Demonstrating GHG Emission Reductions in California and Midsouth Rice Production

Grantee Name:	Environmental Defense Fund, Inc.
Project Title:	Demonstrating GHG Emission Reductions in California and Midsouth Rice Production
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Project End Date:	07/31/2015

Project Deliverables

1. GHG practice methodologies and process documentation*
2. Presentations from outreach activities to recruit and assist EQIP eligible producers in CA and Midsouth*
3. New data collection methodologies and user interface tools**
4. Calibrated and validated version of De-Nitrification Decomposition (DNDC) model for major rice growing regions of the U.S.**
5. Project Description Document for rice cultivation emissions reduction pilot projects in California and Arkansas (Midsouth)*
6. Verification report(s) for pilot projects***
7. Comparative analysis of alternative GHG calculation methods and methodologies*
8. Documentation of methods for conducting spot-checks, audits, and project reviews*
9. Summary of participant surveys which assess ease of protocol use, costs, and other concerns, and implications for project replication*
10. Supporting materials for the California Air Resources Board (ARB) review; documentation of the potential approval of one or more rice methodologies*
11. Report to NRCS summarizing findings on technical feasibility, operational constraints, mitigation costs, transaction costs, and voluntary and compliance market potential*
12. Report to NRCS analyzing scale-up potential in CA and Arkansas and Report to NRCS analyzing replication potential in LA, MS, MO, TX*
13. Presentation from a training workshop for aggregators and other entities interested in implementing projects using the rice methodologies employed by this project*
14. Environmental analysis*
15. Innovative approach fact sheet*

* Supporting materials are attached, linked or reported on in this Final Report.
** Materials were previously submitted or reported on through Semi-Annual Reporting.
*** Reports will be finalized by December 2015.

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Executive Summary

This final report summarizes the results and recommendations from the *Demonstrating GHG Emission Reductions in California and Midsouth Rice Production Conservation Innovation Grant*, which took place from 2011-2015. CIG partners used the results from a previous Conservation Innovation Grant (NRCS 69-3A75-7-87) and efforts by the Environmental Defense Fund (EDF) and Winrock International (Winrock) to establish the feasibility for greenhouse gas (GHG) emissions-reducing practice implementation in the California and Midsouth rice-growing regions. In California, the acceptable practices for the generation of carbon offsets are dry-seeding, early drainage and baling, while in the Midsouth, rice growers can implement alternate wetting and drying (AWD), early drainage, baling and energy and/or water efficiency practices.

The research from the prior CIG and pilot project implementation informed the development of two scientifically validated carbon accounting protocols: (i) a quantification methodology for use within the voluntary market through the American Carbon Registry (ACR),[1] and (ii) a California Air Resources Board (ARB) adopted protocol for use in the California cap-and-trade compliance market.[2] Both protocols account for methane mitigation from rice management systems in California and the Midsouth, while the voluntary ACR protocol also includes CO_2 emissions reductions associated with reduced fuel use. The ARB protocol allows for dry-seeding and early drainage in California, and AWD and early drainage in the Midsouth.

As of the writing of this report, the California carbon credit project with four California producers representing 5,389 acres and the potential for 5,445 tons of carbon credits between 2012 and 2016 is undergoing the final stages of verification (**Deliverable 5, Appendix H**). A portion of these credits will be eligible as Early Action Offset Credits and could be sold to a regulated entity in California as soon as the ARB protocol takes effect in January 2016. As a result of this CIG, 21 growers on more than 22,000 acres (just under 1% of all rice grown in the U.S.) in California and the Midsouth are participating in offset pilot projects which have been listed on ACR's public registry.[3] Growers in the Midsouth are in the process of collecting the necessary data to generate the carbon credits; we expect the verification for this project to start in early-2016. Additional participation of growers in both regions is expected in 2016. An innovative fact sheet was developed to help continue the expansion of the market (**Appendix Q**).

The recommendations in this report reflect current science on the potential for U.S. rice growers to reduce methane emissions, since rice cultivation contributes approximately 8 MMT CO_2e (around 4%) to the total U.S. agricultural CH_4 emissions.[4] Flooded rice fields provide significant environmental benefits

[1] American Carbon Registry. (2013). Rice Management Systems. http://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-in-rice-management-systems
[2] California Air Resources Board. (2014). Compliance Offset Protocol Rice Cultivation Projects. http://www.arb.ca.gov/regact/2014/capandtradeprf14/3CTAttach2RiceProtocol051115FINAL.pdf
[3] American Carbon Registry. Public registry data retrieved from https://acr2.apx.com/myModule/rpt/myrpt.asp?r=111
[4] U.S. Environmental Protection Agency. (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013. Chapter 5, page 5-2. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Chapter-5-Agriculture.pdf

to waterbird populations that use them as surrogate wetlands.[5] From the economic analyses and pilot projects conducted during this CIG, project partners conclude that early drainage and AWD are feasible, cost-effective and can provide significant co-benefits, such as habitat preservation and enhancement, as well as improved water and energy management.

Project goals were met, and addressed the following NRCS designated priorities in the FY2010 CIG notice including:

Ecosystems Markets

The protocol adopted by ARB as a result of this CIG is part of California's cap-and-trade program, and represents the first crop-based protocol to be adopted by a cap-and-trade program.

- Development of regional partnerships, market infrastructure (such as ecosystem market registries), and integrated tools that facilitate the development of ecosystem markets

In addition to developing critical market infrastructure, ARB adoption of the protocol resulted in the development of regional partnerships to continue the implementation of the conservation practices contained in the ARB protocol. These partnerships have been critical in recruiting the 21 growers to participate in offset projects.

- Development of models and monitoring systems to analyze economic and environmental effects of ecosystem markets

The project included an economic analysis of the environmental practices and project aggregation to determine the break-even cost for a carbon credit in order to reduce the costs of producer participation. The agricultural project aggregation assessment tool (model) can be adapted to help determine the feasibility of projects from other protocols with new crops and in new geographies.

- Development and testing of verification and certification protocols for ensuring environmental benefits from ecosystem market transactions

The carbon protocols developed and adopted by ACR and ARB include monitoring and verification standards for each project submitted to guarantee the validity of the methane reductions and demonstrate that the reductions are real, additional, quantifiable, permanent, verifiable and enforceable. The ACR protocol also includes CO_2 emissions reductions associated with reduced fuel use. These standards are being tested with the first offset project in California, which is in the final stages of verification.

Climate Change Mitigation and Adaptation

Through the development of protocols and creation of pilot projects, this project demonstrated agricultural conservation practices to reduce methane emissions, a potent GHG and short-lived climate pollutant. Project partner Point Blue Conservation Science (Point Blue) investigated the potential impacts of the identified practices on waterbirds, which helped determine the practices to be included

[5] C.S. Elphick and L.W. Oring. (2003). Conservation implications of flooding rice fields on winter waterbird communities. *Agriculture, Ecosystems & Environment*, *94*(1), 17-29.

in the ACR protocols.[6] The project also considered farm profitability and included a feasibility analysis of technical, social and economic factors that influence the ability of rice growers to participate in carbon credit projects (**Deliverable 11, Appendix M**). From this analysis, we believe that there is a potential for reductions in methane emissions from changing rice cultivation practices in California and the Midsouth. While significant technical, social and economic barriers remain, it is clear that rice farmers, and eventually other crop farmers,have great potential to reduce GHG emissions and create carbon offsets.

To increase the likelihood of adoption of these practices, EDF and our partners worked to reduce participation barriers by simplifying and improving communication with growers about the protocols. CIG partners worked to lower the economic costs and administrative burdens associated with grower participation. Our experience underscores the ongoing need to reduce data collection, model validation and project verification costs. The CIG team proposes specific next steps to scale the voluntary and compliance protocols, including: (1) developing educational materials that clearly outline the potential for and risks of implementing emissions reductions for carbon credit projects, (2) providing training to a variety of carbon market participants on the next steps they can take in these and other environmental markets, and (3) further streamlining data collection and verification by aggregating multiple growers into a single project and implementing risk-based and randomized verification of projects.

I. Introduction

In 2011, EDF partnered with stakeholders, including researchers, modelers, landowners, economists, industry representatives and conservation groups, to guide and participate in the CIG process. Since significant research had already taken place under a previous CIG grant, project partners were able to immediately begin drafting the parent methodology and California module of a protocol to be submitted to ACR for consideration and adoption. Additionally, they worked with researchers in the Midsouth to identify appropriate practices locally for inclusion in the Midsouth module.

The project had five main objectives:

(1) Build upon DNDC model performance to:
    - (a) better understand user experience of the model, including associated cost and credit generation in the U.S. rice sector, by implementing two GHG demonstration initiatives involving at least six rice producers in California and Arkansas (combined)
    - (b) analyze its replication potential in other top rice-producing states

(2) Develop an innovative, user-friendly technology for growers to access immediate translation of practice changes to offset credit amounts

(3) Assess the environmental impacts of chosen practices, particularly on waterbirds in California, and provide a framework for similar assessments in other rice-growing regions

(4) Work with the California Air Resources Board (ARB) to obtain review and potential approval of one or more rice sector GHG offset protocols such that offset credits created by the CIG program participants and other producers will have value in a compliance carbon market

[6] Sesser, K.A., Reiter, M.E., Skalos, D.A., Strum, K.M, and Hickey, C.M. Point Blue Conservation Science. (2014). Point Blue Final Report.

(5) Summarize lessons learned and estimate replication and scale-up potential to inform NRCS policy, technical manuals, guides and references

Pilot projects took place in the Sacramento Valley of California and throughout the Midsouth states, although significant focus was on Arkansas, the largest rice growing region of the U.S.

EDF's Belinda Morris and Robert Parkhurst managed the project. EDF led the economic impacts assessment through partnership with academic institutions and internal economists, as well as the work with ARB to obtain adoption of a carbon offset protocol. Winrock, the California Rice Commission (CRC) and the White River Irrigation District (WRID) directed outreach to growers, facilitated pilot meetings and assisted with project development.

Terra Global Capital was responsible for drafting, editing and submission of the ACR carbon offset protocols, with significant input from EDF, Winrock, CRC and WRID. Without Winrock, CRC and WRID's firsthand experiences with these practices, neither the ACR nor the ARB protocols would have adequately reflected the on-the-ground realities of our producer partners. We collected substantial feedback from stakeholders throughout the process. ACR conducted its standard internal review, public comment and expert peer review processes to ensure the submitted protocols' scientific rigor and market feasibility. The scientific review consisted of a total of eight rounds of review, which included feedback about the measurement of nitrous oxide emissions, rigor of the calibration, yield impacts, waterbird impacts and the need to burn straw. This thorough review supported the approval process of the ARB Compliance Protocol and the adoption of ACR's protocols as an ARB-approved Early Action Protocol.

To support the protocol development, Point Blue conducted a detailed study of potential practices in California for waterbird impacts. DNDC-ART calibrated and validated the DNDC model and provided uncertainty analyses. Academic partners at University of California at Davis (UCD) and University of Arkansas conducted field sampling and analysis that laid the groundwork and scientific basis for the quantification methodologies and model calibration and validation. These strategic partnerships were essential to completing the CIG deliverables.

Terra Global Capital also led the creation of a user-friendly technology (Middle Layer) for growers and the generation of the first credits. Partnership with CRC and WRID was critical in identifying the 21 growers who are currently participating in the three projects listed on ACR's public registry.[7] Validation and verification of the first California pilot project is being conducted by Environmental Services, Inc.

This project received matching funds through the support of a number of individuals, foundations and in-kind support from partner organizations. As noted in our final financial report, the CIG met a large portion of its financial match obligation through in-kind contributions from Winrock, WRID and DNDC-ART. Additional matching funds were provided by the Packard Foundation and an anonymous EDF donor interested in the potential for agriculture-based carbon protocols.

[7] American Carbon Registry. Public registry data retrieved from https://acr2.apx.com/myModule/rpt/myrpt.asp?r=111.

II. Background

Growers in the U.S. have an unmet potential to participate in ecosystem markets. This project identified practices that rice growers could implement to potentially receive payments from measurable improvements in resource management and GHG emission reductions. Project partners identified scientifically sound management practices and created carbon offset protocols to encourage GHG emission reduction on rice lands, while producing real co-benefits, such as habitat maintenance and protection. As a result of the work in this CIG, rice producers can be rewarded for achieving real environmental benefits and enhancing the quality of their rice agroecosystem.

Prior to this project, conservation practices had been developed and promoted without a way to monitor and track changes in GHG emissions. However, the California Rice Commission and White River Irrigation District began to increasingly conduct whole farms assessments to identify the most appropriate ways to maintain or increase rice production while decreasing emissions and enhancing wetland habitat. These assessments fed into the success of our project's carbon offset protocols, which address the natural resource issues of land, water and energy use. The new practices and strategies vetted through this CIG add to the toolbox of options that rice growers can draw upon to help preserve important ecosystems while mitigating methane emissions. Most importantly, the ARB protocol is the first crop-based protocol to be accepted into a cap-and-trade system, setting the stage for other protocols to follow, such as nitrogen fertilizer management for corn or almonds, wetlands management and grassland preservation.

Prior to this project, rice growers and land managers did not have access to adequate science to enable them to quantify GHG emission reductions originating on their lands. Now, two carbon quantification methodologies based on foundational research are published as opportunities for rice growers to explore and use in either the voluntary or Californian carbon market. Nationwide, the agricultural community, conservation sectors, climate change researchers and adaptation professionals will benefit from this project.

III. Review of Methods

The practices explored through this CIG will result in positive economic and conservation outcomes for rice growers. However, social and economic barriers remain. The key economic challenges are the cost of project development and the price of carbon. Main social constraints are fears of regulation, lack of market knowledge and confidence, and the substantial investments of time upfront without seeing benefits. Solutions to each of these challenges were explored through this CIG and are discussed in detail in this section.

In addition to looking at the challenges of implementation, project partners used the latest science to identify practices and develop protocols for implementing and accounting for the GHG reductions from those practices. The protocols developed are rigorous and innovative because they account for variations in rice-growing area soils, weather and methane-impacting practices. Rice producers can now generate field-specific credits as a result of the science employed in the development of these protocols; they establish methods for accounting and modeling practice outcomes in different geographies, with

different soil types and dynamic weather. Carbon credits function as an additional incentive for implementing new GHG emission reduction practices.

A thorough discussion and comparison of all the existing rice offset protocols is included in the *Comparison of Protocols* report as **Deliverable 7, Appendix L** for this CIG. Between February 2011 and June 2015, EDF actively participated in and supported the development of five different carbon offset protocol modules with three different organizations. These protocols are: Climate Action Reserve's (CAR) Rice Cultivation Project Protocol, American Carbon Registry's (ACR) Voluntary Emission Reductions in Rice Management Systems (**Appendices A, B and C**), and the California Air Resources Board's (ARB) Rice Cultivation Projects Compliance Offset Protocol (**Appendix D**). The ACR protocol was divided into three different modules – one parent methodology, one methodology for California and a third methodology for the Midsouth. Each of these protocols built on experience from the previous version.

As proposed, the project undertook five main tasks to achieve the following five objectives:

1) Validate/test the DNDC model

Throughout the CIG, project partners, including EDF, Winrock/ACR, DNDC-ART, University of California at Davis and University of Arkansas, identified the data necessary to calibrate and validate the De-Nitrification Decomposition (DNDC) model for the chosen practices in each rice-growing region.

DNDC-ART completed the calibration and validation of the DNDC biogeochemical model for both the California and Midsouth regions. The DNDC biogeochemical model is a process-based model for quantification of GHG emissions from agricultural fields. For California, the model was calibrated and validated using recent field data collected by UC Davis and published data from the 1990s. For the Midsouth, the model was calibrated and validated using field data collected by the University of Arkansas Rice Experiment Station and processed by UC Davis, as well as published data from the 1990s and early 2000s.

This data was the basis for evaluating the accuracy of modeled estimates of baseline and project emissions through comparison to independently collected field data, and calculating the required structural uncertainty deductions to ensure that credits awarded under the methodology are conservative. The first step in developing the uncertainty deduction calculation was to assemble an independent validation data set including a relevant set of treatments at multiple representative locations within the region or regions under consideration. DNDC-ART compiled 87 site-treatment combinations of field measurements from California, Texas, Louisiana and Arkansas. Each of these treatments was compared with the modeled results, and used to compute model errors and residuals. Follow-on testing allowed for the assessment of the presence of bias between baseline and project treatments. These steps were all conducted using maximum likelihood estimation. Through this analysis, DNDC-ART determined that the model is not biased and model performance is not statistically different across the different rice growing regions in the U.S. ARB reviewed and adopted this approach for quantifying model structural uncertainty with a single deduction factor of 0.128 $MTCO_2eq/ha/yr$.

2) Develop a proof of concept for user interface technology and train aggregators and landowners to use the technology to estimate potential GHG reductions on their fields

Terra Global Capital and Applied Geosolutions developed a proof of concept for a user interface technology (Middle Layer) that uses project data to more easily estimate potential GHG reductions on growers' fields. Towards the end of development of the Middle Layer, the California Air Resources Board executed a contract for a separate tool to be used in conjunction with the ARB protocol. The work on the Middle Layer was critical in speeding the creation of the ARB tool. ARB contracted with Michigan State University to develop, deploy and maintain the Rice Cultivation Compliance Offset Protocol Emission Reduction Quantification Tool (RCOT). As part of this effort, DNDC-ART is creating a new version of DNDC to insure that users can only change input parameters allowed by the protocol and that the model outputs are streamlined for efficient post processing of model outputs according to the ARB Rice Cultivation Project Compliance Offset Protocol. The RCOT tool enables users to enter management information, automatically perform rice growth calibration steps, and create and post-process DNDC inputs and outputs. In addition, ARB has contracted a firm to develop training for verifiers on how to verify the protocol. These actions demonstrate significant commitment to support and implement the ARB protocol.

Tools to implement the protocols are one part of the equation toward the adoption of new conservation practices. Outreach and education of growers is another critical component for the broad-scale adoption of the identified conservation practices. Partners in the Midsouth conducted 17 grower outreach workshops, training workshops, and communicated the results of the team's research and experiences developing pilot projects. The majority of grower outreach was conducted in Arkansas, although presentations were made to growers at meetings in Mississippi, Louisiana and Missouri. Attendance at these meetings ranged from as few as 20 participants to as many as 230.

The training workshops focused on translating the requirements of the protocols between growers and project developers. Generally, growers are not familiar with carbon markets and project developers are not familiar with farming. Therefore, education of both parties is necessary. Multiple meetings were conducted during the grant period to train project participants on the aspects critical to making the pilot projects and the future market a success.

Beyond the immediate stakeholders participating in the grant, we have communicated our experience and research to the broader communities that project partners represent. Project partners gave presentations about the practices which could be implemented at scientific meetings, grower meetings and offset trade group meetings. A comprehensive listing of meetings is included as a part of **Deliverable 2, Appendix E**.

3) Implement voluntary GHG reduction pilot projects in California and Arkansas and register GHG reductions on at least one recognized carbon registry

In total, 21 growers on more than 22,000 acres (just under 1% of all rice grown in the U.S.) in California and the Midsouth are participating in three offset projects which have been listed on ACR's public registry. In California, 13 producers representing 19,213 acres are participating in two ACR listed projects. The first project, which was listed in March 2014, includes four producers totaling 5,389 acres and is currently undergoing verification (**Deliverable 5, Appendix H**). Project partners expect to generate the first credits by the end of 2015. A portion of these credits may be converted to Early Action Offset Credits under California's cap-and-trade regulations, pending a successful desk review by a secondary

verification body accredited by ARB, and sold to a regulated entity in California or Quebec as soon as the ARB protocol takes effect in January 2016. These credits will be the largest volume ever generated by a crop-based protocol in the U.S., and they are an important milestone and demonstration of the protocol and the role crop-based offsets can play within an environmental market.

In the Midsouth, the third offset project includes over 3,000 listed acres with eight participating farmers. These growers are working with a project developer to generate the first vintage of credits which are already under contract to the local utility, Entergy Corporation. Partners expect generation of credits from this project in mid-2016.

On June 25, 2015, the ARB Board unanimously voted to adopt the Rice Cultivation Project Compliance Offset Protocol and related regulatory updates. Between now and December 31, 2015, rice growers throughout the U.S. can create offsets for sale to regulated companies in California and Quebec using either the ARB developed Compliance Offset Protocol or the Voluntary Emission Reductions in Rice Management Systems protocol adopted by ACR. Starting in January 2016, growers can continue to use the ARB protocol, but can only use the ACR protocol to generate carbon credits for sale in the voluntary market.

4) Work with partners in Louisiana, Mississippi, Missouri and Texas to evaluate replication potential in those states, based on findings of the pilot projects in CA and AR

The replication potential of the protocols developed by this project is significant. As detailed in our *Analysis of the Scale-up Potential for Carbon Credits from Changing Rice Cultivation Practices,* **Deliverable 12**, **Appendix N**, we estimate that 3,067,637 tons of CO_2 equivalent is the maximum annual abatement potential from the implementation of rice cultivation practices across all rice fields in the California Sacramento Valley and Midsouth rice growing regions. This analysis included the following methane reducing practices: dry seeding, early drainage, AWD, and baling. For California, the maximum abatement annual potential is 599,417 tons of CO_2e. For Louisiana, Mississippi, Missouri and Texas, specifically, the maximum annual abatement potential is 2,468,220 tons of CO_2e.

Recognizing that achieving the maximum abatement potential is difficult, project partners explored the feasibility of implementing all the methane reducing practices across the California and Midsouth rice-growing regions. The results of this analysis can be found in our *Analysis of Rice Protocol Project Feasibility*, **Deliverable 11**, **Appendix M**. As part of the analysis, project partners looked at the technical, social and economic feasibility of implementing the identified practices. While significant technical, social and economic barriers remain, it is clear that opportunities exist for rice farmers, and eventually other growers of crops, to reduce GHG emissions and create carbon offsets.

In addition, not surprisingly, partners determined that improving the economic feasibility of projects will encourage the uptake of technically feasible practices. Currently the largest cost of a project is third-party verification. Key to reducing this cost is aggregating multiple growers into a single project and implementing risk-based and randomized verification of projects. ARB has initiated a Verification Pilot Program to determine how this can be done within California's cap-and-trade program.

Finally, production risks associated with technically feasible practices currently discourage implementation, but can be lessened with advisor guidance on the best practices to implement for each specific farm or field.

5) Assess environmental impacts of GHG reduction practices

Project partners collaborated with a variety of stakeholders to assess the potential environmental impacts of implementing the identified methane emission reducing practices. In August 2014, Point Blue completed a report entitled *Waterbird Response to Practices Aimed at Reducing Greenhouse Gas Emissions from Rice Fields in the Sacramento Valley* (**Deliverable 14, Appendix P**) which provides a detailed study of the potential impacts of methane reducing practices on waterbird habitat based on field research conducted December and January of 2011-2012 and 2012-2013. As noted in their report, post-harvest flooding of rice fields in the Sacramento Valley is estimated to provide 85% of the winter habitat for waterbirds. The potential impacts to waterbirds of these practices, particularly baling and drill seeding, were not well-understood prior to the Point Blue study. The primary conclusions of this study were that baled and then flooded fields have lower densities of waterbirds than fields that were not baled. Furthermore, ducks and shorebirds were significantly associated with flooded fields, with ducks not observed in non-flooded practices. As a result of these findings, the practices of no winter flooding and baling were not included in the ARB compliance protocol, and the no winter flooding practice was removed from the California module of the ACR protocol.

Winrock also provided a synthesis report analyzing the potential environmental impact of the protocol's methane reducing practices on waterbirds in the Midsouth. Their report notes that "baling rice straw may not negatively impact waterfowl if habitat structure, food sources and winter flooding levels are actively managed for bird habitat." Baling may not be the largest driver impacting waterbirds in the Midsouth, however. New hybrids, more efficient harvesting, ratoon cropping and non-rice crops could all have an impact on waterbird populations. The report concludes that additional research in the Midsouth can continue to refine our understanding of how rice and water management practices interact with waterbird habitat and food sources. A complete copy of the report can be found in **Deliverable 14, Appendix O**.

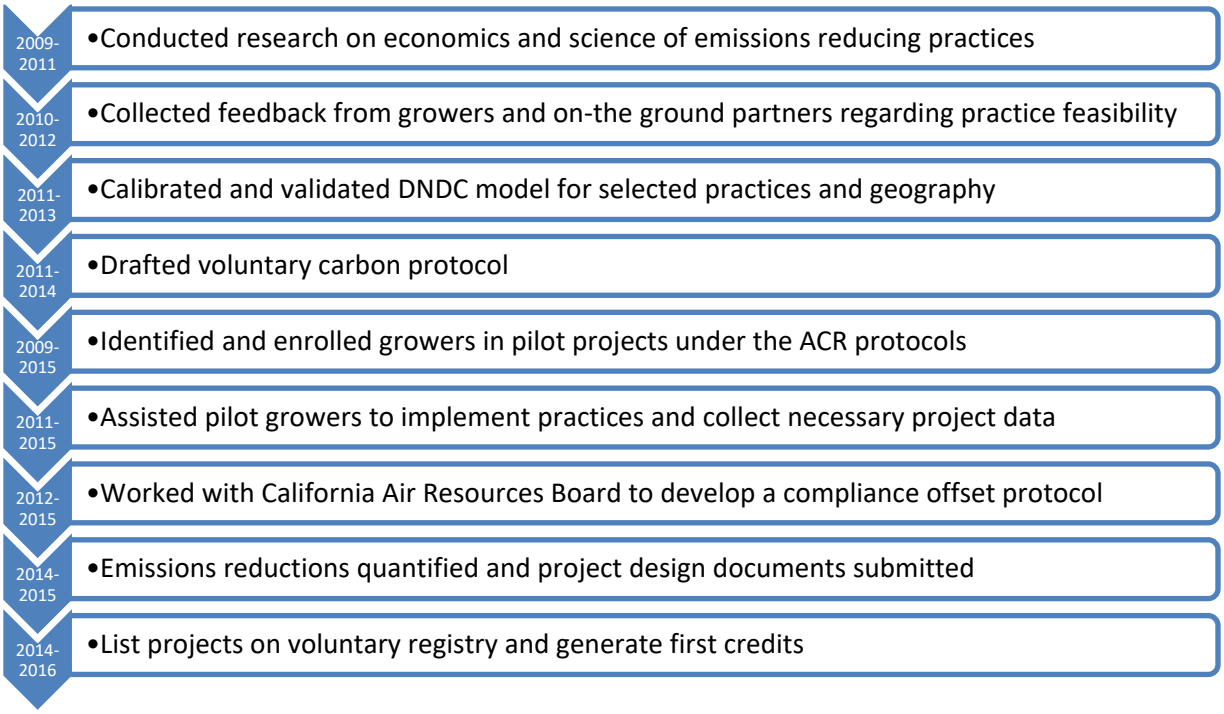
Grant Milestones and Timeline

Milestones

- May 2013 – ACR adoption of *Voluntary Emission Reductions in Rice Management Systems*
- May 2013 – ACR adoption of *Voluntary Emission Reductions in Rice Management Systems – California Module*
- November 1, 2013 – Calibrated and validated DNDC model provided to ARB to support development of ARB's rice cultivation protocol
- March 2014 – ACR adoption of *Voluntary Emission Reductions in Rice Management Systems – Mid-south Module*
- March 2014 – Listing of the first rice offset project with four California growers on 5,389 acres

- August 2014 – Point Blue report on *Waterbird response to practices aimed at reducing greenhouse gas emissions from rice fields in the Sacramento Valley* completed
- December 2014 – Listing of the first Midsouth rice project with eight growers on more than 3,000 acres and listing of the second California rice project with nine growers on 14,223 acres
- June 2015 – Synthesis report on *Rice and Waterfowl Habitat in the Mid-South* completed by ACR
- June 25, 2015 – Unanimous vote by the California Air Resources Board adopting the *Rice Cultivation Project Compliance Offset Protocol*
- Winter 2015 – issuance of the first offset credits under the ACR protocol
- January 1, 2016 – ARB *Rice Cultivation Project Compliance Offset Protocol* takes effect

Timeline



Discussion of Quality Assurance

EDF ensured that the data used by our partners to calibrate and validate the DNDC model and generate carbon credits was of the highest quality by using scientifically accepted data collection procedures and working closely with the pilot producers for farm-specific information. The procedures for calibration, validation and uncertainty estimation were included in significant detail in CIG semi-annual reports. As highlighted earlier in this report, calculating the uncertainty deduction calculation required assembling an independent validation data set, including a relevant set of treatments at multiple representative locations within the region or regions under consideration. The data were used in an information-theoretic approach using Akaike information criterion to identify whether the underlying error structure was additive or multiplicative, and to screen alternative models representing different assumptions about the random effects (site, state, region and year) influencing DNDC prediction errors. Follow-on

testing allowed for the assessment of the presence of bias (using equivalence testing) and homogeneity of variances between baseline and project treatments. These steps were all conducted using maximum likelihood estimation. Once the final model and its error structure had been identified, the model was re-fit using restricted maximum likelihood estimation (REML) to provide more efficient estimates of the variance components of the model.

Development of the protocols included extensive public and scientific review. Each of the bodies creating protocols afforded different opportunities to comment on the protocols. During development of the CAR protocol, 10 organizations provided public comments on the first draft. There were 89 comments in total which thoroughly covered every section except for Reporting and Record Keeping. The scientific review associated with the development of the ACR protocols consisted of eight rounds of review in total. The review included feedback about the measurement of nitrous oxide emissions, rigor of the calibration, yield impacts, waterbird impacts and the need to burn straw. The ARB protocol review included four technical working group meetings, two general workshops and two board meetings. A complete summary of the protocol review process can be found in **Deliverable 7, Appendix L.**

As a matter of practice, carbon credits generated through the use of the ACR and ARB protocols undergo rigorous third-party validation and verification to demonstrate that the offsets meet the requirements of being real, additional, quantifiable, permanent, verifiable and enforceable. Substantial evidence must be provided in order for offsets to be created and sold. This information includes land ownership records, model runs and calculation outputs, raw input data and agronomic data (such as planting and harvesting date). Using current methodologies, the monitoring and verification costs are extensive. Further discussion of these costs is included in the *Analysis of Rice Protocol Project Feasibility*, **Deliverable 11**, **Appendix M**.

IV. Findings

The findings support the goals of the project as evidenced by the creation and approval of the protocols and the listing of the first offset credit projects. With input from partners, growers and stakeholders developed the protocols to provide rice growers with new opportunities and economic incentives for specific methane reducing practices. (The protocols and supporting documentation are included as attachments to this report (**Deliverables 1 and 10, Appendices D, I-K**)). They also pave the way for the development and adoption of other crop-based compliance offset protocols.

Protocols

Through this CIG, a modular rice cultivation carbon protocol was approved by the American Carbon Registry, which includes a parent methodology as well as two regionally applicable modules, one for California and another for the Midsouth. In addition, a Compliance Offset Protocol was adopted by the California Air Resources Board. The experience developing the protocols with ACR was critical to the success of the adoption of the ARB protocol; the ACR protocols were, in fact, used as the template for the ARB protocol and were the only protocols granted authority for the generation of Early Action Offset Credits. Furthermore, without the calibration and validation of DNDC, neither the creation of the ACR nor the ARB protocol would have been possible. These protocols provide rice growers and other land managers with new options and economic incentives for specific GHG reducing practices. (The protocols

and supporting documentation are included as attachments to this report (**Deliverables 1 and 10, Appendices A to D and I to K**)).

Using experience gained through this CIG, project partners were active participants in ARB's rice cultivation protocol rulemaking between March 2013 when it started and the end of the grant period on July 31, 2015. EDF worked closely to educate stakeholders and Board members on the various aspects of the protocol (**Appendix R**). On June 25, 2015, ARB Board unanimously voted to adopt the Rice Cultivation Project Compliance Offset Protocol and related regulatory updates. This represents the first crop-based protocol to be adopted by a cap-and-trade program and, beginning January 1, 2016, regulated entities in California and Quebec can use offsets generated under either the ARB protocol or Early Action Offset Credits generated under the ACR protocol. Furthermore, it sets the stage for the adoption of other compliance offset protocols for agriculture. Project participants are continuing to support this effort beyond the grant period and through the finalization of the documentation required to add the rice protocol to the California Code of Regulations, as well as to generate the first offset credits under both the ACR and ARB protocols.

Information and research collected through the economic analysis of this CIG have been especially helpful, highlighting the need for further development of analyses for future agriculture-based protocols. As identified in the project feasibility analysis, verification of projects is one of the – if not *the* – largest costs to credit generation. Therefore, despite the interest in these practices and protocols, the overhead costs to create these projects must be reduced for this market to become self-sustaining. The verification costs alone can be equal to or more than the value of the credits generated. This is primarily because ARB regulations currently require that verifiers "must make at least one site visit for each Reporting Period that an Offset Project Data Report is submitted."[8] For this type of project, a Reporting Period is a growing season. To address this cost, ARB has initiated a Verification Pilot Program, in large part due to CIG project partners' advocacy demonstrating the cost-effectiveness of risk-based and randomized mechanisms rather than the time-consuming and intensive field-based approach that was included in the ARB compliance protocol. The Verification Pilot Program is expected to start in early 2016. This Pilot will test alternative, less costly verification options to determine if they result in a similar outcome. Results will inform opportunities for ARB to modify the regulations to allow for other verification methods to be used to reduce the costs of developing a project. The leading approach at this time is the implementation of risk-based and randomized verification, which has already been successfully implemented on agricultural carbon projects under Alberta's GHG reduction policies.

Analysis of Rice Methane Mitigation Practices

In our initial proposal, we suggested that California pilot producers undertake at least one of the three following practices: minimizing/avoiding winter flooding, removal of rice straw or drill seeding. We proposed that Midsouth growers consider at least one of five practices: early drainage, use of hybrid seeds, remote sensing and remote flooding control, water pump efficiency improvement, and shifts from contour levee to precision-grade fields.

[8] California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms to Allow for the use of Compliance Instruments Issued by Linked Jurisdictions. (2015). 95977.1 (b)(3)(D).

Through this CIG, we have narrowed down the overall list of acceptable practices in California to dry (drill) seeding and early drainage, and in the Midsouth to AWD, early drainage, and increasing water and/or energy use efficiency. Water and energy use efficiency is not an acceptable practice for the ARB Protocol because fuel use is regulated in California. Baling is also not included in the currently adopted Compliance Offset Protocol as ARB "determined additional time and information is needed to accurately assess the impacts of baling on the environment and wildlife."[9] ARB staff did commit to continuing to "review and evaluate information and propose the addition of this project activity, if warranted, in a future update to the protocol."[10] These changes have been reflected in semi-annual reports as the science has developed.

Dry seeding, the practice of sowing dry seeds rather than aerially applying pre-germinated seeds, involves additional equipment and, while common in the Midsouth, the practice has not been broadly adopted in California. In fact, in the early part of the 20th century, most California farmers switched from dry to wet seeding rice to manage the wild grass *Echinochloa crus-galli*.[11] Project partners explored the risks associated with dry seeding in California, and identified nine specific risks that must be taken into account before a rice farmer decides to change from wet seeding to dry seeding, including delayed planting and harvesting, water management, weed development and capital costs. More detail about these challenges can be found in the *Analysis of Rice Protocol Project Feasibility*, **Deliverable 11**, **Appendix M**.

Early drainage, the practice of draining a field 7-10 days earlier than usual, yields substantial methane reduction as methane generation reaches its peak at the end of the growing season. It has not been broadly implemented in the past due to concerns about impacts to yield. But recent research has demonstrated that limiting early drainage to no more than 10 days prior to typical harvest does not result in an impact to yield.[12]

Alternate wetting and drying is accomplished by draining a field three to four times during the growing cycle. This practice disrupts the methanogens responsible for methane generation. One of the primary challenges with this practice is that it requires changes in how fertilizer is applied to the crop. If nitrogen fertilizer is applied to a dry soil surface as is done in the Midsouth, much of the nitrogen is lost as ammonia if the field is not flooded within a four day period. Allowing the field to dry for less than 15 days following a urea nitrogen application will result in a spike of nitrous oxide emissions and significant ammonia losses. This process dictates that, following a urea nitrogen application to dry soil, a flood of 2-4 inches must be maintained for a minimum of 12-14 days before the field is allowed to dry.

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[9] Staff Report and Compliance Offset Protocol, Rice Cultivation Projects. (October 28, 2014). California Air Resources Board. http://www.arb.ca.gov/regact/2014/capandtradeprf14/capandtradeprf14isorappb.pdf

[10] *ibid.*

[11] Rao, A.N., Johnson, D.E., Sivaprasad, B., Ladha, J.K., Mortimer, A.M. (2007). Weed Management in Direct-Seeded Rice. *Advances in Agronomy, Volume 93*. 153–255.

[12] Wassmann, R., Lantin, R. S., & Neue, H. U. (Eds.). (2012). *Methane emissions from major rice ecosystems in Asia* (Vol. 91). Springer Science & Business Media.

The water and/or energy use efficiency practice allows growers to adopt any technology or measure that "demonstrably increases water and/or energy use efficiency."[13] The ACR protocol identified five potential practices that could be implemented by growers to reduce water and/or energy use:

1. Conversion of ungraded fields to precision grade, precision grade to zero grade, or ungraded fields to zero grade
2. Improved pipe configuration (e.g., side inlet systems, poly piping/poly tubing systems) which lead to more rapid flood establishment
3. Switch to more energy efficient combustion engines
4. Switch from pumps using combustion engines to electric pumps
5. Adoption of soil moisture sensors that can reduce water consumption by allowing more precise tailoring of flooding and draining to the water needs of rice plants

However, water and/or energy use efficiency practices are not allowed under the ARB protocol because fuel use in California is regulated under the cap-and-trade program. As a result, California growers cannot implement practices that reduce fuel use to generate credits. Since California growers are not allowed to implement these practices, growers in the Midsouth are not allowed to generate credits from them either.

As noted in **Deliverables 11 and 12** (**Appendices M and N**) , the most feasible practices for any unique grower will vary depending upon farm-specific characteristics, such as soil type, geography and location, and growers' ability to participate in a carbon credit project. While baling yields the highest abatement potential, potential waterbird concerns and expensive practice costs prevent us from recommending that practice (see also **Deliverable 14, Appendix O**).

VI. Summary of Outreach and Lessons Learned

EDF and project partners conducted significant outreach on the rice management practices throughout the grant period and, based on the number of growers participating in projects listed with ACR, we are pleased with the results – 21 growers on more than 22,000 acres. A number of factors contributed to this success of outreach. First, the majority of GHG reduction practices developed under this project were not significantly different than current practices. Draining fields 7-10 days early does not require significant effort on the grower's part, yet the practice yields very significant reductions in methane emissions. Alternate wetting and drying requires modest investment, but yields substantial co-benefits of up to a 30% decrease in water use in the Midsouth.

In addition, using trusted advisors to communicate with growers helped gain their confidence and support. The California Rice Commission (CRC) has as long history of working with growers to implement environmental projects, and growers trust their recommendations. CRC conducted outreach through multiple channels including routine conferences, CRC committee meetings, mailers and personal outreach to key influential growers. CRC was aided in their outreach by the University of California Cooperative Extension which assisted greatly with the technical understanding of these practices and

[13] ACR Protocol

their impacts on rice cultivation in California. Ultimately their combined outreach resulted in the enrollment of 13 growers on 19,213 acres during the project period.

In the Midsouth, White River Irrigation District (WRID), a trusted voice in the region, led the effort that pulled together an impressive network to support carbon credit outreach. WRID was supported by Winrock, Mississippi State University, Arkansas State University, USDA's local Agricultural Research Service branch and the University of Arkansas Cooperative Extension Rice Experiment Station. WRID's role was to provide the organizational structure and local interaction between the "carbon trading structure" and the growers who are ultimately the decision makers and carbon credit generators. Partners in the Midsouth have honed their message, becoming more specific given market realties, difficulties in measurement methods and recordkeeping requirements (**Appendices F and G**). They focused on obtaining at least one AWD cycle about 20 days after the initial flood and converting contour levees to zero grade or precision leveled fields. Ultimately, adoption will be driven by an increase in the carbon price and decrease in administrative costs, as has been highlighted throughout this report.

Traditionally, outreach and education are seen largely as a one-way flow of information from experts (usually agricultural scientists) to producers. For this grant, we took a different approach, as described in our original grant application, by including local agronomic experts who helped advise and shape the development of both the ACR and ARB offset protocols. These experts were critical in identifying the practices to be made available under the protocol, adopting realistic monitoring and measurement requirements, and educating project developers, environmental groups and ARB staff about on-the-ground practices and realities. The result of their early engagement and partnership was the significant participation of growers in initial projects.

A final consideration driving outreach and participation was in the October 28, 2014 draft protocol, where ARB stated that "[a] project may be eligible for ARB offset credits, as specified in subarticle 13 of the Regulation, for GHG emission reductions as a result of implementing eligible project activities in cultivation years that started as early as 2006 if the project is listed with an Offset Project Registry or ARB prior to December 31, 2014."[14] The ACR protocol was the only protocol available for use at the time and this prompted nine California growers to list 14,223 acres in a second project on ACR's registry on December 30, 2014. In the May 20, 2015 final draft of the protocol, ARB extended the early action deadline to December 31, 2015, which allows even more rice growers to participate in early action projects.[15]

Outreach around each of the protocols supported the goals of the project. CIG project partners will continue to gather input from crucial stakeholders to inform updates to these protocols and to improve the science, economics or geographic applicability of these practices. Additional outreach will be necessary to expand the use of these protocols in ways that maximize the benefits to the environment and to U.S. rice growers.

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[14] Compliance Offset Protocol Rice Cultivation Projects. (2014) California Air Resources Board. Retrieved from capandtradeprf14isorprotorice.pdf, page 17

[15] Modified Regulation Order. Retrieved from http://www.arb.ca.gov/regact/2014/capandtradeprf14/2CTAttach1RegOrder051215FINAL.pdf, 95990 (c)(1), page 9.

VII. Conclusions and Recommendations

This project demonstrated how carbon markets can encourage farmers to reduce GHG emissions in a way that does not significantly impact yield and provides for a new revenue stream. The practices identified by the project provided improved quantitative measurements of practices that reduce GHG emissions and contribute to climate change mitigation potential from U.S. rice cultivation.

The project will also generate the first compliance-eligible carbon credits for any crop-based practice. By the end of 2015, credits will be generated for the first California rice cultivation offset project. By mid-2016, the first credits are expected for the first project in the Midsouth. These credits will not only provide new revenue for farmers, but will also provide regulated California companies with a cost-effective method of meeting their compliance obligations.

For these protocols to be successful and expanded, however, several major hurdles must be overcome. First, verification costs must be reduced for growers to be willing to consider implementing the practices identified by this protocol. Verification is the largest single cost of creating a credit and can exceed the current market price of credits. Successful implementation of the ARB Verification Pilot Program and modification to the cap-and-trade regulations are the next key steps in identifying opportunities to streamline the process and reduce costs.

The complexity of collecting the data and calculating the corresponding GHG reductions is another challenge. Running the DNDC model is extremely complex and requires significant expertise. This is why project proponents developed the Middle Layer proof of concept user interface technology that allows farmers to more easily enter data and estimate potential methane reductions. This information was also of significant value in the ultimate development of the Rice Cultivation Compliance Offset Protocol Emission Reduction Quantification Tool (RCOT).

Some farmers believe they will not be paid enough for their efforts. While many farmers want to be good stewards of their land, they will need to see high market prices to justify conforming to carbon protocols. Under current compliance market prices of about $10 per acre, the farmer is expected to receive approximately $7 per acre. In the Midsouth, the typical cost for monitoring can exceed $5 plus the initial costs of monitoring equipment, yielding no financial return. But the good news is that the "floor" price of allowances in the California cap-and-trade program increases annually at 5% plus inflation and, to date, the offset market has tracked those increases. Over time, this effect is expected to increase the interest and participation of farmers.

While the practices identified through this grant are technically feasible, there may be production risks associated with practice implementation that should be taken into account. Project partners explored potential concerns associated with each of the practices to better understand decisions farmers would make when implementing a project. To improve the technical feasibility and reduce production risk associated with carbon mitigating practices, we recommend that NRCS advisors, cooperative extension and other crop consultants receive information on the emissions reduction potential of practices, the cost of implementing the practices, and the potential revenue which could be generated through carbon markets. As uptake of these practices increases, farmer partners will continue to identify ways to

facilitate appropriate implementation that minimize production risks and maximize implementation of the technically feasible practices.

Throughout the pilot project implementation, project partners collected significant feedback from participants regarding social constraints and possible solutions. General concerns raised reflect the nascency of the market for agricultural carbon credits and a need for trusted agricultural advisors to understand and translate carbon market language into the agricultural world. Increasing agricultural community buy-in for carbon credits will require continued education of trusted farm advisors, routine public communications about the opportunity to generate offsets, trainings on the carbon market, and establishing local cooperatives to aggregate interested growers. Additionally, the pilot projects identified a number of opportunities to improve and clarify the current ACR and ARB protocols. Key among them is further streamlining data collection and verification by aggregating multiple growers into a single project and implementing risk-based and randomized verification of projects. The stakeholder engagement process for the ARB Rice Protocol has proven to be extremely informative and effective; other protocol support groups have referenced this process as a success.[16] This process also improved the outcome of the ARB protocol by including on-the-ground knowledge, such how to measure AWD and the potential environmental impacts of baling.

Despite all of the challenges with the creation of current and future carbon credits, this project has been extremely successful. As of the end of September 2015, 21 growers on more than 22,000 acres (just under 1% of all rice grown in the U.S.) in California and the Midsouth are participating in offset projects which have been listed on ACR's public registry.

Even more transformative, the development of both voluntary carbon offset protocols and an ARB compliance offset protocol send an important message and set a critical precedent. Rice growers throughout the U.S. can now implement practices that reduce methane generation, measure those reductions, get them independently verified and ultimately sell them to regulated California companies (**Appendix Q**). And implications go far beyond rice growers. The lessons learned and infrastructure developed under this grant can be leveraged to develop additional protocols for other crops grown throughout the U.S., including protocols for fertilizer optimization or grassland restoration.

[16] Statements from ARB Board meeting June 2015 by Forestry advocates.

Bibliography

American Carbon Registry. Public project registry data. Retrieved from https://acr2.apx.com/myModule/rpt/myrpt.asp?r=111

California Air Resources Board. (2015). Compliance Offset Protocol Rice Cultivation Projects. Retrieved from http://www.arb.ca.gov/regact/2014/capandtradeprf14/3CTAttach2RiceProtocol051115FINAL.pdf.

Elphick, C.S., and Oring, L. W. (2003). Conservation implications of flooding rice fields on winter waterbird communities. *Agriculture, Ecosystems & Environment*, *94*(1), 17-29.

Climate Action Reserve. (2015). Grassland Project Protocol. Retrieved from http://www.climateactionreserve.org/how/protocols/grassland/

U.S. Environmental Protection Agency. (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013.*Chapter 5*, page 5-2, Retrieved from http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Chapter-5-Agriculture.pdf

Wassmann, R., Lantin, R. S., & Neue, H. U. (Eds.). (2012). Methane emissions from major rice ecosystems in Asia. *Springer Science & Business Media. Vol. 91*.

Appendices

GHG practice methodologies and process documentation

A. Voluntary Emission Reductions in Rice Management Systems – Parent Module. (May 2013). American Carbon Registry. http://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-in-rice-management-systems/rice-meth-acr-v1-0_july-2013_final.pdf

B. Voluntary Emission Reductions in Rice Management Systems – California Module. (May 2013). American Carbon Registry. http://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-in-rice-management-systems/california-module_v1-0_errata-corrected.pdf

C. Voluntary Emission Reductions in Rice Management Systems – Midsouth Module. (February 2014). American Carbon Registry. http://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-in-rice-management-systems/midsouth-module-acr-v1-0-feb2014-final.pdf

D. Compliance Offset Protocol Rice Cultivation Projects. (2014). California Air Resources Board. http://www.arb.ca.gov/regact/2014/capandtradeprf14/3CTAttach2RiceProtocol051115FINAL.pdf

Presentations and participant surveys from outreach activities to recruit and assist EQIP eligible producers in CA and Midsouth

E. *Midsouth Grower Outreach Summary*. (July 2015). Dennis Carman, White River Irrigation District.

F. *Post CIG Survey 060515 Responses*. (June 2015). Dennis Carman, White River Irrigation District.

G. *WRID Summary Report, Rice CIG*. (July 2015). Dennis Carman, White River Irrigation District.

Project Description Document for rice cultivation emissions reduction pilot projects in California and Arkansas (Midsouth)

H. Emission Reductions in California Rice Management Systems. (July 2015). Terra Global.

Supporting materials for the California Air Resources Board (ARB) review

I. Final Regulation Order. California Cap on Greenhouse Gas Emissions and Market-based Compliance Mechanisms. California Air Resources Board. http://www.arb.ca.gov/regact/2014/capandtradeprf14/ctfinalregorder.pdf

J. Compliance Offset Protocol Rice Cultivation Projects. California Air Resources Board. http://www.arb.ca.gov/regact/2014/capandtradeprf14/ctriceprotocol.pdf

K. Li, C. (2013). Steps for Calibration and Validation of DNDC. California Air Resources Board. Retrieved from http://www.arb.ca.gov/cc/capandtrade/protocols/rice/steps-for-dndc-12-20-13.pdf

Reports on methodologies, feasibility, and scale-up potential

L. Comparative analysis of alternative GHG calculation methods and methodologies. (July 2015). Environmental Defense Fund.

M. Analysis of Rice Protocol Project Feasibility. (July 2015). Environmental Defense Fund.

N. Analysis of scale-up potential in CA and Arkansas and Report to NRCS analyzing replication potential in LA, MS, MO, TX. (July 2015). Environmental Defense Fund.

Environmental analysis

O. Rice and Waterfowl Habitat in the Midsouth. (June 2015). American Carbon Registry.

P. Sesser, K.A., Reiter, M.E., Skalos, D.A., Strum, K.M, and Hickey, C.M. (2014). Point Blue Final Report. *Waterbird response to practices aimed at reducing greenhouse gas emissions from rice fields in the Sacramento Valley*. Point Blue Conservation Science.

Innovative approach fact sheet

Q. Parkhurst, R. (July 2015). Development of Protocols and Accounting Methods for Greenhouse Gas Emissions Reductions from Rice Cultivation Practices. Environmental Defense Fund.

R. Parkhurst, R. (November 2014). Rice Cultivation Projects Compliance Offsets Protocol Summary. Environmental Defense Fund.