

MA Healthy Soils Guide for Site Design + Construction

Introduction to the Healthy Soils Guide

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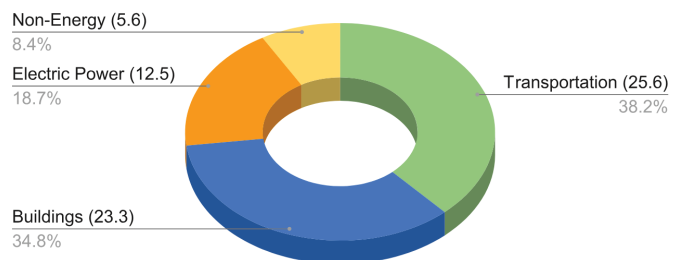
Highlights

- The building sector is the second largest source of greenhouse gas emissions in MA.
- Soil management during and after construction has a significant impact on the net carbon emissions of a development project.
- Soil health is vital for basic ecosystem functioning, stormwater management, and climate resilience.
- Limiting soil disturbance and maximizing the Soil Organic Carbon (SOC) sequestration potential is the only way a development site can truly become carbon neutral or a carbon sink.
- This guide recommends strategies and best management practices (BMPs) to maximize soil health in all phases of a site project.

Why Soil Matters

The architecture, engineering, and construction industries have a myriad of opportunities to improve the health, sustainability, and resiliency of the built environment in Massachusetts. The building sector is the second largest source of greenhouse gas emissions in Massachusetts, at 35 percent (OEEA 2022). The Commonwealth's main building decarbonization strategies hinge on maximizing energy efficiency and transitioning heating from fossil fuels to renewable sources of electricity. The use of high-performance building technologies, tight thermal envelopes, and lower emissions building materials are the main strategies for achieving the ambitious goals set by the **[Commonwealth's 2025/2030 Clean Energy and Climate Plan \(CECP\)](#)**.

Statewide Gross Green House Gas (GHG) Emissions in 2021, by Sector:
out of 67 million metric tons of CO₂ equivalent (MMTCO₂e)



Source: MA Clean Energy and Climate Plan for 2050

Find this and other resources at the MA Healthy Soils Guide website:

<https://masshealthysouls.org/guide>



However, these widely accepted strategies to minimize the embodied carbon footprint of development projects overlook a foundational element of the built environment: the soil, the very ground we build on. The way we design and construct buildings and landscapes can impact the overall net carbon emissions of a development more than all the energy, materials, and long-term use combined.

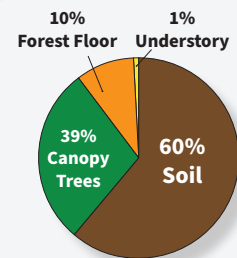
Soil is one of the earth's largest carbon reservoirs, and soil disturbance is a major contributor to greenhouse gas emissions all over the world.

Including healthy soil management practices as part of the overall effort to decarbonize the building sector could prevent unnecessary carbon from being released into the atmosphere and increase long term carbon sequestration and storage capacity in existing and new construction. Limiting soil disturbance and maximizing the Soil Organic Carbon (SOC) sequestration potential is the only way a development site can truly become carbon neutral or a carbon sink. The protection and restoration of healthy, high-functioning soils onsite is an underutilized approach for developers who want to reduce the carbon footprint of the building sector and bring greater coherence to our ability to live and thrive in both urban and rural environments.

Spotlight on Soil Carbon

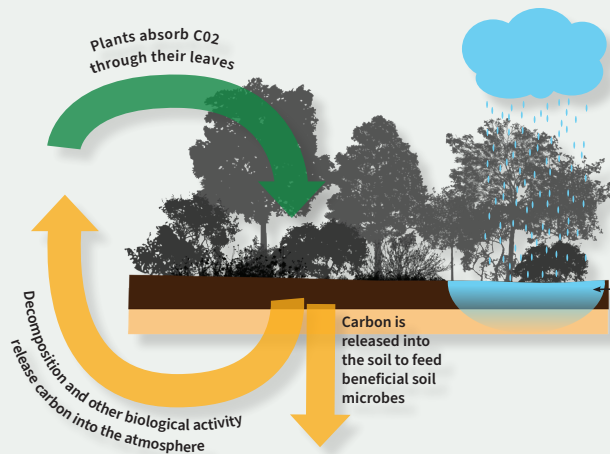
Carbon content is one of the few universally agreed-upon indicators of soil health and is related to most of the important soil functions.

Plants remove atmospheric carbon dioxide and convert it into sugars, fibers, lignins, and other compounds. Within an hour, 10-40% is exuded from the roots to feed beneficial soil microbes.



Where Carbon is Stored in Our Forests

60% of the carbon storage of temperate forests is in the soil



Organic matter is roughly 57% carbon on a dry-weight basis. The carbon in organic matter is referred to as "soil organic carbon" (SOC). Every ton of SOC is the equivalent of 3.677 tons of carbon dioxide.

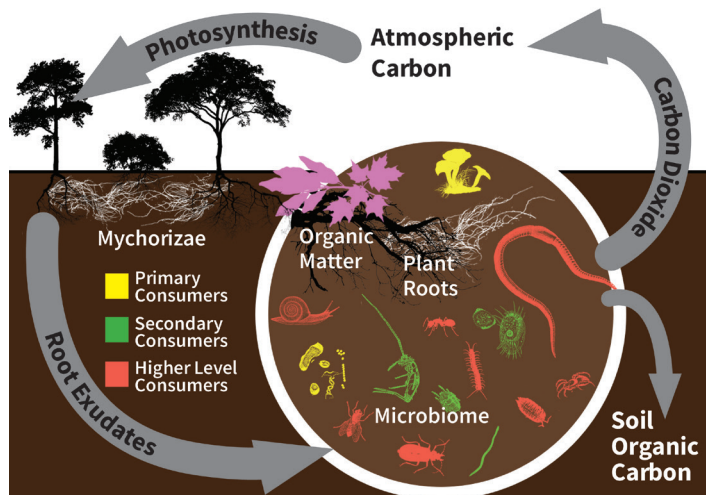
Healthy soils are like sponges

For every 1% organic matter increase, soils can hold 10,000 more gallons of water per acre.

Source: BSC Group

The Benefits of Healthy Soil

Healthy soils increase drought resilience, mitigate flooding, adsorb excess nutrients, filter sediments, decompose pollutants, and moderate peak stream flows and temperatures. Healthy soils also perform important stormwater management functions; they increase water holding capacity and support vigorous plant and tree growth that intercept rainfall, returning much of it to the atmosphere through evaporation and transpiration. Preserving and enhancing healthy soils during the construction process can prevent expensive problems such as poor drainage, nutrient leaching, and erosion from developing later on.



Healthy soil supports robust communities of microorganisms that contribute to the increase of soil organic carbon. Credit: RDG

Beyond these well-documented benefits, or **ecosystem services**, the soils around our buildings also have an enormous untapped potential to sink and store many metric tons of atmospheric carbon.

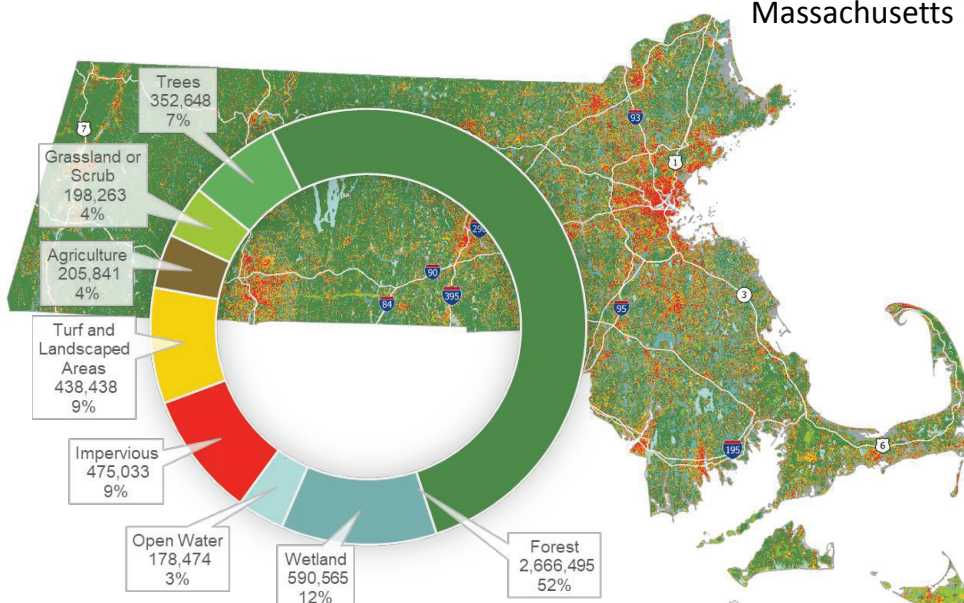
Landscapes are the only element of the built environment that have the potential to provide ongoing carbon sequestration after the completion of a project.

Protecting soils and minimizing soil disturbance should be a primary objective in reducing the embodied carbon footprint of the construction process; however, disturbance cannot be entirely avoided in the built environment. Building and construction is, by nature, a disturbance event that disrupts biological, geological, and chemical cycles in the soil. Disturbance is also a natural and even necessary component of high-functioning ecological systems, not unlike periodic wildfires and earthquakes.

With proper planning and a better understanding of healthy soil functions, *we can use the necessary disturbance of construction to intervene and improve soil function.*

Designing and building “soil-smart” developments means working with the cycles of natural ecosystems and actively situating human activity within the larger story of dynamic ecological processes.

Humans are not only consumers of natural resources, but also catalysts for transformation that can either prevent or fortify the mutual flourishing of life both above and below ground. We have an incredible opportunity at hand to design our built environment to protect, serve, and enhance the natural environment.



Massachusetts Land Cover

The MA Healthy Soils Action Plan estimates soil organic carbon stocks by land cover type. Based on the 2016 Landsat data, nearly 10% of the state is turf, ornamental, and recreational land cover, all of which are designed and built landscapes. That leaves a significant opportunity for site design and construction teams, as well as homeowners, business owners, and landscapers, to influence the future carbon storage and sequestration in Massachusetts. *Source: RDG*



Why This Guide

Over 360,000 additional acres of soil in Massachusetts may be impacted by development over the next 35 years (HSAP 2023). Every time soil is disturbed, SOC is transformed into carbon dioxide and lost back into the air. Every ton of SOC is the equivalent of 3.677 tons of carbon dioxide. Agricultural research is fueling a movement toward no-till agriculture, but this science is just as applicable to the soil disturbance in site development and landscaping services.

The difference developers and construction professionals can make is significant: there is roughly twice the amount of land in turf and ornamental landscapes in Massachusetts as agricultural land. Shifts in design and management practices—such as planting 25% of open lawn with trees, and increasing organic matter content in the top 8" of lawns to a minimum of 3%—could sequester an additional ~180,000 tons of carbon dioxide equivalent per year, the same as taking over 38,000 gas-powered passenger vehicles off the road.



Depleted soil (left) next to soil rich in SOC (right). Source: RDG

There is a wealth of information, guidance, and ongoing research into building healthy soils. Yet, it is not straightforward for those in the building industry to apply them, and soil health is often overlooked in the development process. During final grading, a minimal layer of topsoil may be brought in to cover the site and install aesthetically pleasing vegetation, hiding the damages of disturbance from view. However, the underlying damages to soil health often become visible after the project has been completed in the form of issues such as poor drainage, erosive runoff,

and failed plantings that make long-term management difficult and resource-intensive. Poor soil health outcomes are invariably more carbon-intensive as well.

This guide strives to synthesize the most impactful ways to intervene within today's design and construction practices, and address some of the challenges that design and construction professionals face in integrating healthy soil practices into their work:

- **Lack of Information/Research**

There is no comprehensive, regionally-specific resource on achieving soil health in construction. Existing research is fragmented across multiple fields, and Best Management Practices (BMPs) can be hard to find, much less apply consistently. Training for construction workers to implement these practices is rarely provided.

- **Lack of Universal Standards**

Current healthy soils standards and specifications are fragmented and buried in other low- or net-zero green building project certifications (LEED, SITES, and the Living Building Challenge) or professional certifications (EnviroCert, SSSNE, SSSA). They are not universally applicable or accessible to construction professionals engaged in most MA development projects. Basic soil management literacy should be standard for all site development.

- **Lack of Understanding and Accountability**

Development projects are often complex and involve many disciplines, yet most lack a single party responsible for soil BMPs. Many professionals have a minimal understanding of soil health principles, and even those with the best intentions of sustainable design may produce projects that damage soils in the end.

- **Lack of Support**

Addressing the gap between soil science and economic development is crucial for industry change. The current lack of support for education, evidenced by the perceived high costs of implementation, hinder the widespread adoption of best practices.

This guide aims to bridge these gaps for design and construction professionals by recommending healthy soil standards and specifications, along with recommended best management practices from a variety of disciplines in plain language for professionals across the construction industry

The The Massachusetts Healthy Soils Guide was produced by Regenerative Design Group in partnership with Linnean Solutions, BSC Group, and Sasaki, and funded by the Massachusetts Healthy Soils Challenge Grant through the Executive Office of Energy and Environmental Affairs (EEA). It is published in print and in digital format to ensure it stays up-to-date and accessible to a wide range of users, who will help raise the profile of soil health and the enormous untapped potential of optimizing healthy soil functions throughout the design and construction process. Visit masshealthysouls.org or scan the QR code (right) to learn more.



Establishing “Soil-Smart” Project Goals

What is possible when it comes to protecting, managing, and enhancing soil health and function? What is a “soil-smart” design, and how can planners, designers, and contractors all work together to use “soil-smart” practices that prioritize healthy soil outcomes?

SOIL SMART DESIGN + CONSTRUCTION:

- Preserves high-quality soils and geodiversity on site
- Restores degraded soils
- Sequesters atmospheric carbon in biologically active soils
- Increases ecological capacity of engineered soils
- Delivers high-impact ecosystem services
- Reduces long-term maintenance needs

There are several ways to approach the goal of protecting and enhancing soil in the built environment. Establishing soil health goals will help to clearly articulate the rationale behind implementing new and perhaps unfamiliar soil management techniques.

Thinking through these overall goals at the beginning of each project will help to guide the other decisions made throughout the construction process. Asking some of the following questions can help to create a basic framework for approaching each project with soil health in mind:

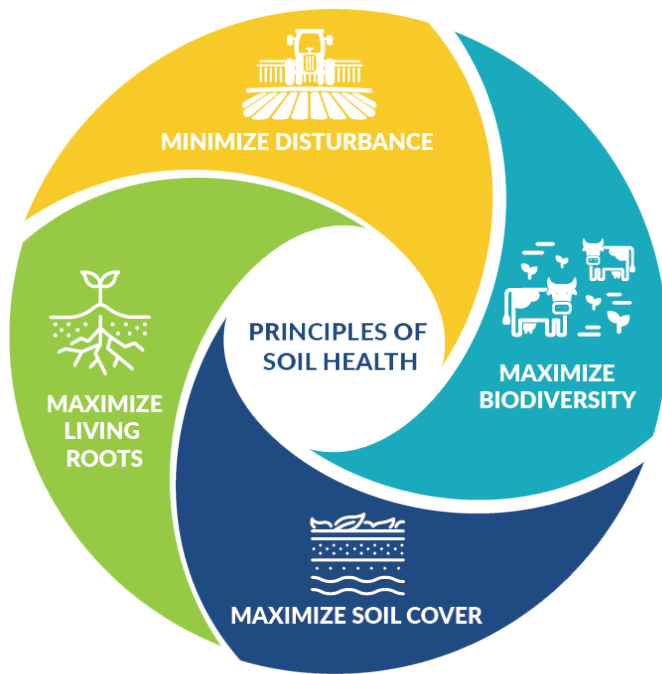
- What can we do to protect existing healthy soils?
- How can we maximize soil functions (i.e. for filtration, or a particular human/habitat use)?
- How can we limit disturbance to only the most necessary actions and areas?
- What do we want this site to look like in 10 years? In 30 years?
- How can we increase the amount of ecological diversity on this site?
- How can we reduce the need for regular long-term maintenance of this landscape?



Two 2.5-acre sites: Site A showing business as usual, Site B showing 'Soil-smart' practices. Looking solely at soil disturbance and the designed revegetation, Site A has a 30-year carbon loss of 290 metric tons, or the emissions equivalent of 2.7 million driving miles. Site B has a 30 year carbon loss of 121 metric tons, or the emissions equivalent of 1.1 million driving miles. If no development had occurred in either side, these 2.5 acres would each have an estimated 30 year carbon gain of 56 metric tons, equivalent to the emissions offset of 500,000 miles. *Source: RDG*

How To Use This Guide

The Healthy Soils Guide provides a roadmap for designing and implementing “soil-smart” practices that optimize healthy soil functions for productive, resilient, carbon-rich, thriving landscapes. This guide can be used by professionals, homeowners, and concerned citizens to improve industry standards across the board when it comes to protecting and enhancing Massachusetts soils. The sections are organized in chronological order, beginning with the design process and moving through onsite and final grading practices, including soil specifications and amendments. Additionally, each section is designed to stand on its own, and can be referenced as needed.



Source: USDA NRCS

The following steps will aid you in using this guide for ‘soil smart’ development:

1. **WHO:** Identify what kind of **actor** you are
2. **WHAT:** Identify the **soil functions** that you are trying to achieve/protect
3. **WHERE:** Evaluate the potential of the **site** you are working with
4. **WHEN:** Decide where in the **process** you can intervene
5. **HOW:** Apply the appropriate **level of intervention** for your project

1. WHO: The Actors

This guide is written for site development professionals, including but not limited to general contractors and subcontractors, architects and landscape architects, designers, planners, developers, regulators, and civil, environmental and structural engineers. The information in this guide can also

be used by homeowners who are hiring any of the above professionals or doing their own design, landscaping or construction work.

In most development projects there is a high level of overlapping expertise and influence over decisions. A *landscape architect* can contractually protect soils by specifying a Limit of Work and Critical Root Zones in the construction documents; however, in their absence, the *general contractor* may also establish them onsite. An *architect* may work together with both a *landscape architect* and *civil and environmental engineers* to site the building and design the foundation, which has direct repercussions on soil health. A *general contractor* has control over the means and methods of construction, which can impact soil health outcomes over the entire site. As more professionals become familiar with strategies to protect and improve soil health, implementing healthy soil BMPs will become easier and more straightforward.

2. WHAT: Soil Functions

The soils and landcovers on every site are unique. Soil texture, parent material, climate, historical land use, and vegetation greatly impact aspects of soil formation, nutrient availability, and biological activity. Soil health is determined by a **soil’s capacity to operate as a dynamic, living system that maintains essential environmental and ecological functions**. For this reason, a ‘healthy’ soil found in one geographic area can be composed of completely different “ingredients” than a ‘healthy soil’ found in another area.

There are **five main soil functions** that can be used to assess soil health and are referenced throughout this guide:

Biological Activity: The capacity of the soil to support plants and plant growth (primary production), and provide habitat for diverse communities of organisms (primary and secondary production and ecosystems), including humans

Carbon Sequestration & Storage: The ability of the soil to hold on to carbon that plants have removed from the atmosphere and store it for extended periods of time as soil organic carbon and below-ground biomass

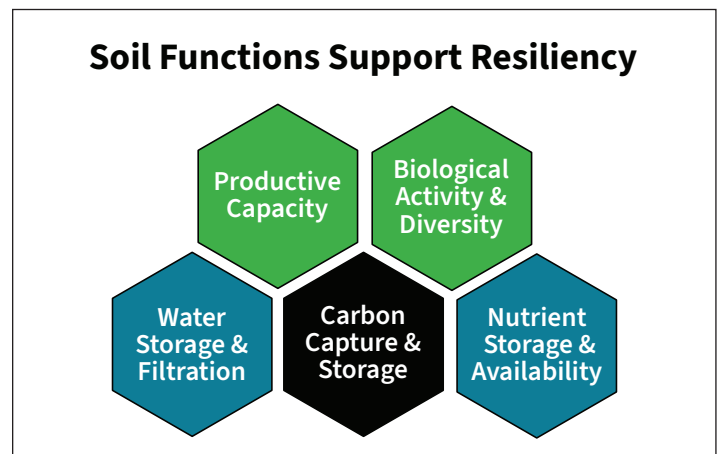


Image: RDG

Nutrient Availability & Capture: The ability of the soil to capture, hold, and be a source of nutrients for organisms

Water Storage, Filtration & Infiltration: The ability of the soil to infiltrate and hold water, and remove nutrients and pollutants from water that is moving through it

Structure, Stability & Porosity: The ability of soil to withstand erosion and compaction and support infrastructure

Not all landscapes can, nor necessarily ought to, maximize every soil function. Whether defining soil specifications for construction projects, or installing ornamental landscapes post-construction, **it is important to understand both the functionality of the soil prior to development, as well as the desired soil functions post-development** in order for the construction process to produce the best possible soil function outcomes on impacted soils.

3. WHERE: Landscape Types

The Healthy Soils Guide aims to provide recommendations for achieving healthier soil functions in a diversity of settings. The chart below compares typical healthy soil functions within several different landscape types.

A “high-functioning” soil across all five functions is relatively rare. Different landscape types naturally have different constraints and may be limited in their functions or capabilities. For example, typical lawns have fibrous, mat-forming root systems that do not penetrate deeply into the soil horizons. Therefore, their ability to store carbon is limited, but with the right soil conditions, they can be a place of high water filtration and storage capacity.

Typical Soil Functions Within Different Landscape Type

Landscape Type	Carbon Capture and Storage	Nutrient Storage and Availability	Water Infiltration, Capacity and Filtration	Productive Capacity	Biologic Activity
Cultivated Areas:					
Ornamental + Recreational Lawns	Medium	Medium	Medium	Medium	Low
Gardens	Medium	Medium	Medium	Medium	Medium
Farmland	Medium	High	Medium	High	Low
Environmental Services:					
Green Infrastructure	Medium	Low	High	Medium	Medium
Wetland Replication	High	High	High	High	High
Natural Landscapes:					
Northeastern Meadow + Shrubland	High	Medium	High	High	High
Reforestation	High	High	High	High	High
Wetland	Very High	Very High	Very High	Very High	Very High
Protected Soils (rare habitats, intact and undisturbed, polluted)	Varies By Context	Varies By Context	Varies By Context	Varies By Context	Varies By Context

WHEN: The Design/Build Process

A typical construction project follows a general order of phases, such as:

(1) Site Selection + Analysis → (2) Design + Permitting → (3) Site Prep → (4) Excavation → (5) Foundation + Hardscaping → (6) Final Grading + Planting → (7) Maintenance

Although the sections in this guide are organized chronologically, as in a typical project timeline, knowing the desired final outcome will better inform planning and design. In the interdisciplinary fields of design and construction, the more each actor understands the implications that each phase has for soil health, the better they will be able to collaborate.

Guide Sections

Introduction

Soil Primer + Assessment Toolkit

Site Analysis + Planning: Soil Smart Designs

Specifying Amended + Blended Soils

Managing Soils Onsite

Landscape Management + Maintenance

4. HOW: Levels of Intervention

Every project impacts the soils on a construction site to some degree. The goal of this Healthy Soils Guide is to offer guidance for **soil management strategies** that minimize negative soil outcomes such as erosion and compaction while maximizing the potential of the soil to recover quickly from disturbance, and if possible, improve upon the initial conditions long term as part of an overall “soil-smart” approach to development.

A “soil-smart” project may utilize several different soil management strategies on the same site to achieve the highest overall standards of soil health, both during and after construction. These strategies can also be considered as varying **levels of intervention**, from low cost/low intervention (protect) to high cost/high intervention (recreate). The four main strategies used in this guide are:

- a. **Protect** sensitive and valuable areas from impact
- b. **Rehabilitate** soils for better ecological function
- c. **Relocate** soils that will be disturbed by construction using best management practices
- d. **Recreate** soils using offsite mixes and amendments to add to, alter, or replace removed or compromised soils.

The planning and design phases are the best times to communicate and make decisions about soil management that will ensure optimal soil function outcomes with the lowest costs to developers. Recommended actions or BMPs to achieve these soil management strategies can then be implemented by the rest of the construction team with clarity, efficacy, and efficiency.

Healthy Soil Management: Levels of Intervention

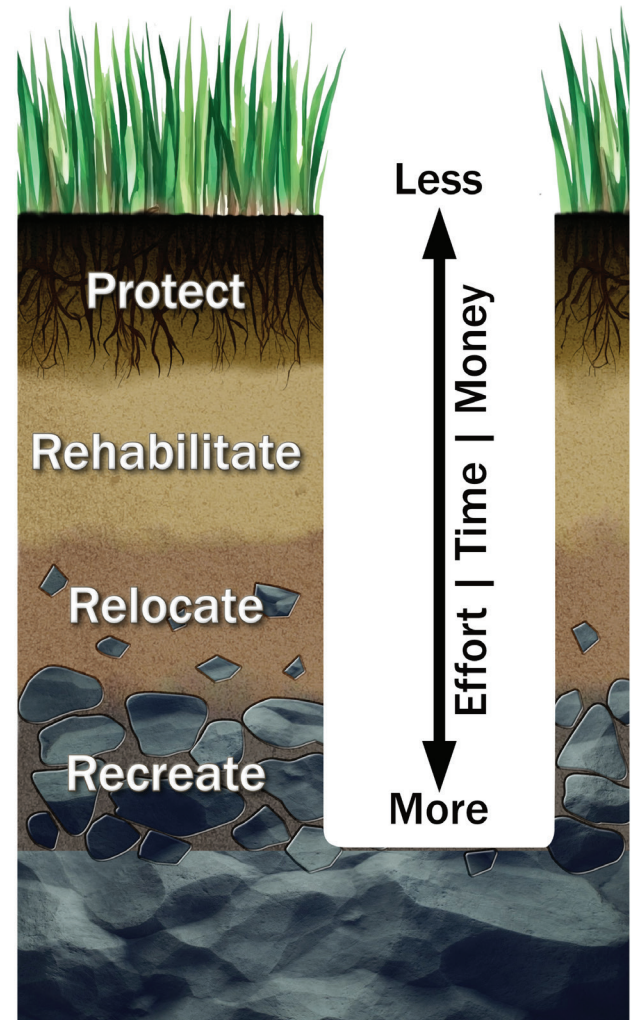


Image: RDG



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