Regen Network
Whitepaper

Version 0.8
April 9th, 2018

G. Booman, A. Craelius, B. Deriemaeker, G. Landua, W. Szal, B. Weinberg

For more on our system architecture please reference the Regen Network System Architecture document. For more on scientific underpinnings, please reference the Regen Network Ecological State Protocols document.

Abstract

In this whitepaper, we propose a remedy to ecological degradation and climate change. This approach leverages distributed ledger technology (DLT) to create a systemic multi-stakeholder, market-driven solution to facilitate verifiable ecological monitoring. We outline the key technological challenges to creating a decentralized system to monitor and verify ecological state and change of state, and the computational needs, frameworks, and governance that can create a trusted infrastructure for an ecological accounting ledger capable of rewarding ecological regeneration through smart contracting capabilities.

We address the role of crypto-assets and DLT in creating cooperative open source community-change endeavors. We explore how we overcome challenges our platform faces with: data quality, land tenure and trust issues, smart contract system challenges, and problems facing DLT projects in governance and legal jurisdiction. We illustrate how Regen Ledger, our domain-specific distributed ledger, will provide coordination, verification and coherence for living capital accounting, data and monitoring through the structured, decentralized data system of distributed ledger technology.

Table of Contents

1. Introduction

1.1. Context

From Nakamoto's publication of the Bitcoin whitepaper almost a decade ago, distributed ledger technology and the crypto-asset world has developed from a novel fascination into a force that's disrupting sectors from fintech to adjudication, from identity to democratic voting systems. It is clear to us at Regen Network that DLT and crypto driven innovation, and indeed the hi-tech space in general has not yet established a coherent relationship with the biosphere. We believe that one of the highest potential uses of DLT-enabled decentralized governance, crypto-economics and distributed computing is to bring forth a game-changing paradigm shift in the relationship between financial systems and ecosystem health.

This whitepaper outlines how a tokenized distributed ledger running decentralized protocols for the verification of ecological outcomes and smart contracting capacity can enable numerous industries—from carbon markets, to consumer product companies, to the insurance sector—to tie their decision-making back to an accurate shared understanding of their impact on natural systems.

This whitepaper is written with the assumption of a high degree of literacy in crypto economics, blockchain and DLT, as well as literacy in data science, remote sensing and monitoring and ecosystem dynamics. For those who are not able to follow the more esoteric descriptions in this whitepaper, please excuse our expediency in choosing to focus attention on creating a document that outlines the details of *how* we plan to build Regen Network usinging DLT to create the information technology infrastructure for an ecological accounting ledger.

1.2. The Potential of DLT in Service to Ecosystem Health

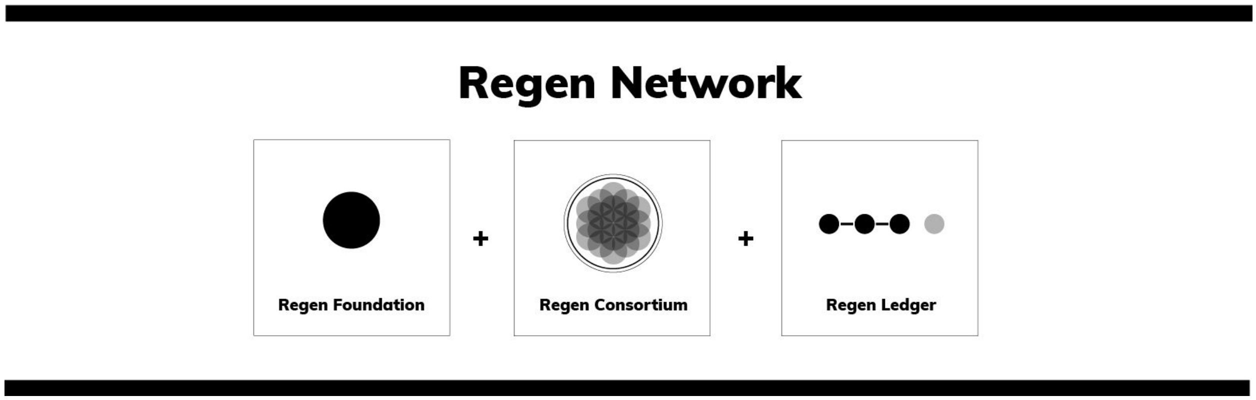
The ecological crisis facing humanity is the result of failing to account for the aggregate impact of decisions initially made for increased efficiency, profit and comfort. This process of externalizing costs causes degradation of common resources. (Bollier, 2014). Coupled with the imperative for economic growth, this degradation has followed an exponential curve over the past two centuries, culminating in accumulation of atmospheric carbon, mass extinction of species and depletion of the natural resources key to a thriving and healthy human society. Then the question becomes: who is keeping track of the balance sheet for the biosphere?

Soil is the foundation of the health of our economy, and the health of the world. Our current degenerative global agricultural system results in 75 billion tons of topsoil loss per year through erosion. This has an estimated cost of USD 400 billion to farmers and society (Lal, 2001). In addition, agriculture currently releases up to 12 gigatons of CO2 equivalent per year, with the food system as a whole releasing up to 16.9 gigatons per year (Gilbert, 2012). Meanwhile agribusiness and food are a $5 trillion business globally (Goedde, 2015).

At the same time, agriculture holds the potential to become a massive net carbon sink, sequestering billions of tons of CO2 per year into the world's soils and above-ground biomass (Toensmeier, 2016). Land stewardship (farming, ranching, forestry) as well as ocean management (fisheries and mariculture) are the key intervention points to reverse these flows of carbon. The value that healthy soil brings—not only to the nutrient density of our food, but also as soil's key function in the carbon cycle that regulates the earth's atmosphere—is not accounted for in the financial ledgers of agribusiness.

Considering the market trends in the outpacing of natural products over conventional products in consumer packaged goods, and the growing market power of labels like Organic, "eco," "green" and "sustainable," we can see there is considerable consumer interest in taking our planet into account. However, critics point out that these "market led" efforts have mostly failed to create significant change. In addition, we see a growing governmental mandate to address systemic environmental and climate change issues. The UN, EU, and China have all taken steps to at least mitigate environmental impacts. Yet none of these efforts add up to a coordinated or adequate response to the current existential crisis. We must create the ability to explicitly track the ecological impacts of our actions right alongside the financial.

To achieve this aim, we are launching the Regen Ledger as the balance sheet for the Earth. Regen Foundation will spearhead the scientific research and infrastructure development necessary to create transparent and open Ecological State Protocols. Regen Consortium will act as the democratic body that stewards the ledger and the cultural shift towards true-cost accounting.



DLT provides the technological foundation needed to both transparently track ecological data and incentivize shifts in land use toward more regenerative practices. It is also an apt technology for encouraging collaboration amongst diverse stakeholders, which ultimately have shared aims but may not otherwise be so inclined to cooperate. Through the Regen Consortium, we aim to create a culture of collaboration towards building the infrastructure needed to bring the Earth's needs into our collective awareness and capacity for action. The real world application of DLT to create a global ecological accounting system and unlock the potential to reward increases in ecosystem health is imperative to creating a coordinated response to climate instability, soil loss and biodiversity decline.

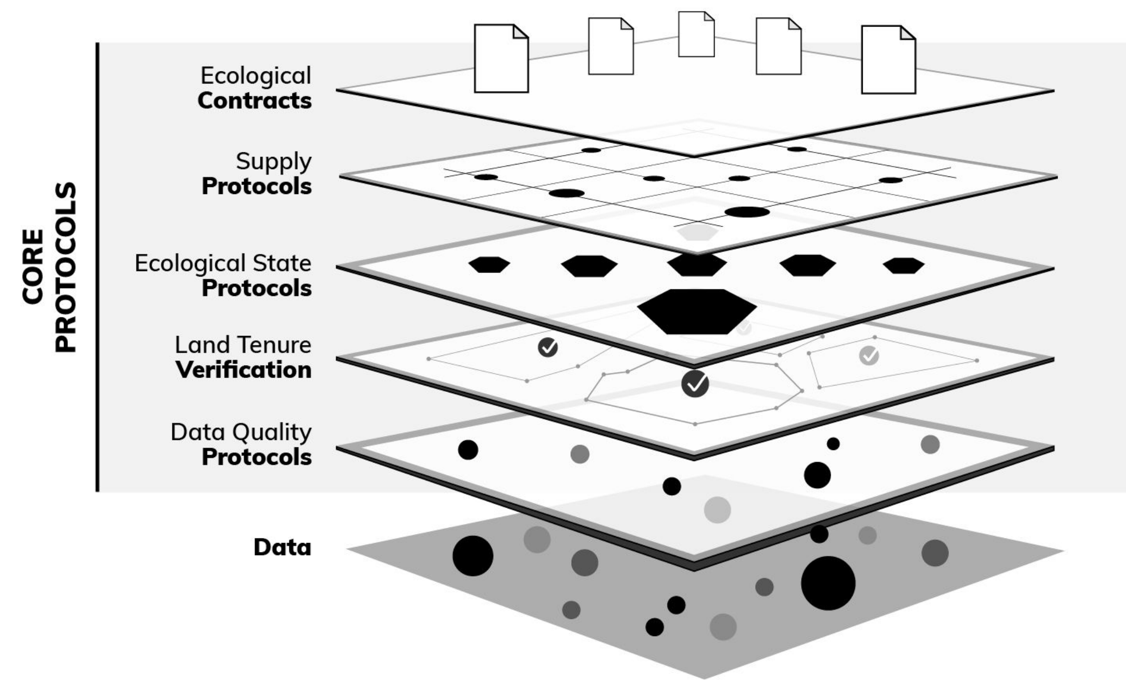
1.3 Regen Ledger: Balance Sheet for the Earth

For market-driven solutions to achieve regenerative outcomes, full ecological accounting must be available for the private and public sectors. One of the great leaps forward of DLT and blockchain is the ability to tokenize the protocol or "infrastructure" layer of information technology and the internet. This is essential because it allows for a new economic model to emerge where open source, cooperative, distributed innovation is possible and needed to maintain and increase the value of the token that represents access to that underlying infrastructure. By tokenizing the common asset or infrastructure upon which economically (and in the case of Regen Network, ecologically regenerative) generative applications can be built, it becomes possible to make the evolution and development of this core infrastructure not only viable, but attractive to both developers and funders. Regen Ledger's native token, XRN, will offer the ability to collaborate to build information technology infrastructure to account for ecological value.

2. System Architecture

For a more detailed treatment of our system architecture, please reference the Regen Network System Architecture document.

System Architecture



The core attributes of Regen Ledger's design, and indeed the aim of the larger Regen Network community, is the ability to use smart contracting capacity to reward ecological regeneration. The system architecture outlined in this document illustrates the most expedient way to create a system for trusted attestations of ecological state based on verifiable ecological data.

2.1. Ecological Protocol Frameworks

Regen Ledger provides three core ecological protocol frameworks:

- Ecological State Protocols (ESPs) define the algorithms and conditions necessary to "verify" a certain state or change of state on a piece of land
- Ecological Contracts (ECs) allow us to fund and reward desired change in ecological state
- Supply Protocols (SPs) allow us to tie ecological state into supply chains in trusted ways

2.1.1. Ecological State Protocols (ESPs)

An ESP specificies algorithms and criteria needed to verify a certain ecological state or change of state. A single protocol produces a boolean (yes/no) or numeric result representing the calculated ecological change of state. Hypothetical examples include:

- a score on a scale from 0-10 representing suitability of a piece of land as endangered species habitat
- the number of tons of carbon sequestered on a given piece of land in a given time frame into soil and/or above ground biomass
- verification of increase in biodiversity of insects, birds or plantlife
- a boolean true/false value representing whether a piece of land has sufficient groundwater holding capacity to prevent flooding within a given range of rainfall

The basic function of an ESP is simply evaluating state and change of state for a specified area. This can generally be done without actually knowing who is the rightful land owner or steward if reliable, geo-tagged data is available. One compelling application of ESPs is using them as a class of decentralised digital certification (like Organic or Fair Trade), with the goal of promoting good land use practices. In order to link the outcome of an ESP to a land steward's identity, a Land Tenure Verification Protocol (LTVP) [insert link] will need to be run.

ESPs are specified using a domain specific language and can reference the results of computations run both on and off-chain.

Each ESP is managed by a curating organization that can upgrade existing ESPs with new versions as improvements to the underlying algorithms are made.

2.1.2. Ecological Contracts (ECs)

Ecological Contracts (ECs) allow for trusted funding and/or incentivization of specific ecological outcomes. Example use cases include:

- An organization that wants to issue rewards for a specific level of carbon sequestration in a certain region
- A community group that wants to both solicit funds and have them directed to appropriate landowners to support endangered species habitat in a region
- A landowner that wants to request funds to support them to achieve a specific ecological outcome

The EC platform is primarily a smart contract framework for crowdfunding positive ecological change. However, in order to achieve this capability we must also achieve smart contracting capabilities that make it possible to write ECs for reparations when damage to ecosystems is generated through activity (of course this is not a coercive punishment function, but a system to value ecosystem health whereby two parties would agree that it is in their best interest to value ecosystem health accordingly). In addition to monetary exchange dependent on ecological state there are a wide variety of other smart contract terms that could be used by parties, including ownership, governance and special rights that could be dependent upon a given verifiable change in ecological state. ECs are specified not using a full programming language, but rather via a domain model with lightweight programming constructs where needed. This is to ensure that the meaning of ECs are unambiguous and can be easily presented in a visual and/or natural language form to end users while minimizing the surface area for bugs.

An EC is first and foremost constructed using phases. Each phase represents a logical progression in the contract process. The successful completion of each phase is necessary to proceed to later stages, and each stage may or may not involve financial rewards. For example, a restoration project may include an initial phase which simply requires submission of a plain-language description of the specific efforts to be undertaken by the landowner. This initial phase may carry with it a grant to cover costs. A second phase may then involve a reward for reaching a pre-specified benchmark in ecological change-of-state.

ECs will generally reference one or more ESPs and may set thresholds for ESPs with scalar results (ex: > 5 on the biodiversity index). The results of an ESP may also be used to scale reward amounts. For instance an ESP may say that 10 tons of carbon were sequestered on a piece of land and accordingly an EC can specify that $100 is rewarded for each ton of carbon sequestered and thus a total reward of $1000. Since smart contracts should be easy to visualize and understand for end users, the “micro-language” for referencing ESP results will include certain constraints to make this possible.

In addition to referencing ESPs, ECs may include other criteria such as submitting plain language text or photos to be reviewed by a specific trusted third party, as well as minimum thresholds for land tenure verification.

ECs define three distinct roles: funders, land stewards, and curators. The curator is always the party that has created the EC, but this party could also be the land steward or a funder. If a land steward creates an EC, then it works somewhat like a traditional crowdfunding system where a land steward is requesting donations. A funder, such as a non-profit, may create an EC to solicit various land stewards to apply for grants from its funds. An entity which is neither a land steward nor a funder could also start an EC to solicit both funders and land stewards as participants. For example, this approach could be taken by poorly funded local non-profits to make improvements in their community’s environment. In cases where a non-profit is the curator, the EC framework will designed in such a way that funder’s donations to the EC can flow through the contract as tax deductible contributions if the non-profit has taking steps to design the EC in a way that aligns with their nonprofit mission.

In part due to the volatility of supply-constrained cryptocurrencies, Regen Ledger intends to whitelist other cryptocurrencies besides the XRN token for use in ECs. These can include stable coins or other coins such as ETH, BTC and the Cosmos ATOM, and will be transferable in and out of Regen Ledger via the Cosmos Hub and/or VulcanizeDB.

2.1.3. Supply Protocols (SPs)

Regen Ledger will have basic features to support supply tracking as well as a Supply Protocol (SP) framework that allows for more sophisticated assessment of verified ecological supply. The Supply Protocol framework will build on top of the Ecological State Protocol framework and allow for algorithms to be specified in a similar manner, but that take supply chain tracking data as input in addition to land use data.

2.2. Network Components

2.2.1. Regen Ledger

Regen Ledger is a domain-specific, public permissioned blockchain built on top of the Tendermint consensus engine. It is built with the design approach that the most secure way to support its target functionality is through domain-specific frameworks first and full-fledged programming languages second.

2.2.2. Compute Infrastructure

Regen Ledger will feature a scalable “almost on-chain” compute feature. All validator nodes running the Regen Ledger are staked and run by known entities so they have both money and reputation on the line. By using random audits and short challenge windows, a subset of nodes on the network can run expensive data analysis computations with a similar level of transparency as if they were run by the whole chain.

Some data analysis computations will need to use private data and thus with current technologies cannot be run in a trustless public setting. The foundation will create a private compute “oracle” that verification protocols can use as a trusted compute engine for this use case. Regen Ledger’s frameworks will also be designed to allow other third party compute engines to be used.

2.3. Data

An attestation on the blockchain, used to unlock a smart contracted reward for improvements in ecosystem health, is only as good as the data that is used. In order to triangulate and create assurance of accuracy, as well as deter gaming of the system, Regen Ledger accepts data from multiple sources linked to the same geographical location, and has several layers of safeguards against bad data (whether it be falsely generated to game the system, or simply data from poorly calibrated or inaccurate sensors.)

In addition to assurances of accuracy and integrity of data, the architecture of Regen Ledger is built to continually incentivize better and more accurate data from multiple sources, and Regen Network as a whole aims to push the envelope on data collection in several key ways.

2.3.1. Data Sources

Many data sources will be used to verify claims of ecological state. These include:

- remote sensing data such as satellite and drone imagery
- IoT sensor data
- public GIS datasets
- user-submitted data such as the soil testing results

More details are provided in the Regen Network Ecological State Protocols document.

2.3.2. Data Schemas

For the Regen Network ecosystem to function coherently, shared data schemas are required. We intend to build open the work of the W3C to create globally namespaced identifiers through efforts such as RDF, and on open data efforts in the agricultural space such as GODAN. Our aim is to support schema development that maximizes interoperability, semantic meaning, and the forward compatibility of identifiers in schemas that evolve over time.

2.3.3. Data Integrity and Timestamping

In order to ensure the trustworthiness of user-collected data (whether it is public or private), users can submit a content descriptor for data stored off-chain that includes the hash of the data, a permanent URL from which to access it, a geographic identifier tying it to a piece of land, and metadata about the data stored at this URL. When this descriptor is submitted to the blockchain it will generate a secure trusted timestamp for the data. This timestamp together with the data's hash will ensure that data hasn't been manipulated since its collection date.

2.3.4. Data storage

Most raw data used in the system will be stored outside of Regen Ledger and tracked on the ledger as described above. Essentially, any data storage layer that can be referenced by HTTP could be used (such as IPFS). Some users may want to keep their data private and hosted on a server they control. As long as the data hosting software implements the protocols necessary to make it accessible when needed for computations, it can be used as a storage layer. Specific integrations are planned for interfacing with data stored on Streamr and FarmOS.

2.3.5. Data Quality Protocols (DQPs)

The Data Quality Protocol (DQP) framework allows for a structured way of assessing the quality of input data and can be used by the ESP framework as a way to filter input and/or qualify it with a confidence score. DQPs may correlate user-submitted data with implicitly trusted data sources like public satellite imagery and use an anomaly detector to look for inconsistencies. DQPs may also take into account user-submitted feedback (i.e. ratings) on data sources.

2.3.6. Data marketplace

One ancillary function of Regen Ledger will be to coordinate conditional access to network members' private data by other network members possibly via a fee system. Data Access Protocols (DAPs) allow users to create a contract specifying the conditions under which they will grant access to their data. This will effectively enable a data marketplace functionality on top of Regen Ledger.

2.4. Supporting Ledger Functionality

2.4.1. Land Tenure Verification Protocol (LTVP)

One of the most difficult challenges in certifying or rewarding ecological change of state is verifying that the party claiming a reward actually has land tenure rights to the piece of land in question. To support a diverse array of verification providers, Regen Network will specify a standard API, called a Land Tenure Verification Protocol (LTVP), for verification providers to implement in order for them to be referenced by ESPs and ECs. The foundation will develop relationships with one or more third party verification providers and steward their implementation of this API to bootstrap the ecosystem.

2.4.2. Token issuance

It will be possible for organizations to issue their own tokens on top of Regen Ledger that allow new tokens to be minted when specific Ecological Contracts are fulfilled. Tokenizing living capital assets can be a way to bring value to whole watersheds or bioregions, or to tie value to the health of soil.

2.4.3. Identity, organizations, key management and arbitration

In order for other components of the system to function, Regen Ledger and its protocol frameworks will need to address issues regarding identity, key management, organizational management, and arbitration (in the case of disputes regarding Ecological Contracts for instance). Where possible, we will leverage efforts by existing projects in these spaces such as Sovrin for identity and key management or Aragon for arbitration.

2.5. End-User Applications

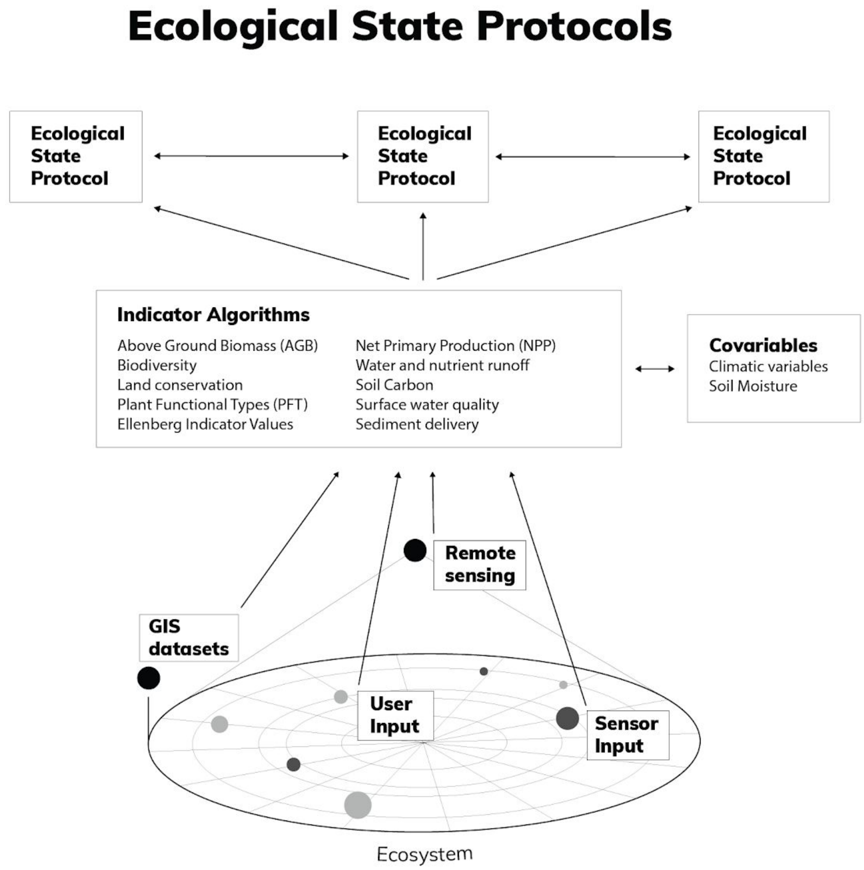
A number of frontend apps will be needed for the Regen Network ecosystem to flourish. Some of these may be existing applications such as FarmOS (which would provide data for ESPs), while others will be created from scratch to support the development, management, and fulfillment of ESPs, ECs, and SPs. It will be a primary Regen Foundation function to support the development of these apps.

3. Foundational Ecological State Protocols (ESPs)

Regen Foundation will create and steward a core set of open-source Ecological State Protocols (ESPs). While Regen Ledger is optimized for the purpose of verifying ecological outcomes, it can only actualize its potential with a flourishing ecosystem of protocols. The core set of ESPs stewarded by the foundation will be developed by working groups of scientists, ecologists, farmers, and community members using an open source development process and open source license. This will allow the community to be actively engaged in the development process through public comment forums, public working group meetings and each ESP's issue tracker and merge request features. It will also allow the community to fork ESPs as necessary.

As more and more data is collected through the use of ESPs, this data will serve as input for the development of the next generation of ESPs, and as training data for associated machine learning algorithms. Since the governance structure of the foundation gives Regen Consortium the responsibility to replace Regen Foundation's outgoing board directors, the long term maintenance of these core ESPs will effectively become a shared responsibility of the consortium. While the foundation and consortium will be stewarding this core set of ESPs, this effort will provide a template for other organizations to create ESPs suited to their needs and perspective, leading to an active, multi-stakeholder community working to further the state of ecological verification.

In the following sections, we propose several core protocols to be stewarded by the foundation, including a brief discussion of the rationale for each protocol and the proposed verification mechanisms. It should be kept in mind that each protocol can be used independently or in combination as an attestation of regenerative land use with various EC contracts to reward and incentivize change.



3.1. Carbon Sequestration Protocol

Earth's soils are the most important carbon sink available for the reduction of atmospheric CO2 levels via carbon sequestration (Toensmeier, 2016). There are other larger carbon sinks available (such as our oceans), but because soil is the basis of all agricultural output, none is so directly coupled with the human economy. Many agricultural practices known to increase carbon sequestration also have environmental and economic benefits, such as reducing erosion, improving water quality, enhancing wildlife habitat, and biodiversity revitalization (Toensmeier, 2016). The single most important indicator for determining carbon sequestration is Soil Organic Carbon (SOC). Carbon does not exist in its elementary form in nature and is encountered in soils as a complex chemical component. Therefore, SOC does not have specific spectral reflectance behavior and cannot be measured directly by remote sensing techniques. Instead, measurement requires the use of parameters that link SOC and terrestrial surface reflectance. Because Regen Network protocols rely on an entire network of information, the protocols will employ a threefold strategy for the estimation of SOC.

The protocol will require:

1) direct SOC measurements performed by soil spectroscopy, lab tests, or the use of farm management software like FarmOS, which collects different user provided information like soil color, farm practices, and sensor input.
2) various indicators as proxies for detecting an increase in Soil Organic Carbon (SOC)—see the Regen Network Ecological State Protocols document. The initial pool of indicators proposed are:
    a) Above Ground Biomass (AGB)
    b) Land Conversion
    c) Net Primary Production (NPP)
    d) Biodiversity
    e) Plant Functional Types (PFT) / Ellenberg Indicator Values
    f) Soil Erosion
    g) Nutrient and Water Runoff
    h) Soil Organic Carbon (SOC)
    i) Surface Water Quality
3) SOC to be modeled using the newest remote sensing techniques. Advanced spectral unmixing methods applied to the hyperspectral Hyperion data have given SOC fractions similar to those observed in the field (Gomez et al. 2008).

Improvements to protocol accuracy aim to:

1) detect changes in the local ecology linked to known carbon sequestration rates,
2) quantify the amount of carbon sequestered in a given location, and
3) link the sequestered carbon to the set of practices that are directly correlated to the carbon drawdown (the removal of atmospheric carbon into other sinks, such as soils). Some examples of practices that are correlated with carbon sequestration are no-till agriculture, intercropping with perennials and trees, managed rotational grazing, and compost application. This protocol enables a new class of contractual agreements between any land manager and a party that is interested in rewarding for ecological outcomes. For instance, a reward contract could to be issued by a corporation buying grain for a cereal product that pays out for increases in soil organic matter. Farmers that innovate and achieve verified SOC receive the reward The corporation may use proof for their role in this carbon sequestration in any number of ways. For example, they could convert the verification data into carbon credits and sell them or used as part of their brand messaging.

A proof of concept protocol is currently under development and more information on the indicators, algorithms and method can be found in the Regen Network Ecological State Protocols document.

3.2. Other Proposed Ecological State Protocols (ESPs)

3.2.1. Grassland health and grazing patterns protocol

Grasslands, including rangelands, shrublands, pasturelands, and croplands sown with pasture and fodder crops, cover approximately 3.5 billion hectares. This represents 26 percent of global ice-free land area and 70 percent of global agricultural area. This land contains about 20 percent of the world's SOC stocks (FAO, 2015). Grasslands on every continent have been degraded due to human activities, with about 7.5 percent worldwide having been degraded because of overgrazing (Conant, 2010). Regular monitoring at national and global scales is necessary for maintaining awareness of changes in natural and cultivated areas. Using geospatial data, the grassland open verification protocol will analyze grasslands for their ecological value and assess different ecological characteristics such as: biomass estimation, carbon sequestration, species diversity and land use patterns. An intended outcome of this open verification protocol is the incentivization of rotational grazing and holistic management practices to regenerate and restore degraded grassland. Conversations have begun with Savory Institute to work towards adapting or building on their existing Ecological Outcome Verification system.

3.2.2. Blue Carbon Protocol (BCP)

Naturally occurring and artificial coastal wetland ecosystems are critical for biodiversity and broad ecosystemic health. Wetland soils contain some of the highest stores of SOC in the biosphere and coastal wetlands tend to have exceptionally large carbon stocks. Their protection and restoration would constitute an effective mitigation strategy to climate change. The BCP would ensure inclusion of wetland ecosystems in mitigation strategies and deliver accurate carbon accounting in coastal areas.

Wetlands are transitional zones between water and terrestrial environments. Wetland ecosystems are also seasonal and have high inter-annual fluctuations. By observing or processing satellite images over time, it is possible to monitor the spatio-temporal dynamics of the plant biomass production in a wetland ecosystem in a given year. This protocol will map surface open water and vegetation, and assess the state of the connectivity of these landscapes. The BCP could also compare year by year land cover and boundary changes. Data collected over longer time-frames is capable of determining trends and the magnitude of these trends, like deposition or erosion in river deltas and wetland habitats. Using multi-temporal data analysis of high resolution imagery coupled with landscape spatial analysis in GIS, it is possible to distinguish between anthropogenic and climatic causes of wetland aerial changes (Booman et al. 2012) and map the vegetation species composition of an area of interest with a high level of accuracy.

Thus, by having a BCP that maps and measures water quality and pollution, analyzes the distribution and dynamics of coastal vegetation, and applies impact predictions of certain disturbances, it becomes possible to verify coastal ecological outcomes using GIS, satellite data and smart water quality monitoring systems. Integrating ECs with the BCPs unlocks the potential for ecological rewards as described in the SOC section above. For example, in now may be financially viable to shift from the monoculture chemical intensive practices of brackish shrimp farming, and regrow complex and biodiverse mangrove fisheries. Additionally, rewards for ecosystem improvements can be coupled with ECs and SPs to create a multi-layered, multi stakeholder approach to ensure economic viability and reward ecological regeneration.

3.2.3. Adoption of Regenerative Agricultural Practices Protocol (RAPP)

While agriculture is responsible for 18% of global greenhouse gas (GHG) emissions, it also holds incredible potential as a net-carbon sink. Regenerative agriculture practices aim to reverse climate change by capturing carbon in soil and aboveground biomass. Regenerative agriculture increases functional biodiversity, enriches soil quality, improves water cycling, and enhances all major ecosystem services. This results in increased yields, resilience to climate instability, and higher overall health and vitality for farming communities (Soloviev, 2016). The RAPP employs a set of peer-reviewed ecosystem functions linked to regenerative agricultural practices. The protocol requires high definition satellite data, real-time ecological monitoring, and verified user input as its main sources for verification. This protocol can then be used by many ECs to incentivize a shift in agricultural practices.

3.2.4. Methane Emissions Protocol (MEP)

Methane is one of the GHGs with the greatest impact. Anthropogenic methane emissions are primarily caused by landfills, rice cultivation, livestock, biomass burning, coal mining, tundra melt, peatland destruction, and gas supply and flaring (NASA, 2016). In October 2018, level 2 products of the Sentinel 5-p satellite on methane emissions become available to the public through the Copernicus open access hub. The Sentinel 5-p uses the TROPOMI (passive grating imaging) instrument, which has a spatial sampling resolution of 7x7 km^2 and 4 separate detectors. This sensor is able to detect geolocated columns of ozone sulfur dioxide, nitrogen dioxide, carbon monoxide, formaldehyde, and methane as well as geolocated aerosol and cloud formation (ESA, 2017). By developing the methane emissions protocol to ensure compatibility with the newest Sentinel 5-p data products and integrating in-situ measurements that are able to decipher the distinct chemical fingerprints of a variety of methane sources, the MEP will both visualize and predict alterations in methane emissions.

One of the goals of the MEP will be to encourage and verify reduced flooding in rice paddies in order to curtail the large amounts of methane emitted due to anaerobic digestion. This is a powerful example of a SP where monitoring and verifying ecological improvement becomes an element of both a multi-stakeholder initiative to shift farming practices as well as a brand story. Lotus Foods, a US rice brand is already taking leadership on this front, and would benefit greatly from trusted protocols and DLT for verifying the methane specific ecological outcomes and, in telling this story through their branding and marketing, can offer added value to their customers and industry.

Additional protocols can be found in the Regen Network Ecological State Protocols document.

4. Market

Regen Network will open up a new economic paradigm in which markets are able to appropriately incorporate ecological health. The ability to tokenize the information and data layer of this ecological ledger is key for functionality, but the larger disruptive potential of this new economic paradigm that is being ushered in by DLT is the tokenization of specific living ecological capital assets. The market section of this document explores four existing markets that will be fundamentally transformed by the ability to access verifiable ecological data and incorporate this data into Regen Ledger's smart contacting framework to create ecological contracts.

4.1. Economic Model

There are three key mechanisms core to Regen Network's ability to reroute a trajectory towards a livable planet for future generations:

- rewarding regenerative ecological outcomes
- incentivizing accurate ecological data to be produced and shared
- open source technological development aimed at ecological and agricultural applications in DLT, remote sensing, IoT, machine learning and fintech

4.2. Application

The strength of a cryptographic network providing common utility is defined by the applications built on top of it. This section explores the applications that may be built on top of Regen Ledger's Ecological State Protocols (ESPs), Ecological Contracts (ECs), and Supply Protocol (SP) layers (described in Sections 3 and 4).

4.2.1. Carbon market case study

Carbon markets currently exist as a way to help reduce the emissions of carbon and other greenhouse gases. 195 countries committed to curbing carbon emissions via the Paris Climate Agreement. Of the 195 signatories, 172 countries have ratified the Paris Climate Agreement (UN, 2017). This Agreement attempts to set a a 2° C maximum global temperature rise ceiling due to climate change and sets an internationally accepted goal at 1.5° C (Meyer, 2015). As we've already had 1° C of warming, such goals are extremely ambitious and will require not just cuts in emissions (due to efficiency and green energy) but active drawdown (Hawken, 2017). "The IFC's Climate Investment Opportunities Report, released in November 2016, identified $23 trillion in investment opportunities in emerging markets by 2030 ." Carbon markets represent one key pathway towards these ends within which there are two types:

1) Voluntary Carbon Markets, which are primarily utilized by corporations aiming to offset carbon emissions. The voluntary market is estimated to be $191 million in volume in 2016—significantly down from its 2008 peak of $790 million (CBD, 2017). There is a surplus of carbon credits in the market and price varies depending on the type of activity, location, age, standard etc; not all credits are considered equal. "The most-transacted project types by volume in 2016 were: REDD+, wind, landfill methane, large hydropower, and community-focused energy efficiency" (CBD, 2017).
2) Compliance Carbon Markets. These are cap-and-trade markets setup by signatories of the Kyoto Protocol, and had a market volume of $57 billion in 2015 (Reuters, 2016). Compliance Carbon Markets are much more heavily regulated where entities exchange emission allowances to meet predetermined regulatory targets. Reductions are imposed by public authorities and regulators with high penalties for non-compliance.

The current carbon market system engages as many as 13 different third-party certifying standards to validate and verify project claims—most commonly the Verified Carbon Standard (58% of certifications in the 2016 voluntary market).

Many of the credits popular in the voluntary markets have been criticized as being weak in impact. Carbon credits are issued for "avoided deforestation" and the installation of solar panels. With current accounting methods, credits are often double-counted, sometimes repeatedly.. This is fundamentally different than a net positive or carbon drawdown effect. In other cases there have been little to no penalties if the outcomes are not reached—a subject of scandals and fraud. The provenance of ecological outcomes traded in the marketplace matters.

In application, Regen Network provides three major upgrades for carbon markets:
1) Automation could significantly reduce verification overhead by using a technology-driven model as part of the certification process. This decentralized and cost-efficient process could allow a significant population of farmers previously not able to participate in the carbon markets to join in. According to Nori, a

blockchain-powered drawdown carbon marketplace, carbon credits traditionally have an overhead of 40-60% of the sales price, with the remainder going to the outcome.

2) Outcome results will be more precise and trustable in their relation to actual carbon levels. With a decentralized and self governed blockchain that is able to verify carbon in an open and transparent way, all verified outcomes will be recorded in a public ledger.
3) Activities currently being verified as carbon credits will be challenged and a market for superior drawdown credits will be created. It also will have the added benefit of organizing communities, improving land steward/farmer livelihoods, and creating healthier soils.

As the challenges from climate change become more visible in the coming decades and governments (and society) move to take action to fulfill their commitments in the Paris Agreement, Regen Network can support the evolution of the effectiveness of this work to meet the scale of the challenge.

4.2.2. Risk mitigation case study

According to the National Oceanic and Atmospheric Administration, 2017 was a record-breaking year in terms of both the number and cost of weather and climate disasters, with 16 separate billion-dollar disaster events causing $306.2 billion dollars in damage (Source). From the aftermath of Hurricanes Harvey, Irma, & Maria, to the wildfires (and subsequent mudslides) across California and the extreme freezes and storms across the U.S. midwest, the reality of the threats to ecosystems, communities and economies are becoming more visible than ever before.

As this climate instability intensifies, private institutions such as banks and insurance companies, which accounted for $11 Trillion dollars (Source) of the global economy in 2011, will need to find creative ways to hedge exposure to these risks and increase resilience of the communities with whom they are engaged. Many of these natural disasters will be unavoidable and ultimately increase the cost of doing business to a new ''normal''. From the physical buildings where companies (and employees) reside, to active risk mitigation in portfolio management, a local understanding of regenerative practices can support ecosystem health. For example, each one-percent increase in soil organic matter results in an increase in an average water retention of 50,000 gallons per hectare (Bryant, 2016). One or a syndicate of companies could stake a reward for the verified outcome of an increase in soil organic matter in the watersheds above flood-prone cities. Once the verified outcome is achieved via reward-incentivized land stewards throughout the bioregion, the potential damage will be greatly reduced.

Regen Ledger can be used as a preventive tool in the face of natural disasters. At-risk industries like financial services (and communities at large) can rally together to restore health to local bioregions and reduce the cost of damages. By pledging rewards in Ecological Contracts to achieve specific ecological outcomes in their coverage areas, exposure can be quantifiably reduced. This use of the reward function of an Ecological Contract is only one way insurance companies can use smart contracting mechanisms to mitigate expense and maximize protection of clients. More complex data sets combined with Ecological Contracts also open up the possibility of reduced premiums for particular actions that reduce community risk in an area.

4.2.3. Supply certifications case study

The Lifestyles of Health and Sustainability (LOHAS) market—defined as goods and services focused on health, the environment, social justice, personal development and sustainable living— has an estimated market share of $290 billion. This consumer base has grown to reach 13-19% percent of U.S. adults, nearly 41 million people (Source) who trust certifications like Organic, B Corp, USDA, Fair Trade USA and Rainforest Alliance to guide their purchasing of products that support their ecological and social values. Given their unique capacity, skill sets, and supply systems, companies like Patagonia and Starbucks have elected to create their own standards. These standards are often nuanced and difficult to decipher for the average consumer.

"Regenerative Agriculture" as a superlative for consumer products is trending as the new gold standard. You can find the term showcased at the largest natural and organic consumer packaged goods trade show events in the world, such as Expo West 2018. Leading edge companies like Patagonia, Numi Tea, Clif Bar, Annie's Organics, Guayaki, Megafood, Organic India, Dr. Bronner's, Blue Apron, and General Mills are in the process of adopting regenerative agriculture into their supply systems and/or have created regenerative agriculture departments within their companies. As we become more connected to where our products come from and the impact of their production in the wake of climate change affects, these standards will become more valuable.

In application, Regen Leder's smart contracting framework can provide several upgrades to supply system certifications and the overall consumer experience. Using the integrated framework of Ecological State Protocols (ESPs) and Data Quality Protocols (DQPs), costly verification systems can become more transparent, precise, and efficient. This creates the potential for disintermediation in the market and improvement to methodologies as the public compares existing opaque systems, with the transparent, easily verifiable open source systems provided by Regen Network.

When popular comparison charts take stock of this, people will be able to see the reality of certification claims in relation to actual verified ecological outcomes (such as carbon sequestration), using methods that are inherently tied to farmer livelihood improvement and holistic regenerative agricultural methods. Credibility will be maintained as meaningful due to community participation in both verification and standard setting. Consumers will also be able to engage with products in unprecedented ways. Since rewards can be staked in token markets, consumers will be able to filter products based on carbon drawdown and even earn tokens themselves by engaging in local land data verification methods. This does far more than a stamp of approval for consumers; it supports the transition to a more connected human culture and deeper understanding of the state of foodshed/watershed health in the the specific bioregions in which we live.

Regen Consortium's governance model lends itself well to certification organizations joining to utilize the power of Regen Ledger and global database to lower the cost and increase the quality of their certification processes, and perhaps even transcend the older compliance model with a newer direct connection to trusted participation through a democratically governed, distributed trust layer.

4.2.4. Farmer software & data exchange case study

"Globally, food and agriculture is a $7.8 trillion industry, responsible for feeding the planet and hiring well over 40% of it" (AgFunders, 2017). According to the International Fund for Agricultural Development (IFAD), there are an estimated 500 million smallholder farmers worldwide producing about 80% of the food.

At the same time, investments in agri-food tech startups have grown from $4.9 billion in 2014 to an expected $8.8 billion in 2017 (Burwood-Taylor, 2017). "Funding is diversified across 702 unique investors including Silicon Valley venture firms, state-backed government funds, pension funds, corporate entities, as well as the growing number of agrifood tech specialists." While agriculture is the least digitized of all major industries, it is no exception to the disruptive market opportunity: Big Data (Manyika, 2015). The corporate giants—Monsanto, Cargill, IBM, DuPont, Cisco, Google—have already caught on, making heavy investments signaling this emerging market, helping the global market for agricultural robotics to grow to a projected $14-18 billion by 2020 (Goedde, 2015).

One legacy issue between farmers and agri-food tech companies has been ownership and control of data. Big profits from these agri-businesses don't necessarily trickle down to the farmers on the land. This has remained an ambiguous gray area and source of tension for most companies trying to forge these relationships with farmers who have too often been taken advantage of in the past. The result has been the emergence of open sources companies like Farmer Business Network, FarmOS, NGO's like Open Ag Data Alliance, and government data exchanges like Data.gov/food dedicated to farmer data privacy, control, and empowerment. These renewed commitments to farmer empowerment and control are an important aspect of upgrading the current agricultural system. Currently, most of the world's farmers are struggling to compete in an economy that undervalues what they do and asks them to produce the highest quantity at the lowest price, which is purely extractive. This has led to the degradation of soils, the poisoning of our waterways, the loss of community resiliency, the de-nutrification of our food, and a disconnected culture to the health of food systems and the planet.

Regen Network provides a great deal of value that can be integrated with existing agritech farmer decision-making platforms as well as custom Eco-Apps. Farmers, who traditionally have struggled to make ends meet, will be able to access supplemental income by taking advantage of the capacity of their land to solicit Ecological Contract rewards placed by committed individuals, corporations, and governments. Additionally, the sheer amount of farmer-owned and controlled data available on the system will be extremely valuable in and of itself. The timestamped data index and data access protocols of Regen Ledger effectively create a data marketplace that allows farmer data to be bought and sold. This data could be queried via a custom DApp and/or integrated into existing agri-tech platforms. Investors interested in drawdown can locate and support farmers without the ability to regenerate their land financially or technically. Those farmers with the interest and land capacity can engage in smart contracts to split the rewards in a cooperative effort to increase livelihoods, drawdown carbon, and improve ecosystem health - all with the bonus of higher crop yields and reduced management costs.

5. Governance

5.1. Regen Foundation

Regen Foundation has applied to be a Delaware 501(c)(3) Public Charity created to support the growth of Regen Network and develop and maintain Regen Ledger software, associated compute infrastructure, key protocols, and frontend apps for achieving and rewarding ecological regeneration.

At the heart of Regen Network will be a native network token called Regen Token (XRN). Regen Tokens will run natively on Regen Ledger. This token will allow for access to trusted data fueling protocols and Eco-Apps, be used to reward ecological outcomes, and have full cryptocurrency functionality backed by a renewable-energy validation and compute network (instead of energy inefficiency and anonymous mining). XRNs purchased through Sale Agreements for Future Tokens (SAFTs) from Regen Foundation will give project supporters the rights to receive token allocations once Regen Ledger is operational. From the initial Token Generation Event forward, newly minted tokens will be issued by Regen Consortium.

Regen Foundation's governance is founded on the understanding that humans in conscious relationship with ecosystem functioning can engage in systemic developmental co-evolution. The Foundation's mission is to explore the use of technology to grow human capacity to understand, value and incorporate ecosystem health into our accounting and decision making across all governmental, corporate and citizen activities.

In order to fulfil the mandate set out in its mission, Regen Network will pursue three concurrent areas of activity:

1. The development and launch of a distributed ledger specifically tuned to support the verification of ecological outcomes, incentivization of positive ecological outcomes, supply system tracking, and related functionality.
2. The development of protocols for the verification of ecological outcomes.
3. Ongoing engagement with and support of the emergent movements surrounding regenerative agriculture, ecological land/water/air stewardship, and alternative economics.

5.2. Foundation Governance

Regen Network will have a board of five directors:

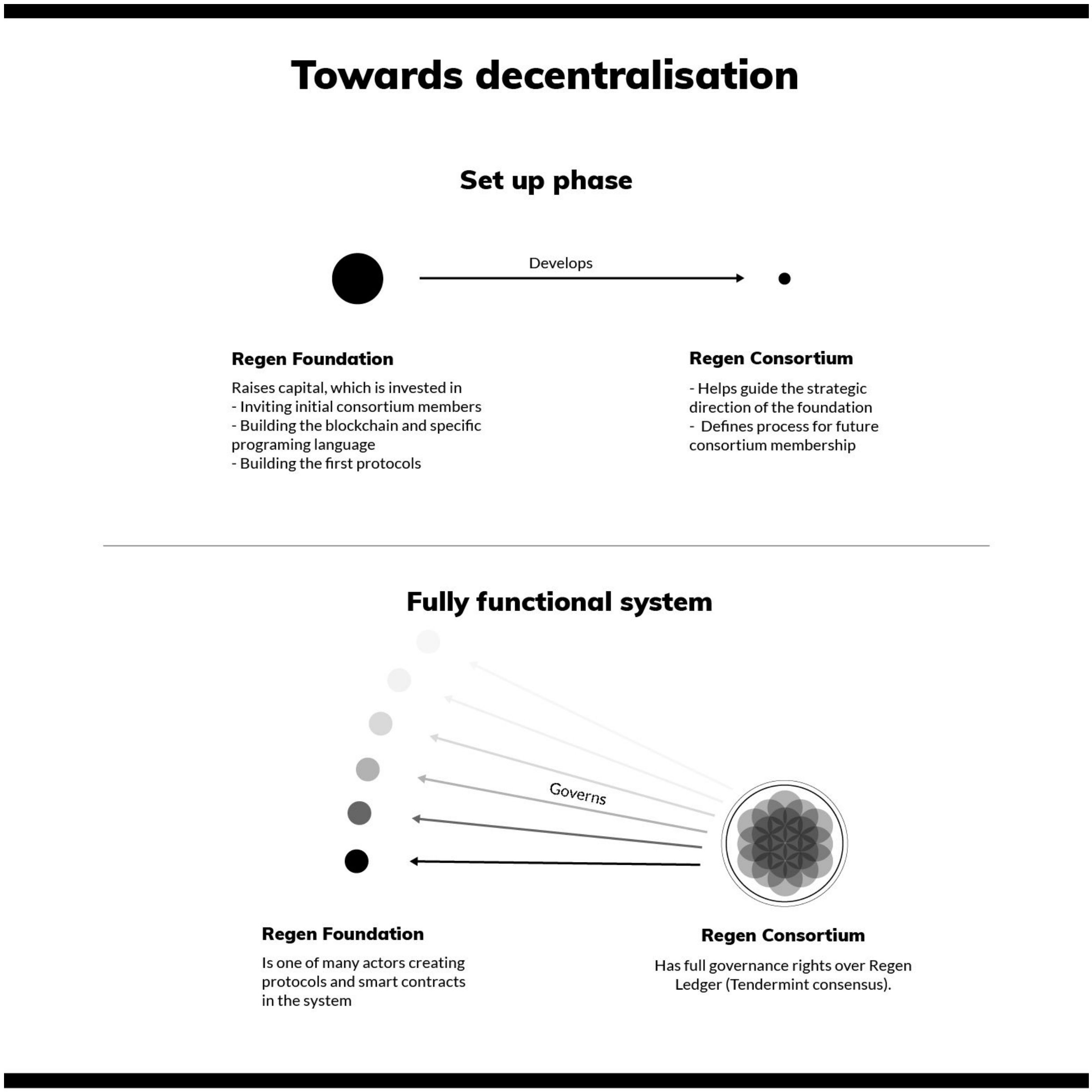
- Gregory Landua (Regen Network co-founder)
- Will Szal (Economics at Regen Network)

Beginning three years after the formation of the legal entity, a board seat will come up for appointment each year, so that the board will have full turnover by year eight. External seats will come up for appointment first. From year three forward, board seats will have a five year term. Appointments from year three forward will be determined by Regen Consortium.

Specific responsibilities of Regen Foundation towards the consortium will be:

- Convening a yearly gathering of consortium members and other members of the larger Regen Network community (data providers, farmers, user groups, developers etc)
- Granting and investing in businesses, not-for-profits, or independent initiatives that further the aforementioned aims
- Providing software interfaces for network transparency and consortium voting
- Growing the consortium of trusted organizations around the world working in the domain of ecological monitoring, regeneration and data science

Once created, Regen Ledger will be governed autonomously by an independent body, Regen Consortium. At this stage, Regen Network will be a Decentralized Autonomous Organization (DAO). The Consortium is an a-legal entity, meaning that even if something happens to Regen Foundation, Regen Ledger will be able to continue to operate under the stewardship of Regen Consortium. This structure creates a firewall between the Foundation and Ledger to ensure that our mission will be seen out in the face of a range of possible challenges.



5.3. Domicile: US 501(c)3

Regen Foundation is being incorporated as a US 501(c)3 registered in the state of Delaware. There are three main reasons why this choice made the most sense over any of the jurisdictions that we researched:

1. **Security Law:** Many other projects in the crypto and blockchain space pursuing the issuance of utility tokens hoping to avoid US securities laws have shied away from US jurisdiction. We believe there is a need to be clear with our early backers that the

token, at the stage of issuance via a SAFT is indeed a security, even though as the system matures we believe the token will evolve into what should most appropriately be considered a commodity. Additionally, the SEC has global reach, and a foreign domicile doesn't always offer better protection if US contributors are involved.

2. **Corporate Governance:** In order for Regen Network as a whole to succeed, Regen Ledger must be adopted and governed by institutional organizational stakeholders. This application of DLT is an innovation to existing market and governance mechanisms and must be understandable and trusted by our stakeholders; the 501(c)3 structure can serve as a bridge between these paradigms. There are many examples of comparable public-benefit entities that maintain infrastructure that are already recognized by the IRS, which lead us to believe that our application also warrants charitable status. We wish to maintain explicit and democratic governance over this infrastructure, both on and off chain.
3. **US-Centric Team:** Although Regen Network will be a global project, and already has a team distributed around the world, the founders of the project are mostly US citizens. This means that the project will need to comply with US law, so we deem it to be easier to simply use the US as the jurisdiction of choice.

5.4. Overview of Regen Consortium

Regen Consortium is the group of organizations governing Regen Ledger. The initial consortium members will be invited by Regen Foundation, and from that point forward this body will be self governing. Regen Consortium enables an unprecedented democratic and cooperative movement to be built around growing the capacity to account for ecological health in decision making, and reward increases in ecological health.

The consortium model has two major benefits in this application. The first is that authority over consensus is held by known actors, which we believe will be beneficial for health, security and growth of the network. Essentially this enables organizations to govern the blockchain they use to help track ecological health and issue direct rewards for increases in ecological health that benefit their communities. Consortium members will be organizations with expertise and leadership in the domains of the platform: regenerative agriculture, remote sensing, circular economy, ecology, earth systems, blockchain, and regenerative economics. Each consortium member will be granted one voting seat.

XRN will be powered by the Tendermint consensus engine. Consortium members delegate their seat to a validation node on the network. As these organizations will be publicly associated with their engagement in the consortium, they have a significant real-world reputation at stake.

5.4.1. Consortium membership process

The spirit of this process is to grow a diverse and committed community of validators in order to maintain integrity, usability and evolution of Regen Network as a publicly accessible ecological ledger and reward system. Because consortium members will be in control of the system itself, there must be a threshold to join this group, taking into account the responsibility and privilege of voting on consensus, token allocation and software upgrades, and, whom will eventually govern Regen Foundation itself in executing its charter to serve the evolution and utility of Regen Network and Regen Ledger.

The first Regen Consortium members will be invited to join the Regen Foundation founding team. These organizations will be carefully selected to bring key expertise and assets, as well as a common spirit and approach. The initial organizations will be engaged in a participatory process to generate the ongoing framework for consortium membership including onboarding, voting, and removal of consortium members.   This process will be lead by an experienced team of facilitators to chart the course for future governance.

To ensure integrity and shared aim and to ensure access for important groups that may be excluded from many blockchain or technology projects, the initial Regen Consortium members must demonstrate:

- organizational history of commitment to domain-relevant activities,
- transparency around legal and financial relationships,
- agreement to at least quarterly remote meetings with other consortium members and participation in a transparent and online voting and governance in which members will lose reputation if not participating, and will eventually be removed from the consortium,
- agreement to send a representative to the annual consortium meeting that is hosted by Regen Foundation, and
- signature of agreement to the principles of Regen Consortium

Through a participatory process, the initial consortium members and Regen Foundation will be amending, updating and evolving these initial membership frameworks.

In addition to the initial requirements for consortium members we listed above, candidate consortium members will provide documentation of the above requirements via an on-chain process that distributes this information to existing consortium members. Upon completion of this process, the candidate member will automatically become a provisional member.

During this period, which will probably last for about a quarter, the candidate must demonstrate adherence to membership responsibilities, and can and should participate in all processes but will not have a binding vote. If no existing member expresses reasonable doubts about a candidate's ability to uphold the responsibilities of membership, the provisional member will automatically became a full voting member at the end of the provisional phase. If an existing member does have doubts about a provisional member, there will be a well-defined on-chain process to trigger a more detailed evaluation and approval process by the full consortium. Key decisions will be membership buy in or fees which the founding group thinks is a healthy restraint, while also wishing to maintain inclusivity.

5.4.2. Removal process for consortium member

As outlined above, the rules concerning Regen Consortium members will be co-generated with the initial cohort of consortium members. However it should be noted that the founding team strongly believes in the following approach to removal of consortium members.

Consortium members can be banned from the consortium and have their authority to vote on-chain and off-chain revoked through a clear on-chain and legal process. For example, meeting attendance will be tracked, and when too many meetings have been missed, a consortium member will enter a process to determine if they are still a good fit for consortium membership. In this case, members can simply re-apply if and when they are ready to dedicate the appropriate time to supporting the governance of the system.

If a consortium member is actively undermining the integrity of Regen Ledger, or Regen Network as a whole, they will be removed from the system and not allowed to return as consortium members. Activities that warrant immediate expulsion from Regen Consortium through on chain mechanisms are:

- falsifying data
- hacking or tampering with XRN wallets
- manipulating monetary supply
- manipulating consensus on state

5.4.3. Governance and consensus mechanisms

Some of the actual mechanisms of consortium governance arise from the underlying Tendermint consensus engine. Based on the dynamics of the Tendermint, ⅔ of validator consensus power is needed to make any change to the underlying blockchain protocol.

Tendermint has Byzantine fault tolerance of up to ⅓ of participants and will halt progress rather than forking in the event of a larger discrepancy. Consensus power in Tendermint can be scaled differently for each validator and the set of validators is known to all other validators and constrained by them. Because of this, Tendermint is well suited for Proof-of-Stake and consortium systems, and is inherently more energy efficient and faster than public Proof-of-Work systems.

Validator nodes earn fees for providing validation and compute services to the Regen Ledger. The set of validator nodes in the consortium will generally be constrained to be equal to or smaller than the number of consortium members (and set to a number that ensures Byzantine Fault Tolerance and limits energy consumption). Consortium members who do not run their own validator node will delegate their vote to a consortium member who runs a validator node. A validator node's consensus power is thus equal to 1 + the number of consortium members that have delegated their vote to it. In order to ensure transparency and to make sure that members' reputation is at stake, all consortium members must reveal their organizational identity. Every validator node must also stake a certain amount of XRN tokens in a bond that can be slashed (forfeit) partially and/or entirely in the case of a validator failing in their responsibility to uphold network health. Validator nodes that consistently fail in their responsibilities can be removed.

5.5. Background on Governance Design

Many alternative models were considered before adopting a one-member, one-vote model. These include a stake-based model where participants receive voting power based on token holdings and a reputation-based model where an algorithm is used to grant voting power based on positive participation in the network.

The stake-based model was ultimately deemed inappropriate for the goals of Regen Network because it effectively allows participants to buy power in the network. This is out of alignment of the overarching goal of Regen Network to support planetary regeneration because it would allow power over the network's functionality to be effectively bought and sold, undermining trust in the shared ecological ledger being used to ECs (Ecological Contracts)

Reputation-based systems were also considered and we believe they have many attractive qualities. An on-chain reputation system could provide further incentives to be a benevolent actor in the system. In the future the consortium might vote to move towards an on-chain, algorithmic reputation system, but ultimately analysis of this approach led us to the conclusion that an algorithmic reputation system was not necessarily any better than using a decentralized and socially visible human council at this point, and in fact carries significantly higher risk.

Despite the idea of unbiased machine governance that has been popular of late, we see very few, if any, of these systems that are functioning well, and none of them have been able to escape human social reputation. Instead, we've opted to design a distributed ledger that embraces the qualities of our existing social reputation systems. If an actor with supposedly good reputation starts behaving maliciously, they can quickly lose the support of others. This, of course, can be abused too, but at least there is the opportunity to adjust one's trust in others based on feedback and reasoning.

It is possible that after the system has been active for a while it will become evident how reputation can be measured in an effective, "non-gameable" way. This is difficult to know in advance and for the time-being, we have concluded that the most prudent approach is to adopt a one member, one vote model that relies on existing social reputation as well as staked tokens for security. Ultimately, there are certain social aspects to decision making that we feel can't be avoided or re-engineered easily with technology, and we have designed our network with this in mind. With this philosophy , we have suggested in-person participation in governance meetings to be the responsibility of consortium members.

6. The Regen (XRN) Token

Regen (XRN) will be a blockchain token native to Regen Ledger for the purpose of carrying out functions central to the operation of Regen Network. In essence XRNs are programmable digital tokens that can be used to access the mix of functions that make it possible to verify ecological outcome and distribute rewards for those outcomes.

Similar to holders of any currency or token, XRN holders have the ability to participate in the Regen Network economy. XRN is part of what incentivizes stakeholders from various sectors of the economy, government and citizens groups to come together to govern a shared system to achieve ecological accounting. The token itself both represents the ability to access ecological knowledge and reward ecological outcomes, it also represents a shared stake in maintaining and using the common infrastructure of Regen Ledger.

6.1. Token Minting and Granting

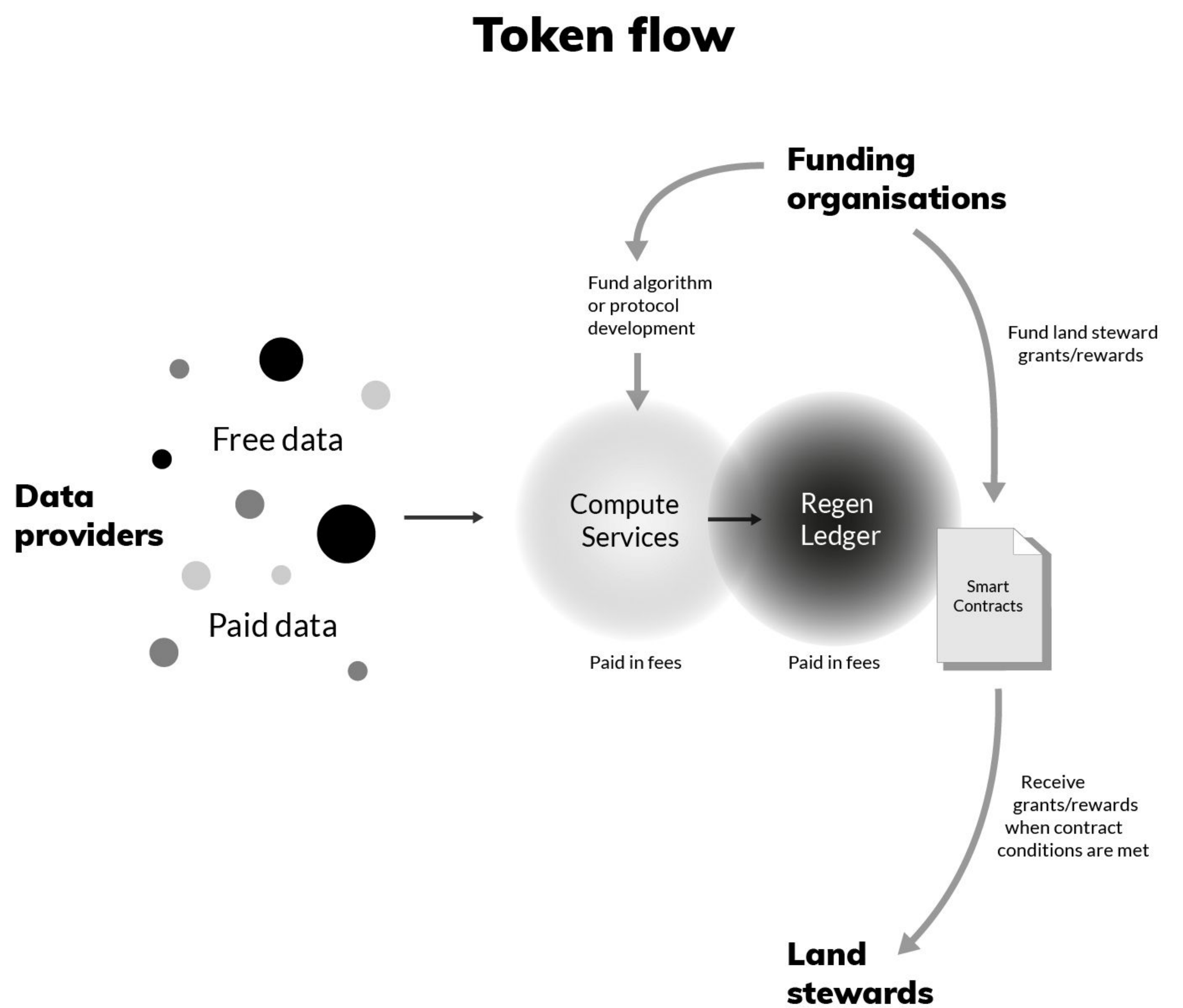
Regen Ledger will include token minting and granting functionality (inspired by Dash). The blockchain will launch with an annual increase in token supply of 1%. Token minting will occur on a quarterly basis and newly minted tokens will be awarded to network participants who submit funding proposals that are approved by the consortium governance. Grant proposals should be submitted as an EC requesting a specific number of newly minted XRN tokens. Proposals will need a simple majority approval by the consortium to receive funding. Proposals should be focused on network health and development (ecological, social, or technological), and decisions by the community should be made to grow the capacity and capability of the network by rewarding key activities for this growth to occur. If there are not enough approved proposals to use all the newly minted tokens, those tokens simply won't be minted. The consortium will be able to vary the rate of token supply increase or decrease up to 25 basis points per quarter via on-chain voting.

6.2. Fees

Like other distributed ledgers, Regen Ledger will collect fees in XRN tokens for all transactions. These fees will be distributed directly to validator nodes as payment for their services. There will also be fees for algorithms that are run on a subset of Regen Ledger nodes as compute tasks (see the ESP framework discussion) and on Regen Foundation's private compute cluster.

It is a general design goal that transaction fees be appropriate to the use case and predictable wherever possible. For instance, if we charge a farmer a transaction fee for timestamping a sensor reading, this fee should be small enough so that it is of minimal cost to the farmer. It should also be predictable so that the farmer knows how much they will pay and their transaction doesn't fail if the transaction actually costed more than the farmer was willing to pay and had to be aborted before completing (which wastes both computational power and the farmer's time and money).

Regen Ledger will be designed such that whenever possible transaction costs are pre-computed and transactions either succeed completely or fail completely and return all tokens if not enough tokens were provided. For data analysis operations which use off-chain algorithms, it may be hard to predict the total cost so users requesting verification will need to put up more tokens than they expect the operation to take and computations will likely be metered in milliseconds of compute time. Ideally, these algorithms will be benchmarked well so that the costs can be predicted relatively well, but it is for this reason that it is a design goal for the ESP framework to develop Ceres into a full-fledged data analysis language that can effectively pre-compute maximum costs.



6.3. XRN Allocation, Timeframe, and Access

During the Token Generation Event, the initial supply of XRN will be distributed as follows:

- Up to 40%—SAFT contributors
- 10%—team and advisors
- 50% (or more if the SAFT isn't fully subscribed)—Regen Foundation

SAFT contributors will receive their XRN tokens once the XRN blockchain is operational, planned within one year of closing the pre-sale.

Team and advisor XRN will vest on a three-year schedule from the closing date of the pre-sale (or delayed accordingly, if they join later): 25% at closing, with an additional 25% each year following.

Tokens will be allocated when Regen Ledger is functional. There will be a Regen Wallet available, and through an ERC-20 peg, XRN tokens may be held in any ERC-20 compatible wallet.

7. Conclusion

In this whitepaper we have provided a roadmap to the creation of a distributed ledger solution that allows stakeholders to issue smart contracts that value increases in ecosystem health. We have explained the key technological hurdles that Regen Ledger must overcome, and differentiated the unique challenges faced by a domain-specific blockchain project focused on creating an ecological ledger. We have introduced the concept of Ecological State Protocols and the Regen Ledger protocol frameworks, and shown how data quality can be assured and improved. We have provided an overview of the market forces and the economic potential that can be fostered as well as linked this economic potential to ecological regeneration outcomes. Finally, we have outlined a democratic and decentralized governance structure that can interface with local and international stakeholders to safeguard the intended utility of the system.

Regen Network represents a holistic solution that makes it possible to take coordinated, transparent action to increase ecosystem health for the benefit of all stakeholders. These actions take place through an open data platform with decentralized governance. All of these facets are unified before our native digital currency, XRN.

Regen Ledger is a platform that simultaneously serves as a true cost accounting machine, an ecological data marketplace, a distributed computational network, and a biospheric monitoring device. Regen Network puts technology to work in service to the biosphere. It will track changes in ecosystem health and contractually reward land stewards for regenerative outcomes. We invite you to be part of transforming human impact on the planet. Welcome to Regen Network.

8. Bibliography

Bollier, David. *Think like a commoner: a short introduction to the life of the commons*. New Society Publishers, 2014.

Booman G C, Calandroni M, Laterra P, Cabria F, Iribarne O and Vázquez P. 2012. “Areal changes of lentic water bodies within an agricultural basin of the Argentinean Pampas. Disentangling land management from climatic causes”. Environ. Manage. 50 1058–67

Bryant, Lara. “Organic Matter Can Improve Your Soil's Water Holding Capacity.” *NRDC*, 15 Dec. 2016, www.nrdc.org/experts/lara-bryant/organic-matter-can-improve-your-soils-water-holding-capacity.

Burwood-Taylor, Louisa. “AgriFood Tech Startups Raise $4.4bn in H1-2017 as Global VC Market Signals End of Downturn.” *AgFunderNews*, 20 Sept. 2017, agfundernews.com/agrifood-tech-startups-raise-4-4bn-h1-2017-global-vc-market-signals-end-downturn.html

“Carbon Market Monitor: America to the Rescue.” *Thomson Reuters*, 6 Jan. 2016, http://trmcs-documents.s3.amazonaws.com/3501ec8eae589bfbef9cc1729a7312f0_20160111104949_Carbon%20Market%20Review%202016_1.5.pdf

CBD. “Unlocking Potential: State of the Voluntary Carbon Markets 2017.” *Convention on Biological Diversity*, 2017, www.cbd.int/financial/2017docs/carbonmarket2017.pdf

Cosmos. “Cosmos/Constitution.” *GitHub*,2017, github.com/cosmos/constitution/wiki

FAO. “Fast facts: The State of the World’s Land and Water Resources.” *United Nations Food and Agriculture Organization*, 2015, www.fao.org/fileadmin/user_upload/newsroom/docs/en-solaw-facts_1.pdf. Accessed 14 Dec. 2017.

Gilbert, Natasha. “One-Third of our greenhouse gas emissions come from agriculture.” *Nature*, 31 Oct. 2012, doi:10.1038/nature.2012.11708.

Goedde, Lutz, et al. “ Global Agriculture’s Many Opportunities.” McKinsey on Investing, vol. 2, Summer 2015, https://www.mckinsey.com/~/media/McKinsey/Industries/Private%20Equity%20and%20Principal%20Investors/Our%20Insights/Global%20agricultures%20many%20opportunities/Global%20agricultures%20many%20opportunities.ashx

Gomez, C., Viscarra Rossel, R.A., McBratney, A.B., 2008. Soil organic carbon prediction by hyperspectral remote sensing and field vis-NIR spectroscopy: an Australian case study. Geoderma 146 (3–4), 403–411.

Hawken, Paul. *Drawdown: the most comprehensive plan ever proposed to reverse global warming*. NY, NY, Penguin Books, 2017. http://www.drawdown.org

Manyika, James; Sree Ramaswamy, Somesh Khanna, Hugo Sarrazin, Gary Pinkus, Guru Sethupathy, and Andrew Yaffe. *Digital America: A tale of the haves and have-Mores*. McKinsey & Company, Dec. 2015, www.mckinsey.com/industries/high-tech/our-insights/digital-america-a-tale-of-the-haves-and-have-mores

Meyer, Robinson. “A Reader's Guide to the Paris Agreement.” The Atlantic, 16 Dec. 2015, www.theatlantic.com/science/archive/2015/12/a-readers-guide-to-the-paris-agreement/420345/

Lal, R. “Soil degradation by erosion.” *Land Degradation & Development*, vol. 12, no. 6, 2001, pp. 519–539., doi:10.1002/ldr.472.

Soloviev, Ethan Roland, and Gregory Landua. “Levels of Regenerative Agriculture.” *Terra Genesis International*, Sept. 2016, www.terra-genesis.com/wp-content/uploads/2017/03/Levels-of-Regenerative-Agriculture-1.pdf

Toensmeier, Eric. *The Carbon Farming Solution: a Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security*. Chelsea Green Publishing, 2016.

UN. “Paris Agreement - Status of Ratification.” *United Nations Framework Convention on Climate Change*, 2017, http://unfccc.int/paris_agreement/items/9444.php