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An ASABE Meeting Presentation
DOI: 10.13031/aim.20162460868
Paper Number: 162460868

Development and Initial Verification of Effectiveness for Agricultural Best Management Practices (BMPs) in Florida

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Written for presentation at the
2016 ASABE Annual International Meeting
Sponsored by ASABE
Orlando, Florida
July 17-20, 2016

ABSTRACT. *In 1999 the Florida Watershed Restoration Act implemented the TMDL program in Florida. Best Management Practices for agriculture must be adopted by Florida Department of Agriculture and Consumer Services (FDACS) rule. Growers using these practices are presumed in compliance with water quality standards. In 2005, revisions were made that required BMPs to receive an initial verification of effectiveness from the Florida Department of Environmental Protection (FDEP) before FDACS could begin the rule adoption process.*

This paper discusses the process developed for FDACS production of commodity-based BMP manuals and the FDEP collaboration and review to ensure that the manuals meet the legislative intent of pollutant reduction and environmental stewardship. Matrices of references were developed to log the sources reviewed in generation of the manuals. A simple model was developed using individual practice ratings from the USDA Conservation Practice Physical Effects (CPPE). The model helps to provide the reviewer and the FDACS authors with confidence that the manual addresses all pollutants of concern at an appropriate level despite the wide variability in climate, soils, types of agriculture, farm sizes, and available resources found in the state.

Keywords. *agriculture, Best Management Practices (BMP), environment, nutrient management, water quality.*

Introduction

In 1999, the Florida Legislature adopted comprehensive total maximum daily load (TMDL) legislation (Chapter 403.067, Florida Statutes) that clarified the Florida Department of Environmental Protection's (FDEP) statutory authority and established administrative procedures for the program. The Legislature declared that the waters of the state are among its most basic resources, and that the development of a total maximum daily load program will promote improvements in water quality throughout the state through the coordinated control of point and nonpoint sources of pollution.

The Legislature found that a scientifically based TMDL program was necessary to fairly and equitably allocate pollution loads to both nonpoint and point sources. Implementation of an allocation is to include consideration of a cost-effective approach coordinated between contributing point and nonpoint sources (NPS) of pollution for impaired water bodies or water body segments and may include the opportunity to implement the allocation through non-regulatory and incentive-based programs. (Thomas and Joyner, 2002)

Section 373.4595, Florida Statutes defines Best Management Practices (BMPs) as "a practice or combination of practices determined by the coordinating agencies, based on research, field-testing, and expert review, to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality in agricultural and urban discharges. Best management practices for agricultural discharges shall reflect a balance between water quality improvements and agricultural productivity."

The law identifies BMPs as the preferred method of addressing non-point sources of pollution to meet TMDL requirements. It also provides a process to obtain a presumption of compliance with water quality standards if nonpoint sources implement applicable BMPs that are adopted by the Florida Department of Agriculture and Consumer Services (FDACS) for agricultural sources, or by FDEP (for non-agricultural sources), and verified effective by the FDEP. All current agricultural BMPs are available at the FDACS Office of Water Policy web site at http://www.floridaagwaterpolicy.com.

This legislation recognizes the good faith effort of the farmer to implement BMPs recommended by the state, and holds the state, not the farmer, responsible where the recommended practices are found inadequate to protect water quality. As BMPs are revised and improved, the farmers are informed and must adjust their practices accordingly to maintain the presumption of compliance.

The law (Chapter 403.067, Florida Statutes) also authorizes the FDEP, with stakeholder input, to develop and adopt by rule Basin Management Action Plans (BMAPs) to implement TMDLs. While in general, BMP implementation is voluntary, since 2005, the law states that if BMPs are identified in a BMAP for TMDL implementation, or anywhere in the Northern Everglades region, FDEP or regional water management districts (WMDs) may require water quality monitoring of any party that fails to implement BMPs. They may be required to conduct agency-specified water quality monitoring at their own cost to prove compliance with the TMDL.

In the 2005 revisions to the law, verification was clarified and the FDEP was required to use best professional judgement (BPJ) to provide an initial verification of effectiveness for a new BMP prior to commencement of rulemaking. This paper will describe the process used to develop BMP manuals for agriculture in Florida, and the process used to meet the initial verification requirements. The required post-implementation confirmatory verification of BMPs at representative sites will not be discussed in this paper. In addition to monitoring issues, lag time presents a difficult issue (Meals, et al. 2010).

In 2005, a technical advisory committee (TAC) was formed of FDEP and FDACS staff, academic experts, consultants and other governmental and stakeholder representatives, to specifically address the issues of verification. The recommendations of the TAC addressed initial verification of the new BMP manuals to be written, and revisions of older manuals, and a framework for the development of confirmatory process in the future. Per the statute, initial verification (statutory term) shall be by BPJ based on information obtained from the BMP development process and other relevant existing information. The TAC then defined BPJ to be "evaluation, using available information, of expected BMP outcomes, conducted by individuals qualified by training and experience in BMP development and implementation." The recommendations were released in May 2006.

Even knowing the general type of agriculture to be practiced, verifying the effectiveness of specific practices is virtually impossible without knowing the specific properties of the land area. The property information generally needed includes which of Florida's seven soil orders (Histosols, Spodosols, Ultisols, Mollisols Alfisols, Inceptisols, and Entisols) are present, the size or type of farming operation, information about slopes, the presence of Karst, rainfall patterns and grower resources. Therefore¸ "FDEP and FDACS recognize that it is not possible or necessary to verify the effectiveness of individual BMPs at each site of application or under all conditions. Where appropriate, BMPs within a specific FDACS-adopted manual should be verified as a collection of practices, recognizing that overall effectiveness is usually best achieved by implementing a combination of applicable BMPs."

The TAC determined that it is critical that FDEP and other stakeholders are involved in all aspects of agricultural BMP development. This participation provides the foundation for the initial verification process. During BMP development, FDACS and FDEP should document relevant existing information on BMP effectiveness to assist in FDEP's exercise of BPJ in determining initial verification. The documentation should include, where available and appropriate, the expected range of pollutant removal efficiencies for individual BMPs or typical suites of BMPs, as applicable.

Sources for obtaining relevant existing information regarding the BMPs under development should be identified in the documentation, and may include consultation with qualified stakeholder participants familiar with Florida BMP development methods and academic resources in the field; pertinent literature review in support of nonpoint source pollutant reduction potential; out-of-state databases and BMP tools where applicable to Florida; existing BMP manuals from other states and countries, and credible modeling assumptions.

In short, the Technical Advisory Committee determined that initial verification using BPJ should be based on relevant existing information obtained through FDEP involvement in BMP development, as described above, and consideration of the collective expertise used in BMP development including knowledge of applicable mechanistic and qualitative factors.

Development of BMP Documentation

As the TAC report was finally released, FDEP and FDACS staff were beginning work on two new BMP manuals. The Cow-Calf operations manual was to be a revision to an earlier manual that had minimal environmental review at the time. In 2007, 53% of the cattlemen in South Florida claimed to use the manual, but of the 75% with open water on their property, "The survey indicated that 97% of the producers allow cattle to have access to open water areas." (Crawford and Wiggins, 2007)

The Sod manual was to be a completely new manual, as the sod industry was pleased with the FDEP Green Industries BMPs for the urban lawn and yard maintenance industry, and wanted the presumption of compliance protections that other agricultural commodities were receiving. These manuals would also be new in that the FDACs staff would take the lead on writing the manuals as opposed to contracting with UF faculty or others to produce the initial draft.

This also required staffs of both agencies to become more familiar with many details of various farming and ranching operations. The first step in development of the new manuals required agency authors to understand farming operations at a much deeper level than just applying filter strips and fencing. They also needed to understand the specific timing of nutrient and water requirements of various crops on different soil types, animal water and nutrient requirements, and how feed fiber, protein, and micronutrient content affect growth rate, profitability, and nutrient form and content in excreta. A practical knowledge of farm operations, management, and economics also became essential to producing a functional manual. As staff has become better over time at searching out non-traditional BMPs and the deeper complexities of farming in a diverse region, the volume of references logged has expanded far beyond merely the traditional soil conservation practices. In addition to creating a spreadsheet log of references used in development of the manual, this log also serves as a note pad of relevant information and helps in the creation of a cross-reference tracking specific BMPs in the manual back to original references where more information can be found. The logs have varied from 93 references for the original sod manual to a high of 462 for the dairy manual completed in 2015. Of course, more references were reviewed, at least at the abstract level, than were logged as relevant and useful. Where specific information was present on effectiveness of practices, it was noted in the appropriate column, and often discussed in the comment fields.

The second part is that of estimating the effectiveness of a new BMP manual to reduce pollutants that have been addressed in TMDLs, but is intended for a statewide audience in which only the general commodity and the State are knowns. This is a difficult task. In many areas TMDLs have not yet been determined, and while nutrients are by far the most common agricultural concerns, coliforms, metals and pesticides are also potential targets.

Obtaining the quantity of data required to model the potential interactions of dozens of conservation practices and how they interact with each other on a single large farm, has proven difficult for the best equipped institutions. Multiply that by the near infinite variations between physical, managerial, and financial characteristics in the real world and the concept of detailed mechanistic modeling becomes out of the question. A more practical goal is to become familiar with the impacts of these variables on the ranges of BMP effectiveness, and to utilize this understanding in developing a realistic comprehension of the extent of improvements via BMPs.

Attempting to sort out all of the literature on even a single practice like filter strips has proven difficult (Dillaha et al. 1986, Mayer, 2005). Frydenborg and Frydenborg (2016) recently attempted to characterize BMP efficiencies in Florida for cow-calf operations, vegetable crops, and agronomic crops using meta-analysis techniques borrowed from the medical and pharmacological fields. Only about 4% of approximately 1000 promising publication titles contained adequate information needed for meta-analysis. Key information that was lacking usually related to measures of variance and information about treatment controls. Still, enough data was available to determine that certain practices were productive.

In late 2006, while working on the Sod production BMP manual, it was decided that the information in the USDA CPPE matrix could provide a useful tool to evaluate a BMP manual based on grouping the long-term effects on critical pollutant pathways for each practice cited in the manual. While the CPPE is derived only for stand-alone practices, the -3 to +3 scale (now -5 to +5) still provided a useful ranking mechanism. Practices in a series treatment train do not add arithmetically, as each can act only on the pollutants discharged from the upstream treatment. Practices installed in parallel probably do not interact at all unless there is downstream intermixing.

The purpose of utilizing the CPPE tool was not to estimate the effectiveness of any specific practice on any given farm or production area. Rather it was to confirm that the manual included several practical options to present as possible solutions to any given problem that a given grower or rancher may face.

Conservation practices were rated for Erosion, Water Conservation, Groundwater Pesticides, Nutrients and Other, Surface Water Pesticides, and Profitability. Runoff Quantity was later separated from water conservation, as both are under the water quantity heading. The initial spreadsheets did not present any type of efficiency ranking, rather the basic goal being at least 10 practices with positive effect for each category. In 2010, USDA dropped the profitability rating as too inaccurate for use in specific farm conservation plans, but it continues to be used from the 2004 matrix as the overall best available estimate for the economic effects of practices recommended in the manuals.

In 2010, an attempt was made to make a more intuitive interface. The new interface geometrically added the average CPPE value for a column for the effective number of practices. The number of practices assumed to be used on any given farm was one half of the available practices with a positive effect. Series or parallel relationships cannot be known in advance, so this method tries to recognize that at least some series configurations may exist. The estimated efficiency for a column is the average positive effect for that column multiplied by a practice efficiency conversion factor, and by the effective number of practices. This is determined by the geometric addition factor r, where the effective number of practices is:

$$(1-r^n) / (1-r) \qquad (1)$$

where n = 1/2 the total number of practices with positive effect. As may be seen in Figure 1, A value of r=0.70 provides a maximum effective number of about 3.3. Under the older 0 to +3 CPPE scale for positive effects, a practice efficiency conversion factor of 7% provided an average BMP reduction value of 0-21%, or a maximum efficiency of about 70% for that column. These were also added back into the CPPE sheets for the cow-calf and sod manuals to check consistency. This assumed a linear relationship for the CPPE ratings from 0 to 100%.

After 2011, the new USDA/SmarTech 2011 CPPEs used the 0-5 scale for positive effects. This was addressed by a reduction in the practice efficiency conversion factor from 7% to 4%, which yields a 20% reduction for a CPPE rating of 5.0. The maximum for any column is a slightly lower 66.6%, but still maintained a reasonable consistency between the older and newer manuals. A later attempt was made to increase consistency by multiplying the average positive value on the 0-3 scale by 1.67 to provide a slightly better match to the modern 0-5 scale, as shown in the table below. By ensuring that the model could not provide a score above 75%, a built in margin of safety was produced.

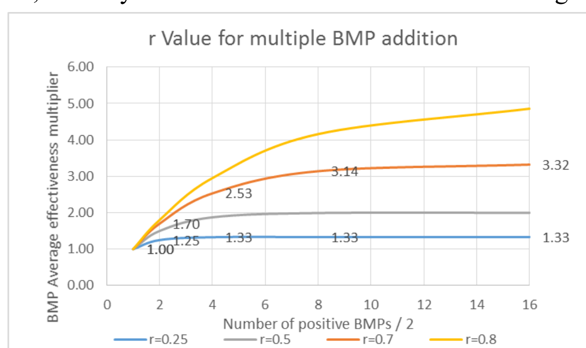

Figure 1

USDA Keyword	USDA % reduction	2004 CPPE Value	2010 CPPE Value	2004 vs. 2010 vs. 2016 with 32 positive CPs (Linear)			2016 (Quadratic)
Slight	<10%	1	1	23%	13%	22%	5%
Moderate	10-50%	2	3	46%	40%	44%	30%
Substantial	>50%	3	5	70%	66%	67%	75%

In 2016, a new web page (USDA 2016) was found that identified a percent reduction efficiency rating for the CPPE qualitative statements, and the scale was found to be non-linear. Using the midpoints of the 3 ranges, a quadratic regression was determined to yield a better fit than the linear relationship used earlier. The regression equation for the 0-3 scale is:

$$10x^2-5x \qquad (2)$$

and for the 0-5 scale is:

$$2.5x^2 + 2.5x \qquad (3)$$

R= 1.0 for both.

Because the BMP efficiency is now directly provided based on the midpoints of the CPPE range, the geometric addition factor was lowered to 0.25 in order to avoid reduction estimates of more than 100%. This lowered the estimated efficiency, especially at the lower end as a rating of 1, or "slight," corresponds to less than a 10% reduction. It should be kept in mind, however, that even one significant digit of accuracy in reduction percentage is unlikely given the vast variation in actual field conditions, BMP selection and quality of implementation.

After re-scaling the first three manuals to use this newer method, the effectiveness rating scores for all 9 nine of the current manuals is presented in Figure 2. The manual dates are the year adopted into the Florida Administrative Code.

While not a direct correlation, data from Bottcher (2008) was compared to the surface water nutrient removal effectiveness estimate for related BMP manuals (Figure 3). Bottcher divided BMPs into three types; no-cost-owner installed, cost-share installed, and alternatives, including chemical treatment. Florida BMP manuals also use three groupings, Level I, to be installed, if applicable and feasible, within 18 months; Level 2, these are more expensive, may require engineering or other assistance, and are based on answers to specific questions about serious conditions, but may be delayed if level 1 actions will address the issue in a reasonable amount of time; and Level 3, which usually require engineering, may include permitting, and may require significant capital expenditure and longer planning, with or without cost-share. In this review, Levels 1 & 2 were roughly comparable to Bottcher's "Owner" and general "Cost-Share" practices, while level 3 was roughly similar to his "Alternative" BMPs.

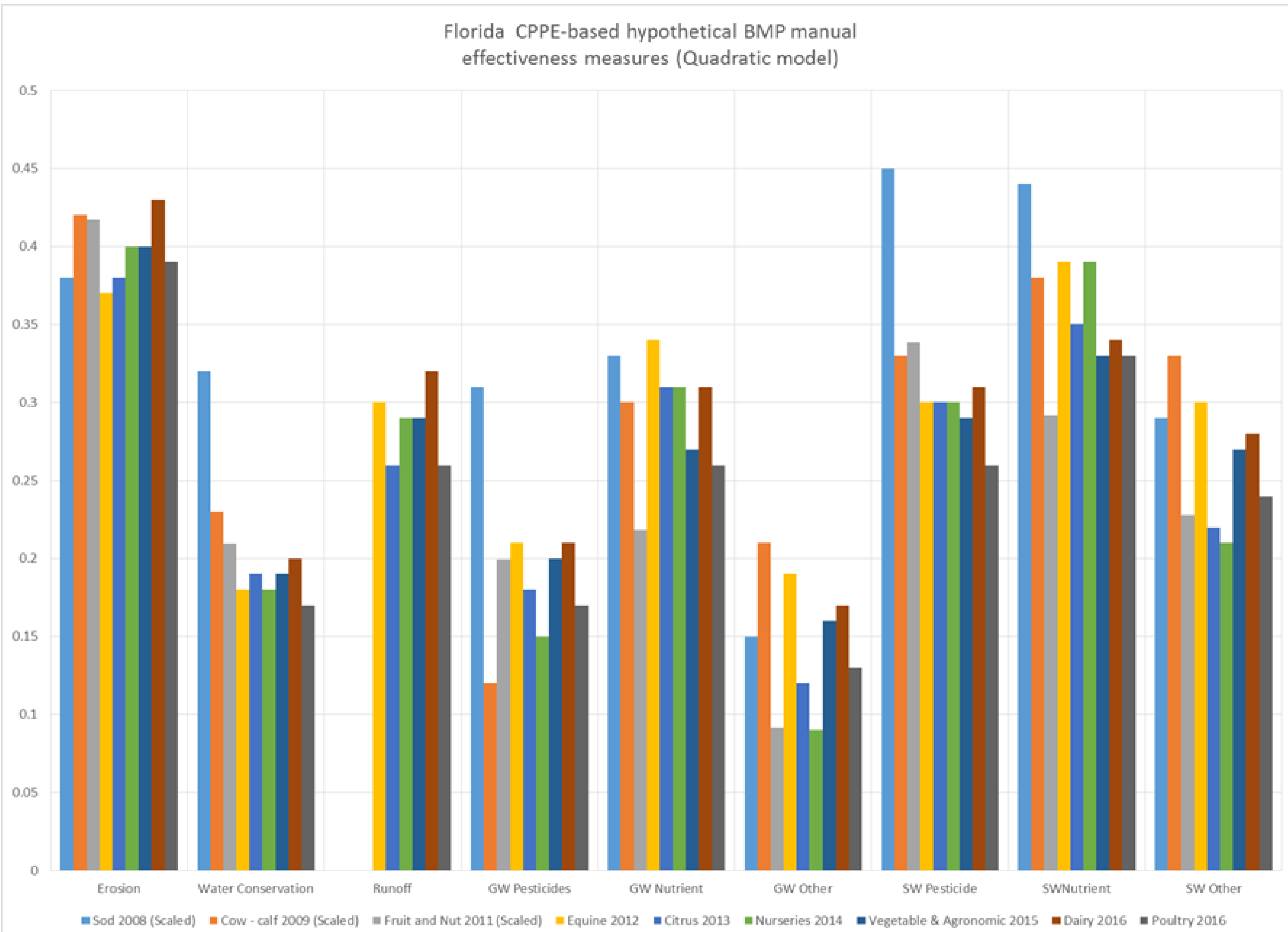

Figure 2

BMP Manual Implementation

The proper location, selection, and implementation is the key to BMP effectiveness. While Florida's manuals have attempted to provide a comprehensive list of practices to address most potential pollutant streams, either by elimination of the source, in-field mitigation or treatment, or edge of field treatment, they have not always addressed the proper siting and implementation of those BMPs. The recent completion of 10 years of USDA CEAP studies and their findings has been discussed in several articles, (Tomer and Locke, 2011, Meals, et al. 2012, and Tomer, et al. 2014).

These studies raise serious questions about whether the correct sources are being identified and about the effectiveness of merely describing and listing the practices as opposed to providing more detail on the specific siting, operation, and maintenance of the practices. Unfortunately, this can make a book too large and complex, and may discourage use of the book and the practices. One must find a balance between imparting enough knowledge to be effective, while not putting off the reader that already has a full plate.

FDACS Implementation Assurance questionnaires and on-site visits have been conducted on a rotating basis. To date, citrus, vegetable/agronomic crops, container nursery, sod, and cow-calf operations have been reviewed, with mixed results. Some practices have higher sign-ups, but a lower percentage of implementation, others have many more actually implementing the practice. It is unclear why, but possible reasons could be that the farmer either did not know that the practice was something he was already doing, or found that what seemed easy to do when signing up was actually impractical or he did not know where or how to implement it. Either way, it indicates a need to improve the clarity of the manuals.

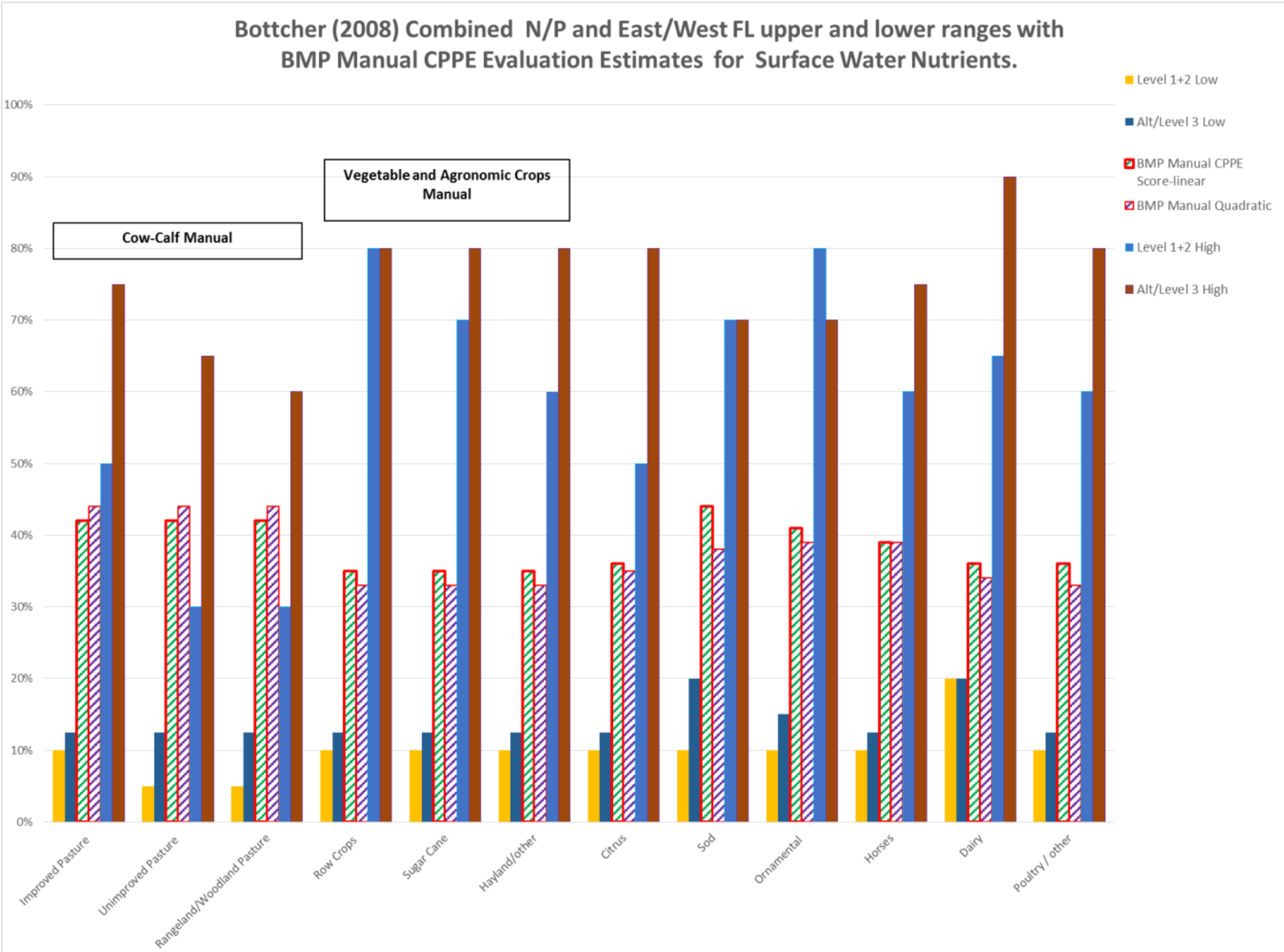

Figure 3

Conclusion

The only situation where the BMP manuals did not fall within the ranges for Level 1 and 2 BMPs (Bottcher's owner/cost-share) was for unimproved pasture and wooded rangeland This is because the BMP manuals consider all pasture, not only improved pasture, to be subject to the BMPs if applicable in the specific situation.

In the meta-study cited earlier (Frydenborg and Frydenborg, 2016), the cattle study only had one study each for exclusion and stocking rate, and two studies of water retention/detention BMPs. No statistically significant reductions were determined. The agronomic crop studies included one cover crop, two irrigation, and three nutrient management studies, and determined that a 60% reduction for nitrogen was significant, but found no significance for phosphorus. The vegetable crop studies included one cover crop and one water management study, two wetland treatment studies, two water only studies, and seven nutrient and irrigation management studies. BMP Reductions of 66% for N and 35% for P were significant. It should be noted that these reductions apply only to the studied fields, not to the entire farm area.

The CPPE model estimates shown above are lower than the meta-study estimates and many of Bottcher's estimates of typical values. The CPPE ratings for Nutrient Management (Code 590) and Irrigation Management (code 449) are 5 and 4 respectively. However, after geometrically adding all 25 vegetable manual practices with a positive effect, the average rating for nutrients in surface water is only 2.7. By its nature, this process is therefore quite conservative in its estimates of reductions to be achieved. However, because this method address all practices used throughout the farm, it may be more representative of what a whole-farm reduction might be in practice.

Recommendation for Further Research

Future research should include modeling groups of conservation practices likely to be used in common scenarios across the country. Research efforts that include modeling as well as field experiments will build a multi-factor library of standardized effects that could prove a useful tool for both growers, extension personnel and agency TMDL modelers. Improved estimates of statistical variability as affected by ecoregion, soils and grower capabilities will greatly enhance the CPPE model usefulness.

References

Bottcher, A. B. (2008). Final Report Tasks 1, 2, and 3 For Project Entitled: Nutrient Loading Rates, Reduction Factors and Implementation Costs Associated with BMPs and Technologies. Prepared for South Florida Water Management District by Soil and Water Engineering Technology, Inc. Gainesville Florida.

Crawford, S. C., and Wiggins, L.F. (2007). Beef Forage Range Practices in South Florida. Institute of Food and Agricultural Sciences, Cooperative Extension Service, University of Florida. http://sfbfp.ifas.ufl.edu/files/pdf/BeefForageRangePractices_2007_survey.pdf

Dillaha, T. A., Sherrard, J. H., & Lee, D. (1986). Long-term effectiveness and maintenance of vegetative filter strips. Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University.

FDACS. (2009-2015). Reports on the Implementation of Agricultural Best Management Practices. Office of Agricultural Water Policy, Florida Department of Agriculture and Consumer Services http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy/BMP-Implementation/BMP-Implementation-Assurance

Frydenborg, B. R. and Frydenborg, R. B. (2016). *A Meta-Analytical Approach for Determining the Effectiveness of Agricultural Best Management Practices (BMPs) for Reducing Nutrient Pollution in Florida. Phase 2: Cow/Calf Operations, Vegetable Crops, and Agronomic Crops.* Final Report to the Office of Agricultural Water Policy, Florida Department of Agriculture and Consumer Services for P.O. No. S-4200-D1755. Frydenborg EcoLogic, L.L.C.

Hamilton, S. K. (2011). Biogeochemical Time Lags May Delay Responses of Streams to Ecological Restoration. *Freshwater Biology*, 57 (Suppl. 1), 43–57

Mayer, P. M., Reynolds, S. K., Canfield, T. J., and McCutchen M. D. (2005). *Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: A review of current science and regulations*. EPA/600/R-05/118 https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=140503

Meals, D. W., Dressing, S. A., and Davenport, T. E. (2010). Lag Time in Water Quality Response to Best Management Practices: A Review. *J. Environ. Qual.* 39:85–96

Meals, D. W., Sharpley, A. N. and Osmond, D. L. (2012). *Lessons Learned from the NIFA-CEAP: Identifying Critical Source Areas*. NC State University, Raleigh, NC.

Thomas, M. V. and Joyner, D. (2002). TMDL Legislation and Policy in Florida. p. 312-317 in *Total Maximum Daily Load (TMDL) Environmental Regulations*. Publication Date March 11, 2002. ASAE Publication Number 701P0102

Tomer, M. D. and Locke, M. A. (2011). The challenge of documenting water quality benefits of conservation practices: a review of USDA-ARS's conservation effects assessment project watershed studies. *Water Science & Technology* 64(1) 300-310.

Tomer, M.D., Sadler, E. J., Lizotte, R. E., Bryant, R. B., Potter, T. L., Moore, M. T., … Walbridge, M. R. (2014). A decade of conservation effects assessment research by the USDA Agricultural Research Service: Progress overview and future outlook. *Journal of Soil and Water Conservation*. 69(5) 365-373

USDA (2016). Explanation of CPPE Values. Visited 3/7/2016, http://smartech.sc.egov.usda.gov/SmarTechHelp/CPPE/Explanation_of_CPPE_Values.htm