Exploring the State of U.S. Soil Health Legislation: A Qualitative Policy Analysis

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Abstract

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Proposal of soil health bills in U.S. state legislation has increased over the last few years. While some links between soil health and public health are well established, the extent to which current soil health legislation addresses public health implications is unknown. In particular, little is known about the scope of current legislation, including whether legislation references known links between soil health and public health. This represents a potential gap in existing legislation which will only grow more pressing as population growth is expected to place a higher yield demand on soils in the future. This project utilized a two-phase qualitative policy analysis to address this gap. During phase one current proposed and passed legislation was identified and coded for themes. Subsequently, soil health professionals involved with identified bills were recruited for semi-structured interviews. Interviews were coded and compared for themes. In total, 12 bills from 11 separate states were analyzed. Legislation focused primarily on soil's capacity to sequester carbon and improve water quality, while public health accounted for a minimal proportion of total codes. Interviews illuminated contextual themes such as climate change motivating bill proposal, understanding of soil as a living ecosystem, and soil nutrient level as a link between soil and public health. Including a reference to climate change was

reported as a barrier to bill passage in certain states, while a focus on improving farmers' profit margins reportedly facilitated bill support. Interviewees commonly cited state soil and water conservation districts and the National Resources Conservation Service as key partners but did not report collaboration with public health entities. While these findings provide perspective into the scope soil health legislation, more research will be needed to evaluate legislative programs as more bills are enacted as well as to determine future opportunities for interdisciplinary collaboration from a public health perspective.

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Background

Since 2016, there has been a rise in the introduction of agricultural policies targeting soil health in U.S. state legislature. The escalation in state soil health legislation as well as the addition of soil health language to the 2018 federal farm bill may suggest a turning point in current soil conservation efforts. Usage of the term "soil health" is also a relatively new phenomenon in the scientific community. In 1996 soil researchers Doran, Sarrantonio, and Liebig defined soil health as the "continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, maintain the quality of air and water environments, and promote plant, animal, and human health"[1]. This definition has since become standard language among researchers[2–4] and was adopted by the U.S. National Resource Conservation Service (NRCS) in 2012[5].

Translating the definition of soil health into metrics for quantitative evaluation has been greatly debated, leading to heterogeneity in assessment tools[6]. While indicators used across assessment tools vary, generally a combination of three categories are used: physical, chemical, and biological indicators. Commonly used indicators of physical soil health include soil aggregates and bulk density. Soil organic matter, particularly soil organic carbon (SOC), is the most widely used indicator of chemical soil health[7]. Biological soil health can be measured by indicators such as microbial biomass, diversity, and community stability[7,8].

While the language of "soil health" is relatively new in conservation policy, U.S. soil policies date back to the 1930's dust bowl[9]. During this time conservation policies focused mainly on mitigating the erosion of topsoil and preserving agricultural viability [9,10]. Since the early 20th century the scientific understanding of soil properties has greatly advanced to consider soil as a complex system, capable of supporting diverse microorganisms and cycling of SOC[11]. Intensive

practices common to the U.S. industrial agricultural system – such as frequent tillage, synthetic pesticide and fertilizer application, and large-scale monoculture – threaten the health and viability of this underground ecosystem[12]. Well-established evidence demonstrates these practices degrade soil by influencing increased erosion and a loss of soil biodiversity, organic matter, and structural complexity[13,14]. The industrial agricultural system also poses negative climate impacts as the 5th largest contributor of greenhouse gas emissions (GHG) in the U.S., accounting for 9.3% of total U.S. GHG emissions in 2016, according to the EPA[15].

Soils can act as either sources or sinks of atmospheric carbon through participation in the carbon cycle wherein plants pull CO_2 from the atmosphere through photosynthesis and carbon is deposited in soil when plants decompose[16]. Articulation of soil's capacity to sequester atmospheric carbon led to the promotion of new soil management practices as a way to mitigate climate change[17]. Soil management practices, including no or low-tillage, cover cropping, and crop rotations, have been found to increase SOC concentration and storage time[4]. Generous estimates suggest soils, globally, have the potential to sequester 5-15% of greenhouse gas emissions[17]. A more conservative 2015 meta-analysis estimates carbon sequestration has the global potential to compensate for 8% of CO_2 emissions from the agricultural sector[18].

These agricultural practices pose additional benefits outside of SOC. No-till and low till systems have also been linked to improved physical soil health such as aggregate and structural stability, improved water holding capacity, and decreased erosion[19]. Research demonstrates rates of soil erosion under no-till systems are nearly approximate rates of soil production. Therefore, no-till systems could mitigate the high topsoil loss associated with conventional tillage[20]. No-till systems and cover cropping can also improve biologic soil health by increasing microbial abundance, diversity, and community stability in comparison to conventional farming[21]. Crop

rotation improves soil microbiomes with research demonstrating that the number of different crops in a rotation is linearly correlated to number of different soil microbes and total population of soil microbes[22]. In addition to the myriad of benefits sustainable land management practices have on soil health, improving soil health itself may benefit human communities.

At the most basic level, soil is the foundation for almost all agriculture and food production necessary in sustaining human populations, yet the breadth of ecosystem services soil provides reaches far beyond agriculture itself. Soil serves as a biofilter protecting drinking water supplies from contaminants such as pesticides, heavy metals, pathogens, and nitrates[23]. Airborne dust from agricultural soils can carry pathogens, organic chemicals, heavy metals, and animal waste particulates which can cause respiratory irritation and lung tissue damage[24,25]. Healthy soils are less erodible by wind and therefore create less particulate matter detrimental to air quality[25]. By limiting the spread of pathogens through air and water, soil also plays a role in human disease control[25,26]. Healthy soils can also help protect communities from the hazardous effects of floods and droughts, while depleted soils are known to worsen the effects of such natural events[27]. Soil nutrient-depletion due to high production loads have reduced yields, necessitating higher application of chemical fertilizers, of which exposure to has been linked to increase risk of certain cancers, birth defects, and thyroid conditions[28,29]. In terms of crop nutrients, the research linking soil health to nutrient quality of fruits and vegetables is limited[30]. However, evidence suggests healthy soil root microbes may increase food crops ability to uptake soil nutrients, therefore increasing the nutrient content of food for human consumption[30]. Humans rely on soils to provide many ecosystem services, demonstrating a paradox wherein anthropogenic activities are the cause of much soil degradation, yet soils are also necessary for preserving public health.

While some links between soil health and public health are well established, the extent to which current soil health legislation addresses public health implications is unknown. This represents a potential gap in existing legislation which will only grow more pressing as population growth is expected to place a higher yield demand on soils in the future[31,32]. Simultaneously, the pressures of climate change will continue to contribute to degradation and loss of soil, lessening agricultural capacity to meet growing needs[31,33]. The inclusion of public health in soil health legislation could be a means of addressing and mitigating future threats to soil ecosystem services. The aims of this project are two-fold, to assess the scope of recently introduced U.S. soil health legislation and to identify opportunities to better connect soil health and public health in state-level soil health legislative policies.

Methodology

Policy Framework

This project utilized qualitative policy analysis research methodologies to assess the current state of U.S. soil health legislation through document review and open-ended interviews. Walt and Gilson's *Health Policy Triangle* (HPT) was chosen as a theoretical framework to inform and structure two study phases. The HPT consists of four policy components which must all be working synergistically for policies to be effective: content, context, process, and actors[34]. For this project, content refers to the text of legislation documents. Context is the environmental or situational context in which policy processes occur, including

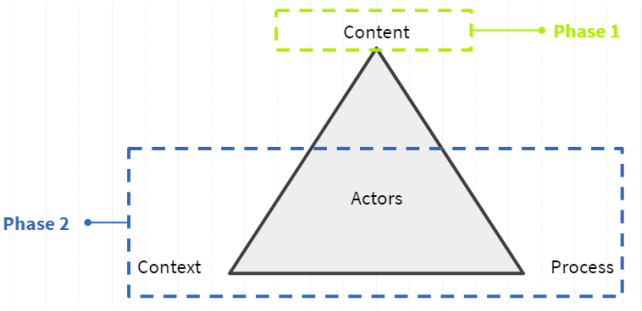

Figure 1: Walt and Gilson's Health Policy Triangle

but not limited to agency structures, resources, and values. The third arm of the HPT is process, or how the policy works (such as style of decision-making, interventions, and evaluation). Sitting within the HPT are the actors, the stakeholders who identify problems and shape decisions[34].

To address all aspects of the HPT, this project was divided into two phases. Phase one examined content via an analysis of current legislation. Phase two assessed context, process, and actors through semi-structured interviews with individuals involved with soil health legislation.

Legislation Collection

State legislation databases were used to identify current state soil health legislation. Databases were searched for key words (soil health, healthy soil, regenerative agriculture, and carbon farming) from the years 2000-2019. Text copies were subsequently procured from legislative libraries. The search identified 24 bills, and included both introduced and enacted, from 15 separate states. Any bills from the 2019-2020 legislative session that were proposed before February 2019 were included in analysis. Bills were excluded if soil health was merely mentioned but was not an aspect of legislation interventions. Amendments and concurrent resolutions without related soil health interventions were also excluded from analysis. Of the original 24 bills, 12 bills from 11 states were analyzed.

Table 1: Summary of Phase 1 Codebook Categories and Codes

Category	Code
Terms	Soil Health Definition
Determinants	Biodiversity Bioproductivity Air quality Water quality Animal health Carbon sequestration Public health
Influencers	Land management Climate Change
Interventions	Policy actions or interventions Evaluation Finances

Legislation Analysis

A codebook (Appendix A) was developed to ensure consistent bill content analysis. Codebook categories were chosen based on the determinants of soil health commonly recognized in scientific

literature: biodiversity, bioproductivity, air quality, water quality, animal health, soil organic carbon (SOC), and public health[2–4]. Soil health definitions as characterized in the legislation were also coded. Two codes for influencers of the soil health determinants were included: land management practices and climate change. Lastly, bills were coded for proposed interventions, outcome evaluation methods, and financing. Each bill was color coded and subsequently, codes from each bill were recorded in Microsoft Excel.

Determinant codes (Table 1) from all bills were compiled and the number of total determinant codes counted. Codes from each determinant were divided by the number of total codes to find the proportion of codes for each determinant. Additionally, determinant codes were analyzed bill-by-bill to compare the diversity of codes utilized within each bill. Number of codes per determinant were compiled for each bill. These totals were subsequently divided by the total number of determinant codes per bill to normalize the data for comparison.

Interview Recruitment, Collection, and Analysis

An interview script (Appendix B) was created to address the remaining three aspects of the HPT: context, process, and actors. All questions were submitted to and approved by the University of Washington Institutional Review Board (IRB). Potential interview participants were identified through a state soil health legislation Google group and the Soil Health Institute's policy resources webpage and subsequently sent a recruitment email. Interested participants were scheduled for a one-hour phone interview. A consent script was read prior to each interview and interviews were audio recorded with participant's permission. Recordings were then transcribed for coding in Phase 2.

An additional codebook was created for Phase 2 based on the interview guide. Codes were organized by the remaining HPT concepts (context, process, and actors). Validity of the

Table 2: Summary of Phase 2 Codebook Categories and Codes

Category	Code
Context	Motivations Vision/goals Target audience Self-reported soil health definition Perspective on increased proposal of legislation Factors linking soil health and public health Gaps or barriers to linking soil health and public health
Process	Evaluation Challenges and barriers to bill adoption Challenges and barriers to law implementation Rationale Facilitators/enablers
Actors	Key partners in creation Intervention stakeholders Connected programs

codebook was confirmed through double-coding 10% of interviews and updating the codebook until an 80% match rate was achieved. The final codebook (Appendix C) includes seven context codes, five process codes, and three actor codes (Table 2). Interviews were then color coded, recorded in Microsoft excel, and compared for reoccurring themes. Participant's names have been changed to Interviewee 1-9 to maintain confidentiality.

Results

Legislation Status

Three states – California, Hawaii, and Maryland – had passed soil health legislation prior to the 2019 legislative session. California was the first to enact soil health legislation with the passage of the Healthy Soils Initiative in 2016. Maryland and Hawaii followed shortly after with the passage of the Healthy Soils Program in Maryland and the Carbon Farming Task

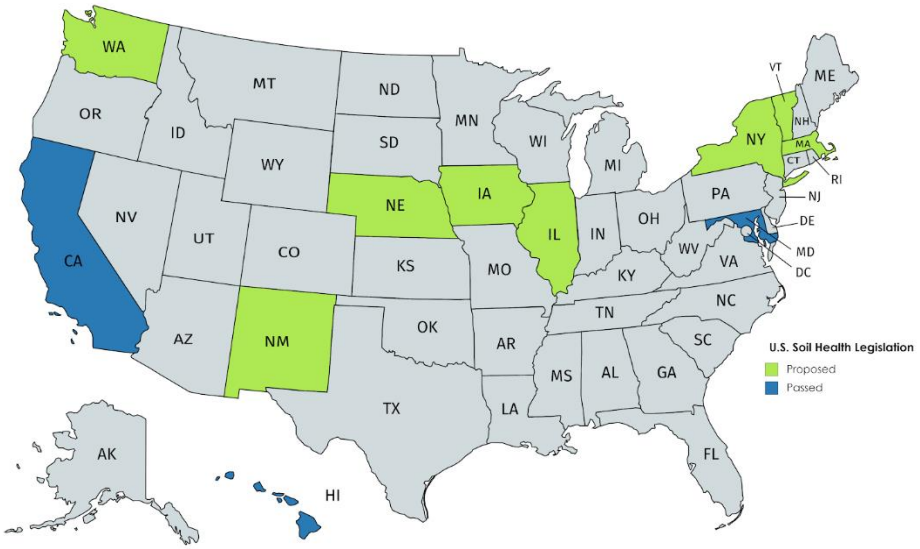

Figure 2: Map of states with proposed or passed soil health legislation as of February 2019

Force in Hawaii in 2017. In 2018, Hawaii replaced the Carbon Farming Task Force with new legislation enacting the Greenhouse Gas Sequestration Task Force.

Nine soil health bills were proposed during the 2019 legislative session including bills from Washington, New Mexico, Iowa, Illinois, New York, Vermont, Massachusetts, and two from Nebraska. A spreadsheet of included bills with bill number and current status as of July 10, 2019 can be found in Appendix D.

Legislation Content

Defining Soil Health

While all included bills mention soil health, only legislation from California, Massachusetts, Maryland, New Mexico, and Illinois define the term. Of those 5 states, little diversity in definition exists with most bills using a variation of the definition outlined in California's law:

"Healthy soils mean the continuing capacity of soil to function as a biological system, improve soil organic matter, improve soil structure and water and nutrient holding capacity, and to sequester carbon to reduce greenhouse gas emissions" ~ California Healthy Soils Program Law (SB 1350).

The one exception is Illinois, whose bill adds a reference to soil's capacity to "sustain plant, animals, and humans" as a characteristic of soil health.

Some states chose to use or define a different overarching term in place of soil health. For instance, the definition of regenerative agriculture in Vermont's bill closely resembles soil health definitions found in other state legislation:

"Regenerative agriculture describes farming and grazing practices that, among other benefits, reverse climate change by rebuilding organic matter in soil and restoring degraded soil biodiversity, resulting in carbon drawdown, improved retention of water in soil, and improved water quality" ~ Vermont Regenerative Agriculture Program (H 903).

New York and Washington used the term carbon farming, which represents a more targeted approach focusing primarily on carbon sequestration. New York defines carbon farming as the "implementation of a land management strategy for the purposes of reducing, sequestering, and mitigating greenhouse gas emissions …" (NY Carbon Farming Tax A02781). Although all bills discuss soil health, the difference in terms used demonstrates variation in the broader legislative vision and goals.

Legislation Coding Results

Determinants

Overall, 142 determinant codes were identified among the 12 bills. Carbon sequestration was cited the most often, accounting for 45 of the 142 codes (31%). Water quality followed with 36 mentions (25%) but was mentioned more widely (11/12 bills) than carbon sequestration (10/12 bills). Biodiversity and bioproductivity represented a similar proportion of determinant codes (12% and 13% respectively) and were also mentioned in a similar number of bills (9/12 and 8/12). More than half of the bills referenced public health (7/12), but public health was mentioned only 11 times total, contributing to 8% of determinant codes. Animal health appeared slightly less than public health, accounting for 10 of the 142 determinant codes (7%) and mentioned in 5/12 bills. Air quality accounted for both the lowest proportion of total determinant codes with only 5/142 codes (4%) and the least common determinant with mention in only 2 bills (See Figure 3).

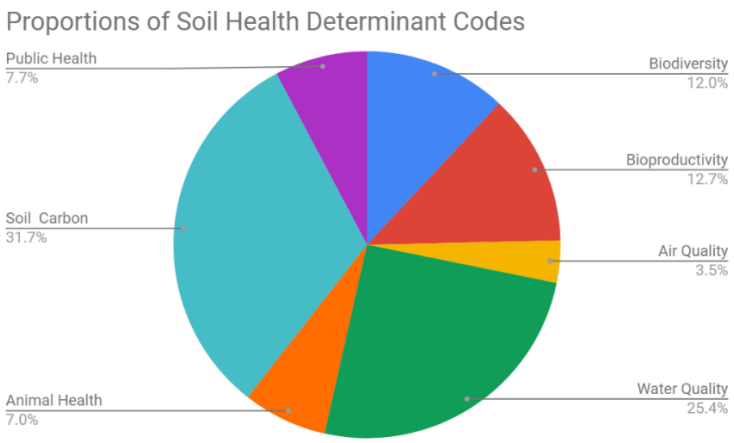

Figure 3: This pie chart shows which soil health determinants were mentioned the most often in soil health legislation by illustrating the proportion of each soil determinant over total codes from all bills.

Figure 4 illustrates the relative composition of each bill by determinant code. No bill addressed all 7 soil health determinants as outlined in the legislation analysis methods. The average diversity in determinants mentioned was 4.3 determinants. California, Illinois, and Nebraska's Bill 243 included the highest diversity of soil health determinants with 6 of the 7 determinants cited, followed by New Mexico (5/7). Washington's bill included the least variety of soil health determinants, citing only carbon sequestration (1/7).

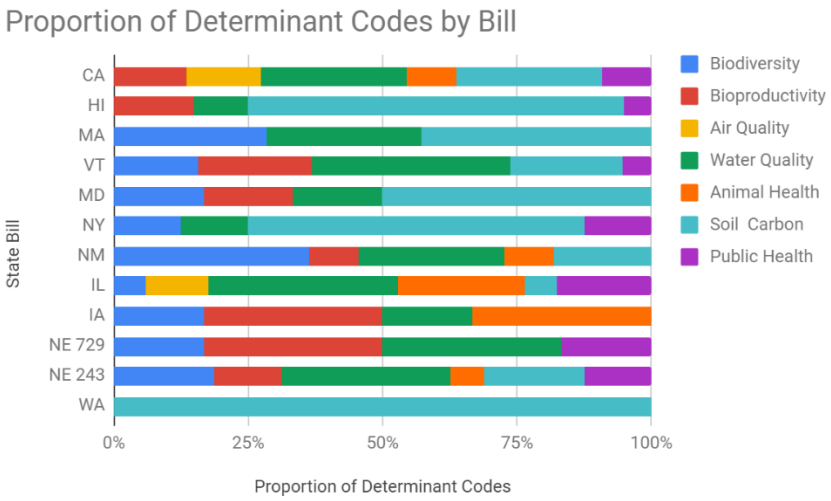

Figure 4: This stacked bar chart shows the proportion of soil health determinant codes mentioned by state. Each color represents a different soil health determinant. The more colors per bar demonstrates a higher diversity of determinants in a bill.

Influencers and Interventions

Land management practices were the primary influencer and focus of legislative interventions, with mention in 11 of 12 bills. Only 7 of those 11 bills cited specific land management practices, cataloged in Table 3. The most commonly cited land management practices included no-till or conservation tillage and cover cropping. Main legislative interventions (Table 4) include financial and technical assistance programs offering incentive-based grants, equipment loans, and education. Five of the 12 bills included methods of intervention evaluation. Only four bills (Hawaii, New Mexico, Massachusetts, and Vermont) discuss funding sources, and of those four bills only Hawaii and New Mexico list numerical financial commitments with general funds from Hawaii providing $25,000 during year one and general funds from New Mexico providing $5,150,000 a year.

Table 3: Land management practices cited within bills, by number of bills that refer to practice

Land Management Practice	Number of Bills that refer to practice
Cover cropping	7
No-till/low-till	4
Rotational/planned grazing	4
Agroforestry	2
Compost/Manure application	2
Integrated crop-livestock systems	2
Planting perennials	2
Reduce chemical application (fertilizers, insecticides, and herbicides)	2
Biochar application	1
Planting hedgerows	1
Planting native vegetation	1
Mulching	1
Multi-cropping	1
Soil microbial inoculation	1

Table 4. Distribution of legislative interventions by state

Legislative Intervention	States
Task force creation	NE 243, HI
Technical and financial assistance program	CA, MD, NM, WA, VT, MA
Financial assistance only	NE 729
Tax credit	NY
Expanding scope of Soil and Water Conservation Districts	IL

Interviews with Soil Health Professionals

Soil health professional interviews were conducted with interviewees in 9 of the 11 states with soil health legislation. Interviewees from Iowa and New York were unable to be interviewed within this thesis timeframe. Professional affiliations of interviewees varied (Table 5) and included government agency program coordinators, policy directors at environmentally focused non-profit organizations, volunteer citizens, a farmer, and an organic business consultant. Interviewees were involved with soil health legislation in different manners. Four interviewees helped draft soil health legislation through researching soil health practices, writing the bill, and gaining support from influential groups and legislators. Three interviewees helped manage soil health programs that passed prior to the start of this project. One interviewee testified for soil health legislation before congress. Several themes emerged from these interviews and are organized below within the overarching Health Policy Triangle framework categories of context, process, and actors.

Table 5: Distribution of SHP affiliations

SHP Affiliation	Number of Interviewees
Volunteer citizens	3
Environmental non-profit policy director	2
Government agency employee	2
Farmer	1
Organic business consultant	1

Legislative Context

Context, as described by Walt and Gilson, is the background information on the environment and situational factors influencing policy development[34]. Many context themes emerged during interviews, including 1) the desire to normalize and mainstream soil health, 2) climate change motivating bill proposal, 3) extreme weather events and improved research increasing bill support, 4) understanding of soil as a living ecosystem, and 5) connections

between soil health and public health. Each of these themes is further discussed below with illustrative quotes from interviewees.

Normalize and Mainstream Soil Health

An overarching mission amongst bills, as described by interviewees, was to increase the visibility of soil health to make soil health practices more normalized and mainstreamed. Interviewees noted that while many of these land management practices have been around for hundreds of years, they have yet to be thoroughly articulated in policy. While gathering research for writing legislation, Interviewee 4 noticed very little adoption of soil health practices by farm and land managers, such as no-till or cover cropping. Many different entities were promoting soil health as a concept, but the efforts had yet to be translated into increased action.

"We needed to figure out a way to promote wider use of these practices among farmers and land managers. We thought we needed to put a big spotlight on these practices through the creation of a healthy soils initiative and the formation of a task force." – Interviewee 4

Related, one interviewee underscored the need for more focus on the history of soil degradation in the U.S. and believed that creating legislation was one way to increase an issue's visibility.

"We aren't working in a vacuum; we are working with other very forward moving leaders who are already doing a lot around the country. What we want to achieve is to spread this good work and make it mainstream. So, it becomes the norm and not the exception." – Interviewee 3

Another interviewee noted many soil health efforts focused solely on preserving topsoil and saw a need for broadening perception to include preserving an environment that is sustainable for crops and animal production over time. This interviewee also noted that accomplishing this goal means educating not just farmers, but lawmakers as well.

"We want to get some of these practices to be more commonplace and not make it something wacky that one of your neighbors is doing that you don't understand." – Interviewee 7

Two other interviewees echoed these sentiments, adding that normalizing ideas with legislators is the first step to change-making. According to them, lawmakers often are unaware of healthy soils concepts prior to bill proposal and a large portion of the energy in promoting a bill is spent educating legislators.

"When you take just 15 minutes to explain how soils can store carbon from the atmosphere and how that helps with life within the soil, therefore plants and animals people get it. People understand. It's just trying to make people see how wide the reach of soil health is. That it's not just one metric like soil carbon but also biodiversity, water, animal and human health. It's a very large system to explain." – Interviewee 2

Climate Change Mitigation

The capacity for soils to sequester atmospheric carbon as a potential mitigator to climate change was cited as a motivating factor for many interviewees. According to interviewees, climate change policy has historically focused on transportation and energy systems, but only recently have people considered agriculture as a player in the climate change solution. An interviewee noted, "there is this upward trend in recognizing how soils are an untapped climate change mitigator. I think as climate change has become more dire, people are looking for any and all options."

In some states, like California and Washington, the passage of climate action plans motivated healthy soil legislation as a strategy to meet emission goals. In contrast, other states with more conservative constituents used healthy soils to address climate change indirectly.

"We realized the chance of getting the climate action plan passed was limited, so we started to look at alternatives. We found that healthy soil has a lot of benefits to the agricultural community, but also had benefits beyond in terms of its ability to sequester carbon and reduce greenhouse gas alternatives. So, we decided to make a healthy soils bill as a plan B to the carbon action plan." – Interviewee 4

And for others, lack of climate change action at the federal level served as a powerful motivator. Interviewee 2 believes the increase in proposal of soil health legislation over the last few years is

a result of people being "tired of waiting for things to be done by the national government, so they are starting to find ways to protect nature themselves through state action." Interviewee 1 also noted that frustration with the absence of federal efforts has likely "encouraged some states to get their act in gear."

While climate change was a major and primary motivator, one interviewee pointed out that the other co-benefits of improving soil health trump those of carbon sequestration.

"My argument is that if someone waved a magic wand and there were no more problems with carbon, we were essentially at pre-industrial levels of greenhouse gases, we would still have only 60 years of topsoil left. We would still have all these flooding problems because of soil compaction. We would still have water quality issues because of chemical amendments. If we address all these other issues, carbon [sequestration] is a significant bonus." – Interviewee 6

The Perfect Storm

When discussing the recent increase in proposal of soil health legislation, interviewees referenced two chief explanations as to why there has been an increase in farmer support for soil health policies: recent research and the increasing frequency of extreme weather events. In 2012, the Natural Resource Conservation Service, a part of the U.S. Department of Agriculture, started a soil health campaign entitled "Unlocking the Secrets of Soil Health"[5]. Since then, this initiative, mentioned by several interviewees, has helped spread awareness of soil health through educational programming around the country. Interviewees also reported increased discussion of soil health from local news publications, university extension programs, and community non-profits.

"There has been enough research, successful case studies, and examples of farmers adopting things like no-till and cover crops that people are starting to recognize the benefits to their bottom line. Also, in terms of yield, soil retention, and water retention." – Interviewee 9

"Soil health has almost become a buzz word in agricultural conservation with the explosion of scientific knowledge in the last few years. Historically, soil health was very much

considered by farmers. I think a rediscovery is occurring due to the increased support from the scientific community" – Interviewee 5

At the same time, Interviewee 9 reports that many farmers and ranchers are starting to feel the pressure of extreme weather such as droughts and flooding, both of which have increased in frequency over the last few decades[35,36]. Interviewee 4, whose state has experienced multiple severe floods recently, has observed farmers who don't believe in climate change are starting to notice that "things are changing" and the risks those changes pose to agricultural production. Interviewee 6 believes the perceived increase in extreme weather events improved issue visibility to create the "perfect storm" for legislation proposal.

"The latest changes to storm water and drought have elevated the awareness about the need to address soil issues. In a way the ground was ready for legislation to take hold." – Interviewee 6

Soil as a Living Ecosystem

When asked to define soil health, interviewees provided a resoundingly unified answer: soils are a living ecosystem. While interviewees cited more specific soil health characteristics such as those defined in Doran, Sarrantonio, and Liebig's definition of soil health (such as biodiversity, water system health, and plant and animal health) many stated soils can be thought of simply as a living ecosystem.

"Soil is a living organism with worms, fungi, insects, and organic matter. We are just trying to increase the naturally occurring nutrients and minerals to make a perfect medium for growing plants and crops." – Interviewee 4

"Healthy soil is soil that is full of life. That is the short answer because if you picture it like that and treat [soils] as a living organism then the rest flows from there." – Interviewee 3

Some interviewees described the soil ecosystem as a metaphor for the human body, relating the different soil functions to organ systems.

"When we think of health we think of systems function and lots of different services. So I think there is a natural metaphor with the body. Soil health means soils that are biologically functioning and providing the ecological services that they would provide in their natural state." – Interviewee 9

"Soil is it's whole own ecosystem. I like to think of soil as earth's digestive system. Just like your body takes food and breaks it down into something your body can use for energy, the earth is taking inputs and breaking them down into products plants can use, and then animals can use." – Interviewee 2

Interviewee 3 also compared soil to the human gut, specifically drawing parallels between soil and gut microbiota. Similarities have been made between the systematic functions of both microbiotas in immunity and metabolic capacity[37]. Interviewee 3 believes the lack of acknowledging these connections is based on limitations in people's imagination and perception of soil because the life underground is not visible to the naked eye.

"Otherwise we might have compassion for its inhabitants. […] We cannot see what we kill in the soil every day, so it escapes our compassion." – Interviewee 3

Connecting Soil Health and Public Health

Interviewees not only reported analogies between soil and the human body, but also discussed ways soil health directly impacts public health. Seven of the 12 bills analyzed mentioned soil health's connections to human health through improving water quality, increasing crop yields, and improving community health. Interviewees touched on similar factors but focused on two main associations: soil nutrient level and chemical pollutants.

Five of the nine interviewees reported soil nutrient level as a main connection between soil and public health due to soil's capacity to transfer nutrients, specifically micronutrients, to food crops.

"I think one of the things that comes to mind immediately is nutrient density of foods. Those are very closely related. A healthy soil is integral in increasing nutrient density and nutrient density is critical for healthy food. Which leads to a healthy population."

– Interviewee 1

Specifically, interviewees reported conventional agriculture as a culprit in soil nutrient degradation, therefore reduced food nutrient density. Interviewee 3 states concentration of certain micronutrients in produce has drastically decreased or gone "completely missing" over the last 50 years. Interviewee 2 agrees:

"The old saying that an apple a day keeps the doctor away is no longer true, now it takes something like 15 apples to equal the nutritional equivalent of an apple from the 1930s when that saying gained popularity. We've changed nature to the point where it looks the same, but it is fundamentally different." – Interviewee 2

Interviewee 1 believes an inverse association also exists wherein the type of crops that fuel an unhealthy diet are also related to agricultural practices that have led to an erosion of soil health. Significant amounts of herbicides and chemical fertilizers are often used in the production of commodity crops such as corn and soybeans to maximize yields. These crops are often used to produce more highly processed food products.

"We know those foods in the Western diet are not particularly healthy, which leads to multiple issues. And we know that the desire to produce as much of those crops as cheaply as possible is what is leading to a significant negative impact on soil health. So, it flows both ways." – Interviewee 1

Interviewee 8 and Interviewee 9 expanded the connection between soil and food to the food system itself stating that healthy soils are crucial in maintaining future crop yields as climate change continues to put stress on our food system.

"Especially in the next couple of decades soil health is going to become increasingly crucial to overall food system resiliency. Events that capture this are droughts and flooding. NRCS says that a 1% increase in soil organic matter results in soil having the capacity to hold 2500 more gallons of water per acre. That's a drought and flood resilience solution, but also erosion control. So that will be really important for food security in the future." – Interviewee 9

In addition to improving food crop nutrient density, Interviewees also associated healthy soils with reduced pollutants that have negative effects on public health.

"If you can reduce the amount of chemicals and fertilizers you put on the soil, you are going to reduce the exposure that farmers have to things that have been scientifically proven to have carcinogens in them and produce cancer." – Interviewee 4

"Healthy soil practices pretty much exclude using harmful pesticides or chemical fertilizers, so you do create a healthier product." – Interviewee 3

Interviewee 4 and Interviewee 9 both discussed nitrate pollution of drinking water due to water running off agricultural lands into streams and rivers, as well as nitrates seeping into groundwater. According to Interviewee 9, improving soil health through the application of organic fertilizers and compost to build up soil organic matter and increase microbial diversity will also benefit water quality by reducing nitrogen seepage.

"What that [would do] is reduce the leaking of nitrogen in any direction. So, it would reduce volatilization of nitrogen into the air and leakage of nitrogen into waterways." – Interviewee 9

Legislative Process

Under the framework of the HPT, process describes how policies were developed and how the policy is implementing change[34]. One key process theme identified in interviews was how discussing climate change posed either limitations or benefits during the bill proposal process. Interviewees also discussed other process limitations that did not fall under one unifying theme. Lastly, limitations to evaluation plans was identified as a process theme.

The Climate Change Divide

For some states, addressing carbon sequestration and climate change in the text of the legislation reportedly facilitated bill support or passage. In contrast, for other states, interviewees shared that discussing carbon or climate change in legislation presented a significant barrier to legislation proposal and passage.

"If you mention climate change to the legislature, then 50% of them are already against what you are going to talk about." – Interviewee 4

"Any program that mentions carbon is sort of toxic to begin with regardless of where the money flows. It seems to be a domino theory where [people believe] if you have a program that relies on cap and trade funds to incentivize agricultural practices that will add more momentum to the cap and trade carbon initiatives that could hurt farmers down the road by increasing the costs of diesel or what have you." – Interviewee 1

The push back comes not just from legislators, but from agricultural organizations in the state as well, such as state Farm Bureaus.

"[The Farm Bureau] did not want us to talk about carbon at all. So we ended up taking it out so that they would have our back going forward. There is a weird stigma with some of those words like carbon. Ultimately our organization believes climate change is a very real thing and that the conventional farming practices have contributed a lot in the way of our carbon loss and dead zones in the gulf. We believe this is all man's doing in the end. But organizations like the Farm Bureau aren't on board with admitting that yet." – Interviewee 7

"The folks that seem to be the most opposed to the bill are the Farm Bureau and Dairy Federation. I still don't understand why they would be opposed to [the bill] since it is tax dollars going to farmers to upgrade pumps and put in equipment and such. So, I don't understand the rationale to their opposition, but it's politics so it doesn't always make sense." – Interviewee 1

Both Interviewee 7 and Interviewee 1 believe words such as climate and carbon have an innate political tie because many farmers in rural America are very conservative and do not believe in climate change. Therefore, using these words presents a barrier for passing legislation.

"The realities of being pragmatic in a legislative setting is that you need to not say things to keep bipartisan support. Everyone can agree that using a cover crop can reduce soil erosion and adds carbon to the soil. If we know that using a cover crop can increase soil health and therefore increase human health down the road, why even mention it in the first place if you risk losing support of the people you need to get the bill through legislature?" – Interviewee 1

This experience differs from that of Interviewee 3, 6, and 9 who received bipartisan support for soil health legislation that included discussions of carbon sequestration and climate change. Interviewee 6 reported their state's Farm Bureau, Farmers Union, and American Farmland Trust co-sponsored the state's healthy soils bill.

"This is one of those issues that is very bipartisan. The co-sponsors of the bill are essentially the same proportion of Republican and Democrat as the general legislature." – Interviewee 6

Other Process Limitations

Interviewees discussed a variety of additional limitations to the process of adopting legislation that did not fall into any congruent theme. According to Interviewee 2 and Interviewee 4, other limitations included farmer's distrust of laws and desire to remain unregulated.

"There are two big issues beyond climate change. One of them is that farmers don't want to be told how to farm and the other is farmer's fear of regulations." – Interviewee 4

"*You also have a lot of people who are distrustful of laws, even if they agree with the tenants of the legislation. You have farmers who don't want to be told what to do or how to do it, even if they already agree or are already implementing that practice. " – Interviewee 2*

Interviewee 4 reported that while talking to agricultural groups about the soil health bill many pushed back due to fear losing member support if leadership promoted a law creating more regulations on land management.

"I think a lot of people in leadership roles were supportive of our bill if you would get them into a place where nobody could hear what they were saying. But the members of these groups feel so strongly about these two points that [leadership] doesn't want to lose their jobs." – Interviewee 4

Interviewee 7 and Interviewee 1 believe that most farmers have good intentions but telling farmers how to farm creates tension between farmers and policymakers. Interviewee 7 suggests this resistance to change could also stem the financial incentives agribusinesses uses encourage farmers to continue current practices as well as farmer's desire remain autonomous. In Interviewee 1's experience, promoting certain land management practices in soil health bills can

be interpreted by farmers as blaming current practices for environmental degradation, therefore blaming the farmers.

"No farmer goes out there thinking they are doing something bad or with the intention to poison the world. They think they are doing the right thing. They are reducing their inputs and feeding the world. So, if you set a value statement to a particular practice it inherently creates a reaction." – Interviewee 1

Facilitators to Bill Creation and Proposal

In addition to citing limitations to soil health legislation adoption or implementation, interviewees also shared factors that facilitated bill proposal or passage. A commonly cited facilitator to improving farmer buy-in was demonstrating a benefit to profits.

"When we talk to farmers, we really emphasize that over time this could increase their bottom line, their profitability. Because they will produce crops with lower input costs because they won't use as high amounts of fertilizers. And you retain soil moisture and reduce erosion. In some cases, you even increase yields. Most importantly you are increasing your profit margin. Because the really important thing to this population is profit per acre." – Interviewee 4

"No farmer will participate in a program unless it increases their bottom line. So, if you can make an argument for how to do that, like reducing use of fertilizer, pesticides, fuel, and irrigated water, you get their attention." – Interviewee 5

"Like it or not the agricultural market is based solely on bottom lines. So, you have to try and reach [farmers] from an economic basis as well as an environmental lens." – Interviewee 7

In Interviewee 1's experience, focusing on profit as well as farmer experience and farm families helps improve farmer buy-in for adopting new practices.

"1) I'm having fun again, 2) I'm making more money, and 3) my kids are staying home and not going to the city. If you can make those three statements true about a particular practice, farmers will do it in droves." – Interviewee 1

Evaluation Plans

Many interviewees reported no formal evaluation plan to assess the effects of soil health legislation in their state. For some states still in the process of passing a bill through Congress, the evaluation piece is set to come later after the bill is ratified. Different challenges were brought up in deciding future evaluation processes. Interviewee 3 cited the lack of a standardized method to assess soil health that has been endorsed by the scientific community means States will have to create their own standards for measuring change. Interviewee 9 and Interviewee 4 discussed how the time frame could be a limiting factor as it can take up to 3-5 years, reportedly, to start seeing changes in soil health metrics based on changes in land management practices.

The interviewee from California reported the most robust evaluation of any of the interviewees. California's Healthy Soils Program has performed informal qualitative evaluations through focus groups and interviews with participating farmers and technical assistance professionals who are helping farmers apply to the program. The results of this informal evaluation are then shared with the California Department of Food and Agriculture each year. Additionally, the Healthy Soils Program is using a modeling program called COMET Farm managed by USDA and Colorado State University to estimate carbon sequestration on participating farms. These data have yet to be formally evaluated according to the California interviewee.

Legislative Actors

Actors, or the individuals and group members responsible for policy making, make up the last factor of the HPT. Within the HPT model, actors reside inside the triangle illustrating how policy content, context, and process are all influenced by the values of policy actors[34]. Two actor themes emerged from interviews: 1) the common key partners in bill proposal and

implementation and 2) the untapped potential in partnering with public health entities for soil health policy.

Common Key Partners

Interviewees reported a large variety of key partners instrumental in the proposal or passage of soil health legislation in their states. The most commonly cited key partner was local Soil and Water Conservation Districts (SWCD). State SWCDs are managed by the National Association of Conservation Districts which is a national non-profit association aiming to support land managers through grassroots advocacy and education[38]. SWCDs were mentioned by 7 of the 9 interviewees as main partners in bill creation. In some cases, state SWCD employees provided interviewees with research to justify a bill or helped interviewees find other professionals to help write the bill or testify on its behalf. Interviewee 3 describes how SWCD contributed to the creation of soil legislation in their state:

> *"The [SWCD] branch director was a huge help because they are well steeped in the political game and we are beginners. So, she really took us under her wing. And their organization works with ranchers and farmers every year. That was really crucial. I don't think we could have done it without her and the help of those ranchers." – Interviewee 3*

While SWCDs were a commonly mentioned partner in bill creation, the NRCS was mentioned by several Interviewees as a partner in program implementation. Nebraska's bill 243 creates a Soil Health Task Force, a member of which would be the state chair of the NRCS. California's Healthy Soils Program was created to be "supplemental to and unique from the NRCS conservation program." The Healthy Soils Program works with farmers who have already received grant funding through their program to continue to receive funding through NRCS. Additionally, New Mexico hopes the proposed healthy soils program in their state could provide matching grant funds to participating farmers.

Other interviewees mentioned unique key partners such as state universities, local climate initiatives, and tribal communities. Regional key partners also emerged with interviewees from Massachusetts and Vermont reporting collaboration with Northeast Organic Farming Association and a climate organization called Soil4Climate. Overall, all interviewees mentioned more than one key partner, often from governmental and non-profit sectors, but did not indicate collaboration with public health organizations.

Partnering with Public Health

Many interviewees believe there is an opportunity to include public health in conservation efforts, but multiple barriers were identified in increasing collaboration. Some interviewees perceived an education gap wherein the connections between soil health and public health are not well understood by either entity. Interviewee 6 suggested that this knowledge gap can create tension and misunderstanding between the two fields while Interviewee 5 attributes low collaboration to limited scientific research.

"I think it's an education thing. A lot of people who think about public health think about eliminating anything that is a threat to public health, but just because something exists doesn't mean it's 100% bad. So, some of the choices that are being made are based on black and white thinking." – Interviewee 6

"I think one reason is the limited research. Specifically, no definitive research has linked soil nutrients to plant nutrition. Everything should be done with a basis in science." – Interviewee 5

Other interviewees believe the disciplines of public health and natural resources conservation are siloed, creating too much distance for collaboration.

"We are all so siloed. There is a huge disconnect between human health and the natural world. Health care is now what you can take as a pill, not what you are eating. Soil is a major support system for humans, and I think that is very overlooked." – Interviewee 2

"There doesn't seem to be a lot of institutions that are overlapping between the two areas. So just from an institutional capacity and social capital perspective that seems to be a barrier into getting more collaboration." – Interviewee 9

Interviewee 2 believes people like to have their own expertise, and collaboration between disciplines will require a larger paradigm shift. Meanwhile, Interviewee 7 has already started to observe positive changes, especially in the realm of air quality.

"One of the things that we work with a lot is air pollution and public health professionals are already very involved on that front. There are obvious ties between breathing bad air and health. I think nutrient loss and soil health has not received as much attention yet, but as we continue to talk about it there will be more space to see how these practices affect communities around the country." - Interviewee 7

Interviewee 2 perceived a larger limitation to not just collaboration between soil health initiatives and public health, but in promoting conservation efforts in general. Interviewee 2 believes a common motivational tactic used by the media is fear, and that influences how motivated the general public is to enact changes.

"Every few years you have these huge stories that come out about how we are all doomed, like how there is only 50 years of soil left or how cities will all be underwater by 2050. The idea of hope has gone missing and therefore we don't talk as much about action items or ways to start making change. I'd love to see more hope out there to help people see what could happen if we start changing our actions." – Interviewee 2

Discussion

Through the utilization of qualitative policy analysis research methodologies, we assessed the content of U.S. state soil health legislation as well as the context, process, and actors involved with bill proposal and implementation. Proposal of state soil health legislation has increased over the last year, with 9 bills proposed in 2019. Bill content focused mainly on soil carbon sequestration and water quality with little further inclusion of public health topics specifically. Context themes included a desire to normalize soil health, climate change and related weather phenomena as motivating factors to bill proposal, an appreciation for soil as a living ecosystem, and soil nutrient level as a link between soil health and public health. Climate change was also identified as a process theme with reference to climate change limiting

legislative processes in states with more conservative constituencies and facilitating legislative processes in others. Farmers dislike of regulations was also identified as a process limitation, while a focus on profit margins increased farmer support for legislation. The most commonly cited legislative actors were SWCDs and NRCS, but interviewees recognized an opportunity for collaboration with public health in the future. To our knowledge, no prior studies have aggregated data on soil health legislation content, process, context, and actors; therefore, these findings provide a novel perspective into a growing field of state agricultural policy, especially as it evolves in its relationship to public health.

The results of the quantitative legislation analysis in Phase 1 demonstrated a trend towards a specific definition of soil health as well as a focus on certain soil health determinants. Only 5 of the 12 bills defined soil health with little variation amongst definitions as the definition in California's Healthy Soils Program bill has become a widely used model. Yet, California's definition differs slightly from the definition frequently applied in scientific literature. Notably, the definition omits human health and cites carbon sequestration specifically. In terms of determinant codes, carbon sequestration accounted for the highest proportion of determinant codes, followed by water quality. This suggests combating climate change and reducing water contamination are common goals of U.S. soil health legislation. Air quality was the least mentioned soil health determinant and therefore does not appear to be a priority for soil health legislative interventions. Public health was mentioned in more than half of the bills but represented a small proportion of total codes and references rarely included specifics such as air pollution or drinking water quality. This suggests possible limitations in the understanding, or perceived significance, of the connections between soil and public health as well as an opportunity for future improvement.

The results of the qualitative interview analysis reflected the current state of soil health policy legislation. Specifically, more lengthy answers were provided by interviewees for context questions than for process or actor questions, therefore more themes were identified for the context category. This is likely because only three laws had passed prior to interviews, therefore bills that were discussed by interviewees were in the bill passage stage. This may explain the disproportionate weight on context responses. In terms of soil health determinants, air quality was also not heavily discussed in interviews. Interviewees demonstrated a deeper understanding of the connections between soil and public health than suggested in legislative content with references to soil nutrient level's impact on human nutrition, benefits to water quality, reduced air pollution, and resistance to extreme weather events. Interviewees concentrated on the transfer of soil nutrients to food crops and the decline of food nutritional value with agricultural intensification. While the connection between soil nutrients and crop nutrients has been colloquially understood for centuries[39], there is no strong scientific evidence that has been published in peer-reviewed scientific journals showing a decline in crop nutrient density. This could explain the absence of soil health and human health connections in legislation.

Momentum for state soil legislation continues to build. During this project, three of the analyzed bills were ratified into law, including NE 243, IL, and NM. The analyzed VT bill was incorporated into a larger "Act relating to miscellaneous agricultural subjects" and was passed this session (2019). Additionally, VT passed a second bill regarding soil health that was proposed after the inclusion window of this research (VT S. 160). According to the Healthy Soils Google group there has been legislation drafted in Ohio that has yet to be proposed and efforts to draft legislation in Maine, New Hampshire, Rhode Island, New Jersey, and Pennsylvania by the 2020 legislative session. In addition to the growing number of state laws, soil health has also

received increased attention at the national level with inclusion of soil health in the 2018 Farm Bill. The new farm bill provides NRCS with 25 million dollars annually for On-Farm Conservation Innovation Trials, allocating grant funds for farmers trying to implement land management practices associated with soil health. The 2018 Farm Bill also created the Soil Health Demonstration Trial initiative, providing similar grant incentives for healthy soil practices, but specifically targeting soil carbon sequestration. These new initiatives add on to the robust soil health services NRCS already provided, such as educational resources for children, contacts for local soil health experts, cover cropping guides, and more.

A key strength of this research is incorporation of both quantitative and qualitative methods as well as the participation interviewees from diverse backgrounds, from governmental agency employees to an organic farmer. Nevertheless, qualitative legislation analysis involves several inherent limitations, especially when comparing legislation between different U.S. states. Firstly, each state has different legislative requirements such as bill length and structure. To address this, Phase 1 code analysis was calculated proportions to normalize the appearance of code data, in the hopes of offsetting confusion due to the varying lengths of legislation. To create the proportions, the total number of bill codes was used as a denominator and bills were also compared by using each bill was its own denominator. Additionally, only one soil health professional from each state was interviewed, providing singular insight for contextual factors that may not reflect the viewpoint of other policy makers involved. Perspective on limitations and facilitators to collaboration between soil health and public health disciplines are also one-sided as no public health professionals who were involved in soil health legislation were able to be identified for interview.

More research is needed to fully understand the scope of soil health legislation as more bills continue to be proposed and enacted. Future research should focus on the process and actor categories of the HPT with implemented legislative programs. Additional interviews from individuals at each bill location as well as with public health professionals are warranted to enhance understanding of limitations to interdisciplinary collaboration as well as opportunities for improvement as the links between soil and public health become more imperative.

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Appendices

Appendix A: Phase 1 Codebook for Legislation Analysis

Theme	Code	Description
Terms		
Soil health definition	SH_DEF	Discussion on how the term "soil health" is being used for the purpose of this legislation.
Determinants of Soil Health		
Biodiversity	SH_BIODIV	Discussion of soil in connection with soil biodiversity, microbial content, or plant diversity. Includes discussion of soil as a living system.
Bioproductivity	SH_BIOPRO	Discussion of soil in relation to soils productive capacity, crop yield, or fertility.
Air quality	SH_AIRQUAL	Discussion of soil in relation to air quality including pollution or airborne particulate matter.
Water quality	SH_H2OQUAL	Discussion of soil in relation to water quality determinants such as pollutants and runoff, water stores (groundwater, soil water holding capacity, etc).
Animal health	SH_ANIMAL	Discussion of soil's connection to livestock and other animal's health or general wildlife.
Carbon sequestration	SH_SOC	Discussion of soil's capacity to sequester carbon, the length of time soil can hold carbon, soil carbon reservoirs, or increasing soil organic matter.
Human health	SH_PH	Discussion of how soil health can affect human health, public health, or communities.
Influencers		
Land management	FACTOR_MANAGE	Discussion of how land management practices can influence soil health. Can include land management practices aimed at increasing soil health such as cover cropping, no till, conservative till, and crop rotations.

Climate change	FACTOR_CLIMATE	Discussion of how climate change can affect soil health or how soil health can mitigate climate change.
Interventions		
Policy actions and interventions	POLICY_ACTIONS	Discussion of the actionable interventions the legislation is initiating, funding, or supporting. For example, funding education, grants, equipment exchanges, research, etc.
Policy Evaluation	POLICY_EVAL	Discussion of how the policy/interventions will be evaluated, amended, or deemed appropriate.
Policy Funding	POLICY_FUND	Includes proposed funding support and financial commitments

Appendix B: Interview Script

INTERVIEW GUIDE STATE SOIL HEALTH PROFESSIONALS

1. To begin, can you please state your name, position, and agency?
2. One of the reasons I wanted to interview you today was because of the soil health policy/legislation in your state [describe the policy specific to the interviewee]. Can you tell me how you have been involved in or know about that policy?
3. Can you tell me a little more about this policy in terms of its vision/goals and target audience?
   Probe for:
   - Vision/goals
   - Target audience? Farmers, researcher, other policymakers, general public?
   - Actions/interventions embedded in the policy. Is it more regulatory with standards or guidelines?
     - More focused on quantifying (how to measure soil health) vs. adoption of best practices (actions to improve it)? (i.e., how aggressively do you monitor/track vs. mandating best practices?)
   - Is it related to the CRP program or a stand-alone focused more on soil health? (e.g., is it a rebranding of existing efforts? Or something new?)
4. Can you tell me what motivated this policy in your state?
   Probe for:
   - Beliefs and values relating to including soil health in conservation, in public health, in other outcomes.
5. What changes do you hope to see as a result of this legislation?
   Probe for:
   - How are you or do you plan to evaluate changes?
   - How will you know if the policy is successful?
   - If the policy is being implemented, is the policy meeting intended goals? Why or why not?
6. Were there any challenges/barriers to creating and adopting this policy?
7. How about in terms of implementation? Have there been any challenges/barriers to implementing this legislation?
8. Were there any key partners in helping to create, support, and pass this policy?
   Probe for:
   - Disciplines or fields, organizations (national, state, local), other public agencies
     - (e.g., govt, for or non-profit, education)
   - How about public health professionals? Such as those doing food policy work? How so? Or, if not, do you see a place for PH professionals?

Now, I'd like to switch gears and ask some questions about the phrase soil health. We've been starting to see this phrase used more recently in policies [including yours?] and are curious to learn more.

9. Have you heard of or used the term soil health? If so, can you please describe soil health in your own words?
   Probe for:
   - Factors that make up soil health
   - If they see a difference between soil health and soil quality?
10. Do you think it is important to define or characterize soil health?
    Probe for:
    - In your position, how is this definition used in practice?
    - Why did your program/state choose these variables to categorize soil health?
      - What led you to choose this definition of soil health?
11. Proposal of state soil health legislation has increased in the last couple years, do you have any insight in this trend?
    a. Many states have soil health programs, but do not have soil health legislation. Do you think soil health legislation adds to the improvement of soil health practices?
    b. If not, what do you perceive as the purpose of soil health legislation?

Finally, I'd like to ask just a few more questions about soil as it relates to human health. As part of this research project we are looking at the connections between human health and soil health.

12. Currently there is a movement afoot in agriculture that improving soil improves public health. Is this something you've heard of? If not, what do you think about this connection?
    a. When thinking about connections between soil health and public health, what comes to mind? (e.g., is it only toxic endpoints? In other words, do they know soil can hurt/kill but not that it can help or be of potential PH benefit?)
13. We've done some analysis on recent soil health policies and noticed that human health is not always included. Why do you think human health is not included in current legislation?
    a. What are some current barriers?
14. Do you think human health should be considered in soil health laws? Is there an opportunity here? Why or why not?
    a. If we move the dial on soil health can we move the dial on human health?
    b. If they see an opportunity….is it a matter of educating folks (and if so, whom), a perception that the state of the science needs to be improved to connect data gaps, or is a matter of siloes and getting the right people together?

15. Last question: We are hoping to interview individuals from public health, other soil health folks (agencies, profit or non-profit, national orgs), and businesses to add their perspective to this project. Were there any key partners you would recommend? Anyone from public health who might be interesting to interview? Could you share their name, org, email, # with me (by email)?

That's the end of my questions, is there anything else you would like to add?

Great, thank you so much for your time and contribution. Would you like the results of this project to be shared with you upon completion?

Appendix C: Phase 2 Codebook for Interview Analysis

Interview Category	Code	Definition
Context Codes		
1. Motivations for Bill Creation	CXT_Motivations	Descriptions of motivating factors to create legislation
2. Bill Goals	CXT_Goals	Statements of changes one expects to see as a result of the implementation of legislation
3. Bill Target Audience	CXT_Audience	Population's legislative interventions aim to target, such as general communities, farmers, ranchers, farmworks, etc.
4. Self-reported Soil Health Definition	CXT_SHDef	Interviewee's own definition of soil health and factors that encompass soil health
5. Perspective on Increased Proposal of Soil Health Legislation	CXT_Perspective	Interviewee's what has motivated the increase in proposal of soil health legislation.
6. Factors Linking Soil Health and Public Health	CXT_SHPH	Descriptions of ways public health is affected by soil health.
7. Barriers/Challenges to Linking Soil Health and Public Health	CXT_Barriers	Perspectives on why collaboration between public health and soil health professions is limited. Or why laws are not considering public health currently.
Process Codes		
1. Evaluation	PRC_Evaluation	Discussion of methods of evaluating whether legislation is meeting goals or will meet goals.
2. Challenges and Barriers to Bill Adoption	PRC_Adoption	Description of challenges, barriers, or limitations to passing soil health legislation. Applicable to states with enacted and proposed legislation.

3. Challenges and Barriers to Bill Implementation	PRC_Implementation	Description of challenges, barriers, or limitations to the implementation of bill interventions. Applicable to states with passed legislation.
4. Intervention Rational	PRC_Rational	Statements regarding why the law or specific interventions where chosen.
5. Facilitators	PRC_Facilitators	Perceived factors that made proposal or implementation of legislation more successful or easier.
Actor Codes		
Key Partners in Bill Creation	ACT_Creation	Description of partners key in the writing, submission, or testification of bills. May also refer to partners who served as resources/experts during bill creation.
Stakeholders in Bill Intervention	ACT_Intervention	Discussion of individuals or programs involved in implementation of interventions.
Connected Programs	ACT_Programs	Examples of pre-existing programs linked to legislation interventions

Appendix D: Legislation Status at beginning and end of project

State	Bill	Status as of February, 2019	Status as of July, 2019	Year/ Session
CA	SB 1350	Passed	Passed	2016
HI	Act 15	Passed	Passed	2018
MA	S438	In committee	In joint committee	2019
VT	H.903	In committee	Incorporated into H.525 and passed	2019
MD	H.373	Passed	Passed	2017
NY	A2781	In committee	In committee	2019
NM	S.218	In committee	Passed	2019
IL	S1980/H2737	In committee	Passed	2019
IA	H102	In committee	In committee	2019
NE	LB243	In committee	Passed	2019
	LB729	In committee	In committee	2019
WA	S5947/H2095	In committee	Passed senate, tabled in house committee	2019