High Residue, Minimum Soil Disturbance: definition and recommended sediment and nutrient reduction effectiveness estimates

Recommendations for Approval by the Water Quality Goal Implementation Team's Watershed Technical and Agricultural Workgroups

Brief Summary

This practice represents the highest level of soil conservation and soil cover management to improve soil organic matter content and soil quality, and to reduce runoff and sediment and nutrient losses. This practice is proposed to provide stackability with other best management practice (BMP) reductions, such as cover crops and nutrient management.

Introduction

A high degree of soil cover dramatically increases water infiltration and storage and decreases soil erosion and soil-bound nutrient losses. Over time, this practice also typically results in increased nitrogen (N) retention in soil due to increased soil organic matter content. The Continuous No-Till (CNT) practice was proposed for inclusion in the Bay Model in 2005. CNT is considered an enhanced version of the Conservation Tillage BMP and thus can be applied to a subset of the acres receiving Conservation Tillage. However in previous iterations, the N, phosphorus (P), and sediment reduction efficiencies associated with CNT were inclusive of reductions due to Nutrient Management and Cover Crops, both associated cropland BMP's. In order to maximize the potential impact of the panels' limited time and scope for potential revisions to the overall set of conservation tillage practices, the panel decided to focus emphasis directly on a "stackable" CNT practice. After considerable time spent reviewing the literature and discussing the various effects of no-till practices, the panel agreed that the preponderance of evidence indicated that a high degree of soil cover, over 60%, had the greatest impact on water quality benefits. Research from soils and cropping systems within the Chesapeake Bay watershed and from similar conditions elsewhere suggests the effects on infiltration and sediment loss are predominantly determined by residue cover and not by soil disturbance per-se.

This document summarizes adopted recommendations and plans for future recommendations of the 2012-13 Conservation Tillage Expert Panel for N, P, and sediment reduction efficiencies associated with high-residue, minimum soil disturbance cropland management.

Panel Members:

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Practice Definition

Continuous High-Residue Minimum Soil-Disturbance (HR) Best Management Practice Definition and Nutrient and Sediment Reduction Efficiencies

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies recommended for the Continuous High-Residue Minimum Soil- Disturbance (HR) Best Management Practice. The definition does not currently exist in the model but is ultimately intended to replace the current CNT practice.

Continuous High-Residue Minimum Soil-Disturbance Best Management Practice Definition

The Continuous High-Residue Minimum Soil-Disturbance (HR) BMP is a crop planting and residue management practice in which soil disturbance by plows and implements intended to invert residue is eliminated. Any disturbance must leave a minimum of 60% crop residue cover on the soil surface as measured after planting. HR involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living or dead material) is to be met immediately after planting of each crop.

The purpose of implementing the HR BMP is to improve soil organic matter content and soil quality, and to reduce runoff and sediment and nutrient losses coupled with a continuous high-residue management system. Multi-crop, multi-year rotations on cropland are eligible. The system must be maintained for a minimum of one full crop rotation.

The Chesapeake Bay Watershed Model has hi-till (0-29% crop residue or conventional tillage) crop land-uses and low till (30+% crop residue or conservation tillage) land-uses, but does not have an explicit land use that defines the properties of continuous HR with minimum soil disturbance. Since continuous HR will be considered a sub-set of the current conservation tillage land use, it is necessary to calculate the effects of HR as reduction efficiency relative to the efficiency already achieved by the conservation tillage land use. The continuous HR with minimum soil disturbance practice can be combined with other associated, applicable BMP's for additional reductions, including nutrient management and cover crops.

This practice could be tracked through field transect surveys (CTIC methodology), through remote sensing and limited field transect surveys, or through state or federal programs that collect information on high-residue minimum disturbance practices. The panel discussed the importance of obtaining complete information about implementation of this practice. Therefore, information about implementation obtained through programs needs to be supplemented with other information to report acres where farmers practice HR voluntarily.

Effectiveness Estimates

Relative Reduction Efficiency Estimates

Panel Proposed HR BMP	
TOTN Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD	TOTN Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD
TOTP Uplands Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD	TOTP Coastal Plain Continuous High-Residue Minimum Soil-Disturbance lbs/acre Low-Till → Continuous HR (Stackable) Load Reduction TBD
TSS Uplands Continuous High-Residue Minimum Soil-Disturbance tons/acre Low-Till → Continuous HR (Stackable) Load Reduction -64.0%	TSS Coastal Plain Continuous High-Residue Minimum Soil-Disturbance tons/acre Low-Till → Continuous HR (Stackable) Load Reduction -64.0%

Sediment

The panel found ample evidence in the existing literature comparing sediment losses from conservation tillage systems with those of high residue examples, generally from no-till systems. In many cases the cited work did not provide estimates of soil cover after the conservation tillage practice was applied, however the professional judgment of the panel was that the practices indicated would likely produce the minimum 30% residue for the Conservation Tillage category. Also in support of this was that the RUSLE2 estimates of sediment loss reduction were very similar to the values from literature and these runs were conducted with at least 30% soil cover estimates for the conservation tillage practice.

In general, small plot studies with simulated rainfall produced higher reduction estimates than the watershed-scale studies, which the panel assumed to be more reliable and indicative of real-world conditions. Erosion reduction values from small plot studies were thus reduced by 15% to

compensate for this effect. Values from watershed-scale studies, small plot experiments, and RUSLE2 simulation were evaluated for corroboration. While the absolute values for sediment losses varied by region, soil, and slope the relative reduction was similar across the watershed. The panel recommends a single efficiency value of 64% sediment reduction for this practice.

Brief Citation	% sediment reduction, Conservation Till to High-Res, Min Disturbance (NT)
Sm. Watershed-scale studies	
Shipitalo and Edwards, 1998	-61.5%
Staver, 2004	-67.5%
AVG	**-64.5%**
Small plot studies	
Verbree et al, 2010	-85.2%
Truman e al., 2005	-91.5%
Benham et al., 2007	-77.2%
Eghball and Gilley, 2001	-79.6%
Kleinman et al., 2009	-38.0%
AVG	**-74.3%**
15% small plot adjustment	**-63.1%**
RUSLE2 model runs	
Coastal Plain, 1% slope	-49%
Coastal Plain, 2% slope	-80%
Coastal Plain, 4% slope	-78%
Piedmont, 3-4% slope	-65%
Piedmont, 5-6% slope	-68%
Piedmont, 9-10% slope	-58%
Ridge & Valley, 3-4% slope	-66%
Ridge & Valley, 5-6% slope	-71%
Ridge & Valley, 9-10% slope	-70%
Plateau, 4% slope	-75%
Plateau, 6% slope	-77%
Plateau, 10% slope	-76%
AVG	**-69.4%**

Phosphorus

While there were numerous papers reporting P losses in response to residue cover and tillage, there was no clear consensus among the panel membership for a reduction value for P, based on

the existing data. The panel discussed the possibility of using placeholder, estimated values for P reductions as well as relying more heavily on modeled results for inclusion in this progress run. The group decided to delay this recommendation until a solid base of evidence could be built and consensus for a reduction value reached by the panel. The panel expects to benefit from new simulation modeling capacity within USDA-ARS and from further refinement of the data available in the existing literature. The panel expects a final recommendation can be developed by spring, 2014 and available for future progress runs.

Nitrogen

Due to a lack of available time, the panel was unable to evaluate a significant body of literature for Total N reduction efficiency from the new high-residue MSD practice. The group decided to delay this recommendation until a solid base of evidence could be built and consensus for a reduction value reached by the panel. The panel expects to benefit from new simulation modeling capacity within USDA-ARS and from further refinement of the data available in the existing literature. The panel expects a final recommendation can be developed by spring, 2014 and available for future progress runs.

Recommendation and associated benefits

The panel is currently recommending that the HR practice and sediment reduction value recommended for HR be treated as stackable with other applicable BMP's. At this time, the stackable HR practice would be given no N or P reduction credit, however any reduction values associated with other practices applied to that same area would be included. Further, the panel recommends that until final N and P reduction estimates for HR can be developed (2014) that the jurisdictions still have the opportunity to report to the CNT (non-stackable) practice. However the same acre could not be reported to CNT and HR.

Justification for Recommended Effectiveness Estimates

The panel found no instances in the literature where this practice increased sediment loss.

The panel was diligent about selecting data that would be representative of this practice alone and not dependent on the inclusion of other potential BMP's such as cover crops or nutrient management. The RUSLE2 simulations included only crop residue, with no cover crops included, to reach the minimum required levels of soil cover.

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Truman C.C., Shaw J.N., Reeves D.W. (2005) Tillage effects on rainfall partitioning and sediment yield from an ultisol in central Alabama. Journal of Soil and Water Conservation 60:89-98.

Verbree D.A., Duiker S.W., Kleinman P.J.A. (2010) Runoff losses of sediment and phosphorus from no-till and cultivated soils receiving dairy manure. J. Environ. Qual. 39:1762-1770.

References used for sediment estimates

Shipitalo and Edwards, 1998
Staver, 2004
Verbree et al, 2010
Truman e al., 2005
Benham et al., 2007
Eghball and Gilley, 2001
Kleinman et al., 2009
All included in estimate and weighted as described in earlier section

Application of Practice Effectiveness Estimates

- Units of measure: acre
- Load sources addressed: 64% sediment reduction over that credited for low-till with manure (LWM).
- Condition under which the BMP works: Relative effectiveness for sediment reduction is similar across regions, soils, and slopes. Uneven distribution of cover could decrease effectiveness. Values were derived with greater emphasis on watershed-scale studies and natural rainfall, which more closely represent the real work than rainfall simulations. Sediment values are only relevant as surface transport.
- Considerations for benefits in load reduction: The panel reviewed and included seven peer-reviewed studies over a wide range of soil textures, slope and drainage. Because of this and the similar relative sediment efficiency values noted, the panel did not differentiate by texture, etc.

Geographic Considerations

- This practice is applicable to row crop land throughout the watershed.
- Load reduction estimates reflect edge-of-field reductions
- The baseline condition was Conservation Tillage, as currently defined. Efficiency values represent reductions relative to this baseline.

Temporal Considerations

- HR involves all crops in a multi-crop, multi-year rotation and the crop residue cover requirement (including living or dead material) is to be met immediately after planting of each crop in rotation.
- The practice is expected to provide full benefits at all times when the minimum residue cover is in place and effecting as long as that condition persists.

Modeling Considerations

Practice Monitoring and Reporting

- This practice could be tracked through field transect surveys (CTIC methodology), through remote sensing and limited field transect surveys, or through state or federal programs that collect information on high-residue minimum disturbance practices.

Data Gaps and Research Needs

If remote sensing of residue cover is adopted, additional research validation will likely be required and protocols for evaluation developed

Additional small watershed scale studies of nutrient and sediment losses from representative locations within the Bay watershed would provide highly valuable information.

Attachments

- Summary of literature included in Sediment reduction estimate
- Summary of literature reviewed for P reduction estimate
- Options considered by the panel for placeholder nutrient reductions
- Initial Expert Panel survey summary, conducted by TetraTech