California's Climate Change Policy Leaves Agriculture in the Dust:

Major missed opportunities for synergies in climate change mitigation and adaptation

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Executive Summary

Climate change presents California agriculture with two major challenges: how to reduce its contribution to climate change while arming itself against the threats a warming planet poses to agricultural production.

Fortunately, many of the measures that would reduce greenhouse gas emissions or sequester carbon in the soil will also make agriculture more resilient to extreme weather patterns, such as the current drought. Cover cropping, composting, conservation tillage, organic fertilization and other best management practices will increase the amount of soil organic matter, reduce erosion, conserve water and enhance fertility. This, in turn, will help increase crop productivity and drought and pest resistance in the face of an increasingly dry and hot climate. According to a January 2009, ground-breaking study by University of California at Davis researchers, these practices, when combined, will generate significant greenhouse gas reduction benefits, primarily through carbon sequestration.[1]

None of these measures were adopted or promoted in California's climate change strategy. In fact, agriculture was almost entirely left out in the California Air Resources Board's (ARB) implementation strategy for AB 32, the Global Warming Solutions Act. Of the 174 million metric tons of CO2 emissions reductions targeted in California's legally binding "Scoping Plan," not one ton is expected to come from agriculture. Of the additional possible 37.4 million tons in voluntary reductions identified in the strategy, just one million tons are expected from agriculture.

Making matters worse, the California Department of Food and Agriculture (CDFA) recently closed its environment division and currently has no full time staff, resources or web-based information specifically dedicated to the issue of agriculture and climate change. The Agriculture Climate Action Team (AGCAT), an inter-agency group established to give input to the Air Resources Board and ensure follow up on agriculture and climate change measures, has been disbanded; and most of its recommended follow-on actions were ignored.

For a state with a $33 billion-a-year agriculture industry and a history of leadership on climate change, this is completely unacceptable.

The Economic and Technical Advancement Advisory Council (ETAAC), which advises the Air Resources Board on climate change matters, estimates that by 2020, agriculture could achieve an estimated reduction of 17 million metric tons per year, or about 10 percent of California's goal.

As things currently stand, however, virtually none of this will be achieved, leaving California farmers even more vulnerable to the higher temperatures, increasing drought, frost, floods and shrinking water resources that are already putting significant stresses on the agricultural sector. By 2050, estimates show average temperatures rising by as much as 3.6° F in certain regions and the Sierra Nevada snowpack declining by as much as 40 percent.[2] These changes will result in declining crop yields, increased pests and invasive weeds, soil erosion and diminished productivity.

If for no other reason than to protect agriculture from the devastating impacts of warming temperatures, California needs its best minds and most powerful institutions working actively to

[1] De Gryze, Stephen, Catala, Rosa, Howitt, Richard E., Six, Johan. "Assessment of Greenhouse Gas Mitigation in California Agricultural Soils." California Energy Commission, January 2009.

[2] California Air Resources Board, Scoping Plan Measures Implementation Timeline, July 15, 2009

devise programs, incentives, and in a worst case scenario, regulations, that will dramatically expand the implementation of management practices that both reduce the impact of global warming on agriculture and reduce its contribution to global warming.

This must include research, communication, technical assistance and incentive programs to promote cost-effective best management practices that will reduce emissions as well as help farmers cut energy use, improve water conservation and water quality and build healthier, more productive soils. These are all critical elements in a comprehensive strategy for minimizing and adapting to the serious threats that climate change poses to California agriculture.

As a first step, the Air Resources Board, together with the California Department of Food and Agriculture, the California Energy Commission and the Natural Resources Agency, should establish an inter-agency working group on agriculture and climate change. Federal agencies, NGOs and farm groups all have critical roles to play and should be actively involved. The group would provide a much needed forum for the intensive stakeholder engagement and outreach needed to motivate real change in California's skeptical agriculture sector.

In the conclusion of this report, EWG recommends 10 specific actions that should be carried out under the auspices of a new inter-agency working group and/or under the leadership of California's chief state agencies concerned with agriculture and climate change.

Introduction

In 2006, California made history by passing the Global Warming Solutions Act (AB 32), the most far-reaching climate change legislation in the nation. In December 2008, the California Air Resources Board (ARB) approved its roadmap for implementing the law, known as the Scoping Plan. This landmark strategy sets out specific targets, rules and policies for cutting the state's emissions to 1990 levels by 2020 and for achieving an 80 percent reduction by 2050. The Air Resources Board has provided visionary leadership in addressing the potentially catastrophic threats that climate change poses to our planet and our food system – except when it comes to agriculture.

The Air Resources Board's Scoping Plan mandates 73 measures that together will reduce California's greenhouse gas emissions by the equivalent of 174 million metric tons of carbon dioxide by 2020.[2] None of these reductions will come from agriculture, even though agriculture is both a significant emitter and has the potential to take large amounts of carbon out of the atmosphere. The strategy also contemplates voluntary measures that could potentially eliminate another 37.4 million metric tons of CO2 equivalents (MMTCO2e), but only one million metric tons would come from agriculture.

In 2006, according to the Board's latest estimates, agriculture accounted for about 6 percent of California's greenhouse gas emissions, or the equivalent of 27.5 million metric tons of CO2. More than half -- 56 percent -- are in the form of methane, primarily from livestock digestive systems and manure management. Nitrous oxide (N20), a gas that arises primarily from the application of nitrogen fertilizer, constitutes another 34 percent, and the remaining 10 percent is carbon dioxide (CO2).[3] Nitrous oxide and methane are powerful greenhouse gases, 310 times and 25 times more potent than carbon dioxide, respectively.

Estimates of agriculture's greenhouse gas contributions would be substantially higher if emissions from the production of pesticides and fertilizer and from irrigation pumping were included.

Over the past two decades, extreme weather patterns linked to climate change -- heavy rains, flooding, droughts and higher temperatures -- have taken a heavy toll on US and California's agriculture, and worse is still to come.[4] By 2050, scientists estimate that temperatures will rise as much as 3.6° F in some regions and the Sierra Nevada snowpack will shrink by as much as 40 percent.[5] The consequences will include reduced crop yields, increased pests and invasive weeds, soil erosion and diminished productivity. Farmers' livelihoods and global food security are dependent on making sure that California agriculture survives and thrives by implementing strategies and policies that will reduce greenhouse gas emissions while making agriculture more resilient.

(See Appendix A for definitions of key terms)

Failed Leadership on Agriculture and Climate Change

The Scoping Plan lays out only two specific voluntary measures for agriculture: installation of methane digester systems by large livestock operations and a three-year collaborative research program into the factors affecting nitrous oxide emissions. A handful of other voluntary measures

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[3] California Air Resources Board, Emissions Inventory, <http://www.arb.ca.gov/app/ghg/2000_2006/ghg_sector.php>

[4] From1980 to 2005, US farmers suffered more than $44 billion in total weather-related crop and livestock losses. In California, farmers saw crop losses as high as 1.3 billion from the 2007 frost.

[5] Weare, Bryan C. "How will changes in global climate influence California?" California Agriculture 63(2):59-66. DOI: 10.3733/ca.v063n02p59. April-June 2009. http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v063n02p59&fulltext=yes

have agriculture-related components, including water use efficiency and increased production of and markets for compost.

Similarly, the state's first-of-its-kind draft Climate Change Adaptation strategy issued by the California Natural Resources Agency (CNRA) failed to recommend any specific agricultural measures among its top twelve priority actions. It also gave little attention to promotion of organic and sustainable management practices that can increase resiliency in the face of climate change.[6]

The Scoping Plan's lack of a serious program of action, meaningful reduction targets and policies for agriculture misses an urgent opportunity to focus action on carbon sequestration measures that will reduce emissions while helping farmers and the environment to better cope with climate change.

By 2020, according to estimates by the Economic and Technical Advancement Advisory Council (ETAAC), which advises the Air Resources Board on climate change matters, agriculture could reduce its emissions by about 17 million metric tons per year through a range of measures, including soil carbon sequestration. (see Appendix B)[7] This represents about 10 percent of California's statewide goal of a 20 percent reduction by 2020. The Agriculture Climate Action Team, an inter-agency advisory group, also provided estimates and identified various options and further actions for reducing agricultural emissions, but they were ignored by the ARB.[8]

In numerous conversations with EWG, the Air Resources Board's staff defended their limited approach by raising concerns about the potential lack of permanence of agricultural sequestration measures and the fact that California soils reach a carbon saturation point, also known as a "steady state," within just 5-to-10 years. Their biggest concern, however, appeared to be the need for more accurate baseline emission measurements and greater certainty about how much emissions will be reduced by particular practices.

These are all valid concerns that need to be addressed in the course of developing a mandatory reduction program and/or any program that allows entities to purchase agricultural "offsets" under a cap-and-trade system. However, these issues should not prevent the Air Resources Board, together with other agencies, from moving forward with voluntary targets and a more robust action plan for agriculture.

In the near term, the ARB should recognize that much is already known about the ability of best management practices to reduce nitrous oxide emissions and/or capture carbon from the atmosphere and sequester it in the soil. Until we have better data, there are tools on the market, however imperfect, that can approximate measurements of greenhouse gas emissions and reductions. By putting off action until more data is collected or difficult methodological issues are resolved, the ARB is missing a critical opportunity to motivate the agricultural sector.

Given the urgency and potential payoff, California policy makers should devise strategies, policies and research initiatives, along with outreach, technical assistance and financial incentive programs, to

[6] It should be noted that this strategy is still in draft form and will hopefully change to reflect greater attention to land based management practices; the final version will be released later this Fall.

[7] Recommendations of Economic and Technology Advancement Advisory Committee, Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California. p. 6-2. Available at: http://www.arb.ca.gov/cc/etaac/ETAACFinalReport2-11-08.pdf

[8] California Air Resources Board. "Agriculture Sector Write Up for Public Distribution AB 32 Scoping Plan," p 8.

promote practices that simultaneously reduce greenhouse gas emissions, limit energy use, deliver environmental co-benefits and build the resiliency of the farm sector.

Best Management Practices Can Reduce Greenhouse Gas Emissions

In January 2009, the California Energy Commission published a groundbreaking study by researchers at the University of California at Davis that documented major greenhouse gas reductions of .25-to-.54 metric tons per acre/per year from the adoption of four agricultural best management or alternative practices. In order of highest to lowest benefit, they are: cover cropping; organic fertilization; conservation tillage; and lower nitrogen fertilizer use. The benefits are significantly higher when these practices are combined, mostly due to increases in soil carbon rather than reduced nitrous oxide emissions.[9]

The study based its conclusions on four long-term field experiments. It applied their results, using the DAYCENT computer model, in order to estimate changes in crop yields and emissions for eight of the most abundant annual crops in 10 counties in Sacramento and San Joaquin Valleys, taking into account variations in soil, land use and climate. The study covered about 1.6 million acres in Sacramento Valley and 1.5 million acres in San Joaquin, or about 64 percent of the agricultural land in those counties.

Table 1. Estimated Emission Reduction Potential Using Alternative Practices: DAYCENT Model Applied to Sacramento and San Joaquin Counties

weighted average in metric tons of CO2 equivalents per acre per year

Single Practice	**Sacramento Valley emissions reductions per acre**	**San Joaquin Valley emissions reductions per acre**
25% reduction in fertilizer application	.35 (±.30)	.25 (±.23)
Conservation tillage[10]	.42 (±.14)	.37 (±.13)
Organic fertilizer use	.46 (±.31)	.19 (±.35
Cover crop	.54 (±.35)	.54 (±.42)
Combined Practices	**Sacramento Valley**	**San Joaquin Valley**
Conservation tillage/organic[11]	.88 (±.42)	.55 (±.36)
Cover crop/organic	1.04 (±.74)	.74 (±.56)
Organic/cover crop/ conservation tillage	1.41 (±.82)	1.08 (±.60)

Organic fertilization combined with cover cropping shows the greatest promise. Of all the practices considered in the UC Davis study, this combination (a very common practice among organic farmers), would provide the greatest greenhouse gas reductions. The estimated payoff is significantly larger with the use of other common organic agricultural practices not covered by the UC Davis

[9] De Gryze et al. (2009).
[10] This includes decreased emissions from decreased fuel use, estimated by De Gryze et al (2009) to be .10-.20 year/acre. We use an average of .15/year acre.
[11] Ibid.

study, such as composting, mulching, continuous cropping, riparian buffers, etc. Emission reduction benefits would also be greater if you account for indirect energy savings from reduced use of energy-intensive pesticides and fertilizers.

Given the significant mitigation and adaptation potential, as well as rapidly growing market opportunities, the Air Resources Board and other state agencies should make it a priority to significantly expand the .6 percent of crop acreage currently under organic practices in their strategy for reducing California agriculture's greenhouse gas emissions.

Of the best practices in this study, conservation tillage is the most widely promoted, researched, and applied, in large part due to work by the Conservation Tillage Workgroup (WG), an effort coordinated by the University of California Agriculture and Natural Resources Division and USDA's Natural Resources Conservation Service.[12]

Although the greenhouse gas benefits of limiting nitrogen fertilizer use are the smallest of the four practices, the UC Davis study strongly endorses this approach because the resulting nitrous oxide reductions are permanent, indefinitely recurring and could provide cost savings for growers. It also points out that even a 25 percent cut in fertilizer use had a minimal effect on yield, demonstrating that conventional agricultural systems often apply more fertilizer than is actually taken up by crops.[13]

Minimal Impact on Crop Yield from Best Management Practices

Overall, the DAYCENT model used in the UC Davis study predicted minimal to no changes in yield under each of the four alternative management practices.[14] This is a very important finding because farmers often resist alternative practices out of fear that their yields will decline significantly. To the contrary, many studies have shown that implementation of these practices leads to formation of healthier topsoils with greater moisture-holding capacity -- which in turn engenders higher productivity. Snapp et al (2005) found that cover cropping often increases yields by up to 15 percent, and various studies in California and Mediterranean climates have found little to no change in yields.[15] A soon-to-be- released Cooperative Extension study found increased yields in California low-desert vegetable and cantaloupe production following the use of selected summer cover crops. The same study showed that while organic yields initially lagged behind conventional production, over time organic lettuce and cantaloupe production fared just as well.[16]

This is just the beginning of what agriculture can contribute to achieving California's greenhouse gas reduction goals. There are many other carbon sequestration and emissions reduction options with important co-benefits that also need to be pursued, including continuous cropping, composting, afforestation, riparian or conservation buffers, rangeland and pastureland management, and improved animal waste management, among others.

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[12]The group, which is made up of "over 540 UC, farmer, USDA NRCS, private sector, and other public agency and environmental group members, develops knowledge and exchanges information on CT production systems, coordinates related research and extension programs related to CT, responds to needs for information on reduced tillage production alternatives, and conducts conferences, workshops, and training demonstrations."

[13] De Gryze Stephen, Albarracin, Maria V., Catalá-Luque, Rosa, Howitt, Richard, Six, Johan. 2009. "Modeling shows that alternative soil management can decrease greenhouse gases." California Agriculture. 63(2):84-90. DOI: 10.3733/ca.v063n02p84

[14] De Gryze, et al. (2009), p. 47.

[15] De Gryze, et al (2009), California Agriculture, p. 88.

[16] Blake, Cary. "Cover Crops Offer Vegetable Improvements." Western Farm Press, September 21, 2009, http://westernfarmpress.com/vegetables/cover-crops-0921/index.html

Table 2. Co-benefits of Agricultural Best Management Practices

Practice and Description	Co-benefits	
Cover Crops Cover crops, such as winter rye, clover or vetch, are fast-growing crops planted between periods of regular crop production primarily to prevent soil erosion, increase nutrients in the soil and control weeds and pests. Cover crops build organic soil matter and often add nitrogen to the soil.	*increases carbon sequestration *reduces soil erosion *reduces insect pests, weeds and diseases *attracts beneficial insects	*enhances soil fertility * reduces nutrient leaching *produces forage crop *increases water infiltration, retention * reduces need for chemical nitrogen fertilizer
Use of Organic fertilizer Use of naturally occurring organic fertilizers such as manure, slurry, worm castings, peat, seaweed, sewage, compost, and guano helps to fertilize the soil without synthetic chemicals/minerals or industrial manufacturing. Manure's slow nitrogen release better synchronizes nitrogen supply and the crop's nutrient demand.	*increases carbon sequestration *reduces N_2O emissions *reduces evaporative water loss *reduces soil erosion	*improves soil organic matter and soil fertility *reduces energy use in production of fertilizer
Conservation Tillage Crops are grown with minimal disturbance of the soil, leaving most or all of the stubble or crop residue on top of the soil, rather than plowing it under. The new crop is planted into this stubble or on small strips of tilled soil. Conservation tillage is often associated with increased herbicide use.	*increases carbon sequestration *reduces evaporative water loss *reduces runoff and soil erosion by slowing water movement	*improves soil fertility *reduces air pollution *reduces fuel consumption *reduces labor requirements *lowers production costs *grants planting and harvesting flexibility
Reduced nitrogen fertilizer use Increasing fertilizer efficiency involves matching the supply of nutrients with the specific requirements of a given crop while minimizing loss of nutrients from the soil. It can be achieved by numerous practices including: ensuring the appropriate timing of nutrient applications; increasing irrigation efficiency; using controlled-release fertilizers and nitrification inhibitors.	*reduces nitrous oxide emissions *reduces GHG emissions from fertilizer production *reduces fertilizer costs	*reduces nitrogen leaching into nearby surface and ground water *improves water quality

Reducing the Negative Effects of Climate Change on Agriculture and the Environment

The beauty of these land based management practices -- as well as others not included in the UC Davis study such as composting and mulching -- is that they will also help farmers and the environment cope with severe climate change. While they won't solve all the problems associated with a warming planet, they can help moderate four of the most important predicted consequences:

- declining water availability
- increased soil erosion
- declining yields due to heat stress and diminished soil quality
- increased pests and weeds.

By increasing soil organic matter, these practices will reduce soil erosion, conserve essential nutrients and enhance fertility, helping to increase productivity, maintain yields and resist weeds and pests. High levels of organic matter and water content will also make farming based on these practices more drought-resistant and reduce farmers' water demand/needs by improving water capture, infiltration and storage. For example, increasing soil organic matter by one percent can enhance water storage in

the soil by 16,000 gallons per acre-foot.[17] In contrast, leaving the land exposed to the hot sun greatly increases heat absorption -- leading to a significant increase in evaporation. Typical industrial farming systems have levels of soil organic matter of 3-to-4 percent, whereas organic farming systems have an average of 4-to-5.5 percent.[18]

Alternative management practices will also be essential for reducing the use of energy-intensive chemical fertilizers and pesticides that pollute California's air and water. Pests and weeds are expected to thrive as temperatures rise. Without strong alternative practices in place, it is likely that farmers will increase their use of these chemicals, with serious impacts on human health, the environment and their bottom line. Besides offering energy savings and indirect emissions reductions, organic management practices like cover cropping and advanced pest management can effectively and safely address weed and pest problems. Furthermore, by learning and implementing techniques for reducing nitrogen fertilizer applications now, farmers will be less likely to respond to diminished soil fertility by increasing their use of chemical fertilizers.

Soil-based Solutions to California's Drought

California faces an unprecedented water crisis with no end in sight. The state has had three consecutive dry years, with key supply reservoirs registering 66 percent of capacity on average heading into the 2009-2010 water year. In May 2009, UC Davis researchers predicted direct economic losses in the Central Valley of between $627 million and $710 million and increased groundwater pumping costs of between $148 million and $154 million. [19] While there are disagreements about the causes of and solutions for California's diminished water supply, one thing is certain: Persistent drought and diminished water supplies will remain a constant challenge for California farmers. These challenges will get steadily worse as temperatures rise, snowpack decreases and less rain falls.

By 2090, summer temperatures could increase by as much as 3.87°-to-14.9° F; winter temperatures will also likely increase by 3.87°-to-7.2°F. Under best-case, low-greenhouse-gas-emission scenarios, by 2090 the Sierra Nevada snowpack is expected to decline by 30 percent. Worst case, high-emission scenarios put the loss as high as 73–to-90 percent.[20] Reduced irrigated acreage in the future is expected to lead to more rapid temperature increases in the Central Valley than elsewhere, putting additional stress on plants that are already coping with dryer conditions.

Low Tech, Effective Solutions: Often lost in the mix of technological fixes to California agriculture's water problems is the capacity for cost-effective soil management practices to use water resources more efficiently and to reduce overall demand for water. Widespread promotion of practices like cover cropping, composting, mulching, conservation tillage, and use of organic fertilizer must be part of the solution. By building up soil organic matter, these practices will help farmers become more resilient by increasing soil water content, reducing evapo-transpiration and improving water infiltration so that more water can penetrate and reside in the soil. State policy makers must make it a priority to support and create incentives for these kinds of win-win, cost-effective, environmentally friendly adaptation and emission reduction measures in their efforts to address California's persistent water crisis.

[17] Kresge, Lisa, Mamen, Katy. "California Water Stewards: Innovative On-farm Water Management Practices." California Institute for Rural Studies (January 2009) p.9 Available at: http://www.cirsinc.org/Documents/Pub0109.1.pdf

[18] Troeh, Frederick R, Hobbs, J. Arthur, and Donahue, Roy L. "Soil and Water Conservation for Productivity and Environmental Protection", Prentice Hall, 2004.

[19] California Department of Water Resources. "California's Drought Update," August 31, 2009 http://www.water.ca.gov/drought/docs/DroughtUpdate-083109.pdf

[20] Hayhoe, Katharine, Cayan, Daniel, Field, Christopher B., Frumhoff, Peter C., Maurer, Edwin P., Miller, Norman L., Moser, Susanne C., Schneider, Stephen H., Cahill, Kimberly Nicholas, Cleland, Elsa E., Dale, Larry, Drapek, Ray, Hanemann, R. Michael, Kalkstein, Laurence S., Lenihan, James, Lunch, Claire K., Neilson, Ronald P., Sheridan, Scott C., and Verville, Julia H. "Emissions pathways, climate change, and impacts on California," June 2004. Proceedings of the National Academy of Sciences.

Predicted Climate Change Trends in California

- Increased drought
- Higher sustained temperatures
- Decreased chill hours
- Increased extreme temperatures, including frost
- Increased downpours and flooding
- Saltwater intrusion into farmland soil

Major Economic Impacts

- Increased damage to crops and reduced yields
- Delayed spring planting, jeopardizing profits from high-value crops (e.g. melon, sweet corn and tomatoes)
- Reduced productivity of livestock, almonds, cotton and dairy products
- Reduced quality of cherries, almonds, apples, and walnuts[21]
- Shorter growing season for cooler-temperature crops (broccoli, spinach, potato, lettuce)
- Increased productivity of okra, melon, sweet potatoes[22] and expansion of citrus and olive production
- Increased pests and weeds, leading to higher pesticide costs
- Gross revenue losses of up to $3 billion by 2050[23]
- Reduced agricultural water deliveries in Central Valley (by up to 37 percent) and reduced irrigated acreage (by 14-to-28 percent).

Major Agriculture-related Environmental Impacts

- Increased soil erosion, leading to increased sedimentation and runoff in rivers and streams
- Reduced soil fertility, leading to increased use of chemical fertilizers
- Increased chemical fertilizer runoff and nitrogen pollution in streams
- increased pests and invasive weeds, leading to increased use of chemical pesticides and tillage[24]
- Significant increases in the use of groundwater, leading to higher pumping costs and depletion of groundwater resources
- Increased salinity in soil, surface and ground water

Agriculture Offers California a Cost-Effective Path to Emissions Reductions

Adoption of these and many other agricultural best management practices would provide a cost-effective way for the state to reduce its greenhouse gas emissions while delivering improved water quality and conservation, better soil productivity, reduced air pollution and greater resiliency in the face of climate change. The state's farming community, consumers and the environment would greatly benefit from a strong state program that establishes voluntary targets, sets research priorities and offers intensive outreach, technical assistance and financial incentives to promote these practices.

In its final recommendation for the Air Resources Board's Scoping Plan, the Economic and Technical

[21] Moser, Susanne, Franco, Guido, Pittiglio, Sarah, Chou, Wendy, Cayan, Daniel. "The Future is Now: An Update on Climate Change Science Impacts and Response Options for California." California Energy Commission. May 2009, p. 45.
[22] Weare, Bryan C. "Global climate change will affect air, water in California." California Agriculture, 56(3):89-96. DOI: 10.3733/ca.v056n03p89. May-June 2002.
[23] Lee, Juhwan, De Gryze, Stephen, Six, Johan. "Effect of Climate Change on Field Crop Production in Central Valley." California Energy Commission. (March 2009) CEC-500-2009-041-D.

[24] Moser, et al. May 2009.

Advancement Advisory Council reached a similar conclusion:

"California should establish a long-term program to encourage new technology for reduced tillage, organic fertilization, cover cropping and low-input farming. This should include research (in-field and modeling), monitoring and incentive/education/outreach programs for farmers to convert to new equipment and techniques. Coupling conservation tillage systems with the use of high efficiency, slow-release nitrogen fertilizer materials under California conditions needs to be investigated, too."

Unfortunately, the inter-agency Climate Action Team on agriculture has been disbanded, leaving a leadership vacuum for implementing these recommendations and moving the ball forward. It is clear that none of the estimated emissions reductions will be achieved without more concerted action.

The Air Resources Board, meanwhile, is pursuing a very limited agenda -- supporting nitrous oxide research and voluntary reductions through methane digesters. ARB's position on agriculture is fairly well reflected in the Scoping Plan:

"As we evaluate the role that this sector can play in California's emissions reduction efforts, we will explore the feasibility of developing sound quantification protocols so that these and other related strategies may be employed in the future."

By putting off action until more data is collected, the Board is missing a crucial opportunity to inspire greater action on agriculture and climate change today, and no other state agency is taking up the slack. The California Department of Food and Agriculture has no full-time staff, resources or web-based information dedicated to the issue of agriculture and climate change. If a grower in the state wants to reduce emissions, even voluntarily, no state agency can offer specific assistance or resources. Not one state-sponsored web site has been established to provide information to help growers understand simple ways to reduce their emissions.[25] The California Energy Commission is publishing important academic papers on these questions, but there are few efforts to translate the findings into meaningful, practical guidance. This gap must be fixed.

EWG's Recommendations:

Work on climate change adaptation and mitigation must go hand in hand. The California Air Resources Board, together with the Department of Food and Agriculture (CDFA), California Energy Commission (CEC) and California Natural Resources Agency (CNRA), **should reconvene the defunct Agricultural Climate Action Team and create an Interagency Working Group on Agriculture and Climate Change** similar to the Interagency Work Group on Forestry and Climate Change.[26] The group should be charged with identifying and seeking funding for policies and programs **to reduce greenhouse gas emissions and build resiliency in California's agriculture.** Federal agencies, NGOs and farm groups all have critical roles to play and should be actively involved. The Economic and Technical Advancement Advisory Council made a similar recommendation:

[25] ARB has a manure management strategies web page; the latest posting is April 16, 2008, and the site simply posts meeting announcements. It does have a web page devoted to information on voluntary manure management protocols and information about nitrous oxide research. However, this is far from the comprehensive information portal that California farmers need for understanding how to take action to reduce greenhouse gas emissions and the threats that climate change poses to agricultural production.

[26] Information about the Interagency Forestry Work Group from ARB's website: "The purpose of the committee is to provide recommendations and technical information to assist the Board in achieving the Board's goals and objectives as outlined in the Board's report to the Air Resources Board on AB32 and in relation to the climate adaptation strategies as referenced in EO-13-08. The IFWG will establish, for Board consideration, a clear list of priorities for policy development by March 31, 2009. Available at: http://www.bof.fire.ca.gov/board_committees/interagency_forestry_working_group/

"The keys to developing the full menu of opportunities in the agricultural sector is to prioritize research needs, establish easily accessible guidance methodologies, protocols for monitoring and verification, provide ability to receive carbon credits or private and/or public incentives, conduct grower outreach and education, and receive the cooperation of regulatory agencies in developing needed infrastructure. **All of these barriers can be overcome but will require a robust multi-agency and industry cooperative effort.**"[27]

Priority should be given to promoting best management practices that reduce greenhouse gas emissions and energy use and build resiliency in the farm sector. EWG recommends the following specific actions to be carried out by a new interagency working group or the relevant state agencies.

1. **Dedicate institutional resources:** Appoint at least one, and preferably more, dedicated full-time staff to manage a program on agriculture and climate change to ensure follow-up to the ETAAC and Agriculture Climate Action Team reports and to shepherd the activities of an inter-agency working group on agriculture and climate change. Ideally there should be one full time staff at each of the relevant agencies: CEC, CDFA, CNRA and ARB.

2. **Establish a baseline**: Commission a comprehensive survey that would:
   a) establish a baseline for the current rates of adoption of land-based mitigation and adaptation practices in California;
   b) assess farmers' interest and identify barriers to implementing these practices;
   c) assess farmers' attitudes and knowledge about potential effects of climate change on agriculture.

There is currently no reliable information at the aggregate level on adoption of conservation practices in California.[28]

3. **Establish a voluntary target** for reducing agriculture's greenhouse gas emissions by 2020 and update the recommended actions in the Scoping Plan accordingly. Establishing a clear goal is a first step towards defining an action plan and measuring progress. Demonstrating compliance with voluntary targets is also an effective way for the agricultural community to avoid regulation.

4. **Provide follow-up to ensure** implementation of the agricultural measures outlined in California's Adaptation Strategy, with an emphasis on practices that provide both mitigation and adaptation benefits.

5. **Establish new incentive programs** and develop protocols for practices that will simultaneously help farmers adapt to climate change and reduce their emissions and energy inputs. Priority should be given to cover cropping, conservation tillage, organic agriculture and fertilizer efficiency, as well as other farmscape sequestration practices such as hedgerows, riparian buffers and tree planting.

6. **Increase funding for research** to:
   a) further assess soil carbon sequestration potential from a wide range of best management practices

[27] Recommendations of Economic and Technology Advancement Advisory Committee. "Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California," p. 6-2. Available at: http://www.arb.ca.gov/cc/etaac/ETAACFinalReport2-11-08.pdf

[28] De Gryze et al. (2009), p. 57.

b) identify various options for helping farmers overcome barriers to adopting soil and land-based management practices.

In addition, the inter-agency work group should monitor ongoing research activities, identify gaps, and provide a space for organizations, farmers, researchers and agencies to share information and build collaboration. [29] The information generated by these efforts should help inform scaled-up incentives, outreach and technical assistance programs needed to galvanize a significant expansion of best management practices in California agriculture.

7. **Establish specific practice-based work groups** (modeled on California's conservation tillage work group) that include UC cooperative extension, technical service providers, Natural Resources Conservation Service (NRCS) staff, farmers, researchers, NGOs and state agencies in order to build capacity, share research and practical field experience, inform policy and promote the adoption of alternative management practices that will reduce GHGs and build resilience.

8. Work closely with NRCS, the University of California Cooperative extension and state technical committee members to increase funding for technical assistance, grower outreach and cost sharing around best management strategies for greenhouse gas reduction and adaptation within USDA conservation programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program.

9. **Identify and seek support for new funding sources**, including the use of set-aside allowances from future California or federal cap-and-trade programs, to fund agricultural incentive and adaptation programs.

10. **Strengthen communication and outreach by creating a comprehensive web site and communications effort** dedicated to providing farmers with information about climate change impacts; adaptation and emission reduction strategies; and sources of possible funding, technical assistance and greenhouse gas measurement tools.

Agriculture has an important and unique role to play in helping protect our environment and food supply as part of a comprehensive policy designed to reduce greenhouse gas emissions and minimize the adverse impacts of climate change. In an era of scarce resources, the key to meeting these twin challenges effectively and efficiently is to identify and implement agricultural strategies and policies that will reduce emissions while also making agricultural systems more resilient. Unfortunately, the implementation of climate-friendly best management practices described in this report remains the exception rather than the rule in California. Clearly agriculture has a long way to go to reach its potential in reducing and mitigating emissions and the threats posed by climate change. Much stronger public and private sector leadership, an effective communications program, increased collaboration, and decisive policy action will be needed to succeed. We are confident that the establishment of a new, dynamic inter-agency working group with strong civil society and farm sector engagement and a clear agenda for action, would be a good start along the path to success.

[29] Various efforts are ongoing that would benefit from greater coordination and information sharing. In addition to ARB, CEC and CDFA sponsored research on greenhouse gas emissions from fertilizer applications. The Agricultural Sustainability Institute and CDFA are engaged in reviewing best management practices for fertilizer efficiency and nitrogen reduction. Other groups such as Sustainable Conservation, Environmental Defense and American Farmland Trust are involved in pilot programs with growers focused on nutrient efficiency and other emission reduction strategies. Industry groups, including the rice, almond and wine grape growers, are involved in carrying out research to better understand their carbon footprint and how to reduce their emissions. The Conservation Tillage Workgroup is an extraordinary source of information and experience for research, information dissemination and promotion of conservation tillage practices.

Appendix A

Key Terms/Abbreviations

Afforestation – planting forest on never-forested land

California Air Resources Board (ARB) – state agency charged with reducing air pollution by most cost-effective means possible

Conservation tillage – growing crops with minimal disturbance of the soil, leaving stubble or crop residue on top of the soil, not plowed under

Continuous cropping – growing a variety of crops year-round on a field, rather than leaving it fallow part of the year

Cover cropping – growing fast-growing crops such as winter rye, clover or vetch between periods of regular crop production on the same land

DAYCENT – widely used computer model used to simulate plant growth and microbial processes in soil that produce emissions

Enteric fermentation – fermentation that occurs in the digestive tract of ruminant animals such as cows, producing methane and other gases

Farmscape sequestration – the use of natural woody features like hedgerows, shrubs, and trees on farms to reduce greenhouse gas accumulation by extracting carbon dioxide from the air and maximizing carbon retention in the soil

Global Warming Solutions Act (AB 32) – California law enacted in 2006 that mandates a cap on the state's greenhouse gas emissions at 1990 levels by 2020

Methane digesters – devices that extract methane from cow manure for use as fuel

Riparian buffers – vegetated areas along streams and rivers that can reduce chemical and waste runoff

Scoping Plan – document prepared by the California Air Resources Board laying out its plan for compliance with the Global Warming Solutions Act (AB32)

Soil carbon sequestration – extraction and storage of carbon from the atmosphere in soils through physical or biological processes, such as photosynthesis.

Appendix B

Estimates of Feasible Emissions Reductions for 2020[30]
ETAAC – Economic and Technical Advisory Council
AG CAT – Agriculture Climate Action Team
in million metric tons of CO2 equivalents (MMTCO2E)

Activities	ETAAC estimates		AGCAT estimates	
	(MMTCO2E)	implementation rate	(MMTCO2E)	implementation rate
Manure-to-Energy Facilities	3.1	50%	1.0	100%
Enteric Fermentation	0.8	50%	0.1	50%
Agriculture Biomass Utilization	4.1	26%	0.6	25%
Dedicated Biofuels Crops	1.0	50%	1.0	100%
Soil Carbon Sequestration	3.1	50%	1.0	50%
Farmscapes Sequestration	2.9	25%	0.5	25%
Fertilizer Use Efficiency	1.8	50%	1.0	100%
Ag Pump Efficiency	n/a	--	0.2	5%
Tractor Tire Inflation	n/a	--	0.1	100%
Total	**16.8**	**--**	**5.5***	--

*The Agriculture Sector Write-Up published by ARB puts the total at 6.3 MMTCO2E; however, the estimates in the report only add up to 5.5 MMTCO2E.

[30] ETAAC, Ibid., p 6-1, and California Air Resources Board, "Agriculture Sector Write Up for Public Distribution AB 32 Scoping Plan", p 8.