Carbon Cycle Institute

June 15, 2022

Shelby Livingston, Undersecretary
Matthew Botill, Branch Chief
CA Air Resources Board
1001 I Street
Sacramento, California 95814

Dear Ms. Shelby Livingston and Mr. Matthew Botill:

The Carbon Cycle Institute (CCI) is disappointed with the Draft Scoping Plan Update (Draft SPU) in that CARB neither adequately assessed the potential of the NWL (especially the working lands portion) nor addressed many of the technical and methodological issues we and other stakeholders have repeatedly raised with CARB. CCI has been engaged in the NWL Scoping Plan process for many years now, and we have continued to offer substantive support to CARB and its staff. The SPU represents an abrupt and unfounded departure from the path we have been on with CARB; the SPU betrays the science and on-the-ground leadership, and the value and spirit of our ongoing partnership. As we stated before, CARB's current working land scenarios would severely (and unnecessarily) limit California's investments in leveraging one of its essential pillars of climate change mitigation and would risk stifling the innovative and ambitious actions that are already taking place at the local scale across the State.

We have summarized several ongoing concerns we have with CARB's modeling and analyses; we also summarize several issues we have uncovered during our review of the Draft SPU (we have not had adequate time to fully review the entire Draft SPU, including the technical appendices). We intend to provide further comments and technical review as well as propose recommendations for moving forward in the SPU process, both in writing and during forthcoming meetings with CARB and other state agency staff (CDFA, CNRA, and CALEPA).

Sincerely,

Jeffrey Creque, Ph.D., Director of Rangeland and Agroecosystem Management

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Summary of Comments and Questions

CARB's analysis does not model the actual potential climate change mitigation of the State's agricultural lands, nor does it offer a path to directly informing strategies and targets for the State's NWLs.

A few examples illustrating the shortcomings of CARB's modeled scenarios include, but are not limited to:

- Soil carbon stocks are severely underrepresented at the State scale, biasing the SPU from its inception: By limiting its analysis to a soil depth of 30 cm, CARB is artificially constraining both the estimated size of existing soil organic carbon stocks and the magnitude of potential for soils to either lose or accumulate carbon under its NWL scenarios. For context, an estimated 30–75% of soil organic carbon is located below 30 cm worldwide (Tautges et al. 2019), and these deeper SOC pools play a critical role in carbon accumulation and storage (Dynarski et al. 2020). CARB explicitly states that "priority was given by carbon stock size in land types" (Appendix I p. 5), therefore the limitations of the soil carbon stocks has directly impaired CARB's prioritization of soil-based strategies and has led to a fundamental analytical bias.

- CARB's analysis does not model the actual potential of the State's agricultural lands.
    - All scenarios are constrained for agricultural lands. As its most ambitious scenario for agricultural carbon sequestration, CARB uses an acreage of ten times the acres awarded funded through CDFA's 2021 Healthy Soils Program totaling approximately 116,000 acres per year with less ambitious scenarios 2, 3, and 4 assuming 75%, 50%, and 25% of those acres, respectively. CARB provides no justification for these acreage scenarios.

    - In contrast, the USDA NRCS currently supports conservation on far greater acreage than CARB's most ambitious target. In 2020, 921,870 acres were receiving conservation support through NRCS EQIP (NRCS 2020). While not all of these practices are focused on carbon sequestration, the scale of NRCS's reach indicates that CARB's agricultural scenarios are severely lacking.
    - Furthermore, CARB's analyses only includes practices on cropland (9,597,439 acres according to the 2017 Ag Census), and does not

consider pasture or rangeland, which together make up an additional 11,606,249 acres (2017 Ag Census). CARB's modeling explicitly treats rangeland separately from agricultural lands; however, the significant areas of intensively managed pasture and rangelands present important opportunities for enhanced carbon sequestration.

  - CARB's analysis of organic acreage is problematic for at least three reasons. First, treating organic management as a broadly carbon-sequestering practice and separate from the other specific healthy soils practices is at odds with CARB's detailed modeling approach. Second, CARB's analysis does not account for changes in nitrous oxide emissions under organic management. Third, CARB's most ambitious target of 30% organically managed cropland by 2045 is hardly ambitious, considering that organic production already accounted for approximately 27% of farmland in 2019 (CDFA 2019–2020).

- There are numerous other flaws in CARB's modeling (please see Compost section below, p.126).

(Draft SPU language in plain text, *comments in bold italics*)

Draft SPU, p. 47

The management actions that were included in the model were selected because of the State of California's previous work to quantify these actions' impacts. It was not feasible to model every land management strategy for NWLs, and so it is possible that larger volumes of sequestration (e.g., in soils or in oceans) could result from additional non-modeled activities. California's Natural and Working Lands Climate Smart Strategy includes a more comprehensive listing of priority nature-based solutions and management actions. It is important to note that the absence of a particular management action or its climate benefit in the modeling is not an indication of its importance or potential contributions toward meeting the target or toward supporting the carbon neutrality target for California.

So, what is this modeling being used for? If this is just a starting point, what is the process moving forward? What engagement and data will be consulted moving forward?

Draft SPU, p. 66-67

To achieve carbon neutrality, any remaining emissions must be compensated for using carbon removal and sequestration tools. The following discussion presents more detail on the options available to capture and sequester carbon. Carbon removal and sequestration will be an essential tool to achieve carbon neutrality. The modeling clearly shows, there is no path to carbon neutrality without carbon removal and sequestration.

[...] At this time, no CCS projects have been implemented or generated any credits under that protocol. However, CCS projects have been implemented elsewhere since the 1970s, with over two dozen projects operational around the world, and over 100 more at the stages of advanced or early development.112 CCS projects are in development for addressing emissions from fuel, gas, energy production, and chemical production.

[...] It is important to recognize that the EJ Advisory Committee has raised multiple concerns related to the inclusion of CCS and mechanical CDR in the Draft Scoping Plan. Concerns range from potential negative health and air quality impacts to safety concerns related to potential leaks, to viability of current technology. Additionally, the EJ Advisory Committee has policy concerns about the strategy and wants to ensure that engineered carbon removal is not used as a substitute for strategies to achieve emissions reductions onsite or result in delays in phasing away from fossil fuels. Given these and other concerns and the importance of building public awareness, CARB recognizes the need for a multi-stakeholder process including other state, federal, and local agencies; independent experts; and community residents to further understand and address community concerns related to CCS.

These statements (and analyses) are in direct conflict with "Cost-Effective Solutions Available Today" as stated on p. VII.

Draft SPU/Cropland Modeling, p. 121

In California, croplands contain approximately 90 million metric tons of carbon, which accounts for 1.6% of all statewide NWL carbon [63].

How many acres are included here? At 20M acres of cropland, this is 4.5 metric tons of C/acre; at 10M acres, it is 9 metric tons/acre (which is far from accurate).

..once the perennial crop type and age are determined, the model can estimate the above ground live carbon per unit area. The model then uses the statewide age

distribution of perennial crop types and total crop type acreage to calculate the statewide carbon per crop type. The orchard types quantified in this modeling are oranges, pistachios, almonds, and walnut.
Much more important than crop type is the management system. Note only above ground biomass is quantified; soils are not included in this analysis (a significant omission).

Draft SPU/Cropland Modeling, p. 122

The amount of statewide perennial agricultural carbon in a particular year is calculated using allometric equations and the number of acres within an age distribution. Every year the acres within an age distribution for the 4 orchard types tracked is calculated. Using the number of acres that are a certain age and a particular orchard type, the carbon is calculated. Then the carbon for all ages is summed.
This proposed approach is acceptable for above ground orchard biomass assessment. It is unacceptable for total C estimation.

Where TPA is trees per acres given an orchards age, and Ct is the above and below ground live carbon per tree given the orchard age.
Note that above it says only above ground C was quantified. Not sure which is correct.

Draft SPU/Cropland Modeling, p. 124

The limitations of this model are that it currently only estimates biomass carbon. Water, soils, and other resource demands may be included in the future. Additionally, no alternative agricultural practices are incorporated in this model, such as alley cropping, or composting.
In other words, it misses most of the C in the system and most of the potential C.

Draft SPU/Annual Croplands, p. 125

Annual croplands are modeled using the Daycent model [68].
The practices that were modeled using Daycent are cover cropping with legumes, cover cropping without legumes, reduced-till, no-till, and composting (Table 36).

Practices that were taken from previous modeling exercises are riparian forest buffer, alley cropping, windbreak/shelterbelt establishment, tree/shrub establishment, and hedge rows. The impact that these practices have were done in the development of COMET-Planner [76].

The soil organic carbon impact from transitioning to organic agriculture from conventional is taken from a literature review and meta-analysis [77]. For each acre that transitions to organic, .74 Mg C/acre/year (0.3 Mg C/ha/year) is added to the BAU value for that year. This remains constant for 5 years, after which this benefit declines linearly until there is no sequestration benefit after 25 years. This gradual decline in climate benefit is to simulate the effect of carbon saturation referenced in the literature.
While thresholds of soil C may be reached under a specific management regime, this is not "carbon saturation". Additional C can always be added to the system with additional practices or direct additions of compost, or biochar, or other biomass.

Draft SPU/Compost, ***p. 126***
The analyses undertaken for Compost are incorrect on several points, as detailed below.

Compost replaces synthetic (N?) fertilizer in this model
replaces at what rate and how? Is it assumed all N is derived from compost? (yes, but how this is accomplished is opaque). This is an improbable scenario, given the reliance on legumes and livestock integration in addition to compost, by organic producers.

a C:N ratio of 12.5 was used. This is considered a low N compost by CDFA (78).
CDFA's analyses of C:N ratios is incorrect. While final compost C: N can range from 10/1 to 25/1 or more, 12.5 is a low C/N ratio for finished compost. At a C:N of 12.5, a compost would typically be considered to have a relatively high N content. However, note that C:N is a ratio, and does not actually speak to whether a compost has a high or low N content in absolute terms. For example, two composts could both have the same absolute N content, with very different C/N ratios.

…and is consistent with other reports (79), while still representing compost as a result of manure and municipal waste composting.
Again, this is a low C/N ratio; the cited paper (79) shows C/N ratios of 13 and 14 for greenwaste compost and manure-greenwaste co-composts, respectively, but does not suggest these are either high, or low, N composts. Note this is an example of a higher C/N compost also having a higher absolute N content.

At C:N ratios around 16 or higher, this starts to become parent material for composting, and not the finished compost itself (80, 81).

This is incorrect. Compost is made from any number of organic feedstocks, with C/N ratios varying widely (Rynk et al 1992, Epstein 1997, Rynk et al 2022). Acceptable C/N ratios for initiating aerobic thermophilic composting range from 25/1 to 40/1[1]; 16/1 is well within typical range for finished compost,[2] even as it may reflect the C/N ratio of a particular feedstock.

Currently, over ¾ of CA compost comes from manure sources, followed by yard waste (82).
While virtually all manure collected in CA is ultimately land applied, a relatively small percentage of that manure is composted prior to land application (79), suggesting greenwaste may already be a greater source of compost than manure.

There were 1.75M dairy cows and 0.67M beef cattle on feed in CA in 2017[3]. These two classes of livestock represent the main sources of recoverable manure for potential composting because they are generally relatively confined, allowing for manure collection and diversion. With milking cows producing roughly 2 cu. ft. of manure per day and beef cattle less than 1 cu. ft. per day, these animals produce approximately 7M cu. ft. and less than .67M cu. ft. per day, respectively, at roughly 88% moisture (Lorimor et al 2004). This is 2.8B cu. ft., or 104M cubic yards per year. With a bulk density of 62 lbs/cu. ft., this is roughly 86.8M tons of wet manure at 88% moisture, or 10.4M tons of dry manure. What percentage of this material is currently composted is unclear (79). California disposed of approximately 24M (presumably wet) tons of organic waste in 2018[4], of which about 13.5%, or 3.2M tons was green waste.

This parent material (sic) would lend itself to lower C:N ratios.
C/N ratios of manure and greenwaste are quite similar (Rynk et al 1997).

However, the proportions of parent material are expected to shift away from manure and towards more yard and food or municipal waste. This is due to the expected herd size reductions and expanded municipal waste collection as a result of recent legislation. This would still make manure the largest source of compost, but at a substantially lower majority.
As noted above, if all organics are successfully diverted from landfill, the tons of manure collected in CA, and landfill organics, can be expected to be

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[1] *(https://calrecycle.ca.gov/swfacilities/compostables/feedstock/).*
[2] https://anrcatalog.ucanr.edu/pdf/8514.pdf
[3] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/California/st06_1_0017_0019.pdf
[4] https://calrecycle.ca.gov/organics/slcp/education/

approximately equal in the relatively near future. However, while virtually all manure collected in CA is ultimately land applied, a relatively small percentage of that manure is composted prior to land application (79), suggesting greenwaste may already be a greater source of compost than manure.

Municipal waste, however, also produces compost with relatively low (sic) C:N ratios.
Again, C/N ratios of these various materials are similar and are not, in themselves, determinate of nitrogen content.

Therefore, to capture the current to future changes in composting C:N ratios a value of 12.5 was used that should be slightly higher than manure based, but slightly lower than municipal or yard waste composts.
As noted above, these assumptions are unfounded and have little relevance to the displacement of synthetic nitrogen fertilizer, particularly under an organic farming framework, which engages numerous practices beyond compost application to ensure adequate nitrogen cycling through the farm ecosystem.

Daycent was run on all 435 points across annual croplands in California…this modeling still provides the second most complicated modeling of NWL and incorporates the impacts of management, climate, and ecosystem dynamics into its results.
Because of low acreage assumptions used in the model runs, the net GHG impact was inevitably extremely low. With 20M acres of arable land in the state, CARB once again misses the opportunity to use the models to evaluate the potential of a full suite of sequestration practices applied on CA croplands at scale.

Carbon, N2O, and Synthetic Fertilizer

The ecosystem carbon outputs from this modeling include the biomass and soil carbon stocks and stock changes. Biomass carbon in annual croplands, however, are typically minimal, unless some HWP practices that incorporates increased biomass or even perennial biomass is incorporated.
Increased soil C through direct inputs of organic matter, such as compost, can have a significant impact on total ecosystem C. Why CARB assumes low C stock in cropland implies low C potential is unclear, but underlies the weakness of its cropland analysis.

N2O emissions from annual croplands is also included. N2O emissions can change with HSP practices. For example, with cover cropping using legumes increases

N2O emissions through time. No till can reduce N2O emissions through time. Composting only slightly reduces N2O emissions compared to BAU. … Transitioning from synthetic fertilizer to composting is incorporated in this modeling and is reflected in the Scoping Plan results. In this modeling, it is assumed that when an acre transitions to composting, it no longer receives any synthetic fertilizer. This does not change the N2O emissions very much however, because nitrogen is still being applied to the system and this model cannot distinguish the isotopic differences between nitrogen produced as a result of fossil fuels and nitrogen produced biogenically. CARB knows of no model that distinguishes between different δ15N values.

Whether or not the model is able to recognize the difference between labile synthetic N and organic forms, ACRB here fails to recognize the significant opportunity to dramatically reduce total N applied and N2O emissions from crop production through adoption of a mass balance approach to N dynamics in CA and a dramatic reduction in the influx of N into the state's working land ecosystems. An estimated 69% of the N added annually to cropland statewide is derived from synthetic N fixation, with roughly 675 Gg N applied to CA croplands annually (CNA 2016).

This ongoing infusion of synthetic N fertilizer into California's working land soils is forcing the state's N-cycle, providing much of the excess N driving ground and surface water pollution, and increasing atmospheric N_20. Cropland soils and manure management together represent 32% of N_2O emissions in the state (CNA 2016), and cropland N has been identified as a major contributor to NOX pollution in the Central Valley (Almaraz et al 2018). Leaching from cropland represents 88% of N input to groundwater in the state, with roughly one third of that N coming from dairy manure, a large fraction of which originates from synthetic fixation (CNA 2016).

Successfully addressing the anthropogenic forcing of the N-cycle in CA must involve reduction, if not total elimination, of synthetic N fertilizer use and concomitant tightening of nutrient cycles across the state through careful stewardship of all organic waste materials and their beneficial reutilization through compost production and use. By dramatically reducing use of synthetic N fertilizers, demand for organic sources of N, including diverted landfill organics and livestock manures, and, particularly, of composted organics as a source of biochemically stabilized C, N and other nutrients, can be increased, leading to greater spatial distribution of manure and composts, significantly less synthetic N entering the environment, and less loss of all forms of N to the air

and waters of the state. Substitution of endogenous organic sources of N for imported synthetic N in the state's agriculture would represent a highly significant reduction in total labile N in CA and an equally significant increase in organic C inputs to the state's soils.

Synthetic N production relies on intensive inputs of fossil fuels, with a third of GHG emissions from synthetic fertilizer resulting directly from its manufacture, while two thirds result from its use in the field (Foucherot and Bellesen 2011). As noted by Rosenstock et al (2013), "Overuse of nitrogen fertilizer threatens the health of the state's agricultural, human and natural resources." Excess N can speed soil organic carbon (SOC) decomposition (Parton et al. 2007) and thereby lower (Khan et al. 2007) soil C stocks that might otherwise increase. The high potential for applications of synthetic N fertilizers to result in a net decline in SOC –while increasing emissions of CO2 and N2O from soils- underscores another important consideration in the evaluation of relative impacts of compost versus synthetic fertilizers.

Compost -particularly mature composts made in accordance with CalRecycle standards- is produced from existing feedstocks -waste products that would otherwise require some manner of disposal- with associated potential negative environmental impacts. Critically, therefore, compost manufacture and use does not result in additional forcing of global nutrient cycles, as occurs with the manufacture and use of synthetic fertilizers, and does lead to the conservation of nutrients as well as organic carbon. By supporting the shift in agronomic demand away from synthetics toward compost, composting of waste streams, both on and off farm, can be encouraged and spatial distribution of organic resources in California can be increased, stabilizing the state's water, nutrient and carbon cycles and relieving pressure on eutrophic soils, ground waters and surface waters, while simultaneously reducing CO_2, CH_4, N_20 and NOX emissions, enhancing agricultural resilience to climate change, including drought, increasing soil water holding capacity, supporting working land productivity and sequestering C in soils.

Draft SPU, p. 129

One of the greatest benefits of biogeochemical models is estimating of the cumulative effects of actions and climate through time.

We concur and encourage CARB to evaluate the effects of implementing a comprehensive suite of GHG-beneficial practices across the full scope of the state's 20M acres of cropland.

Appendix I, p. 8

The top 30 cm of the soil is the focus of all NWL soil estimates. This is done for several reasons. First, soil inventories, consisting of empirical data, typically only quantify the first 30cm to 1m. CARB does not collect soils data, but instead relies upon the data collected by other agencies that have jurisdiction to collect such data and extrapolate it to a statewide scale. Second, soil carbon below 30cm rarely changes at a rate fast enough for inventories to detect a change [9]. Finally, best practices from the IPCC on soil carbon direct that the 30cm be the focus of inventories and assessments of climate benefits [10].

IPCC citation [10] is limited to forestry; thus, this is not a sufficient rationale, especially with regards to the C inventory and prioritization.

Appendix I, p. 23

The maximum amount of acres of HSP were determined by the California Department of Food and Agriculture and constitute a 10x increase in HSP compared to 2021 acres (Table 8).

Table 8: Annual acres of cropland climate action for each scenario, and a description of the action.

Climate action	Description	Alt 1	Alt 2	Alt 3	Alt 4
Cover cropping (legumes)	Use of a leguminous seasonal vegetative cover	12,822	9,617	6,411	3,206
Cover cropping (non-legumes)	Use of a non-leguminous seasonal vegetative cover	12,822	9,617	6,411	3,206
No Till	Growing annual crops without disturbing the soil through tillage	7,177	5,383	3,589	1,794
Reduced Till	Growing annual crops with reduced use of tillage	18,440	13,830	9,220	4,610
Compost Amendment	Application of compost to annual croplands	53,522	40,142	26,761	13,381
Transition to organic farming	Transition from conventional farming techniques to organic farming techniques on annual croplands	129,516	97,137	64,758	32,379
Conservation of Annual Cropland	Avoided conversion of annual croplands to other land use	11,120	8,340	5,560	2,780
Establishing Riparian Forest Buffers	Replacing croplands adjacent to watercourses with woody plants or trees	75	56	38	19
Alley Cropping	Planting of rows of trees/shrubs within annual croplands	22	17	11	6
Establishing Windbreaks/Shelterbelts	Planting rows of trees/shrubs within or surrounding annual croplands to reduce wind erosion	23	17	12	6
Establishing Tree and Shrubs in Croplands	Planting trees and shrubs within annual croplands	16	12	8	4
Establishing Hedgerows	Planting dense vegetation surrounding annual croplands	87	65	44	22
Establishing Hedgerows in Perennial Croplands	Planting dense vegetation surrounding perennial croplands	191	143	96	48
Establishing Windbreak/Shelterbelts in Perennial Croplands	Planting rows of trees/shrubs within or surrounding perennial croplands to reduce wind erosion	72	54	36	18

There is no explanation for how the 10x HSP acreage target was determined. It is important to note that applications for 2020 HSP incentives funding alone totaled ~500,000 MT CO2e/year. Awarded projects for 2020 HSP incentives funding totaled ~76,700 MT CO2e/year. NRCS EQIP conservation projects covered 900,000 acres in 2020 in CA.
https://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/fb08_cp_eqip.html

Appendix D, Local Actions

Simply put, the scope of analyses and recommendations provided in the Draft SPU for local action is woefully inadequate. First, the range and number of proposed actions on climate mitigation and resilience are grossly lacking, including the complete omission of potential actions and approaches for the NWL sector. This omission neglects to reflect historic work in the NWL sector and innovative efforts already underway at the local level. In some respects, local action at the regional, county, and municipal levels represents significant contributions in the NWL sector to achieving existing state climate goals. Second, CARB's analyses are largely limited to existing

approaches, including climate action planning, which indicates CARB's complete lack of understanding of existing innovations and refinements for climate resilience planning at the local level. This section is extremely limited and gravely disappointing.

Economic Analysis

Table 62: Cost/Acre of Management Actions

Landtype	Management Action	Dollars per Acre
Forest/Shrublands/Grassland	Biological, Chemical, and Herbaceous Treatments	$135
Forest/Shrublands/Grassland	Clearcut	$6618
Forest/Shrublands Grassland	Harvesting	$1626
Forest/Shrublands/Grassland	Thinning	$1457
Forest/Shrublands/Grassland	Mastication	$800
Forest/Shrublands/Grassland	Other Mechanical	$555
Forest/Shrublands/Grassland	Prescribed Burning	$412
Annual Croplands	Cover cropping (legumes)	$378
Annual Croplands	Cover cropping (non-legumes)	$378
Annual Croplands	No Till	$95
Annual Croplands	Reduced Till	$85
Annual Croplands	Compost Amendment	$200
Annual Croplands	Transition to organic farming	$3482
Annual Croplands	Conservation of Annual Cropland	$7000
Annual Croplands	Riparian Forest Buffers	$9054
Annual Croplands	Alley Cropping	$2107
Annual Croplands	Windbreaks/Shelterbelts	$30492
Annual Croplands	Tree and Shrubs in Croplands	$1024
Annual Croplands	Hedgerows	$29969
Perennial Croplands	Hedgerows in Perennial Croplands	$29969
Perennial Croplands	Windbreak/Shelterbelts in Perennial Croplands	$30492
Developed Lands	Urban Forest Investment	4.x billion in Reference
Developed Lands	Defensible Space in WUI Communities	2,500 per property
Wetlands	Wetland Restoration	$2500
Sparsely Vegetated	Avoided Conversion	$3242

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[1] *(https://calrecycle.ca.gov/swfacilities/compostables/feedstock/).*

[2] https://anrcatalog.ucanr.edu/pdf/8514.pdf

[3]https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/California/st06_1_0017_0019.pdf

[4] https://calrecycle.ca.gov/organics/slcp/education/

Many of the estimated cost/acre are grossly inaccurate and warrant an in-depth review. There was not sufficient background data, methodological assumptions provided, nor adequate time to review these (inaccurate) estimates.

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