UCLA Sustainability Action Research

2024

SOIL HEALTH AND SUSTAINABLE LANDSCAPING

Final Report

Recommendations for soil restoration practices and sustainable landscaping as could be applied to UCLA as an urban campus setting.

Team Leaders: Joy Huang & Jamie Griffith

Team Members: Mercy Shrestha, Sofia Brown, Selena Yu, Kyla Marcello, Soleil Berkson

Stakeholders: Nurit Katz, UCLA Chief Sustainability Officer
Bonny Bentzin, UCLA Deputy Chief Sustainability Officer

Table of Contents:

Abstract

As climate change continues to worsen and natural habitats around the world are showing increasing signs of irreversible degradation, the field of soil restoration and pedology has emerged as a burgeoning field of active research and discussion. There are numerous tools, assessments, and amendments used in the service of soil restoration; from chemical to biological to physical soil modifications, care must be exercised when choosing what practices to implement. Using horticultural or agricultural practices for a project serving native biodiversity or ecological restoration, for example, will not yield the desired results and can ultimately disservice the project as a whole.

Therefore, to complete the task delegated by our stakeholders, our research addresses how soil restoration oriented towards promoting native biodiversity can be best implemented in an urban campus setting. Specifically in the context of native biodiversity, there is ongoing research on how to define, quantify, qualify, and ultimately proliferate the existing biodiversity of an ecosystem. Biodiversity is a broad umbrella term, with many other 'biodiversity' terms branching off from it. This was another fundamental question our research sought to answer: what type of biodiversity do we seek to capture, and how will we obtain this through soil restoration?

As the University of California, Los Angeles (UCLA) rolls out its 2022 landscaping plan and begins modifying and converting on-campus landscaping practices, it is crucial that corrective, appropriate soil management practices are implemented. To answer these questions, we employed a three-pronged methodology in our research: a literature review followed by informational interviews and facility tours. Ultimately, our findings revealed the detailed soil assessment and modification practices, in addition to supplemental education initiatives, required to achieve our goals.

Introduction

Soil Health and UCLA

Soil health is important for any resilient ecosystem, and thus is important to address when hoping to achieve ecological restoration. Soils beds are the places where “life that is foundational for the rest of the ecosystem” resides (Rodbarry, 2023). Soil health is defined as the “state of the soil being in sound physical, chemical, and biological condition, having the capability to sustain the growth and development of land plants” (Idowu, 2020). Thus, healthy soil is multifaceted and requires a combination of practices to achieve. Soil health is important for UCLA to build resilient ecosystems that preserve biodiversity and are well suited for the climate. Soil health in any location requires holistic foresight and preparation, which this project aims to provide for UCLA (Desai, 2018).

Current Problem with UCLA Soils:

The soils on UCLA’s campus face several challenges that impede ecosystem health and optimal plant growth. As the UCLA Landscape Plan highlights, “most soils on campus are likely highly compacted and fill soils of unknown origin are likely present” (*UCLA Landscape Plan*, 2022). Compaction reduces water infiltration and root penetration, interfering with plant growth and decreasing soil biodiversity (Nawaz, et al., 2013; “Mulch & Protect & Grow,” 2023). The presence of fill soils on campus results in inconsistent soil quality. Additionally, “excessive landscaping grooming is not good for wildlife, soil and carbon footprint” and this maintenance practice, along with unnecessary hardscape, exacerbates soil compaction and reduces natural mulch that “fertilizes the soil as it breaks down naturally” (*UCLA Landscape Plan*, 2022).

UCLA Landscape Plan:

UCLA has demonstrated a commitment to biodiversity and sustainability through its 2022 Landscape Plan. The UCLA Landscape Plan emphasizes the importance of soil health and outlines several recommendations for improving soil quality on campus (*UCLA Landscape Plan*, 2022). These include creating an “on-campus green waste/mulching area to stockpile biomass for soil amendment,” removing excessive hardscape to decrease soil compaction, and establishing “maintenance best practices for soil health” (*UCLA Landscape Plan*, 2022). While the UCLA Landscape Plan recognizes the importance of soil management, stating that “soils are the foundation of all gardens,” the Landscape Plan sets broad objectives (*UCLA Landscape Plan*, 2022). Our project builds upon these goals by providing detailed, actionable recommendations for improving soil health and offering specific assessments to test soil quality and composition.

Purpose and Scope

This report provides recommendations on soil restoration practices that can be applied to UCLA's unique urban campus setting. This includes providing restoration, soil testing, and implementation recommendations. By providing these action-based recommendations, this project is a guide for UCLA to achieve its goals of healthy soil and foster biodiversity on campus.

Methods

In order to obtain the most up-to-date and relevant data with regards to soil health, testing, and modification, two main methods were employed. First, a series of interviews were conducted with soil experts, landscape specialists, and others with expertise on a specific topic pertaining to soil. Then, we asked each interviewee for additional contacts while continuing to seek out interviewees on our own. In doing so, we were able to acquire substantial data on recommended soil assessment and modification methods. A comprehensive list of all interviews conducted is available in Appendix A.

In addition to expert interviews, we also partook in several facility tours in order to better understand soil health firsthand as well as to have the opportunity to speak with many individuals with diverse perspectives. These facility tours included sitting in on a microbiology lab class where students were conducting research on soil composition and its properties. Furthermore, we visited Sage Hill on the UCLA campus in order to gain a better understanding of soil conditions in relatively undisturbed environments. Finally, we volunteered at The Gabrielino-Tongva Springs Foundation, where we had the chance to maintain a native garden and gain the perspective of the Indigenous community whose territory upon which UCLA sits.

Since some of our interview contacts were obtained from the recommendations of other interviewees, sampling bias is introduced in which there is a risk of only interviewing experts who work in the same circle. To mitigate this bias, our team also conducted research of our own on other programs and experts to interview; this broader sampling strategy allows us to obtain more holistic findings that are more representative of the current knowledge of soil health and sustainable landscaping. The interviews allow our team to effectively and efficiently gain the most relevant and updated information on the niche topic of soil health and sustainable landscaping as they apply to an urban campus setting and support native biodiversity. The interviews also direct us to other experts we should interview and other literature that can expand our interview findings. For these reasons, we decided to have the interview findings as the main body of our report, supported by tours of facilities and our original literature review.

Throughout the development of our project, we considered how we could incorporate Equity, Diversity, and Inclusivity (EDI) into our methodologies and goals. These values were critical to every step of our project, from data collection to synthesis, and throughout this final report. With regard to interviews, we found that including a diverse set of interviewees would enhance the scope and perspective of our project. For example, we acknowledge that our campus grounds lie on Gabrielino/Tongva lands, so our team wanted to ensure the voices of local Indigenous tribes were incorporated into any proposed restoration plan. This was accomplished through our tour and interviews at the Gabrielino-Tongva Springs Foundation. We also interviewed UCLA Facilities

Management staff to build our understanding of the department's culture, operations, and environment. Facilities Management workers will experience immediate change from any of our recommendations, so it was vital that we created a space to hear and address their needs when developing our recommendations.

We incorporated EDI by ensuring we had a diverse group of interviewees. Since we obtained many of our contacts through word of mouth, we devoted significant time to broadening it beyond academia. This included seeking out indigenous voices, namely at the Gabrielino-Tongva Springs Foundation, and discussing methods with staff on the ground at UCLA. We also targeted some of our questions on the implementation of equitable and inclusive measures when it came to landscaping. Namely, the inclusion of students and community members in both decision-making and the educational process.

Challenges

Throughout our project, we faced multiple challenges, but if you were to ask any team member what the greatest problem was they would reply with one word: Scope. Sustainable landscaping and soil health at UCLA is a topic with incredible breadth, and our objectives have shifted over the months of our project. Every time we were forced to redefine objectives we had to pull our scope back. There are so many areas that can be improved and a truly holistic assessment of UCLA landscaping would require years not months.

Through interviews, we were able to provide a comprehensive review of existing and proposed practices. Our goal was to collect knowledge from people in this rapidly evolving field and synthesize it into actionable recommendations. We had initially planned on incorporating a large literature review and possible survey via iNaturalist but settled on interviews as our primary method since we decided expert testimonials, with associated context, were essential.

After collecting most of our interviews we faced the daunting task of synthesizing them. How should we systematically report the findings from interviews, and how can we build each other's knowledge? We overcame this challenge by first having someone present in each interview compile a summary and putting them all in our “All Interview Findings” summary document. After that, we experimented with different ways to group interviewees and their knowledge, before settling on the existing categories in our report.

Synthesizing these interviews and creating our report required an increased time commitment and to meet that need we reduced our number of Facility Tours, removed our planning tour of Stone Canyon, and finished most of our interviews by the end of Week 5. To facilitate discussion and stay on the same page we also increased our number of team meetings and moved to a more casual format for them. These meetings focused on delegating tasks and reporting back.

Furthermore, we performed both our interviews and our later synthesis of various sections in pairs to increase cohesion and support while also reducing the workload on any one person. We also planned around stressful events such as midterms and massively increased police presence on campus in the face of student protests. By supporting each other, being flexible with deadlines, and acknowledging sources of stress we curtailed burnout and were able to steadily produce and polish this final report.

Recommendations

Soil Assessments

Soil assessments are a great tool that can be utilized in order to gain a better understanding of a soil's composition and quality. There are a plethora of tests that can be done to better understand the composition of a soil sample. The soil assessment methods we focused on were the ten most frequently mentioned assessments that were recommended in our interviews. These assessments include soil compaction, soil pH and salinity, visual soil assessments, water infiltration and retention, biological indicators, soil organic matter, soil texture and composition, mycorrhizal and microbial activity, nutrient levels, and soil aggregate stability. See Appendix B for a table of assessment descriptions and interviewees.

Soil Compaction Testing

Soil compaction assessments are one of the most important and frequently mentioned soil assessment methods based on our conducted interviews. Surface and subsurface hardness, indicators of soil compaction, can be measured using a penetrometer (J. Amsili, March 12, 2024). Joseph Amsili, a Cornell Soil Health Program Associate, recommends that when taking measurements with this device, it is crucial to measure when the soil feels moist, not dry. The highest value encountered should be recorded when the penetrometer is pushed down to 6 inches for a surface hardness measurement, and farther down to 18 inches for a subsurface hardness measurement (J. Amsili, March 12, 2024).

Ben Faber (April 24, 2024), a UC Cooperative Extension Farm Advisor in Ventura County specializing in Subtropical Crops, Soils, and Water issues, emphasized that soil compaction is the most important physical property to assess and suggested conducting multiple samples across different areas with varying soils to ensure accurate readings. According to Faber (April 24, 2024), "Our major problem in an urban environment is compaction" and high compaction levels often indicate heavy foot traffic, impeding root growth and water infiltration. Therefore, it may be necessary to "redirect that physical pressure," such as diverting the physical movement of students walking over the soil to mitigate these issues and help maintain healthy soil conditions (B. Faber, April 24, 2024).

Soil pH and Salinity

Testing soil pH is essential for understanding nutrient availability and microbial activity within the soil. J. Amsili (March 12, 2024) emphasized this chemical indicator for dictating nutrient availability, noting that soil pH can strain microbial life if not properly managed, suggesting a pH range of 6.3-7.2 for many crops. Sheina Crystal

(March 8, 2024), Director of Communications and Campaigns of Re:wild Your Campus, concurred, noting that pH impacts nutrient availability and microbial activity.

Ben Faber (April 24, 2024) added that pH testing is crucial for selecting the appropriate plant for the soil. Many soils have a high pH and nutrient excess, making it more difficult for plants to grow (B. Faber, April 24, 2024). For example, biochar, which has a high pH, may not be suitable for soils in Southern California, which have an inherent nutrient excess (B. Faber, April 24, 2024). B. Faber (April 24, 2024) explained that soil salinity, which generally increases as soil pH decreases, reflects water management practices. Salinity accumulates when there is insufficient irrigation, demonstrating the need for proper irrigation practices (B. Faber, April 24, 2024). Faber suggested taking two or three soil samples when assessing pH and salinity to guide the selection of plants based on their ability to handle the pH and salinity of the current soils to optimize soil health.

Soil Organic Matter

Soil organic matter is the component of the soil that contains plant and animal tissue in various stages of decomposition (Fenton et al., 2008). Measuring the amount of organic matter in the soil is important for understanding soil fertility and biological activity, and is a driving factor in assessing a soil's biodiversity. Dustin Hermann (May 3, 2024), a Principal Scientist at TreePeople, emphasized that organic matter is vital for healthy soil, as the microbial community can turn it into plant nutrients. Hermann (May 3, 2024) also noted that higher organic matter levels contribute to better soil structure and water retention, and that an organic layer is crucial to support healthy soil and plant development. Carol Bornstein (April 1, 2024), a Native Plant Specialist and horticultural consultant, highlighted the importance of organic matter in soils, along with other interviewees.

Soil Texture and Composition

Understanding soil texture and composition is critical for determining the suitability of the soil to support different plant types. In particular, soil composition is important for supporting native and climate-appropriate plant palettes, as emphasized by Bornstein (April 1, 2024). Bob Ramirez, President of the Gabrielino-Tongva Springs Foundation, and his son, Daniel Ramirez (April 23, 2024), suggested using a soil chart or pyramid to show the amount of sand, silt, and clay in a soil to ensure that the plant fits with the soil type. The soil composition can be analyzed using the jar test, a simple experiment recommended by Bob and Daniel Ramirez, Joseph Amsili, and Alison Lipman, an Ecology and Evolutionary Biology (EEB) Professor at UCLA. This method determines the relative percentages of sand, silt, and clay and their soil texture, and the Clemson Cooperative Extension provides a detailed explanation of the full procedure (Jeffers, 2023). This technique involves filling a jar one-third with a sifted soil sample, adding water, shaking the jar, and allowing the soil layers to separate over 48 hours

(Jeffers, 2023). The different layers are measured with a ruler to calculate the percentages of sand, silt, and clay, which are then used to determine the soil type using a soil texture triangle (Jeffers, 2023). Soil texture is an inherent property that shapes what you can do with the soil and is key to interpreting indicators, according to Amsili (March 12, 2024).

Mycorrhizal and Microbial Activity

Mycorrhizae form a symbiotic relationship between plant roots and fungi whose major function is to “enhance nutrient and water uptake by the host plant by exploiting a larger volume of soil than roots alone can do” (Dighton, 2009). Assessing the presence and activity of mycorrhizae and other microbes is crucial to understanding nutrient cycling and soil fertility. Bob and Daniel Ramirez (April 23, 2024) noted that the presence of mycorrhizal activity indicates fertile soil, which Hermann (May 3, 2024) equated, stating that healthy soil will have a diverse microbial community that can convert organic matter into nutrients for the plants. Furthermore, Sheina Crystal (March 8, 2024) recommended microbial biomass analysis to gauge biological activity and nutrient cycling capabilities.

Biological Indicators

There are a wide variety of biological indicators that can provide insight into the health of soil. One of them is the presence of fungi. This was highlighted by Pamela Berstler, the CEO of Green Gardens Group, who mentioned that greater fungal dominance meant that soil was more complex and biodiverse (April 15, 2024). Another key biological indicator is the presence of bacteria. This can be assessed through microbial biomass analysis, which gauges the soil’s biological activity and nutrient cycling capabilities (S. Crystal, March 8. 2024). When there is a greater bacterial dominance in the soil, biodiversity and complexity is missing in the soil, making it only able to support grass species (P. Berstler, April 15, 2024). Another indicator worth assessing is the presence of nematodes, which are roundworms that feed on bacteria, fungi, and other microscopic creatures and are critical to soil and sediment ecosystems. As a result, their presence is a strong indicator of soil health (J. Yanowitz, February 16, 2024). Finally, protozoa counts, like nematodes, are good indicators of the health of a soil sample (S. Wynbrandt, April 15, 2024).

Water Infiltration and Retention

The presence of water in soil is an important indicator in the overall health of a soil sample. For one, healthy soil should be like a sponge, having a strong holding capacity that allows it to retain moisture well. On the other hand, dry soil can indicate that the soil is unhealthy and unable to retain the water it receives (S. Wynbrandt, April 15, 2024). Just as retention is a vital indicator of soil health, as is the drainage capabilities of the soil. An easy test to determine how well a given soil sample is able to drain is to shake the soil with water. This will allow for the separation of the soil to determine its composition and retention capabilities (B. & D. Ramirez, April 23, 2024). Gaining information on soil's temperature is another valuable indicator of the composition and health of a given sample as it indicates the environment around the soil as a whole. (D. Hermann, May 2, 2024)(B. Faber, April 24, 2024).

Visual Soil Assessments

A variety of soil assessments can be made through the mere visual composition of the soil and the ecosystem it supports. For one, the soil can be analyzed using the Munsell soil color chart. By assessing a soil sample with this chart, valuable information can be obtained about the composition of the soil, such as the amount of organic matter present (D. Hermann, May 2, 2024). Furthermore, a lot can be known about soil health from the variety of plants that are growing there. For example, a good indicator of soil health would be looking for the presence of native vs non-native and invasive species as well as taking note of the health and abundance of the plants that are present. Another visual test that can be conducted in order to examine the soil is to take photos of a variety of different soil samples in order to compare and contrast their appearance and the plant life they support (B. & D. Ramirez, April 23, 2024).

Nutrient Levels

The nutrient levels of soil are another important indicator in determining the composition and health of a given sample. One important nutrient to test is nitrogen. California natives thrive in soil with low nitrogen, so excessive nitrogen amounts may hinder plant growth and success and indicate an imbalance in the soil composition (A. Lipman & L. Gorlitsky, February 29, 2024). Testing for phosphorus, oxygen, and carbon levels can also provide useful information with regards to soil health (S. Crystal, March 8. 2024).

Soil Aggregate Stability

The final soil assessment being highlighted in this list of recommendations is the testing of soil's aggregate stability (the ability of soil compounds to stick together when acted on by an outside force). This can be done through the use of a slate test, where soil samples are put into water and it is timed how fast it takes for the sample to fall apart. If it falls apart quickly, this is an indication that little to no aggregation is taking place (P. Berstler, April 15, 2024). With soil, higher aggregate stability is ideal, where the soil will remain relatively intact. This is because higher aggregate soil stability will result in less erosion and less subsequent damage. Especially after major rainfall, the importance of high soil aggregate stability is on full display, where soil with low stability will be more prone to erosion and washing away (J. Amsili, March 12, 2024).

Further Assessments

Finally, the utilization of resources such as the USDA's *Keys to Soil Taxonomy* and *Field Book for Describing and Sampling Soils* are worthwhile assets to consult in order to gain a better understanding of the soil composition and sampling needs of the UCLA campus (M. Fischella, April 24, 2024).

Soil Modifications

Soil is the "foundation" of an ecosystem, as it supports plants, animals, and microbes (Karlen et al., 1997; USDA, 2021; Nolan et al., 2021). Gattinger et al. (2008) and Sofo et al. (2014) highlight that healthy soils are populated with microbial communities that recycle nutrients, fix nitrogen, and decompose organic matter, which are crucial for ecosystem functioning and plant health. As such, the purpose of soil modification is to "improve and restore" the capacity of soils to provide these functional services to ecosystems and improve ecosystem health (Williams et al., 2020; Lal and Stewart, 1992). Consequently, several interviewees have recommended selecting soil modification methods that are best suited to support current and/or desired ecosystem conditions on campus (C. Bornstein, April 1, 2024; B. Faber, April 24, 2024; M. Fischella, April 24, 2024; D. Hermann, May 3, 2024). Moreover, individuals modifying soils should primarily consider the organic carbon input in soils and mineralization, or the "transformation of organic nutrients into mineral nutrients that are usable" for plants and microbes (J. Yanowitz, February 16, 2024). Soil organic carbon is critical for ecosystem functioning and aids the movement and availability of nutrients in soils (Gao et al., 2024), which is why it is a fundamental consideration for soil health. Given these considerations, the soil modification methods we have summarized below seek to improve soil and ecosystem health on campus, several of which aim to increase organic carbon input and mineralization in soils.

Compost

Compost is a nutrient-rich, organic material created through the decomposition of diverse organic matter such as food waste and plant trimmings (S. Wynbrandt, April 14, 2024). According to Fred Magdoff and Ray Weil (2004, p. 283), adding organic compost, derived from different carbon-rich materials, can effectively increase and retain the organic carbon in soils by binding soil particles together and reducing soil erosion and organic carbon loss at the soil surface. Past Sustainability Action Research (SAR) projects have focused specifically on the lack of compost usage on UCLA's lawns. The 2020 Sustainable Lawn Management Team ran an experiment to test the effectiveness of chemical fertilizers compared to compost. By monitoring nitrogen, phosphorus, potassium, and pH levels, students were able to conclude that applying compost is not only cheaper than current fertilizing methods used on campus, but it also produces more nutrient-rich soil and increases water retention (*Sustainable Lawn Management at UCLA, Final Report*, 2020). Similar to our team, these findings led the Sustainable Lawn Management team to recommend proper training and education for groundskeepers on the implementation of new soil modification techniques.

To further explore the benefits of compost on soil health, members of our team attended monthly volunteer events at the Kuruvungna Village Springs and Cultural Center, a facility of the Gabrielino-Tongva Springs Foundation. After years of restoration efforts, the Springs have now become a model for ecological preservation and soil remediation. A day before our second volunteer experience, workers had shoveled out part of the water pools and added the silt and nutrient-rich water to a compost pile. According to one of their workers, this compost consisted mostly of "brown material"—materials that are rich in carbon, providing structural support, absorbing excess moisture, and acting as an energy source for microorganisms. This is opposed to "green material" such as fresh plant trimmings and food scraps, which have high levels of nitrogen and aid in organic matter decomposition (Tongva Springs Visit, April 6, 2024). After hoeing an empty garden bed, we mixed this compost in with the pre-existing soil using a waterfall technique that breaks up the layers of topsoil to ensure complete integration with the compost. According to Assistant Director of the Mildred E. Mathias Botanic Garden Allison Keeney, the full benefits of compost—especially in clay soil common to Southern California—are best realized when it's mixed into the soil as opposed to layered on top (A. Keeney, March 11, 2024).

One of our primary points of contact surrounding the implementation of compost at UCLA has been Steven Wynbrandt, the founder of Wynbrandt Farms. He recommends food waste from campus dining facilities as a primary input for the composting process. Steven's approach also emphasizes that while compost quality can be measured through various indicators such as microorganisms, humus content, and nitrogen cycling, it is important to focus on creating and applying compost rather than exhaustive testing (S. Wyndbrandt, April 15, 2024). Past SAR projects have also considered partnering with other companies such as Athens Services to streamline an official composing program at UCLA, but substantial progress is yet to be made.

<u>Mulch</u>

In addition to compost, many interviewees have also suggested mulching as a method to improve overall soil health. Mulch serves as a protective layer between the soil's mineral layer and the atmosphere and can be used in tandem with the composting methods mentioned above (D. Hermann, May 3, 2024). While mulch can be any material used to cover and protect the soil surface, it is generally composed of decomposing organic materials like fallen leaves and wood chips that are carbon-rich ("Mulch & Protect & Grow," 2023). Mulch is primarily used to retain soil moisture, control weed growth, supply the soil with nutrients as it decomposes, reduce soil compaction and sealing from physical impacts, and insulate soils in hot and cold weather (C. Bornstein, April 1, 2024; B. Ramirez and D. Ramirez, April 23, 2024; “Mulch & Protect & Grow,” 2023). Ben Faber (April 24, 2024) highlights that aeration, organic matter, and water are driving forces of biodiversity in soil, and mulch, along with other methods in this section, provides this by reducing soil compaction, providing nutrients, and improving water permeability in soil. On campus, the Mildred E. Mathias Botanic Garden mulches their grounds with extra care in the winter to prevent weed growth in the spring and protect the roots from the cold and wind (A. Keeney, March 11, 2024). According to Allison Keeney (March 11, 2024), mulch not only improves soil health but also creates a habitat for beneficial insects to further break down organic matter.

Mulching should be used in combination with other soil modification methods in this report. For example, in areas that lack organic matter in soils, nutrient-rich compost and mulch can be used together to increase soil organic matter (“Mulch & Protect & Grow,” 2023). Since most soils on campus contain construction fill that lacks organic matter (*UCLA Landscape Plan*, 2022), a combination of mulching and composting should be employed in most regions on campus after conducting the appropriate soil tests (S. Crystal, March 8, 2023). Generally, to improve soil health, mulching should also be combined with other management practices to protect soil surfaces (“Mulch & Protect & Grow,” 2023). Along with mulching, “Mulch & Protect & Grow,” a 2023 TreePeople report, recommends using physical barriers to “prevent foot traffic, cars, or construction equipment,” encouraging individuals to walk on sidewalks instead of over soils, and growing plants in soils to reduce soil compaction and soil-profile disturbance, which are common in urban landscapes like UCLA (D. Hermann, May 3, 2024). These strategies would better support plants, ecosystems, and soils by improving root growth and water permeability (“Mulch & Protect & Grow,” 2023), and are expanded on in later subsections of this report.

However, it is important to address the caveats of mulching. Carol Bornstein (April 1, 2024) highlights that mulch should be used carefully, as some desert plants might not require mulch to help them grow. Furthermore, Jordan Yanowitz (February 16, 2024), Alison Lipman and Leryn Gorlitsky (February 29, 2024), and Joseph Amsili (March 12, 2024) stress that mulching is a short-term management practice that might not be sustainable in the long term. For future projects, Jordan Yanowitz (February 16, 2024) recommends investigating mulching, including researching what UCLA’s landscape will look like as mulch fades, its effects on the fungal community for native plants, and the long-term sustainability issues that it might pose.

Landscaping Strategies

Along with organic matter, soil aeration and water are fundamental drivers of soil biodiversity and development (B. Faber, April 24, 2024; “Mulch & Protect & Grow,” 2023). To ensure campus soils have a proper balance of aeration and water, several interviewees recommend landscape-design strategies to effectively provision water throughout the landscape and minimize soil compaction, an issue prevalent in UCLA's campus soils (*UCLA Landscape Plan*, 2022). To reduce soil compaction and improve soil resilience on campus, these design strategies can be combined with mulching and planting native plants. In addition, given that adequate amounts of water are crucial for healthy soil development, these design strategies focus on improving water provision and management to strengthen soil resilience and development, rather than merely reducing water use (B. Faber, April 24, 2024; D. Hermann, May 3, 2024).

To start, Pamela Berstler (April 15, 2024), Carol Bornstein (April 1, 2024), and Bob and Daniel Ramirez (April 23, 2024) recommend contouring regions of UCLA's landscape to capture rainfall and efficiently redistribute water to the landscape. One way this can be accomplished is by building bioswales, which are vegetated, permeable surfaces that channel rainwater runoff into soils (Brodsky et al., 2019). Daniel Ramirez (April 23, 2024) highlights that bioswales slow down rainwater runoff and house water in areas for plants, which would especially be beneficial for certain water-intensive, phytoremediation plants. Along with building bioswales, Carol Bornstein (April 1, 2024) also suggests using rain barrels to capture rainwater runoff and redistribute it to plants. Pamela Berstler (April 15, 2024) further echoes that a landscape should act as a watershed, with healthy, living soil that behaves as a sponge and contoured landscapes that capture rainwater and are populated with diverse, climate-appropriate, and preferably native plants.

Additionally, landscapes can be designed to protect soil surfaces and profiles from further compaction and erosion (B. Faber, April 24, 2024; "Mulch & Protect & Grow," 2023). This can be achieved by building dedicated walkways for students, constructing physical barriers to redirect pedestrians and heavy equipment and vehicles, and building a ground cover with native plants (B. Faber, April 24, 2024; M. Fischella, April 24, 2024; "Mulch & Protect & Grow," 2023).

<u>Other Considerations</u>

Finally, we have compiled more miscellaneous advice and strategies that several interviewees recommend below:

1. **Decompaction methods**: To promote water infiltration and make soils less compact, Allison Keeney (March 11, 2024) suggests turning over compact soil and adding nutrients back into the soil if the soil is heavily depleted. To achieve this, Joseph Amsili (March 12, 2024) recommends using an air spader tool to aerate soils and improve water infiltration.
2. **Mycorrhizal inoculation**: For soils that lack mycorrhizal and microbial activity, inoculating them with mycorrhizae may be beneficial, as mycorrhizae help plant roots pull nutrients from the soil (C. Bornstein, April 1, 2024).

3. **Soil imports**: Due to the high cost of soil imports, Bob and Daniel Ramirez (April 23, 2024) suggest not importing soils unless it is absolutely necessary (e.g., in regions that have extremely damaged soils).
4. **Limit synthetic fertilizers**: Sheina Crystal (March 8, 2024), Bob Ramirez (April 23, 2024), and Alison Lipman (February 29, 2024) emphasize the importance of not using synthetic fertilizers, as it can lead to nutrient imbalances and disrupt the soil microbiome. Mike Fischella (April 24, 2024) noted that by integrating more native plants into UCLA's landscaping, less fertilizer will be required to support soil health.

Native Plant Recommendations

<u>Importance of Proper Native Plants</u>

In addition to soil testing and soil modifications such as mulching and composting, our research demonstrated the value of planting and propagating native plants. For one, native plants can stimulate microbial activity and help produce a functionally biodiverse soil composition (Bagnato, April 18, 2024). As Yanowitz discussed in his interview, the microbial activity sparked by native plants can create a positive feedback loop that proliferates native biodiversity. Moreso, in the service of promoting native biodiversity, native plants can also promote faunal biodiversity, as they serve as habitat and fuel for local fauna (A. Klehennsseik, April 22, 2024). Additionally, as Mike Fischella, a graduate student under Professor Okin at UCLA researching soil sciences, explained in his interview, native ground cover is also integral to preventing soil erosion and degradation. This is very important to remember in the context of our project; many of our interviewees, from Andy Klehennsseik, Mike Fischella to Allison Keeney, emphasized the importance of clearing out invasive plants in preparation for soil restoration. In addition to not clearing out an area all at once, in order to prevent erosion and major soil degradation between weeding, it is imperative to establish a strong ground cover to prevent wind, rain, and human interaction from disrupting soils (A. Lipman, February 22, 2024). Lastly, native plants also serve as a reliable metric for determining if soil has been restored to a pre-disturbance state. Native plants have evolved to suit the original soil, and therefore they thrive once soil has been restored to a native state. Therefore, native plants can serve as not only a tool for soil restoration, but also as a barometer for the progress towards healthy, foundational soil.

With this knowledge, it is clear that native plants serve a multitude of benefits. In order to maximize their benefits, appropriate plants must be recommended. Proper plant recommendations are crucial for a variety of reasons. For one, non-native or misplaced plants can exhaust water use and require labor intensive high-labor maintenance, while native plants, plants that have developed over hundreds or thousands of years in a particular region or ecosystem, appropriately picked for a specific microregion can reduce long-term water use and maintenance costs (USDA, 2021). Native plants are well adapted to the region, meaning they do not require as intensive irrigation, and they also do not require fertilizer.

Native plants can be an ambiguous, difficult-to-define category; native can refer to native to a region as specific as the Santa Monica Mountains, or as broad as Southern California. To clarify what we mean when we say “native,” we will define different levels of specificity as we make our recommendations. Drawing from our interview findings from Kleinhesselink, it would be ideal to cultivate native plants present in the Santa Monica mountains, as they would proliferate more localized, endemic biodiversity to campus.

This, however, may be more appropriate for ecosystems that are closer to a desired state, such as Sage Hill or Stone Canyon Creek, sites that we have designated as "intact ecosystems." For other sites, however, it may be appropriate to use natives in a more broad context, such as Southern Californian or Californian natives.

Based on our findings, we have divided our recommendations based on two conditions of the targeted site at hand: the current vegetational/ecosystem health and the topographic state of the site. These recommendations should be applied in conjunction with each other.

Recommendations Based on Vegetational Conditions

As we learned from our facility tour of Sage Hill by Andy Kleinhesselink, to ensure the survival and longevity of planted natives, we must consider the current vegetational state of the site, and whether or not introduced natives could successfully outcompete current, dominant invasive species. Kleinhesselink strongly recommended examining the traits of non-native plants that are thriving in areas intending to be restored, and see what native plants can compete well with those non-native plants. For example, if most plant cover in a region is groundcover or otherwise short in height, it may be advantageous to plant natives that grow taller and thus push out non-native shorter plants while simultaneously growing natives in their place. Furthermore, as Kleinhesselink stated in his interview if a site is overrun with annual, generalist weeds that exhibit an intensive R-life strategy, native plants that are not equipped to proliferate at this rate will not be able to thrive well. With this in mind, we provide the following recommendations based on vegetational conditions.

Current State	Recommended Plants
Non-native/invasive landscaping	• Native annuals ○ Foothill needlegrass ○ Southern bush monkey flower • Fast growing shrubs
Intact ecosystems	• Sage Hill ○ White sage ○ Black sage • Stone Canyon Creek ○ California rose ○ Mugwort
Lots of tree cover	• California Bay, Hummingbird

	Sage, Catalina perfume
Little tree cover	• California Buckwheat, Toyon, Purple needle grass

Recommendations Based on Topographic Differences

Furthermore, different topographic conditions also render different plants more appropriate for certain placements. During our facility tour of Sage Hill, a relatively undisturbed native space located adjacent to on-campus housing, restoration director Andy Kleinhesselink offered insightful advice regarding considering the topographic placement of certain plants. For sloped sites, Kleinhesselink explained, the direction of the aspect—or the direction in which the slope faces— is extremely important to consider. South-facing slopes receive more direct solar radiation, leading to hotter, drier conditions and thinner soils with less organic matter, while north-facing slopes receive less direct solar radiation, leading to cooler, moister conditions and soils with more organic matter. Clearly, with such differing conditions, it is important that plants best adapted to each slope's conditions are chosen.

Topography	**Attributes**	**Planting recommendations**
North-facing	Cooler microclimates, more organic matter, more moisture	Ceanothus species Oak shrubs Woodlands
South-facing	Hotter microclimates, thin soils with less organic matter	Yucca Mrs.Bear creeping sage Arctostaphylos manzanita Southern bush monkey flower Native foothill needlegrass

Further Considerations

Beyond the categorized recommendations above, we also provide a few more recommendations for native planting.

First, we recommend considering function over aesthetics when choosing native plants, as we learned about during our visit to Kuruvungna Springs. While planting, especially on a college campus, requires consideration for aesthetics, we caution against picking plants solely based on visual value. It is important to balance choosing plants that are useful for local fauna species so that entire ecosystems can thrive and continue to nurture healthy soil. Examples of considerations of local fauna species are identifying which birds are in the area and recognizing which plants they utilize as well as how their migratory pathways affect their interaction with flora.

Additionally, we recommend identifying any endemic, species that are only found in one location on the planet, and endangered plant species to place special focus when choosing plants. Although these considerations have less to do with soil health directly, ultimately healthy soil is the goal to achieve healthy ecosystems and healthy ecosystems lead to healthy soils. This cycle of positive interference means ecosystem health and soil health are inextricably linked.

Next, as we learned from our interview with Andy Kleinhesselink, planting "corridors" of native plants to connect larger habitat areas could be utilized rather than the current method of individual pockets of native planting throughout campus. Additionally, it could be strategic to plant natives around the perimeter of campus, which requires less leaf blowing to maintain walkways.

Finally, it is important to consider the timeline of when to plant appropriate native plants when restoring an area's healthy soil. Kleinhesselink recommended following the natural succession of how plants colonize a site when trying to restore an area with native plants. This means first looking at sites to find native plants best suited for the current conditions, start planting with those natives, and then transitioning to natives best suited for the restored soil.

Education

Education of the campus community is essential if you wish to convert to a sustainable landscape. Multiple interviewees, such as Jordan Yanowitz and Lisa Novick, recommended higher visibility of sustainable landscaping projects to students, and 6 described education of Grounds and Facilities team members as essential. If workers are meant to perform sustainable landscaping they must be given the education to implement it and the context to know what a sustainable landscape looks like. Similarly, students and faculty should have the tools to understand and appreciate the beauty of the native landscape being reintroduced.

For convenience, these topics and program methods have been compiled into two tables in Appendix C. Specific recommended topics of education are listed in Appendix C, Table 1. Specific ways to implement education on these topics for staff are listed in Appendix C, Table 2.

Conclusion

Our project highlights several features of the field of sustainable landscaping. The pure breadth of opinions and backgrounds from our interviewees is staggering. Our recommendations come from multiple sources and backgrounds, focusing on how to obtain a high level of biodiversity across various metrics while still meeting the goals of a campus environment. We establish that common landscaping goals such as aesthetics can be achieved through native landscaping. With proper assessment, implementation, and education a sustainable, native landscape can meet and exceed the benefits of a traditional approach.

With soil as the foundation of any landscape, plant palette and maintenance needs are a direct result of how healthy, or unhealthy, the relevant soil is. We have heard from multiple experts that the soil across campus needs improvement. Much of our current soil is construction-fill or otherwise lacks vital nutrients and organic matter. Deciding the extent any patch of soil must be modified should follow an assessment. There will be no one-size-fits-all method available for UCLA campus if a diverse native ecosystem is the goal. The soil of different landscaping zones must be systematically assessed, modified as necessary, and then planted with an intentional native plant palette that can grow towards self-sustainment.

It is essential to facilitate cooperation across campus stakeholders to achieve these landscapes. From facilities to faculty, from students to the Sustainability Office, the community must be involved in sustainable landscaping. Implementing the 2022 UCLA Landscape Plan requires a critical shift in how maintenance is done on our landscapes. Cultivating a native plant palette until it is self-sustaining requires several years of invested time and resources. The payoff is there, but only if we have the foresight of proper planning when implementation begins.

We were limited by a few key factors, from narrowing our scope to limited time. While we managed to interview many key experts we could only do so many rounds of interviews and could have further honed our recommendations with a few more rounds of interviews. Time was the key constraint affecting these factors and if we had more time, we would specifically target more discussions with Facilities Management and the Sustainability Office about current practices.

We recommend a few topics for future SAR projects: First, a project on how to increase the cooperation between our landscaping team and the Sustainability Office, to strengthen that connection and unite them in planning our sustainable landscapes. Second, we recommend a team research how to integrate student groups and funding sources available to students into the existing landscaping framework. This project can primarily address how student voices can be amplified in upcoming projects.

A sustainable landscape with high biodiversity is built from the ground up, with soil tailored to the needs of plants that grow on it, plants tailored to the microclimate present in that section of campus, and modifications built around the history of the site as seen through assessments. When these practices come together, the benefits can transform our community, making it more climate resilient and supportive for our ecosystem.

Appendix A

Table of Interviewees and Date Interviewed

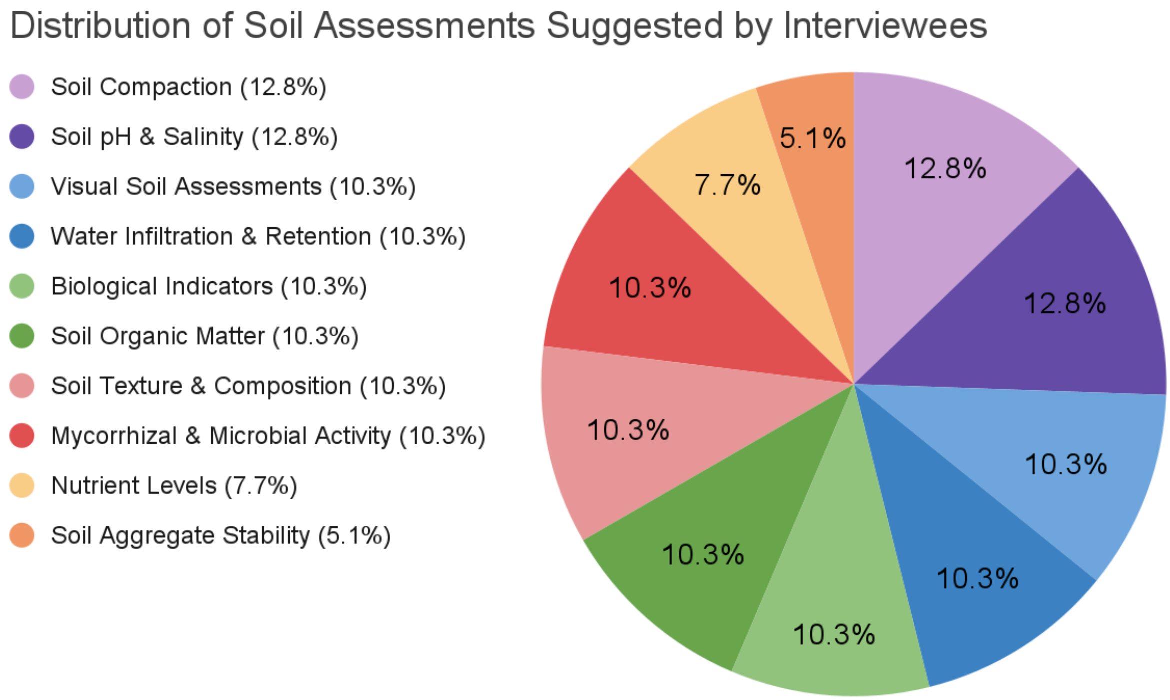
Name	Expertise/Position	Interview Status	Interview Date/Time	Interviewers
Jordan Yanowitz	Ecologist, botanist, writer, and educator	Completed	2/16/2024 9:00 AM	Joy, Kyla
Alison Lipman	UCLA Ecology and Evolutionary Biology (EEB) Professor	Completed	2/29/2024 12:00 PM	Mercy, Sofia
Leryn Gorlitsky	UCLA Ecology and Evolutionary Biology (EEB) Professor	Completed	2/29/2024 12:00 PM	Mercy, Sofia
Sheina Crystal	Director of Communications and Campaigns of Re:wild Your Campus	Completed	3/8/2024 12:00 PM	Jamie, Kyla
Allison Keeney	Assistant Director Mildred E Mathias Botanical Garden UCLA	Completed	3/11/2024 9:00 AM	Sofia, Soleil
Joseph Amsili	Cornell Soil Health Program Associate	Completed	3/12/2024 1:30 PM	Selena, Mercy
Carol Bornstein	Native Plant Specialist, Horticultural Consultant	Completed	4/1/2024 1:00 PM	Kyla, Joy
Pamela Berstler	Green Gardens Group, CEO	Completed	4/15/2024 1:00 PM	Kyla, Selena
Steven Wynbrandt	Wynbrandt Farms, Founder	Completed	4/15/2024 4:00 PM	Sofia, Jamie
Michelle Bagnato	TreePeople School Greening Senior Project Manager	Completed	4/18/2024 11:00 AM	Mercy, Selena
Andy Kleinhesselink	Managing Director of Sage Hill	Completed	4/22/2024 3:30 PM	Joy, Mercy
Bob and Daniel Ramirez	Gabrielino-Tongva Springs Foundation	Completed	4/23/2024, 4:00 PM	Joy, Kyla
Ben Faber	UC Cooperative Extension Farm Advisor, Ventura County	Completed	4/24/2024 1:00 PM	Kyla, Joy
Mike Fischella	Graduate student working with UCLA Professor of Geography Gregory Okin	Completed	4/24/2024 2:00 PM	Soleil
Lisa Novick	Theodore Payne Foundation, Outreach and Volunteer Coordinator	Completed	4/30/2024 11:00 AM	Jamie
Dustin Hermann	TreePeople Principal Scientist	Completed	5/2/2024 2:00 PM	Joy
Alex Gomez	UCLA Facilities Management	Completed	5/13/2024 11:30 AM	Sofia, Mercy

Appendix B

Table 1: Soil Assessment Methods with Description and Recommenders

Assessment Method	**Description**	**Interviewees**
Soil Compaction	Measuring soil compaction using devices like penetrometers.	*Ben Faber; Alison Lipman and Leryn Gorlitsky; Joseph Amsili; Sheina Crystal; Dustin Hermann*
Soil pH and Salinity	Testing soil pH to understand nutrient availability and microbial activity; Salinity reflects water management.	*Sheina Crystal; Ben Faber; Joseph Amsili; Carol Bornstein; Bob and Daniel Ramirez*
Soil Organic Matter	Measuring the amount of organic matter present in the soil.	*Bob and Daniel Ramirez; Sheina Crystal; Dustin Hermann; Carol Bornstein*
Soil Texture and Composition	Soil layer tests and soil charts or pyramids to determine the composition of sand, silt, and clay, and the loaminess	*Bob and Daniel Ramirez; Carol Bornstein; Sheina Crystal; Alison Lipman and Leryn Gorlitsky*
Mycorrhizal and Microbial Activity	Evaluating the composition and activity of mycorrhizae and other microbes.	*Bob and Daniel Ramirez; Sheina Crystal; Carol Bornstein; Dustin Hermann*
Biological Indicators	Assessing the presence of biological indicators like fungi, bacteria, and nematodes.	*Jordan Yanowitz; Pamela Berstler; Sheina Crystal; Steven Wynbrandt*
Water Infiltration and Retention	Analyzing soil water dynamics to assess water holding capacity and drainage capabilities.	*Bob and Daniel Ramirez; Steven Wynbrandt; Ben Faber; Dustin Hermann*
Visual Soil Assessments	Using color indicators like the Munsell soil color chart and photographic comparisons; Plants and weeds as visual indicators	*Dustin Hermann; Bob and Daniel Ramirez; Jordan Yanowitz; Ben Faber*
Nutrient Levels	Testing for key nutrients like nitrogen, phosphorus, and oxygen.	*Sheina Crystal; Alison Lipman and Leryn Gorlitsky; Carol Bornstein*
Soil Aggregate Stability	Evaluating aggregate stability through tests like the slate test and infiltration test.	*Joseph Amsili; Pamela Berstler*

Chart 1: Distribution of Soil Assessments Suggested by Interviewees



Appendix C

Table 1: Recommended Topics of Education

Topic	Description
Knowledge of Native Plants *Sheina Crystal*	Building an understanding of what native plants are, what local native plants look like, and how to care for them, especially during initial years.
Differences between Native and Traditional Landscaping Practices *Lisa Novick, Sheina Crystal*	Native Landscapes have drastically different needs compared with a traditional landscape at UCLA. Both during and after the transition to a native landscape.
Meeting Aesthetic Needs in a Native Landscape *Carol Bronstein, Lisa Novick*	A traditional landscape at UCLA often has a large aesthetic component. It is necessary when designing for these spaces to take into account that aesthetic need. Native plants have been proven to create beautiful and unique aesthetics, but only when there is an understanding of the balance between seasonal variance and shifting aesthetics across those seasons.
The Relationship between Soil and Plants *Pamela Berstler*	Understanding how soil supports different plants is necessary for building a landscape. For example, if soil is heavily compacted many native plants may suffer without appropriate support. Knowledge of the soil beneath a plant makes it far easier to support that plant.
Water Conservation vs. Efficient Water Utilization *Dustin Hermann*	There is a huge difference between using the minimum amount of water period and using all the water we get access to. As part of the Californian coast, UCLA is subject to strong variance in rainfall across years. That means that the creation of high capacity soil will allow retention and self-support for the native landscape. A robust and more natural water system will increase the capacity of our landscape.

Table 2: Recommended Educational Program Formats

Type of Program	Location	Pros/Cons
Certification Program	Example: Theodore Payne Canyon Site (likely offsite)	+ Build skills for our landscaping team + Can outsource education on sustainable landscaping. - Less tailored to Westwood Area, likely expensive.
Tour of Facilities - On campus	Stone Canyon or Sage Hill	+ Shows environments local to campus. + Will look different than landscape in need of more restoration.
Tour of Facilities - Off campus	Previously restored facilities for example the California Botanical Garden	+ Helps visualize what a larger restored environment looks like. - Off-site, likely further away. - Example of the Socal area, less tailored to Westwood area.
In house education through presentations	On campus.	+ Most flexible - Requires collections and presentation of materials by someone in the Sustainability Office.

Works Cited

1. Brodsky, O. L., Shek, K. L., Dinwiddie, D., Bruner, S. G., Gill, A. S., Hoch, J. M., Palmer, M. I., & McGuire, K. L. (2019). Microbial communities in bioswale soils and their relationships to soil properties, plant species, and Plant Physiology. Frontiers in Microbiology, 10. https://doi.org/10.3389/fmicb.2019.02368
2. Desai, D. (2021). The Healthy Soil Program. In: Ginzky, H., et al. International Yearbook of Soil Law and Policy 2019. International Yearbook of Soil Law and Policy, vol 2019. Springer, Cham. https://doi.org/10.1007/978-3-030-52317-6_14
3. Dighton, J. (2009). Mycorrhizae. *ScienceDirect*. https://www.sciencedirect.com/science/article/abs/pii/B9780123739445003278
4. Fenton, M., Albers, C., & Ketterings, Q. (2008). Soil Organic Matter. *Cornell University Cooperative Extension*. https://franklin.cce.cornell.edu/resources/soil-organic-matter-fact-sheet
5. Gattinger A, Palojärvi A, Schloter M (2008) Soil microbial communities and related functions. Perspectives for agroecosystem management, 279-292
6. Gao, G. et al. (2024), Microbial carbon metabolic activity and bacterial cross-profile network in paddy soils of different fertility, Applied Soil Ecology, Volume 195, 2024, 105233, ISSN 0929-1393, https://doi.org/10.1016/j.apsoil.2023.105233
7. Idowu, O. & Ghimire, Rajan & Flynn, R.P. & Ganguli, Amy. (2020). SOIL HEALTH-Importance, Assessment, and Management.
8. Jeffers, A. (2023, December 1). Soil Texture Analysis "The Jar Test". *Home & Garden Information Center: Clemson Cooperative Extension*. https://hgic.clemson.edu/factsheet/soil-texture-analysis-the-jar-test/
9. Karlen D, Mausbach M, Doran J, Cline R, Harris R, Schuman G (1997) Soil quality: a concept, definition, and framework for evaluation (a guest editorial). *Soil Science Society of America Journal* 61: 4–10
10. Lal R, Stewart BA (1992) Need for land restoration. In: Soil restoration. Springer, New York, pp 1–11
11. Magdoff, F., & Weil, R. R. (2004). Soil Organic Matter in Sustainable Agriculture. CRC Press.
12. Nawaz, M.F., Bourrié, G. & Trolard, F. (2013). Soil compaction impact and modelling. A review. *Agron. Sustain. Dev.* 33, 291–309 https://doi.org/10.1007/s13593-011-0071-8
13. Nolan, M., Stanton, K.J., Evans, K., Pym, L., Kaufman, B. and Duley, E. (2021), From the ground up: prioritizing soil at the forefront of ecological restoration. Restor Ecol, 29: e13453.

14. Rodbarry, Lea. (2023). How Healthy Soil Makes Healthy Plants and Ecosystems. *The Conservation Foundation.* https://theconservationfoundation.org/how-healthy-soil-makes-healthy-plants-and-ecosystems/
15. Sofo A, Palese A, Casacchia T, Xiloyannis C (2014) Sustainable soil management in olive orchards. *Emerging Technologies and Management of Crop Stress Tolerance* 2: 471–483
16. TreePeople. (2023, April 14). Mulch & protect & grow. Report. TreePeople. https://www.treepeople.org/resource/mulch-protect-grow-report/
17. UCLA (2022). *UCLA Landscape Plan.* https://www.capitalprograms.ucla.edu/content/PDF/UCLA_Landscape_Plan_220902.pdf
18. United States Department of Agriculture (2021) Soil health. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/ (accessed 31 May 2024)
19. Williams, M.I., Farr, C.L., Page-Dumroese, D.S., Connolly, S.J., Padley, E. (2020). Soil Management and Restoration. In: Pouyat, R., Page-Dumroese, D., Patel-Weynand, T., Geiser, L. (eds) Forest and Rangeland Soils of the United States Under Changing Conditions. Springer, Cham.