Rooting for Soil Health

Fiscal Year (FY)23-FY27

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USDA United States Department of Agriculture

SUMMARY

This Targeted Implementation Plan (TIP) will focus on dryland crop producers in the following counties in the Bozeman area: Big Horn, Broadwater, Carbon, Gallatin, Golden Valley, Meagher, Musselshell, Park, Rosebud, Stillwater, Sweet Grass, Treasure, Wheatland, and Yellowstone. There are approximately 1.4 million dryland crop acres in the Bozeman Area. This TIP will incentivize implementation of a majority of the soil health principles: soil armoring, reduced disturbance, maximized diversity, and maximizing a living root. The integration of livestock is the final principal and is outside of the scope of this project.

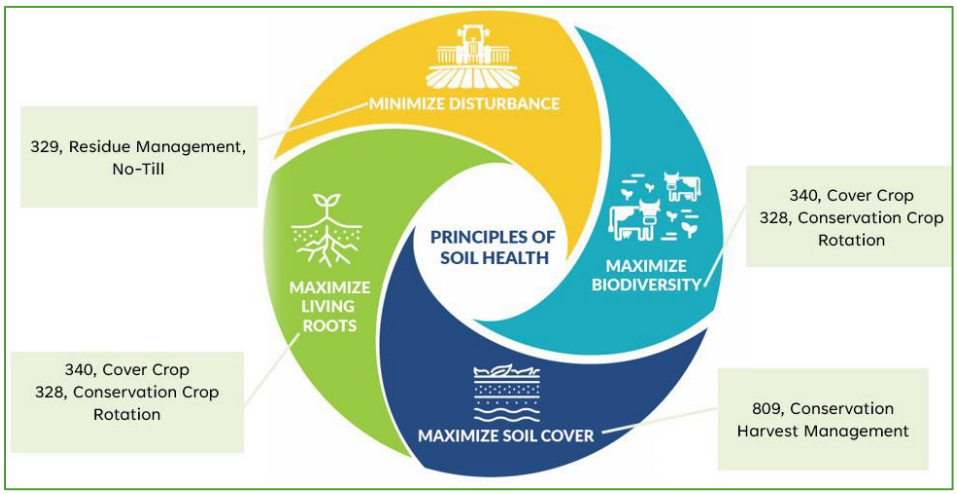

Figure 1 Principles of Soil Health and Core Practices Proposed, NRCS 2022

This TIP aims to build momentum among producers and staff in all fourteen Bozeman Area Counties, so that local field offices can continue improving on all soil health principles beyond FY27, building on this TIP. . Natural Resources Conservation Service (NRCS) will require producers to implement all the practices proposed in Figure One to meet the intent of this TIP.

The primary resource concern is *naturally available moisture* use with a secondary resource concern of soil *aggregate instability*. Naturally available moisture use is an especially critical resource concern on dryland cropping acres in south and south-central Montana (see fig. 3). Activities that meet NRCS planning criteria for this resource concern, are *managed to maintain or enhance water infiltration rates and minimize evaporation to utilize as much natural precipitation as possible*. Activities in this TIP will support the critical role of water in crop production and many soil biological processes. The secondary resource concern is aggregate instability. Soil aggregate stability governs many physical, chemical, and biological processes in the soil and can be improved through reduced tillage or no-till practices (Amézketa, 1999). Aggregate stability influences water movement and holding, aeration, erosion, biological activity, and growth of crops (Amézketa, 1999 & Blanco-Canqui et al., 2018).

This TIP is critical to implement now, for several reasons. First, it would capitalize on the grassroot effort that is growing among producers to address soil health across Montana. Second, it would respond to what the drought across Montana in 2021 highlighted- the importance of residue management, reduced disturbance, and cropping rotation, to maximize moisture efficiency. The increased social interest and ecological pressures, make now the time for NRCS to invest in soil health. Cyclical drought is a natural feature of Montana's climate and will likely have exacerbated impacts in the future because of climate change (Whitlock et al., 2017). Figure Two from the U.S. Drought Monitor shows the critical nature of the 2021 drought, which is still impacting large portions of the Bozeman area in the Winter of 2022. All the dryland crop areas of the Bozeman area are in Stage D2 (Severe Drought) or Stage D3 (Extreme Drought). This TIP falls directly in line with addressing the USDA Secretary's top priority of Climate Change and Climate Change mitigation.

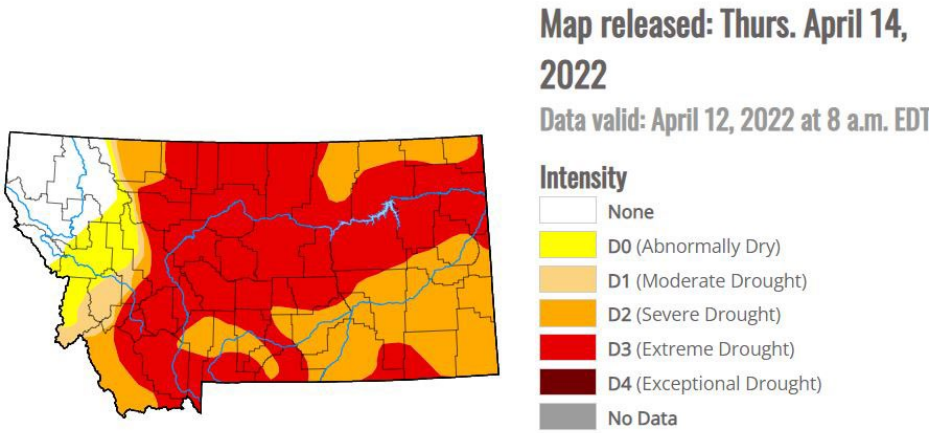

Figure 2. US Drought Monitor Map, released April 14th 2022

FOCUS

The focus of this TIP is dryland crop acres in the Bozeman Area (see fig. 3). The fourteen County geographic area was chosen because dryland crop acres and innovative producers in the Bozeman Area are geographically dispersed. We anticipate participants in this TIP will use funding to alter small grain followed by fallow rotations to more intensive and diverse rotations. The expectation is that this TIP will build momentum in the Bozeman Area on soil health implementation. NRCS will use this TIP to augment the grassroots movement on soil

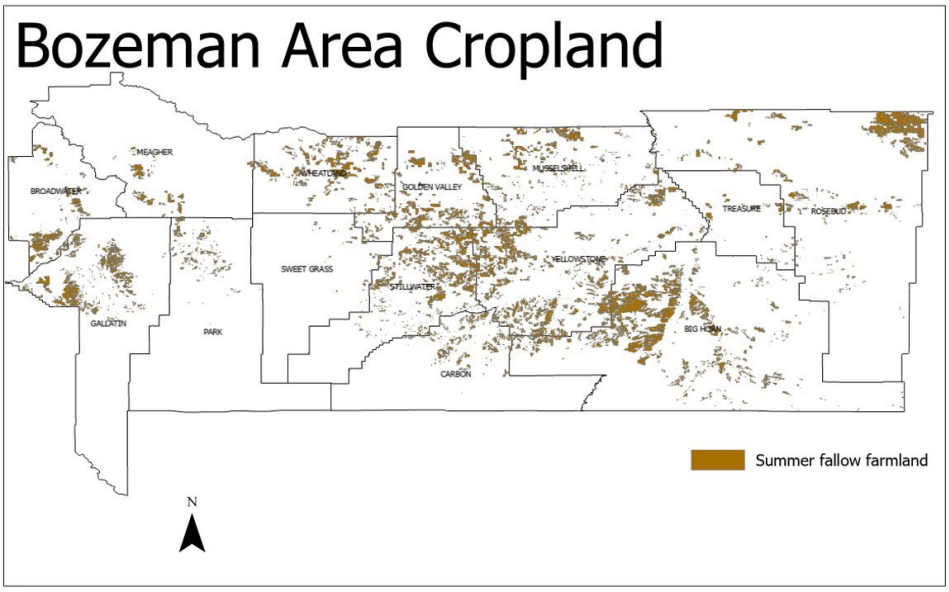

Figure 3 Bozeman Area Cropland NRCS, 2021

health and anticipates future geographically focused TIPs will be proposed to continue the efforts of this area wide TIP.

BACKGROUND

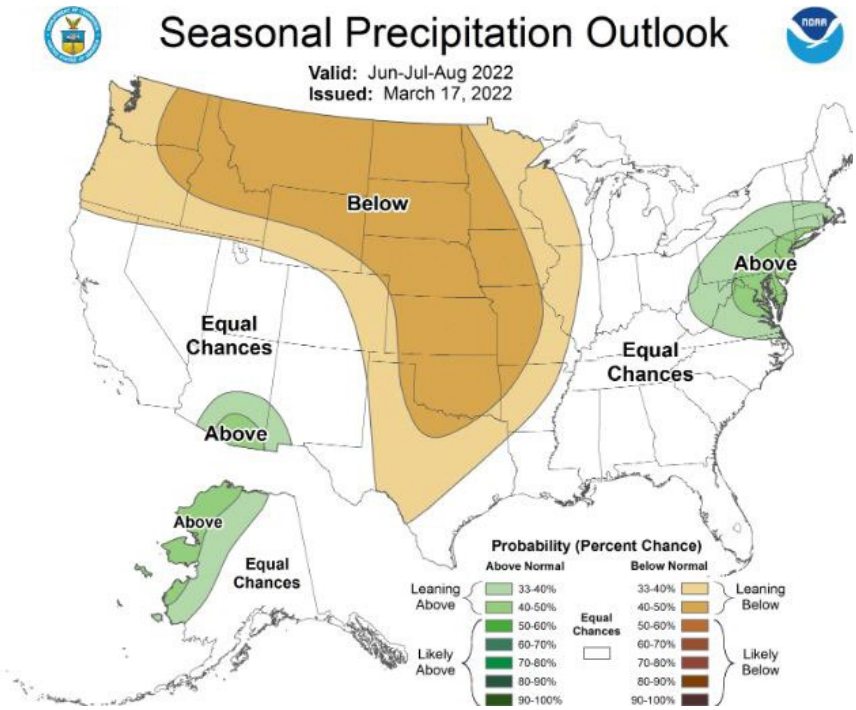

Figure 4 US Seasonal Precipitation Outlook for Summer 2022, NOAA, 2022

Regarding the timing and urgency of this TIP, during 2021, large areas of Montana were in historic drought, which greatly impacted small grain production. The National Agricultural Statistics Service (NASS) showed that wheat production was down 56% and barley production down 52% for the 2021 crop year in Montana. Small grain crops in the state had the lowest production per acre since 1988 (NASS, 2021). While long-term climate forecasts are inherently unreliable, it is still worthwhile to note the Climate Prediction Center anticipates another hot and dry summer which will exacerbate already poor soil moisture conditions (see fig.4).

RESOURCE CONCERN.

Long range plans in all counites in the Bozeman Area list soil health as a resource concern (*Big Horn County Long Range Plan 2021 (LRP), p. 17, para. 4 & p. 22, para. 8; Broadwater LRP 2019 p. 10, para. 2; Carbon County LRP 2020 p. 12, para. 1; Gallatin LRP 2019 p. 15, para. 2; Golden Valley & Musselshell LRP 2019 p.10, para. 1; Meagher LRP 2019 p. 14 para. 4; Park LRP p. 33, para. 3 & p. 34, para. 7; Rosebud LRP p. 7, para 2; Stillwater LRP 2019 p. 33, para. 1; Sweet Grass 2019 p. 30 para. 1; Treasure 2020 p. 26, para. 2; Wheatland 2019 p. 16, para. 4; Yellowstone LRP 2021 p. 20, para. 1). NRCS will promote *naturally available moisture use* as the primary resource concern through this TIP to directly support soil health. NRCS' objective for this resource concern is to manage natural precipitation more efficiently. The secondary resource concern this TIP will address to improve soil health is soil aggregate instability. Increasing crop intensification and increasing residue will address both the primary and secondary resource concerns.

Cropping systems on dryland acres are typically dominated by a small grain grown followed by a fallow year. Fallow is a technique where arable land is left intentionally without vegetation for a growing year. This is achieved either through tillage or more likely now through chemical

burndown. The primary goal of fallow crop years is to store soil moisture in semi-arid environments (McVay et. al, 2010). Although logically this makes sense and has been ingrained in growers in Montana, research shows that fallow is inefficient at storing soil moisture (Nielsen et. al, 2005). Cropping systems that reduce fallow periods (increasing crop intensification) have higher precipitation use efficiency (Nielsen et. al, 2005). Intensifying crop rotations is one method of increasing efficiency of naturally available moisture that this TIP will promote.

Further, Nielsen et. al, recommend increasing the amount and persistence of crop residue. An emerging but not well adopted method in Montana to increase crop residue is to utilize a stripper header. A stripper header goes on the front of a combine and only takes the grain off the plant, leaving high vertical residue in the field. This vertical residue results in slower decomposition, greater shading, and wind speed reduction which decreases soil evaporation losses. Vertical residue will lead to increased precipitation use efficiency that is critical for drought mitigation and agricultural production across these semi-arid cropping systems. This TIP will support the use of the Interim Conservation Practice Standard (ICPS) Conservation Harvest Management (809), which requires leaving tall, vertical residue through the winter.

Regarding the secondary resource concern of soil aggregate instability, North Dakota State University defines soil aggregation as, "arrangement of primary soil particles (sand, silt, clay) around soil organic matter through particle associations." NRCS National Planning Criteria states that management induced aggregate instability results in, "destabilized soil carbon; surface crusting; reduced water infiltration, water holding capacity, and aeration; depressed resilience to extreme weather; increased ponding and flooding; increased soil erosion and plant stress; and reduced habitat and soil biological activity." Soil aggregate stability influences a wide range of biological, chemical, and physical properties and is therefore an extremely important measure when implementing soil health practices (Amézketa, 1999 & Lehmann et al., 2020). Soil aggregation increases porosity, soil carbon sequestration, and retention of moisture and nutrients (Le Bissonnais, 1996). Aggregate stability is influenced by residue cover as well. Residue cover dissipates raindrop energy and decreases aggregate breakdown and surface sealing (Amézketa, 1999). Physical, chemical, and biological properties in the soil interact in complex fashion to promote or degrade soil health.

GOALS AND OBJECTIVES

Table One provides a summary of Resource Concerns, Goals, Measurements, and Implementation timeframes to illustrate TIP goals and objectives. The primary measurable outcome indicating success of this TIP will be an increase in soil moisture the year following a stripper header harvested crop. Soil moisture will be measured by moisture sensors, gravimetric soil water, and yield report methods. Through the Interim Conservation Practices Standard (ICPS) for Conservation Harvest Management (809), NRCS will require producers to install soil moisture sensors at various rooting depths. Adding soil moisture sensors in fields with and without stripper header stubble will give NRCS and the growers critical data for decision making and risk management. NRCS will also ask producers to report yield on fields with stripper header residue

and those without. NRCS anticipates an increase in yield in fields with stripper header residue in comparison to fields without stripper header stubble. Second, an increase in aggregate stability is expected to be detectable as measured through NRCS soil health tools, and lab stability tests. NRCS will conduct the Tier One and Tier Two Montana Soil Health Assessment on all fields under this TIP on three occasions- before implementation of conservation practices, during the contract, and at the end of the contract. Cropland indicators on the Montana Soil Health Assessment Card prior to implementation will range from “least desired” to “most preferred”. It is predicted after implementation cropland indicators will be at least “moderate” with four or more indicators scoring “most preferred.” The Soil Interrogation Lab at Montana State University will also complete in-lab soil aggregate stability tests on all sampled sites.

Third, NRCS anticipates this TIP will result in an increase in soil biological activity that will be evident through monitoring in the form of: before and after pictures of soil structure, soil temperatures, infiltration data, Haney and PFLA tests. There is complex relationship between residue management, soil moisture, soil aggregation, soil organic matter, and soil biological activity. Therefore, with increased soil cover and aggregation, there will be an increase in both the amount and diversity of soil biological activity. Soil cover moderates temperature and water availability on the soil surface. Temperature and moisture fluctuations increase potential evapotranspiration and decrease biological activity. With increased aggregate stability NRCS can expect areas participating in this TIP to experience an increase in soil water infiltration. Increased residue from stripper header stubble will provide snow catch over the winter and in turn increase available soil moisture in the spring. There will be a positive feedback loop as more moisture is available and aggregation increases. Organic matter will build, which will in turn increase water holding capacity and increase biological activity.

Figure 5 100% Residue Cover after Stripper Header Harvest

The **desired future condition** would be an increase of the soil biology, and we anticipate producers would start to realize a decrease of inputs which would make their operations more sustainable in the long-term. Anecdotal evidence across the state indicates this can take 5-10 years to come to fruition. Biological activity can be measured through the proxy measurement of soil organism habitat including soil structure, soil moisture, and soil temperature. NRCS will take before and after pictures of soil structure, soil temperatures, and infiltration data. These measurements can be used to assume the period of soil biological activity. Further, NRCS will require the of the Haney Test and a Phospholipid Fatty Acid (PFLA) test. The Haney test evaluates soil respiration (Solvita CO2 burst test), water-soluble organic carbon and organic nitrogen and their ratio. These results indicate the amount of food

that is readily available to soil microbes. Numbers gained from the Haney test should be used as a comparison over time to determine progress in improving soil health (Ohio State University Extension, 2019). The PFLA is a snapshot at the time of sampling of the abundance and structure of the soil microbial community (Ohio State University Extension, 2019).

Table 1. *Resource Concerns, Goals, Measurements, and Implementation*

Resource Concern	Goal	Measurements	Who Responsible for Collection	When Collected
Naturally Available Moisture Use	Increase soil moisture	Gravimetric Soil Water Content	Soil Interrogation Lab	Prior to seeding
		Soil Moisture Sensors	Producer	Entire growing season
	Increase Yield	Yield	Producer	Harvest
Aggregate Instability	Decrease aggregate instability	MT Soil Health Score Card	NRCS and Producer	Beginning, during and end of contract
		Jornada and In-Lab Aggregate Stability	NRCS and Soil Interrogation Lab	Beginning, during, and end of contract
		Soil temperature	NRCS/ Pheasants Forever	Growing Season or Fallow Year
		Infiltration Rate	NRCS/ Pheasants Forever	Growing Season or Fallow Year
		Soil Health Testing	Producer	Beginning and end of contract

PROPOSED ALTERNATIVES AND ACTIONS

To solve the problem of addressing soil health resource concerns, multiple alternatives have been considered. These include:

ALTERNATIVE ONE – PERNENNIAL PLANTING, (550 OR 512) PRESCRIBED GRAZING (328), OR FORAGE HARVEST MANAGEMENT (511)

Perennial systems have the highest potential to use naturally available moisture, increase aggregate stability, store soil organic carbon, and promote soil health (Rosenzweig, S. T. et al., 2018). While this is the best alternative for the ecosystem services provided by the soil, it ignores the sociologic and economic importance of cropland for rural communities. This is not the proposed alternative as it would be largely unadopted.

ALTERNATIVE TWO – SOIL HEALTH MANAGEMENT SYSTEM, (328) CONSERVATION CROP ROTATION, (329) RESIDUE AND TILLAGE MANAGEMENT – NO TILL, (340) COVER CROPS, AND (590) NUTRIENT MANAGEMENT (SOIL HEALTH TESTING ONLY) AND (809) CONSERVATION HARVEST MANAGEMENT

Cropping systems that maximize diversity, cover, and time a plant is growing, while minimizing disturbance, increase aggregate stability at the highest rate for annual planted cropland. Soil health management is most successful when all the principles are implemented, as they are in this Alternative. Acres available for cost share will be limited to 600 acres per operation. NRCS can leverage a greater participation rate across multiple counties with a practice acre cap.

ALTERNATIVE THREE – NO ACTION

Soil aggregate instability and susceptibility to drought will continue across croplands in southern and central Montana.

SOLUTION

To increase naturally available moisture, use and increase aggregate stability the following conservation practices will be installed on up to 600 acres per operation: (328) Conservation Crop Rotation, (329) Residue and Tillage Management – No till, (340) Cover Crops, and (590) Nutrient Management (soil health testing only) and (809) Conservation Harvest Management. Producers will initiate a cropping rotation that will reduce fallow and include at least three of the four crop types. Crop types include warm and cool season grasses, and warm and cool season broadleaves. NRCS will also encourage the use of a full season, diverse cover crop mix to add a crop type.

Grazing the cover crop will not be required but will be encouraged. Some producers in the TIP Area have no access to cattle or do not have fence in place, so we will not be requiring full implementation of the fifth principle (integrate livestock), however it will be encouraged where possible. The TIP requires the use of no-till disk drills, and each crop will have at total a Soil Tillage Intensity Rating (STIR) value rating less than 10. When small grains are produced and as possible with alternate crops, NRCS will require Conservation Harvest Management to leave stubble heights over the winter as: 10 inches or 80% of the plant stalk height for crops with a row spacing of less than 15 inches; or 15 inches or 80% of the plant stalk height for crops with a row spacing of 15 inches or greater (these numbers will be adjusted when the Final ICPS is published).

To determine benchmark soil conditions prior to installation of the practices and to monitor outcomes throughout the contract NRCS will require soil health testing. This should Haney test, wet aggregate stability test, and phospholipid fatty acid (PLFA) test. These tests will be completed each spring or early summer at the same time each year. These goals will be achievable in three years.

PARTNERSHIPS

NRCS has established relationships with partners through the development of this TIP. Pheasants Forever partner employees will partner on this TIP to assist in data collection for soil sampling, crop residue measurements, and soil temperature measurements. Through the course of this project, NRCS estimates Pheasants Forever partner employees will provide approximately 200 labor hours. Pheasants Forever (PF) has offered finical support for end of season monitoring meetings with participating producers. These will occur in the

late fall or winter of each contract year. PF will provide meals and refreshments for these events.

Further, Dr. Tony Hartshorn, Montana State University, Professor of Soil Science, and the Soil Interrogation Lab will partner on this TIP to provide technical expertise on soil analysis and sampling assistance. It is estimated over the course of the project, the Soil Interrogation Lab will provide approximately 300 labor hours.

IMPLEMENTATION

This TIP will be funded for three years. The total amount requested is 1.8 million dollars over that three-year period. This estimate is based on 2022 Environmental Quality Initiatives Program (EQIP) rates. Table two indicates the amount, cost-share, and extent of practices. Table three represents a typical scenario for a producer who does not currently have the technology to implement Conservation Harvest Management (809) or Residue Management, No-Till (329). Table three is displayed with amounts at the practice extent cap due to the interim conservation practices standard for (809).

Table 2. *Core conservation practices and payment rates for soil health core practices. FY22 EQIP rates.*

Practice Code	Practice	Payment Rate	Extent	Unit
329	Residue and Tillage Management, No-Till	$16.80	600	Acres
328	Conservation Crop Rotation	$10.41	600	Acres
340	Cover Crop	$63.61	125	Acres
590	Nutrient Management- soil health testing only	$141.94	1	Number
809	Conservation Harvest Management	$58.65	600	Acres

Table 3. *Typical Scenario Proposed under TIP on 600 acres.*

Practice Code	Contract Year One FY 2023	Contract Year One FY 2024	Contract Year Two FY 2025	TOTAL
329	$10,080.00	$10,080.00	$10,080.00	$30,240.00
328	$6,246.00	$6,246.00	$6,246.00	$18,738.00
340	$7,951.25	$7,951.25	$7,951.25	$23,853.75
809	$35,190.00	$35,190.00	$35,190.00	$105,570.00
590	$141.94	$141.94	$141.94	$425.82
Annual Payment	$59,609.19	$59,609.19	$59,609.19	$178,827.57

Table 4. *Budget Proposal for Three Years*

TIP Year One FY 2023 Request	TIP Year One FY 2024 Request	TIP Year One FY 2025 Request	TOTAL
$450,000.00	$800,000.00	$550,000.00	$1,800,000.00

The technical assistance and staff time needed from NRCS to complete this plan is based off the process that we already know is effective and is included below.

- Meet with small producer groups in the office: 2 days
- Inventory and Planning: 2 days per producer
- Plan and contract development: 3 days per producer
- Soil sampling, analyze soil test results, clip for AUM's: 3 days per producer
- Follow-up with producers: 2 days per producer per year

OUTCOMES

Soil health indicators will considerably improve across up to 5,500 acres because of this TIP. There will be at least one geographically targeted TIP in future Fiscal Years because of this area-wide TIP that will cover further acres. Increasing soil health will increase aggregate stability, infiltration, and water holding capacity, leading to increased crop production, residue, and improved drought resiliency for participants in the fourteen County area. Also, soil will be less vulnerable to erosion and will have decreased need for crop production inputs, so it will be profitable for both the land and producers in the long-term.

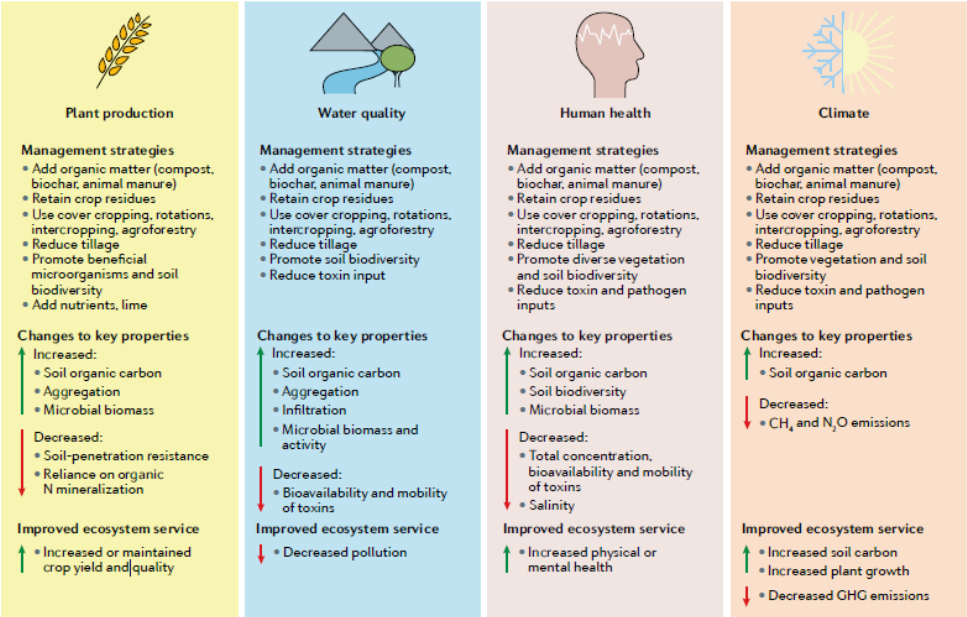

Figure 6. Ecosystem Services Provided by Soil Health Lehmann et al., 2020

This TIP will implement all soil health principles and measure soil physical properties to ensure its' effectiveness. The increase in physical soil stability resulting from TIP implementation will

encourage organic matter accumulation and biological activity. This TIP would enable Producers to decrease chemical and fertilizer inputs by increasing cropping system intensity (reducing fallow years). Research has shown that cropping system intensity increased total and mineralizable nitrogen and decreased herbicide use (Rosenzweig et al., 2018). Therefore, an increase in cropping system intensity should decrease the demand for fertilizer production which accounts for 1 to 2% of Greenhouse Gas emissions worldwide (MIT, 2021).

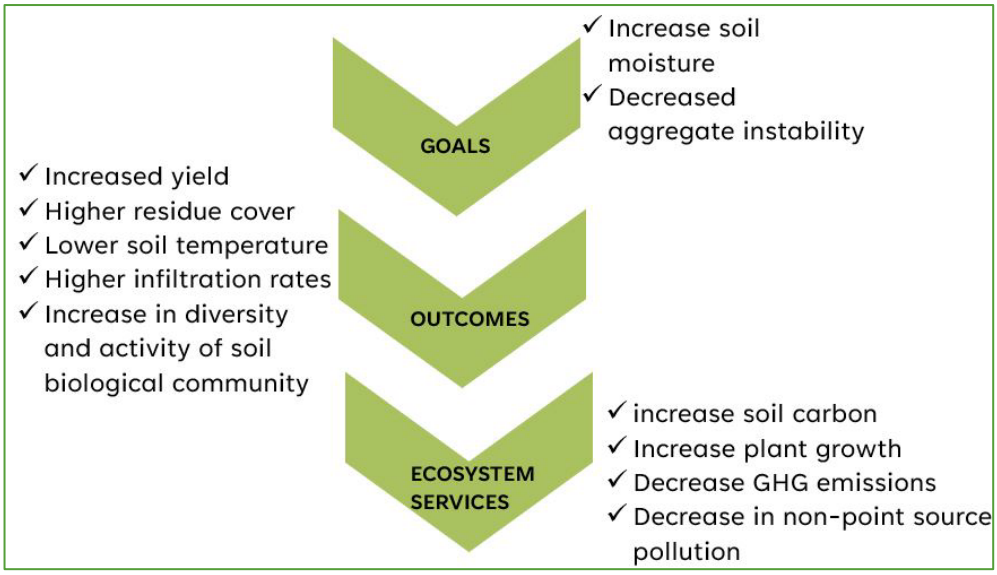

Figure 7 Simplified Goals, Outcomes, and Ecosystem Services

Soil aggregate instability is a resources concern across dryland cropping systems in semi-arid climates due to common cultural practices. Common cultural practices to manage moisture are fallowing the land every other year (crop/fallow) and soil disturbance from drills. This TIP aims to shift these common cultural practices to reduce soil aggregate instability that can result from crop/fallow systems and tillage (Rosenzweig et al., 2018).

Ecosystem services provided by a healthy soil range from plant production to climate change mitigation as shown in figure six. This TIP will result in an annual reduction of greenhouse gas emissions equivalent to 593 passenger vehicles, or a single passenger vehicle driven 6,856,004 miles (estimates derived from NRCS COMET-Planner and Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator tools). Cropping systems because of this TIP will have resilience to climate change and drought.

RANKING

LOCAL RANKING QUESTIONS

1. **How many crop types will the rotation include (not counting a cover crop)?**

    a. **4 of 4 crop types**
    b. **3 of 4 crop types**
    c. **2 of 4 crop types**
    d. **1 of 4 crop types**

2. **Conservation Crop Rotation (328) will decrease years of fallow by what percentage over a four-year period?**

    a. **25%**
    b. **50%**

3. **Through practices in this application, STIR will be improved by**

    a. **0 points?**
    b. **5 points?**
    c. **10 points?**
    d. **20 points?**

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