemble a network of contract oracle, data and contracts, or be full service—able to produce and bond every element to run an ESP and execute ecological agreements.
- **Agreement Curators**: Organizations or individuals who are curating a contract.
- **Arbitrators**: Contracts can specify arbitration options off-chain.
- **Ecosystem/Land**: The land area itself that is the basis of ecological agreements can be considered an agent in the system and be assigned its own unique address, raising interesting DAO-like opportunities.
- **Investors**: Funding the infrastructure and overhead associated with the capitalization of regenerative projects; bearing the risk of project failure and reaping the reward of the margin between project cost and the price of outcomes.

5.4 Delegating $REGEN to a Validator Node

Those who delegate to a validator are eligible to receive block rewards for each validated block. When they unbond from a validator there is a three-week period that the tokens are not eligible for block rewards or fees. This is a direct fork of the Cosmos staking token model. Slashed tokens are burned.

5.5 Earning Fees

Validators, oracles, data providers and Ecological State Protocol curators play a critical role in the network and are compensated for this value through a fee mechanism (contrary to industry norms, we prefer the term "compensate" to "reward" [Sza19b]). These actors receive fees in the form of the fee tokens paid for the transaction, split and distributed to the different actors responsible for generating the value. $REGEN will be the fee token on network launch. Upon the adoption of Cosmos' Inter-BlockChain protocol [IBC], there will be the possibility to use other whitelisted fee tokens, such as ATOMs or Terra, a Cosmos-based stable coin. Ecological tokens, which are essentially derivatives of $REGEN, generated by ecological agreements between parties, could conceivably also be accepted as fee tokens by service providers to the network.

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5.6 Block Rewards

For each block created, a block reward is generated and distributed to validators.

5.7 Token Supply Increase

Commensurate with the Cosmos "inflation" mechanism, an increase in tokens is allocated to $REGEN addresses according to the number of $REGEN tokens that are bonded. This incentivizes $REGEN holders to be actively involved in securing the network, and disincentivized those who do not participate. Inflation will be between 7% and 20% annually, relative to the percentage of $REGEN staked. There will be a 7% increase in token supply when 66% or more of tokens are staked, rising to 20% when less than 66% are staked. Cosmos launched with a one year window for this to change. We will launch with a three-month window (one financial quarter), making supply increase more dynamic.

6 Token Allocations

Supply at mainnet launch will be 100 million tokens (meaning 1 million tokens represents 1% of the supply). Some unsold tokens may be burnt (details below). Numbers are given in million $REGEN.

- **35mm for Community Staking Pool and Regen Foundation**
  - All of this allocation is perpetually locked.
  - Community governance staking model focused on Land Stewards, Science, and Developers
  - Staking rewards will be managed to maintain at least 1/3 voting block power (Byzantine veto) in the long term.
- **23mm Non-sale allocations**
  - 15mm Regen Network Development, Inc.
  - 5mm Network Bootstrapping Fund
  - 3mm ATOM-holder airdrop and work-lock w/KYC
    - Linear unlock over 3 years
- **42mm Fundraising and Market Offerings**
  - Up to 4mm in a legally-compliant public offering $2.8mm at $0.70
    - Pending legal, tax, and exchange approval
    - Not locked
  - 32mm Pre-sale to community
    - $9.5mm-18.4mm sold at $0.21-0.63
    - All tokens locked for a minimum of one year

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    - Discount related to lock schedule
    - At mainnet launch, any tokens reserved for the private sale not yet sold will be burnt
  - 6mm Already sold to investors
    - Locked for varying lengths, deal by deal

7 Governance

Regen Network will be a public Proof-of-Stake network. This means that the primary governance mechanism is via token validators and delegators proposing and voting upon proposals. We are implementing five innovations to the Cosmos' governance design, two of which are off-chain:

1. Community Stake Token Allocation
2. In-Protocol Governance DAOs for constituencies
3. Variable token sale discount
4. Legal responsibility of an organization (Regen Foundation) to steward the culture of healthy governance
5. Democratic governance of Regen Foundation

7.1 Community Stake Token Allocation

Technology platforms often fail to give users adequate say in governance—Facebook being the most notorious example [Zub19]. The platform cooperativism movement, as well as the cryptocurrency community, have made strides towards addressing these failings [Sch14]. And yet standard Proof-of-Stake blockchains still limiting governance to the set of community members with the technical and economic capacity to stake tokens. Especially with projects that have a large segment of their user-bases that are not crypto-literate (such as Regen Network), it becomes important to develop methods of including these constituencies in governance. This can be done through a Community Stake token allocation. This is a pool of tokens which is set aside to be governed by DAOs. For more detail, see the next section and reference [Lan19a].

7.2 In-Protocol Governance DAOs for Constituencies

The Community Stake Token Allocation will be divided across a handful of governance DAOs. These enable specific classes of community members (such as farmers, researchers, and engineers), to gain representation.

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7.3 Variable Token Sale Discount and Airdrops to Community

We are designing an initial community token offering to key network stakeholders in the form of public and private token sales, airdrops, bounties to land stewards for ecological stewardship, and initial rewards for data provision. We are prioritizing the sale and distribution of tokens that are non-transferable (locked) and therefore only useful to stake, over tokens that can either be staked or exchanged. This will increase network security, viability and utility. Our private token sale terms reflect this design. Token distribution to community members (developers, validators, data providers) will similarly represent this prioritization.

7.4 Role and Responsibility of Regen Foundation

One of the explicit roles of the Regen Foundation will be the stewardship and cultivation of a healthy governance culture, the inclusion and education of stakeholders and users into the Community Governance DAOs.

Regen Foundation‘s mission is threefold:

1. To ensure that key users and stakeholders of the Regen Ledger blockchain and platform have a voice in governance through creating constituencies focused on Land Stewards, the Science community and Developers and Software Engineers.

2. To foster robust open science and technology development in service to universal access to accurate ecological state information and monitoring tools.

3. To build community around ecological regeneration and stewardship, and to the degree possible support real world regeneration projects.

7.5 Democratic Governance of Regen Foundation and the Community Staking Pool

The largest threat to democratic governance of a commons or political sphere is the banalization and degradation of the ableness to govern embodied in the citizenry, or in the case of a PoS blockchain, the stakers. This means there is a need to design a robust cultural space in which a forum for discussing the most important issues is curated and engaged with by a majority of the community.

To address these considerations, we propose the creation of a Community Staking Pool with token allocations as follows:

- Up to 10mm $REGEN to land stewards and farmers
- Up to 10mm $REGEN to developers and engineers
- Up to 10mm $REGEN to scientists and researchers

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- At least 5mm $REGEN to Regen Foundation

Each of these four token pools will be managed as a multi-sig DAO focused on ensuring governance voting and participation by a unique Regen Network user group. These groups are outlined above, with the fourth address pertaining to the foundation itself. Upon launch, the Board of the Foundation will have custody of these wallets and a legal obligation to appropriately build the community of constituents pertaining to each wallet. The final distribution to addresses will be determined through a community process.

7.6 Formalizing Distribution and Management of Community Governance Tokens

Regen Foundation, after the first round of our private pre-sale is complete, will convene stakeholders in a series of virtual meetings, using a forum and the Loomio software to track conversations to specify and design the structure of the governance DAOs and suggest an initial token distribution. Stakeholders who will be invited to participate will be Validators running the Regen Ledger Testnet, Pre-Sale Participants, the existing Regen Consortium organizations, and special guests. This group will flesh out a more clear design.

Regen Foundation is member-governed not-for-profit responsible for ensuring that healthy governance is at the heart of Regen Network. For further details about Regen Foundation and Regen Consortium (the governance body of the Foundation), please request a copy of our by-laws.

Our original governance model was articulated in the whitepaper, first published in 2017 [CLS+19]. The above-stated governance model represents an evolution of that original design.

8 Commons

Much of the utility of Regen Network is in agreements about ecological "common pool resources;" as such, it is useful to briefly treat the commons and the role of commons theory in the economics of Regen Network. In 1968, American ecologist Garrett Hardin published his now-infamous *Tragedy of the Commons* article in the journal *Science*. This myth—which most aptly describes Laissez-faire, not commons—has swept the mainstream narrative, contributing to a general malaise when considering commonly-stewarded resources. Nobel laureate Elinor Ostrom has definitively debunked Hardin's myths, and spent her career outlining the conditions not only in which commons are the best governance instrument available, but the attributes by which a commons might thrive [Lan19c]. Commons scholar David Bollier defines a commons as consisting of three elements: a community, a commonly-held resource, and governance [Bol14].

Given the existential threat of climate change that our species now faces, it is imperative that we reconcile the false dichotomy of commons and markets.

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We posit for the sake of argument, that we can view functioning markets—with their standards of engagement, goods, and participants—are one varietal of commons. Regen Network supersedes the tragedy narrative—bringing to bear the best that both market thinking and commons governance have to offer.

Regen Network effectively creates an ecological data commons in which the common pool resource of high quality data and trusted attestation about ecological state can be used by different stakeholders to form public or private agreements.

We refer to our approach as a market-commons approach in which the market mechanisms are designed and maintained nested within the health imperatives of a clear group of stakeholders which govern the system (for more background on this subject, see [Bir19]. This is not to be confused with social democracy or other state-led efforts because this is a voluntary network of actors determining the optimal governance for market mechanisms to generate two key layers of public goods: near-perfect information about ecological health for all, and ecological regeneration outcomes for all.

9 Pilot Project Applications

9.1 Eco-Cacao

Eco-Cacao is a cacao-producing farmer-cooperative in Esmeraldas Province, Ecuador [Zam16]. These farmers steward agroforestry farms that border the last remaining fragment of the Chocoan Rainforest of Ecuador. The Chocoan Rainforest is of high ecological importance for a number of reasons, including its role as a part of the hydrological pump that keeps the continent of South America and the rest of the planet hydrated, and its phenomenal biodiversity.

Regen Network is working with a group of cacao buyers and Eco-Cacao to verify regenerative land stewardship as a part of a price premium paid to farmers who are successfully managing farms that mimic the native forest, generate high carbon sequestration yields, and increase biodiversity on the farm.

In this case, the land health is being recorded on Regen Ledger to create an open, transparent and public view of the ecological state of the larger region and the relationship between that state and the management outcomes of land stewards. The payment for ecological stewardship and land health of the plot being stewarded are also recorded on the ledger. Eventually, direct payment will be possible to land stewards. Layers beyond product premium such as carbon payments and biodiversity payments will be added to the agreement matrix.

Fees are collected by the following entities for generating this utility:

- Validators—as the Regen Ledger is written to for an annual audit
- Validators—as exchange of payment is made to execute agreements
- Verifiers—(in this case Terra Genesis International and the Seed Guardian Network) as attestations about ecological health is made

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- Oracles— as computation of data with trusted algorithms (provided by verifier) is completed

Payment is triggered to Land Stewards when their ecological outcomes are verified.

9.2 Rainforest Foundation

The Rainforest Foundation is an organization that supports indigenous land stewards to protect their ancestral forests. Regen Network is supporting Rainforest Foundation in leveraging the Global Forest Watch system of satellite monitoring to give information to on-the-ground land stewards about potential threats. Regen Network will serve as the public ledger for data and contracts to streamline this operation and eventually payments will also flow through Regen Network.

Fees will be collected by the following entities for generating this utility:

- Validators—as the Ledger is written to for an annual audit,
- Validators—as exchange of payment is made to execute agreements,
- Verifiers—as attestations about ecological health is made: Deforestation Monitors upload data regarding forest health or illegal deforestation activities,
- Oracles—as computation of data with trusted algorithms (provided by verifier) is completed.

These two pilots—actively in-process—represent the tip of the iceberg in terms of what is possible and allow us to generate iterative and ground-up understanding of the economy in action.

10 Modeling the Token Economy for a Validator

Validators are key stakeholders in the maintenance (and governance) of the value of a public blockchain. These are the small business operators that maintain the core functionality of the distributed ledger. We will also model the economics of other various network roles.

10.1 Model

The following projections validate our assumptions on questions such as:

- How many tokens should be minted?
- Should token supply increase, remain constant, or decrease over time, and at what rate?

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- What metrics—technological and economic—are useful in describing how well the system is operating?

While there are many non-financial reasons for entities to use Regen Network, the focus here will be on financial and accounting measures as they relate to two classes of Regen Network participants:

- The operators of technological infrastructure
- Parties that wish to use Regen Network (specifically, Regen Ledger) to record transactions, attestations, and other phenomena to support regenerative Earth systems work.

The following model illustrates the operation of Regen Network's token-based staking approach to the operation of validator nodes.

10.2 Validator Node Operation

This work builds on the dialogue around Proof-of-Stake consensus mechanisms in the blockchain space, and more specifically, on the PoS model developed over the past several years by the Cosmos project. The basic characteristics of the PoS model of Regen Ledger are recapped here:

- Tokens are created and the present-day value is discovered by the market
- Users acquire tokens and bond them to a validator node, representing a stake in the system
- Validator nodes record transactions onto Regen Ledger, providing a record of the actions of entities using the system
- Transaction fees are paid by the party transacting
- Validators indicate the minimum fee they will accept to process a transaction, which will be subject price dynamics over time as network usage ebbs and flows
  - If a validator node performs invalid operations, they are slashed losing a percentage of staked tokens. A validator node has meaningful financial incentives to record only valid transactions onto the ledger for the following reasons:
  - Compensation from transaction fees is contingent on behaving in ways beneficial to network health. The asset value of the tokens staked by a validator node operator also derive from the perceived reliability and truthfulness of transactions recorded on the ledger.

Following is a brief financial summary of a hypothetical validator node.

This example describes a validator node that represents five percent of the total outstanding tokens—in this case, 3,333,333 $REGEN. This consists of

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a node operator that stakes 428,571 of its own $REGEN, plus an additional 2,904,762 tokens delegated by others who do not wish to operate their own validator node. The calculations are presented in Tables 1 and 2:

Total $REGEN Supply (Year 0)	100,000,000	$REGEN
$REGEN staked in validator nodes (assume 2/3)	66,666,667	$REGEN
IEO Price	$0.70	
Market price of $REGEN at purchase from validator	$0.35	USD-equivalent
Dollars spent	$150,000	USD-equivalent
Tokens acquired	428,571	$REGEN

Table 1: Member Purchases $REGEN and Stakes Full Amount in Validator Node

Own stake	428,571	$REGEN
Delegation Ratio (Tokens delegated/Own tokens)	6.778	
Tokens delegated on others' behalf	2,904,762	$REGEN
Total tokens staked in validator noder	3,333,333	$REGEN

Table 2: Tokens Staked

For simplicity, we assume a total token supply of 100 million $REGEN, of which two-thirds, or 66,666,667, are staked at any given time.

Based on reported figures for transaction activity on the Cosmos blockchain, blocks are written at a rate of about one every 6.7 seconds. Assuming Regen Ledger has similar performance characteristics, this means roughly 13,000 blocks will be written to Regen Ledger per day, or about 4.7 million blocks per year.

From this validator node‘s perspective, they can expect to write five percent, or roughly 157,000 of these blocks, summarized in Table 3:

Own stake	20,186
From delegators	136,817
Total fee-bearing blocks per year	157,003

Table 3: Fee-Bearing Blocks

We assume the total transaction fees collected per block average $5.40 (in USD terms, though the actual unit may be any whitelisted currency). A portion of these fees would be passed through to the owners of delegated tokens, modeled here on the basis of a five percent service fee. This results in net revenues of $145,945 to the validator node operator, summarized in Tables 4 and 5:

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Transaction fees from own stake	$109,005
Transaction fees from delegated stake	$738,811
Pass-through to token delegators (Based on Service Fee)	-$701,871
Net Validator Revenues	$145,945

Table 4: Validator Node Revenues (USD)

Expenses (Annualized)	$5,000
Earnings for Validator Node	$140,945

Table 5: Earnings for Validator Node

We also believe validators will be allocating their computing resources to several different blockchains in the Cosmos ecosystem. Assuming the validator has annual expenses of $50,000 (what we've heard from current Cosmos validators) and participates in ten separate zones, the costs attributable to Regen Network are estimated at $5,000 per year. After subtracting these costs, the validator node's earnings would be $140,949 per year. This estimate is assuming that all validator operators are partners and therefore take profit as something like dividends of the total net profit of the operations of the validator, not as a salary.

This figure, divided by the number of tokens staked, gives us Earnings per Token (EPT), one of the financial metrics we will use throughout this analysis. We report three separate EPT figures (as seen in Table 6):

- EPT for the validator node
- EPT for parties delegating tokens to this node
- The Aggregate EPT of node operators and delegators

Earnings per Token (EPT) - Validator	$0.3347
Earnings per Token (EPT) - Delegators	$0.2416
EPT - Aggregate	$0.2554

Table 6: Earnings Per Token (EPT) for Hypothetical Validator Node

The above example illustrates that it is more advantageous in Stage I for token holders to enable the provision of services to the network than to just buy and hold tokens.

11 $REGEN as the Foundation for a New Regenerative Token Economy

Regen Ledger provides a tailor-made blockchain solution to connect a pool of validators and compute oracles providing computation and a distributed ledger

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with tooling and data for ecological and sustainability applications. The most highly impactful potential of Regen Network's approach are found in the second layer of token economics, made possible by our Ecological Agreements and Ecological State Protocols [CLS+19]. A few example token models that can be launched quickly as easily as smart contracts on Regen Ledger are:

- **Automated Carbon Removal**: The opportunity to use Regen Network to generate automated fees for carbon emissions and deploy automated compensation for carbon sequestration outcomes in ecosystem. We plan on offering this service to the Cosmos Hub, as well as other blockchains and tech businesses.
- **Natural Capital Assets**: The process of verification of the existence of natural capital assets such as timber, soil, water can generate representative non-fungible tokens which can be created for internal accounting or exchange.
- **Ecosystem Service Credits**: Similar to the natural capital assets, impact credits are created using the verification of a change in some indicator over time. Examples include biodiversity, clean water, water infiltration, air quality, carbon sequestration, grasslands health, etc. Our partners at Nori will be leveraging our ecological data towards this end, for the production of their Carbon Removal Certificates.
- **Eco DAOs**: Using an Augmented Bonding Curve model, or other DAO funding and management models, a DAO can dedicate itself to ecological services such as regenerating landscapes. These Eco-DAOs can be linked to Ecological Bonds, bounties and other financing mechanisms.
- **Reverse Mining**: Our original schema for connecting ecological regeneration to the protocol layer of incentives as an economic primitive was a powerful way to connect the network to ecological outcomes. This proved to be untenable in the short term but is achievable with the infrastructure represented by Regen Ledger. Reverse Mining was the idea of tying a cryptographic token minting-burning mechanism to ecological regeneration and degradation, so that the faster ecosystem regenerate the faster the token supply would increase. This would necessitate a slashing function as well for the destruction of ecological health. Obviously this is a complex undertaking; however, we feel it's a worthy direction for future research and development. For more discussion on this subject, and related topics of ecological economics, see [Sza19c].
- **Bonding Curves**: Bonding curves enable the pricing of interest through the creation and automated pricing of novel assets. They could be utilized to price the average loss-aversion for natural capital, or support in weighted decision making of commons.
- **Sustainability Applications**: Renewable energy credits, internal corporate accounting and insetting, carbon credits are all use cases that our

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tooling makes easier than any existing public (or private) blockchain solution we are aware of.

12 Conclusion

Regen Network's token model creates a protocol-level incentive structure to operate and maintain the key elements of a trusted and secure platform for reporting and sharing ecological data and making ecological claims. The native token, $REGEN, is used for staking validators and oracles—the two foundational service providers in the network. Regen Network generates utility through a protocol for making claims about ecological state and agreements based on those claims. These agreements may result in the formation of cryptographic tokens that are fungible or non-fungible, depending on the context and agreement. The token model of Regen Network secures the network against attack and censorship making near perfect information about ecological state available for the public and for users. Regen Network's aim is to bring ecological sentience into the economy. A side effect of this will be the mainstreaming of ecological accounting, making it pervasive and affordable. By doing so, this technology creates a viable pathway toward the global recognition of ecological stewardship and a pathway toward planetary regeneration.

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