Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices

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Acronyms

BMP	Best management practice
CBWM	Chesapeake Bay Watershed Model
CRP	Conservation Reserve Program
HGM	Hydrogeomorphic
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
WQGIT	Water Quality Goal Implementation Team

Summary of Findings

The Riparian Buffer Expert Panel reviewed recent data on nutrient and sediment reductions from riparian buffers to determine whether updates or enhancements to the current riparian buffer practice credits are warranted.

Current Practices
Under the current representation of riparian buffers, a buffer is a newly established area along a stream, on average 100 feet wide, of either grass or trees, and is managed to maintain the integrity of stream channels and shorelines and reduce the impacts of upstream land uses. Both grass and forest buffers that are at least 35' wide receive credit. This is part of USDA's standard practice definition (e.g., Practice 391) to receive cost share. Buffers can extend out to 300' wide in some cases. For riparian forest buffers, the average width in the Chesapeake watershed is 101' (CBPO unpublished). The average width of a grass buffer is not known (see Section 4H).

Credit in the model for a forest riparian buffer is partly represented as a land use change from the existing land use to forest land use. Similarly, credit for grass riparian buffers is partly represented as a land use change from the existing land use to hay without nutrients. In addition to the land use change, upland areas receive load reduction efficiencies according to Table 5, with the total nitrogen (TN) efficiency applied to 4 times (4x) the buffer acreage and the total phosphorus (TP) and total suspended sediment (TSS) efficiencies applied to 2 times (2x) the buffer acreage. Grass buffers receive the same efficiencies as forest buffers for TP and TSS; and 70 % the TN efficiency of forest buffers(see discussion in Section 4H).

Summary of Recommendations
The Riparian Buffer Expert Panel concluded that there is insufficient new information on buffer efficiencies at this time to make comprehensive changes to the current set of efficiencies for buffers. The Panel recommends one adjustment to the existing credits for forest riparian buffers for the next model iteration. This adjustment is for an additional 0.014 lb/foot of total nitrogen reduction for instream processing efficiency when riparian forest buffers that are established on both sides of the stream. This benefit was shown by Sweeney (2004) and described by Newbold in Section 4D. It would be in addition to the buffer's upslope efficiency. If a buffer is only on one side of a stream, the instream processing efficiency does not apply.

Weller and Baker (2014) provides the first empirical estimates of how effective buffers are at removing nitrate from cropland throughout the Chesapeake Bay basin (e.g., nitrate is reduced by 50% from fully-buffered croplands). The methods used by Weller and Baker have been proposed for use in Phase 6 of CWBM and adapted as a "flow model" to estimate the amount of nitrogen-laden run-off treated by certain buffers. The Panel is supportive using of the flow model and would like to stay engaged as the details are worked through if it is adopted.

A list of future research and management needs have been identified by the Panel (see Section 7). For instance, the Panel realizes that buffer width and vegetation type are likely to be less important than whether a buffer actually treats nutrient-laden water (hydrologic flow path). The efficiencies for riparian buffers should be reconsidered when, but not before, these flow paths are better understood and can be accounted for in the Chesapeake Bay Watershed Model (CBWM).

Advances in Buffer Science (Summary of Section 4)

A. Buffer width

The prevailing science indicates that a wider buffer is necessary to achieve the full credit for nutrient and sediment reductions. Most research supports effective buffer widths for water quality in the 50–150 foot (15-45 m) range. The Panel had extensive discussions about whether to provide lower nutrient efficiencies for buffers that have a width less than 100'. It was agreed that this would be somewhat arbitrary (unsupported in literature) and not necessary because the average width of forest buffers is still more than 100' (CBPO unpublished). [There is no similar documentation of average grass buffer width and they are generally narrower than forest buffers—see Section H.] Reforestation over the entire width of the flood plain is beneficial to better intercept the substantial flow coming from the toe slope onto the floodplain (Speiran 2010).

Table 1. **Proposed Upslope Forest and Grass Riparian Buffer Load Reduction Efficiencies**

	Forest on one side of stream (same as 2008)			**Grass** on one or both sides of stream (same as 2008)		
	TN	TP	TSS	TN	TP	TSS
Inner Coastal Plain	65	42	56	46	42	56
Outer Coastal Plain (well-drained)	31	45	60	21	45	60
Outer Coastal Plain (poorly drained)	56	39	52	39	39	52
Tidal Influenced	19	45	60	13	45	60
Piedmont (schist/gneiss)	46	36	48	32	36	48
Piedmont (sandstone)	56	42	56	39	42	56
Valley and Ridge (karst)	34	30	40	24	30	40
Valley and Ridge (sandstone/shale)	46	39	52	32	39	52
Appalachian Plateau	54	42	56	38	42	56
Note: Effectiveness credit is applied to upslope land at a ratio of 1:4 for TN, 1:2 for TP and TSS. This is not a new recommendation.						

Sweeney and Newbold (2014) found that in many studies that looked at buffer width, subsurface water flux was not taken into account or was found to be very small. In studies of areas with sufficient flux to supply stream flows, TN reductions above 80 % were only found in buffers greater than 30 meters (98 feet) wide. In a 10-meter (33 feet) buffer, the sediment reduction efficiency was under 60 %. A 10-meter buffer is approximately the minimum buffer width (35 feet) allowed to receive credit in the CBWM.

B. Loading rates and treatment of upslope acreage (spatial relations and flow)

Riparian zones form a transition between upslope soils and streams; and though riparian zones may account for only a small percentage of watershed area, they exert a disproportionately large role in regulating the flux of N to the stream (Cirmo and McDonnell, 1997; Hill, 1996a). The upslope distance above the buffer to ridge should be the area treated. Research supports the 4:1 ratio that is currently used which accounts for the average upslope distance to the buffer.

The CBWM does not currently account for the spatial relationship of riparian buffers and their adjacent land use. Buffers that treat areas of high-nutrient loading will be more effective than those that treat run-off with low nutrient loading. A recent paper (Weller and Baker 2014) provides the first empirical estimates of how effective buffers are at removing nitrate from cropland throughout the Chesapeake Bay basin (e.g., nitrate is reduced by 50% from fully-buffered croplands). The methods used by Weller and Baker are being proposed for use in Phase 6 of CWBM to estimate the amount of nitrogen-laden run-off buffers in a particular watershed would reduce. This "flow model" affects not only forest buffers, but any land use that treats non-point source runoff (e.g., wetlands and grass buffers).

Use of this model would connect nutrient processing to existing land uses and replace the need for the 4:1 upslope ratio currently provided for riparian buffers (e.g., % of cropland/pasture within contributing drainage area to each riparian buffer pixel). The Panel recognizes that use of the flow model would improve the efficiency estimates for riparian forest buffers in most regions (see caveat for Eastern Shore as described in Section 4B), but would like to stay engaged how it is adapted to the CBWM.
The Panel agrees that riparian buffers/floodplain should be treated as a separate land use in the CBWM because of their advantageous position to treat flow from the edge-of-field.

C. Hydrologic flow paths

Subsurface flows are important to understanding buffer efficiency. They can be substantially different from surface runoff pathways and have not previously been considered in the CBWM because they are difficult to measure without intensive study. Mayer et al. (2005) found that when the flow path through a buffer was subsurface, the mean nitrogen removal rate was much higher (90 %) than when the flow path was across the ground surface (33 %). Soil denitrification potential is generally expected to be highest near the surface, where root density and organic matter are highest, and to decline rapidly with depth (Gold et al. 2001).

Hot spots (e.g., present or former wetlands) are part of the subsurface drainage system where groundwater rises to meet with the carbon-rich soils that support high rates of denitrification. Hot spots are areas of increased nitrate processing because of the organic interaction with water and anaerobic conditions. It has not been feasible to map these areas in the past, but new technology such as LiDAR, Synthetic Aperture Radar, and high resolution imagery can help identify these areas, which can also sometimes be identified in the field.

D. Instream processing

It has been demonstrated that forested stream reaches maintain greater stream width (more benthic habitat and area for hyporheic exchange), more nutrient input, and lower stream velocity (Sweeney et al. 2004). It has been shown that these characteristics increase habitat for nutrient processing, more processing time, and more colonization by the organisms capable of denitrification (Vannote et al. 1980). Clinton and Vose (2005) attributed an approximate 50% removal of nitrates, ammonium, and phosphorous to a forested stream reach and associated heterotrophic and autotrophic activity with this removal. Sweeney et al. (2004) showed how streams forested on both sides increased denitrification 2-8x compared to non-forested streams. As explained in Section D of the main document, Newbold attributes an additional 0.014 lb/ft nitrogen removal where riparian forest buffers occur on both sides of a stream *after* water has entered the stream.

E. Practice longevity

In the past, the life of the forest buffer practice has been artificially set at 15 years because it reflects the length of a typical Conservation Reserve Enhancement Program (CREP) contract. However, several studies showed that 80–85 % of Pennsylvania landowners will leave buffers in place in perpetuity (Cooper 2005, Eisenbise 2014). Because this practice is regenerative, it is likely to last 120 years or more, once established. While age and practice longevity do not change the modeled nutrient and sediment reduction efficiency of the practice, practice longevity is important to assure existence, functioning and cost-benefit. A conservative estimate of the riparian forest buffer practice longevity is 40 years.

F. Lag time

Some forest buffer functions are realized quickly following planting and increase as forest soil and canopy functions are rebuilt. Newly-established forest buffers have been found to have reduced pollutant reduction efficiency in the first 5 to10 years, but show significant improvement in efficiency in subsequent years (Straughan Env. Service 2003, in Hairston-Strang 2005). The extent of this reduced efficiency depends on prior land uses and soil development. While it is feasible for the CBWM to assign a lower efficiency for newer buffers, the recommended efficiencies for forest buffers are sufficiently conservative to address any lower efficiency experienced when buffers are new.

G. Grass interface zone as part of riparian buffer

Riparian forest buffers benefit from having a grass interface upslope. Namely, the grass interface can induce uniform flow and help prevent channelization across the buffer. The *Riparian Forest Buffers Function and Design for Protection and Enhancement of Water Resources* specifies a 3-zone buffer that is a minimum of 95 feet: at least 75 feet of forest and 20 feet of grass (Welsch 1991). There are other techniques that can be used to ensure uniform flow into the buffer (e.g., addition of a level spreader or swale, heightened maintenance, etc.) While an upslope grass area should be added to a forest buffer for best results, the Panel is not recommending that this be a requirement.

H. Efficiencies for Grass-only buffers

Both grass and forested buffers have been shown to reduce nitrogen effectively. Grass can provide dense protection of soil surfaces, but usually generates more runoff than forest. Several studies have found that grass buffers are less effective than forest buffers at removing nutrients (Lowrance 1998, Mayer et al. 2005). Sweeney and Newbold (2014) looked at forest and grass buffers through a meta- analysis and found that there is a lack of research on natural landscape grass buffers, as opposed to experimental plots with artificial flow. Few studies were cited that could definitively point to an appropriate TN efficiency for grass buffers. The original TN discount to 70 % of the forest buffer efficiency was reaffirmed in the 2009 BMP Assessment Report which clearly noted that more research was needed to support this (Simpson and Weammert 2009). In the absence of data to support or refute this estimation, the Panel recommends no change.

1 Expert Panel and its Charge

This report summarizes the findings of the Riparian Buffer Expert Panel workgroup in reassessing the representation of agricultural forest and grass riparian buffers in the CBWM. Table 1 identifies the members of the Expert Panel.

Table 1. List of Expert Panelists

Panelist	Organization
Ken Belt	USFS Northern Research Station
Peter Groffman	Cary Institute of Ecosystem Studies
Cully Hession	Virginia Tech
Denis Newbold	Stroud Water Research Center
Greg Noe	USGS
Judy Okay	Consultant for Virginia Department of Forestry
Mark Southerland	Versar
Gary Speiran	USGS
Ken Staver	University of Maryland
Anne Hairston-Strang	Maryland Department of Natural Resources
Don Weller	Smithsonian Environmental Research Center
Dave Wise	Chesapeake Bay Foundation and Stroud Water Research Center

The Expert Panel was tasked with reviewing the available science on the nutrient/sediment removal performance of riparian buffers, provide updated methodology for representing the BMPs, and recommend procedures for reporting, tracking, and verifying the practices. While conducting its review, the Expert Panel followed the procedures and process outlined in the Water Quality Goal Implementation Team (WQGIT) BMP review protocol.

2 Protocol for Defining Removal Rates for BMPs

The Chesapeake Bay Program WQGIT developed a protocol to guide the development, review and approval of BMP loading and effectiveness in the CBWM: *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model* (WQGIT 2010).

According to the Protocol, once BMPs are selected for review, an Expert Panel must be convened by the appropriate source sector workgroup. The Expert Panel must include at least six members with at least three subject matter experts and three environmental and water quality-related issues experts. The Expert Panel must develop a report addressing 21 elements. This report is the riparian forest and grass buffer BMPs Expert Panel report prepared for the Forestry Workgroup. The 21 elements that must be addressed are provided narratively throughout this report and are summarized by each element in Appendix C. The recommendations contained within this report must be reviewed and approved by the Forestry Workgroup. The recommendations will then be reviewed by the Agriculture Workgroup, the Watershed Technical Workgroup, and finally the WQGIT.

The current review builds off of the previous assessment of the riparian forest and grass buffers completed in 2009 (Simpson and Weammert 2009). The review of the buffer BMP efficiencies in this report expands beyond those data used in the prior report. Although new data were identified, there was sufficient uncertainty so as not to recommend changes to the way forest and grass riparian buffers are represented and credited in the CBWM. The Expert Panel frequently cited resources already incorporated into the 2009 recommendations, *Developing Nitrogen, Phosphorus and Sediment Reduction Efficiencies for Tributary Strategy Practices BMP Assessment: Final Report* (Simpson and Weammert 2009). A literature search was conducted by Tetra Tech to identify literature that might be relevant to the BMP review process. This occurred in the early stages of the Expert Panel selection and formation. It is not clear if the Expert Panel made much use of the literature search results. Most Panel members are published experts and appeared to provide their own resources.

The Expert Panel held six conference calls to discuss the key issues that would need to be addressed in reviewing the riparian buffer BMPs. The results of these discussions are summarized in Section 4.

3 Definitions and Qualifying Conditions

A *Riparian Forest Buffer* is an "area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water which is managed to maintain the integrity of streams and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, to supply food, cover, and thermal protection to fish and other wildlife." (Simpson and Weammert 2009) Previous definitions have maintained that the buffer have at least 2 species of trees (Palone and Todd 1997) and that is inherent in the definition (i.e., a tree farm or plantation would not qualify).

A *Riparian Grass Buffer* is an "area of grasses that is at least 35 feet wide on one side of a stream that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals to supply food, cover and thermal protection to fish and other wildlife." (Simpson and Weammert 2009).

Tables 2 and 3 summarize the riparian buffer BMPs and their load reduction representation in the CBWM.

Table 2. Agricultural Riparian Forest Buffer Definition and Representation

Definition:	Agricultural riparian forest buffers are linear wooded areas adjacent to a body of water and managed to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, to supply food, cover, and thermal protection to fish and other wildlife. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with 35 feet minimum width required.
Land use:	*conventional tillage with manure (hwm), nutrient management conventional tillage with manure (nhi), conventional tillage without manure (hom), conservation tillage with manure (lwm), hay-fertilized (hyw), alfalfa (alf), pasture (pas), nutrient management conventional tillage without manure (nho), nutrient management conservation tillage with manure (nlo), nutrient management hay (nhy), nutrient management alfalfa (nal), nutrient management pasture (npa), degraded riparian pasture (trp),* and *hay without nutrients (hyo)*
Efficiency credited:	Landuse change to *forest, woodland, and wooded (for)* and a reduction efficiency for upland areas.
Effectiveness estimate:	Varies geographically TN: 19–65% (4x acres)*; TP: 30–45% (2x acres); TSS: 40–60% (2x acres). See Table 5.

Table 3. Agricultural Riparian Grass Buffer Definition and Representation

Definition:	Agricultural riparian grass buffers are linear strips of grass or other non-woody vegetation maintained between the edge of fields and a water body that help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for riparian grass buffers (agriculture) is 100 feet, with a 35 feet minimum width required.
Land use:	*conventional tillage with manure (hwm), nutrient management conventional tillage with manure (nhi), conventional tillage without manure (hom), conservation tillage with manure (lwm), hay-fertilized (hyw), alfalfa (alf), pasture (pas), nutrient management conventional tillage without manure (nho), nutrient management conservation tillage with manure (nlo), nutrient management hay (nhy), nutrient management alfalfa (nal), and nutrient management pasture (npa)*
Efficiency credited:	Land use change to *hay without nutrients (hyo)* and a reduction efficiency for upland areas. Upland areas efficiencies are credited for four times the buffer acreage for TN reduction and two times the buffer acreage for TP and TSS reduction.
Effectiveness estimate:	Varies geographically TN: 13–46% (4x acres)*; TP: 30–45% (2x acres); TSS: 40–60% (2x acres). See Table 5.

The actual buffer area is treated as a land use change. In addition to the land use, upslope contributing areas receive a load reduction efficiency credit because they are treated by the buffer. Areas upslope of forest buffers receive a total nitrogen (TN) efficiency credit for an upland area four times the area of the buffer. Efficiency credit is applied to two times the buffer area for total phosphorus (TP) and total suspended solids (TSS) reductions. Upland area efficiencies are listed in the Table 4. Both forest and grass buffers receive the same TP and TSS efficiencies. Grass buffers receive 70 % of the forest buffer TN efficiencies.

Table 4. Upslope reduction efficiencies for agricultural forest and grass riparian buffers (2009)

	Forest			Grass		
	TN	TP	TSS	TN	TP	TSS
Inner Coastal Plain	65	42	56	46	42	56
Outer Coastal Plain (well-drained)	31	45	60	21	45	60
Outer Coastal Plain (poorly drained)	56	39	52	39	39	52
Tidal Influenced	19	45	60	13	45	60
Piedmont (schist/gneiss)	46	36	48	32	36	48
Piedmont (sandstone)	56	42	56	39	42	56
Valley and Ridge (karst)	34	30	40	24	30	40
Valley and Ridge (sandstone/shale)	46	39	52	32	39	52
Appalachian Plateau	54	42	56	38	42	56
Note: Effectiveness credit is applied to upslope land at a ratio of 4:1 for TN, 2:1 for TP and TSS. For each acre of riparian buffer 4 acres of upland are treated at the rate assigned for the location in the watershed (this is not a new recommendation).						

The following hydrogeopmorphic regions (HGMs) are currently used by the CBWM:

CPLN Coastal Plain Lowlands Non Tidal
CPDN Coastal Plain Dissected Uplands Non Tidal
CPUN Coastal Plain Uplands Non Tidal
ML_N Mesozoic Lowlands Non Tidal
PCAN Piedmont Carbonate Non Tidal
PCRN Piedmont Crystalline Non Tidal
VRSN Valley and Ridge Siliciclastic Non Tidal
APSN Appalachian Plateau Siliciclastic Non Tidal
BR_N Blue Ridge Non Tidal
VRCN Valley and Ridge Carbonate Non Tidal
CPDT Coastal Plain Dissected Uplands Tidal
CPLT Coastal Plain Lowlands Tidal
CPUT Coastal Plain Uplands Tidal
APCN Appalachian Plateau Carbonate Non Tidal

The regional efficiencies established by Simpson and Weammert (2009) are averages referring published literature from that region when available. More information on the ranges, standard errors, and measures of dispersion among the estimates for each region is needed (see Section 7). The same studies did not provide supporting evidence for grass being 70% as efficient as forest buffers in TN removal (see Section 4H).

4 Review of the Available Science

Hundreds of papers have been written on the effects of streamside buffers that apply to the mid-Atlantic region where streamsides are forested in their natural historical condition (Sprague et al. 2006). It is well established that removing these forests greatly alters the physical, chemical, and biological dynamics of stream ecosystems (Sweeney and Newbold 2014). The long list of habitat and ecological benefits from forest buffers should be noted, but the focus of the paper is on water quality, specifically how riparian buffers affect TN, TP, and TSS. Agricultural forest riparian buffers are the focus of this Review; however agricultural grass buffers are also addressed (Section 4H). Urban buffer efficiencies were not reviewed as part of this panel; refer to Scenerio Builder documentation for current CBWM information on urban buffers.

Earlier papers on buffer efficiency showed high pollution removal potential. Jacobs and Gilliam (1985) observed that up to 90% (10-55 kg ha-1 y-1) of removal of nitrate moving from upland agricultural fields took place in the first 10-15 m of an adjacent riparian zone. Similar percentage reductions of nitrate concentrations have been reported in other areas of the southeast (Lowrance et al. 1984; Peterjohn and Correll 1984). Effective nitrate removal by riparian zones has been reported in agricultural watersheds elsewhere in the world. The 2002 review was based on these earlier studies which showed exceptional promise of this practice to remove nutrients. A more recent riparian buffer review by Simpson and Weammert (2009) reduced riparian forest buffer efficiencies in the watershed by 20% from where they were set in 2002. This was a more conservative interpretation of the available literature.

Recent studies have increased our understanding of how, where, and when riparian zones function as pollutant sinks by incorporating flow path information, more complex and detailed models, and new understandings of how forests benefit stream health and instream processing of nutrients. New information has aided our understanding of subsurface and watershed-scale interactions. The major flow patterns are formed by the landscape and geology, but the vegetation that modifies the surface and shallow sub-surface conditions over time can affect how water moves. Key studies continue to distinguish between hydrogeomorphic regions (Weller 2011, Denver 2010). Other new work by Sweeney and Newbold (2014) has furthered the understanding of riparian forests by examining literature on the function of buffer width, and they also continue to expand our understanding of instream physical, chemical and biological characteristics attributable to riparian forests. Weller and Baker (2014) modeled how Chesapeake watershed buffers that are downslope of nitrate-laden flow reduce more nitrogen.

To determine whether the current BMP effectiveness needed to be modified, the Panel addressed the following “hot” topics in the literature which form the organization of Section 4:

A. Buffer width
B. Loading rates and treatment of upslope acreage (spatial relations)
C. Hydrologic flow paths
D. Instream processing
E. Practice longevity
F. Lag time
G. Grass interface zone as part of riparian buffer
H. Grass buffers

A. Buffer Width

Current regulations and credit: A forest buffer can be 35-300' according to the Standard Practice of the Natural Resources Conservation Service Conservation Practice Standard (Practice 391). All of these buffers (with minimum 35' width) receive the full efficiency in the CBWM. The average forest buffer width currently being restored in the Bay watershed is 101 feet (CBP unpublished).

Narrow Buffer Strips (less than 35')—Narrow buffer strips can be a distinct practice, separate from Riparian Forest and Riparian Grass Buffers of 35 feet and greater. These strips receive the benefit of land-use change only without any upland benefits. The CBWM (Phase 5.3.2) currently allows this practice but labels it as a land retirement or tree planting practice. Defining these as Narrow Buffers would more clearly distinguish that they do not qualify as regular Riparian Buffers. The scientific literature for Narrow Buffer practices was not reviewed as part of this Expert Panel, but the following terms and definitions are suggested for use going forward (in both Phase 5.3.2 and 6.0):

Narrow Grass Buffer - *Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.*

Narrow Forest Buffer *– Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.*

Buffer width is one of the few buffer characteristics, along with physiogeographic province, where there are sufficient data to show a difference in performance. Other factors, such as flow and location, might be better indicators of efficiency, but width is a visual characteristic that is easily measured (Sweeney and Newbold 2014).

There is not universal agreement on the role of width. One Panelist suggested that buffer width makes little difference in the CBWM in which buffers are accounted on an acre-by-acre basis (i.e., a narrower buffer has a small land conversion and small treated area, but not less efficiency on an area basis than a wider buffer). The prevailing science indicates that a buffer of 100' width is necessary to achieve the full credit for nutrient and sediment reductions. The Panel had extensive discussions about whether to provide lower nutrient reduction efficiencies for buffers that have a width less than 100'. It was agreed that this would be somewhat arbitrary (unsupported in literature) and not necessary because the average width of forest buffers is still more than 100' (CBPO unpublished).

Wider buffers can filter out fine sediment which otherwise severely affects stream functioning (STAC 2012). In a literature survey by Mayer et al. (2005) forest buffer widths of 10- 200 m are shown to reduce pollutants from surface flow and shallow groundwater flows at levels of 58 – 100%. Additional water quality benefits diminish beyond 230 feet (70 m) (Sweeney and Newbold 2014), but reforestation of the entire flood plain is beneficial to intercept flow as it comes out of the toe slope and onto the floodplain (Speiran 2010). Most research, however, supports effective buffer widths for water quality in the 50–150 foot (15-45 m) range.

Overbank flooding—flooding that spills stream water onto a vegetated floodplain— can further increase the load reductions attributed to buffers by treating water coming from the stream. Floodplains are often on 3rd order-and-larger streams (sometimes 2nd order), and when overbank flooding happens, the load removal from this process can be larger than buffer retention of loads from uplands (STAC 2012). Restoring floodplain forests can increase retention time on floodplains by increasing roughness from vegetation that influences particle deposition on the floodplain and prevents bank erosion. Kaushal et al. (2008) also noted that longer hydrologic residence times that can occur with overland flooding and other water- floodplain interactions are important to remove nitrogen. Spackman and Hughes (1995) and Castelle et al. (199l), support a minimum riparian buffer width of 50 – 100 ft (15 – 30m) to promote floodplain and stream channel or shoreline stability, which are important to sediment reduction. As with wetlands, mapping the extent of floodplains has not yet been incorporated into the CBWM.

Sweeney and Newbold (2014) found that most studies of buffer width are not measuring the right metrics. In many studies, subsurface water flux was not taken into account or was found to be very small. In studies with sufficient flux to supply stream flows, TN reductions above 80 % were only found in buffers greater than 30 m (98 ft) wide. In buffers less than 30 m wide, the efficiency was lower, ranging from 35 to 80 %. When looking at sediment, many studies used confined, artificial flow. When these studies (no flux and artificial flow) are excluded, remaining studies show an efficiency of 80 % in a 30 m buffer. In a 10 m (33 ft) buffer the efficiency was under 60 %. A 10-meter buffer is approximately the minimum buffer width (35 ft) allowed to receive credit in the CBWM.

A Chesapeake report entitled "The Role of Natural Landscape Features in the Fate and Transport of Nutrients and Sediment" (STAC 2012) recommends that riparian forest, forested floodplains (in general, these are wider and closer to water table than riparian forests), and other wetlands be identified and mapped and that loading rates for the new land use classes should be adjusted based on spatially explicit landscape attributes, including directional connectivity, multi-direction flow fields, and flow path analysis.

Recommendation: The Panel recommends that width continue to be a primary indicator in establishing effective buffers. A variable-width buffer, which takes into account floodplain, water flux, and likelihood of concentrated flowpaths) may be desirable, but is impractical to apply across the watershed at this time. Future work studying variable width buffers, floodplain forest and subsurface flow regimes is recommended (see Section C).

The Panel recommends that the current regulations for width be maintained. Also, they recommend that any buffer practice less than 35 feet in width be considered **a separate practice** in the CBWM and suggest they not receive any upslope benefits(be credited as a land use change only similar to the agricultural tree planting practice), as follows:

Narrow Grass Buffer Strip - *Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.*

Narrow Forest Buffer Strip *– Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.*

B. Loading Rates

An area of riparian buffer that treats flow laden with nutrients (e.g., from cropland) will improve water quality more than the same area of buffer that is treating the same amount of flow with lower nutrient loading (e.g., from forest). The CBWM does not directly account for adjacent land use to a buffer, but does apply the efficiency proportionally to all agricultural land uses in a land-river segment.

A study done by Weller et al. (2011) analyzed stream nitrate levels within clusters of subwatersheds in the four major hydrogeomorphic regions in the watershed. They used a GIS analysis to quantify the proportion of land occupied by cropland in each watershed and then to classify cropland as buffered or unbuffered. Cropland was considered buffered if it was positioned uphill from a streamside forest or wetland. Weller and Baker (2014) applied statistical models to quantify average nitrate loss per acre of cropland, the amount of the nitrate removed by extant riparian buffers, and the amount of additional water quality benefit that would be gained by restoring gaps in buffers below croplands. These benefits are similar to values proposed by Sweeney and Newbold (2014).

The CBWM does not currently account for the spatial relationship of riparian buffers and their adjacent land use. Buffers that treat areas of high-nutrient loading will be more effective than those that treat run-off with low nutrient loading. Weller and Baker (2014) provides the first empirical estimates of how effective buffers are at removing nitrate from cropland throughout the Chesapeake Bay basin (e.g., nitrate is reduced by 50% from fully-buffered croplands). The methods used by Weller and Baker are being proposed for use in Phase 6 of CWBM to estimate the amount of nitrogen-laden run-off buffers in a particular watershed would reduce. This "flow model" affects not only buffers, but any BMP designed to treat non-point source agricultural runoff like wetlands. Use of this model will also connect nutrient processing to existing riparian forest buffers (e.g., % of cropland/pasture within contributing drainage area to each riparian forest pixel).

One region that the flow model may not be valid is the Eastern Shore. Both hydrogeomorphic and hydrogeologic setting need to be considered when looking at nutrient transport and this is especially true in the Coastal Plain. According to Ator and Denver (2012), Eastern and Western Shores of the Coastal Plain are very different with respect to how nutrients are transported to streams and some of the highest N concentrations found on the Eastern Shore have well-buffered streams and intact forested riparian wetlands. Future modeling should include hydrogeology and the geochemical conditions associated with a particular hydrogeologic setting, which have been mapped, explained, and are available as GIS coverages for the Coastal Plain (e.g., see Ator et al. 2013). For the Eastern Shore, the potential impact of engineered stream channels on nutrient transport should also be studied and taken into account.

Treatment of Upslope Acreage

Riparian zones form a transition between upslope soils and streams and though they may account for only a small percentage of watershed area, they can exert a disproportionately large role in regulating the flux of N to the stream (Cirmo and McDonnell 1997; Hill 1996a). The treatment of upslope acreage was covered in depth during the 2009 review (Okay and Weammert 2009) when it was determined that a 4:1 upslope to buffer area ratio was appropriate. This Expert Panel was asked to take another look at the 4:1 ratio to ensure it was appropriate and conservative.

The Panel reasoned that since the upslope area treated is the distance from buffer to ridge. Based on an average drainage density of 2 km/km^2, the average distance from a 1st order stream to ridge is 250 meters. So even for a 100 foot wide buffer on a 1st order stream, the existing 4:1 ratio is conservative. For larger order streams, the entire upslope area should be considered further suggesting that the 4:1 ratio is conservative.

The discussion of adjacent land use, upslope acreage, and loading rates is closely linked to the discussion in Section 4C on hydrologic flow paths.

Recommendation: The Panel acknowledges that source area is important ("what is the buffer buffering?") and encourages that the spatial relationships of source land uses to BMP's be well- explored as part of the Phase 6.0 land use portion of the CBWM. Specifically, the Panel recommends that CBWM continue to examine classifying existing riparian buffers/floodplain as a separate land use and explore the incorporation of Weller and Baker's flow model to inform future changes in buffer efficiencies based on loading rates of upslope land uses. In lieu of the CBWM adopting the flow model, the Panel reaffirms the use of a 4:1 upslope:buffer efficiency application for nitrogen and 2:1 for phosphorus and suspended sediment.

C. Hydrologic Flow Paths

Flow interactions with the buffer zone are important to understanding buffer efficiency. Soil denitrification potential is generally expected to be highest near the surface, where root density and organic matter are highest, and to decline rapidly with depth (Gold et al. 2001). Subsurface flows act differently than surface runoff but are difficult to map and measure without intensive study including well-drilling. Subsurface flow paths do not always allow for contact with the carbon-rich soils that support high rates of denitrification.

Flow can divert water away from buffer functions in various ways. In areas of the Coastal Plain for instance, the bulk of nitrate entering the stream is through groundwater and may be unaffected by buffers. In Karst regions, overland flow may not reach a riparian buffer. Other instances of diversion are treated below (e.g., concentrated flow) and can be a factor of poor design and/or maintenance of the buffer.

Hydrologic flow paths, combined with loading rates (Section 4B) have been the primary means of targeting the placement of buffer restoration. Targeting is an important topic and will continue to be refined based on results from actions recommended in Section 7.

The Panel agreed on the following points regarding the effectiveness of nitrogen removal based on hydrologic flow paths:

- Removal potential is greatest when upland-derived nitrate is moving toward the buffer/stream in shallow subsurface flow.
- Removal is usually less when nitrate is moving in surface runoff. Mayer et al. (2005) found that when the flow path through a buffer was subsurface, the mean nitrogen removal rate was much higher (90 %) than when the flow path was across the surface (33 %).
- Removal is less when nitrate is part of deep groundwater flow that moves below the biologically active area near surface soil and the riparian root zone. Some of these deep flowpaths bypass the riparian zone altogether and discharge directly into the stream bed.
- Removal is less when subsurface flow emerges in the riparian zone as a seep that then flows rapidly across the riparian zone into the stream.

Soil depth and slope are key variables that influence runoff, so hydrogeomorphic region provides a useful distinction for changes in function over the landscape. Narrower buffer widths (10-20 m) are effective where higher amounts of subsurface water moves through a buffer. This subsurface flow, sometimes called water flux, varies considerably from site to site depending on base flow, drainage density, and other edaphic factors.

Some good data on hydrologic flow paths and hydrogeomorphic regions is emerging---there are large-scale hydrogeologic features that affect groundwater and whether or not the buffer is intercepting the flow. For instance, on the Eastern Shore, where there are thick aquifers, most nitrogen comes into the stream transported by groundwater and so bypasses the buffer (Ator and Denver 2012). Similarly, less than 10% of annual flow is surface run-off in the karst region of the Valley and Ridge Province and groundwater discharge is high.

In some cases flow has been manipulated by agriculture practices and this affects buffer function. Beneficial practices like conservation tillage help treat nutrient and sediment at the sources, can slow runoff and complement buffers. Other practices, such as tile drainage can render a riparian buffer less effective because of the concentration of water in the drain and the speed by which the water is moved off of the land.

Other than knowing the general patterns common to hydrogeomorphic regions, there is no way to consistently predict what type of flowpath will dominate at a particular site. Three common flowpaths are discussed below (C1, C2 and C3).

C1. Concentrated Flow Paths

A potential weakness of riparian buffers is that they are susceptible to the formation of concentrated flow paths--- surface water routed quickly through the riparian zone, limiting treatment by the buffer. This can be prevented through good buffer design that uses a grass filter strip edge or a more engineered level-spreader that ensures uniform flow entering the buffer.

Forests maintain high infiltration rates due to protective and absorbent litter layers, high organic matter levels that promote good soil and duff layers (roughness factor (Mannings *n*) that helps slow water, and the presence of larger and deeper root-channel pores, also called macropores (Aubertin 1971 and Jackson et al. 1996), that allow water to infiltrate soil faster. Still, forests have been shown to be more susceptible than grass to concentrated flows because as flow encounters the microtopography around tree trunks, reconcentration of flow can occur, reducing the effective size of the buffer flow path (Winston and Hunt 2011).

C2. Headwaters

Riparian buffers are especially important along the smaller streams which make up the majority of stream miles in any basin (Osborne and Wiley 1988 in Osborne and Kovacic 1993, Binford and Buchenau 1993, Hubbard and Lowrance 1994, Lowrance et al. 1997). These streams have the most land-water interaction and are good opportunities to stop the transport of pollutants downstream. Flow to these streams may be intermittent and slow, with increased movement in and out of the hyporheic zone.

Water is stored in soil, and when the carrying-capacity of soils in a watershed is reached, and the water increases runoff through a variety of paths. Tromp-van Meerveld and McDonnell (2006) saw a threshold response at 2.2 inches (55 mm) of rain in Georgia, where water was added to streams only after storms delivered more than 2 inches (55 mm) of rainfall. Steeper slopes, as found in some headwater streams in the Piedmont and Valley and Ridge regions, may take more precipitation to saturate the soils because surface flow is greater (Sayama et al. 2011).

C3. Hot spots (e.g., seeps, present or former wetlands) are part of the subsurface drainage system where groundwater rises to meet the carbon-rich soils that support high rates of denitrification. Hot spots are often areas of increased nitrate processing. Although sometimes visible in the field, it has not been feasible to map these hotspots. New technology such as LiDAR, Synthetic Aperture Radar, and high resolution imagery can help identify and map these areas.

Recommendation: The Panel does not recommend changes based on flow, except for the previously mentioned incorporation of Weller and Baker (2014) into the CBWM for Phase 6.0. The issue of concentrated flow paths is addressed at least in part in the Verification Guidance (Section 6). Future research and finer-scale mapping technologies will allow the CBWM to continually improve accounting for spatial landscape characteristics and target practices appropriately.

D. Instream Processing

It has been demonstrated that forested stream reaches maintain greater width (more benthic habitat and area for hyporheic exchange), higher allochthonous input and lower stream velocity (Sweeney et al. 2004) than non-forested streams. These actions increase habitat for nutrient processing, increase processing time, and allow for more colonization by the organisms capable of denitrification (Vannote et al. 1980). Macroinvertebrates are the intermediate trophic level of stream ecosystems and serve as conduits in nutrient cycling (Wallace and Webster 1996). More plant litter is retained by streams bordered by forest cover (Cummins et al. 1989). Leaves can remain in water from 1-5 months dependent on species. The various decomposition times of leaves allows for a more or less constant food source for diverse macroinvertebrate species.

Some studies have shown how the sunlight in non- forested reaches resulted in increased algal uptake of nutrients (Webster and Swank 1985). This is not denitrification but a transfer of nutrients, especially as algae are considered to be a short-term uptake and are sometimes classified as suspended sediment. The Panel suggests additional research on the nutrient effects of algal growth in the mid-Atlantic.

Hyporheic exchange (flow from stream to surrounding area and vice versa) has been shown to be important for nutrient processing (Sweeney et al. 2004). The Chesapeake Bay Program recently approved a nitrogen reduction credit for instream and riparian nutrient processing during base flow through hyporheic exchange within the riparian corridor (2012 Stream Restoration Expert Panel). Stream restoration can expand the denitrification zone by changing the stream dynamics through channel widening and bank reconstruction. Streamside forests also improve habitat for greater instream biological processing of nitrogen through organic matter contributions and channel widening—improving hyporheic exchange. Forests on both sides of smaller streams (1st-5th order streams or those draining ~0.05 to~ 100km^2) most effectively contribute to instream denitrification (Sweeney and Newbold 2014).

Sweeney et al. (2004) showed how streams forested on both sides increased denitrification 2-8x compared to non-forested streams. Clinton and Vose (2005) attributed an approximate 50% removal of nitrates, ammonium, and phosphorous to a forested stream reach and associated heterotrophic and autotrophic activity with this removal. Tank et al. (2000) found this particularly in sediments and during the fall when organic matter inputs and demand for nutrients are greatest. Mulholland et al. (2008) observed that instream denitrification accounted for a median of 16% of total nitrate uptake across all streams studied (and this amount does not account for delayed denitrification that may occur after nitrate is remineralized). However, it was debated that that research takes a narrow view of denitrification and reports rates that are substantially lower than what the SPARROW model reflects.

An estimate of the increase in nitrogen removal by instream processes can be made by measuring the increase in bottom habitat (Hession et al. 2003, Sweeney et al. 2004). Denis Newbold presented to the Panel the following conservative, science-based denitrification estimate based on bottom habitat:

Forest increases stream width at the water surface at base flow an average of 1.9 m. This result is applicable to streams with drainage areas of < 1 km2 to about 50 km2 (includes upwards of 90% of all stream lengths in a region). Stream size has an influence: the smallest streams are wider by about 1.5 m, the largest by >3 m.

Using tracer additions of ^{15}N-labeled nitrate, Mulholland et al. (2008) found that the mass transfer coefficient, v_f (cm/s), for denitrification in streams varied with nitrate concentration according to:

$$\log_{10}(v_f) = -0.493 \cdot \log_{10}[NO_3^-] - 2.975 \quad (1)$$

where $[NO_3^-]$ is given as µg/L of nitrogen. Thus the mass transfer coefficient varies by about 2 orders of magnitude over the range of nitrate concentrations observed in streams and rivers. Using a nitrate concentration of 1000 µg/L, as representative of a stream with anthropogenic influences, yields a v_f of 3.5×10^{-5} cm/s. Alexander et al. (2008), using the SPARROW model to route estimated nitrogen loads and fit observed nitrogen concentrations throughout the Mississippi basin, obtained a basin wide estimate for v_f of 17.7 m/y, which is equivalent to 5.6×10^{-5} cm/s. Given that these two estimates were based on completely different approaches, the rough agreement between them supports Mulholland's methods.

Equation (1) can be converted to an estimate of areal mass flux of denitrification, U_{den} (mg m^{-2} s^{-1}) by taking antilogs, multiplying vf by the nitrate concentration, and converting units. Thus,

$$U_{den} = [NO_3^-]^{0.507} \cdot 1.06 \times 10^{-5} \quad (2)$$

According to Eq. (2), the mass flux of denitrification increases approximately as the square root of nitrate concentration and so is far less sensitive to concentration than is v_f. At a relatively low nitrate concentration of 10 µg/L, typical of an undisturbed forest, $U_{den} = 3.4 \times 10^{-5}$ mg m^{-2} s^{-1}. At 1000 µg/L, $U_{den} = 3.5 \times 10^{-4}$ mg m^{-2} s^{-1}. That is, increasing nitrate concentration by a factor of 100 increases denitrification by a factor of only about 10. This suggests that a single estimate for disturbed watersheds of about 3.5×10^{-4} mg m^{-2} s^{-1} is reasonable for crediting riparian buffers.

Using a stream widening of 1.9 m and a nitrogen removal of 3.5×10^{-4} mg m^{-2} s^{-1} (11 g m^{-2} yr^{-1}), we can now estimate that reforesting both sides of a meter of stream will remove 21 g of N per year, or 0.014 lb N per lineal foot of stream per year. There are two important caveats to this estimate: 1) the data for channel widening were derived from streams that were forested on both sides with a minimum average buffer width of 25 m; 2) the reference (no-buffer) stream has no access by grazing livestock.

To estimate nitrogen removal as a proportion of loading, we can use an assumed loading from the landscape of 10 kg ha^{-1} yr^{-1} (1000 kg km^{-2} yr^{-1}) and a drainage density of 2.2 km^{-1} (Baker et al. 2007). Reforestation of both sides of the streams in one km^2 would add 1.9 m × 2200 m or 4200 m^2 of streambed area, removing roughly 4.6% of the nitrogen load. This reduction estimate uses a rather arbitrarily chosen loading rate of 10 kg/ha/y, distributed across the entire watershed, and is provided here as an example only.

Unlike the direct removal function of the buffer, which intercepts nitrogen between an upslope source and the stream, the additional denitrification that occurs in the streambed due to widening removes nitrogen that has already entered the stream and therefore has originated from anywhere in the watershed.

Stream Width to Bank Height Ratio

The 2012 Stream Restoration Expert Panel report based their instream processing credit on obtaining a low stream width:bank height ratio. Hession et al. (2003) observed that the widening effect of forests on urban streams was similar to that of non-urban streams, and occurred despite a significant underlying effect of urbanization on channel width. Hession et al. (2003) concluded that "riparian vegetation exerts a strong influence on channel width regardless of the level of urbanization in the watershed." The Riparian Buffer Panel did not look at bank erosion rates. Neither Hession et al. (2003) or Sweeney et al. (2004) based their findings on the stream width:bank height ratio. The Panel believes both of these assessments of instream processing to be valid. The two types of instream processing credits should however be mutually exclusive—this would relieve those proposing reforestation of the burden of determining the bankfull stage—and allow for some consistency, and no double-counting of instream processing benefits.

Recommendation: The Panel recommends a nitrogen removal credit of 0.014 lb N per foot (21 g/m) of stream length for reforestation of both sides of a stream, applicable to reaches of order 1-5 (watershed areas ~0.05 to ~100 km^2). For a length of stream of 500 feet, N reduction would be 7lbs for instream processing alone; for a mile long length of stream the N reduction is 73 lbs. This credit should be added to the efficiency independently of the type or extent of upslope land use and should not be combined with stream restoration instream processing credit.

Future research could support this by looking at values of concentrations and loadings.

E. Practice Longevity

In the past, the life of the forest buffer practice has been estimated to be 15 years which reflects the length of a typical Conservation Reserve Program (CRP) contract. However, several studies, including two surveys of landowners in Pennsylvania, showed that 80-85% of landowners will leave buffers in place after their contract expires (Cooper 2005; Eisenbise 2014). Surveys completed by CRP participants in 2004 indicate that 90 % of the tree acres would be retained (Onianwa et al., 1999; Moorhead and Dangerfield 1998). Because this practice is regenerative, it is likely to last 40 to 120 years or more, once established. There is no corollary research to support grass buffers having as long a lifespan. Grass buffers require regular maintenance and are more easily converted to cropland.

While not directly impacting the credit of the forest buffer practice, longevity is important when considering its cost-effectiveness. A very conservative estimate for longevity of practice is 40 years as long as the buffer is functionally maintained. However, it is important to note that if forest buffers are not properly designed and maintained, they are susceptible to the development of concentrated flow (discussed above in C1).

F. Lag Time

Some nutrient processing functions are realized quickly following riparian buffer restoration and these will increase as forest soil, and canopy and stream functions are rebuilt. Newly-established forest buffers have been found to reduce pollutant loading in the first 5 to10 years but show significant improvement in efficiency in subsequent years (Straughan Env. Service 2003, in Hairston-Strang 2005).
Where forests are allowed to regrow, increases in water yield are short-lived, usually less than five years, and within 10 years, rapidly growing forests may decrease water yields below pre-harvest levels (Swank et al., 2001; Hornbeck et al., 1997; Hornbeck et al., 1993). Likewise, there is a lag time for instream processing benefits once a riparian forest is newly established.

It is feasible for the CBWM to assign a lower efficiency for newer buffers. A newly established forest buffer could be considered equal to grass filter strips for the first 5 years following installation based on when water quality improvements attributable to the buffer are obvious (Orzetti 2005). There is some science to support a time lag in effectiveness of young buffers. The lag in early efficiency will be offset by longevities beyond the time horizon of the model and most other practices. In addition the current efficiencies for forest buffers are sufficiently conservative to address any lower efficiency in the first few years of buffer establishment and over the lifetime of the practice will account for such potential variation.

The Panel felt there was insufficient science to support sub-allocation of pollutant reduction on a short-term basis. Further, assigning age-related efficiencies would complicate credit tracking, and create a disincentive for forest buffers that other practices are not subject to (even though there are seasonal variations in other nutrient reduction options, such as treatment plant efficiencies).

Simpson and Weammert (2009) posited that forest buffers could receive a 5 % increase in efficiency every five years from year 5 through year 15 to reflect increased efficiency as the buffer matures. It was indicated that this recommendation could be incorporated into the Phase 5 model, but this was never done.

Recommendation: The Panel acknowledged that there was likely some lag time involved with the practice but that it was minor compared to the issues of width and hydrologic flow, and not worthy of detailed tracking.

G. Grass Interface Zone as part of a Forest Buffer

Riparian forest buffers benefit from having a grass interface upslope. Namely, the grass interface can help induce uniform flow and prevent channelization across the buffer (see Section C1 for additional discussion of concentrated flow paths). Another way to ensure uniform flow is to construct a level-lip spreader-- a sort of trench and berm-- that creates a controlled 'fill and spill' action.

It has long been a tenet of the practice that the greatest likelihood of sustained high performance is provided by the 3-zone forest buffer design which combines the benefits of both forest and grass in a buffer. The U.S. Forest Service's *Riparian Forest Buffers Function and Design for Protection and Enhancement of Water Resources* specifies a 3-zone buffer that is a minimum of 95 feet: at least 75 feet of forest and 20 feet of grass (Welsch 1991). The outer grass interface zone acts to slow and spread the flow uniformly to deter concentrated flows through the buffer. This prevents gullies in the buffer.

While these practices may enhance the riparian buffer, they are management decisions. They are not always necessary and to require them as part of the buffer could induce excessive costs and additional land. Buffers are monitored to verify that they belong in the CBWM as an effective practice. Some buffers will be in need of additional management activities that may include a grass zone or level-lip spreader.

Recommendation: The Panel is not recommending that additional measures be required to induce uniform flow in the buffer.

H. Efficiencies for Grass-Only Buffers

The current efficiency for a grass buffer is 70% that of a forest buffer for TN, and equivalent to a forest buffer for TP and TSS. Both grass and forested buffers have been shown to reduce nitrogen effectively. Both act similarly in reducing runoff and sediment. Both types of vegetation take up nutrients, but plant uptake is small compared to other processes (e.g., microbial denitrification in soils).

Grass buffers have not been well studied in this region. This is likely because grass is not the natural land cover. There are no definitive studies that could inform decisions about how to distribute efficiencies by vegetation between regions of the Bay watershed, and many of the functions of forest buffers are assumed to apply to grass buffers (except as noted). The original TN grass buffer efficiency -- 70 % of that of forest buffers--- was reaffirmed in the 2009 BMP Assessment Report which clearly noted that more research was needed to support this (Simpson and Weammert 2009).

Grass can provide dense protection of soil surfaces, but usually generates more runoff than forest; stormwater runoff from lawn averaged 10 times more than forest in Graczyk et al. (2003), although dense fertilized grass was better (Burt and Swank 1992). Price et al. (2010) measured 63 mm/hour (2.5 in/hr) saturated conductivity in forested soils, compared to 7 and 8 mm/hour for lawn and pasture on similar soil textures in Pennsylvania. This implies that more water is able to move through and be treated by forested soils.

Lowrance (1989) concluded that, overall, grass buffers are not effective at removing nutrients from shallow groundwater. More recently, a study of 16 small watersheds showed that nitrogen uptake of forested stream reaches was 2–10x greater than non-forested reaches (Sweeney et al. 2004)—see Instream Processing discussion. Mayer et al. (2005) conducted a meta-analysis on buffer effectiveness, and found that grass buffers were less effective at TN removal than forest buffers. Grass buffers were found to have a mean TN removal effectiveness of 53 %, while forest buffers had a mean of 90 % removal.

Sweeney and Newbold (2014) looked at forest and grass buffers through a meta- analysis and found that there is a lack of research on natural landscape grass buffers, as opposed to experimental plots with artificial flow. They concluded that there is insufficient data to make a distinction between forest and grass buffer performance. Grass buffers have been shown to be effective in reducing surface runoff velocity and trapping of sediment. However, a grass buffer/filter strip can be easily overloaded if trying to intercept excess sediment (Dillaha et al. 1986, and Dillaha et al. 1989 in Barling and Moore 1994). If not maintained, grass filter strip performance declines rapidly (Dillaha et al. 1989).

A related area of concern is the implementation and verification of grass buffers. Unlike forest buffers, little information about width, longevity, or functionality has been collected regarding the practice of grass buffers in the watershed. Grass buffers are not as long-lasting as forest buffers (i.e., they can be plowed under more easily) and need to be verified. Unlike forest buffers, the average width of grass buffers in this region is not documented, and is likely to be much less than 100’. It is not known whether grass buffers are being maintained—if they are clogged with sediment, they would not support treatment of upslope acreage.

Recommendation: The Panel agreed that grass buffers should not be further discounted for TN efficiency in the CBWM. Few studies were cited that could definitively point to an appropriate TN efficiency for grass buffers, and the Panel was divided as to whether to increase the TN efficiency or reduce it for grass. Some of the caveats discussed in the Subsurface Hydrologic Flow section above (Section 4c) apply to grass buffers—e.g., flow is likely to be more important than the type of vegetation. The Panel reiterates the need for further research on grass buffers, including documentation of width, and existence, and maintenance.

5 Recommended Credits and Rates

The Panel found that little substantive evidence has been produced over the last five years to justify major adjustments to the riparian buffer credits. In fact, the most pertinent works by Weller and Baker (2014) and Sweeney and Newbold (2014) fully support the existing nutrient and sediment reduction efficiencies. Some modifications based on best professional judgment were dismissed because of differing viewpoints among the experts.

The one proposed change is the additional credit for instream processing of TN when forests flank both sides of a smaller-order stream (1-5th order). The Panel recommends a nitrogen removal credit of 0.014 lb N per foot (21 g/m) of stream length for reforestation of both sides of a stream, applicable to reaches of order 1-5 (watershed areas ~0.05 to ~100 km^2). For instance, for a length of stream of 500 feet, N reduction would be 7lbs for instream processing alone; for a mile long length of stream the N reduction is 73 lbs. This credit should be applied independently of the type or extent of upslope land use.

The agricultural riparian forest buffer and grass buffer BMPs will still be treated as a land use change AND incorporate 4x the buffer area for TN efficiency and 2x the buffer area for TP and TSS efficiencies, reflecting load reductions from the upslope contributing drainage. In the event that CBWM adopts the use of the flow model based on Weller and Baker (2014), the upslope efficiencies are likely to be replaced with flow estimates based on upslope area.

Table 5. Proposed Upslope Forest and Grass Riparian Buffer Load Reduction Efficiencies

	Forest on one side of stream			**Grass** on one or both sides of stream		
	TN	TP	TSS	TN	TP	TSS
Inner Coastal Plain	65	42	56	46	42	56
Outer Coastal Plain (well-drained)	31	45	60	21	45	60
Outer Coastal Plain (poorly drained)	56	39	52	39	39	52
Tidal Influenced	19	45	60	13	45	60
Piedmont (schist/gneiss)	46	36	48	32	36	48
Piedmont (sandstone)	56	42	56	39	42	56
Valley and Ridge (karst)	34	30	40	24	30	40
Valley and Ridge (sandstone/shale)	46	39	52	32	39	52
Appalachian Plateau	54	42	56	38	42	56

Note: Effectiveness credit of TN is for 4 upslope acres for each acre of buffer (4:1), and 2 upslope acres for TP and TSS (2:1). These efficiencies have not changed as a result of the current review.

The Panel recommends a reevaluation of this practice in 2017 based on the changes in modeling flow and instream processing. It outlines additional research questions that can be the focus of future work to help resolve some of the uncertainties surrounding buffer performance. The Panel found that the current and past research did not adequately address the research questions the Panel was charged with answering.

6 Verification and Accountability

From 2012-2014, the Forestry Workgroup worked with the Chesapeake Verification Panel Steering Committee as well as other workgroup coordinators to develop the following guidance on verification of the agricultural forest buffer practice:

Background

The vast majority of forest practices on agriculture land are cost-shared conservation practices that are long-term in nature (once established, the practice often continues in perpetuity needing relatively little maintenance), and originate with a Conservation Reserve Enhancement Program (CREP) or Environmental Quality Improvement Practice (EQIP) contract. Procedures for approving contracted practices are established by USDA. Often, more than one agency has oversight of these agricultural tree planting practices, including the federal USDA's Farm Services Agency (FSA) and Natural Resources Conservation Service (NRCS), state forestry, Conservation Districts, etc. For simplicity, and because roles vary from state-to-state, all those providing oversight of tree planting activities are referred to as CREP partners. For instance, FSA will keep contracts for CREP, a forestry agency will write a planting plan and check for compliance, and a technical service providing agency may make multiple site visits and have landowner contact. Sometimes multiple databases track the same practice.

Procedures on how to establish a riparian forest successfully are well-documented (Hairston-Strang 2005). It starts with a planting plan designed by a forester. Aspects of a good plan include: species selection, site preparation, and spacing of trees, among other factors. Forest buffer plantings almost always use tree shelters (e.g. 98% of the time in VA) to protect against herbivory. Shelters increase survival from 12% (no shelter) to 74% (with 4-foot shelter). Herbicide treatment is also highly recommended. Some of the trees planted are expected to perish but most must survive or be replanted to comply with contractual specifications. Repeated visits are made during establishment.

After establishment, a buffer planting may need additional maintenance to be fully functional. Adverse impacts include excessive traffic, livestock or wildlife damage, fire, pest or invasive plant infestations, and concentrated or channelized flows. The NRCS standard for this practice (Code 391) says the buffer will be inspected periodically and protected from these impacts. Maintenance is the responsibility of the landowner, and a portion of the public funding provided to the landowner is designated for maintenance expenses.

Below is the current protocol for verifying contractual agreements in CREP:

A. Verify Planting Establishment
    i. In practice, NRCS or another technical assistance partner (e.g., CREP partner) confirms proper establishment on every site at the 1 or 2-year point, and every year thereafter until the planting is determined to be established. "Established" means that the buffer meets the NRCS forest buffer practice standards and any additional state requirements (required stocking/survival rates vary by state).
    ii. If the site visit determines that the practice has not yet been established, replanting is usually required to get the buffer up to standard, and further site visits may be needed until the replanting is established. If the buffer never becomes established, it is taken out of contract.
    iii. Some states include detailed monitoring of plantings as well. Virginia CREP partners - VA Department of Forestry is the primary forestry technical expert -

visit every planting site 3 times and have routine documentation about species planted, survival rate, and other issues.

B. Spot Check Plantings

i. After the practice has been reported as established, USDA has a standard program of compliance checks on a portion of all contracts; the requirement is for a minimum of 5% of the buffer contracts to be spot-checked each year.

ii. State agriculture conservation programs that provide a portion of CREP cost-share may have additional verification requirements, for example, VA DCR also requires spot checks on 5% of practices under contract each year throughout their lifespan.

C. Tracking

Currently, USDA data are used by most states to report accomplishments to the CBP model. These data include acres of practice, but do not currently include width of practice. Because of the CBP agreements and directives emphasizing the need for riparian forest buffer restoration, and to assure consistent, good reporting by jurisdictions, a second complimentary process was developed by the Forestry Workgroup. Since 1997, the Workgroup has been tracking buffers installed on agricultural lands. Each fall, the Workgroup requests geo-spatial data from the Bay states. The following 10 fields are requested from the state contacts and every year CBP maps the point data for analysis:

Field 1: Unique identifier (parcel ID, etc.)
Field 2: State
Field 3: Latitude
Field 4: Longitude
Field 5: Miles of forest buffer
Field 6: Width of forest buffer
Field 7: Planting date
Field 8: Ownership type (public/private: Federal, state, other public, private)
Field 9: Notes/Comments field
Field 10: Watershed name or HUC

The Forestry Workgroup's specialized tracking has been a means of cross-checking what is reported to the National Environmental Information Exchange Network (NEIEN)/Chesapeake Bay (CB) model--- it helps prevent double-counting and it establishes an average width of practice. As improvements are made to riparian forest buffer information coming through the USDA agreement with EPA and USGS, and confidence in the information improves, the Forestry Workgroup will evaluate whether to continue its complementary tracking procedures.

Guidance to the States for Verifying Agricultural Riparian Buffers

1. *Verification methods for cost-shared agricultural riparian forest buffers will utilize and build upon the verification programs already implemented for cost-share contracts.*

- Continue following the current protocol for verifying contractual agreements in CREP and verifying the buffer has been installed according to plan. In the plan, it is suggested to note likely site impacts that need to be addressed with maintenance. After installation, a buffer site should be visited at least twice during the time it is becoming established to assure the buffer will meet practice standards and any problems are corrected. The minority of buffers that are cost-shared using other programs (e.g., EQIP) should follow the same protocol used for CREP buffers.

- A buffer can be credited when its installation according to plan is confirmed. When reporting the buffer for CBP credit, the reporting agency should capture width of the buffer in the NEIEN in addition to acres of practice.

2. Inspection and maintenance are critical: a) to insure riparian forest buffers become established effectively; and b) to verify that the buffer is being maintained throughout the contract and channelization is not occurring.

- After establishment is verified per contractual procedures, proceed with periodic inspections (spot checks) to see how well maintenance issues are being addressed by the landowner. Currently, a minimum of 5% of contracted practices are spot-checked. But additional spot checks are needed to ensure that impacts do not threaten the performance of the buffer.

- States should be 80% confident that water quality impacts are being avoided in the most likely places. Statistical sampling is recommended as a targeted and cost-effective means to have confidence that maintenance is happening effectively. Sampling design should focus on common and specific maintenance issues that have the most potential to impact water quality, such as channelization/concentrated flows. For instance, to protect from concentrated flows, a stratified sampling design could look at all buffer sites that are on slopes of 7% or greater –i.e., where the impact is most likely to occur.

- States should describe in detail how they plan to conduct follow-up checks that go beyond the 5% spot-checking that is the current practice.

- Plantings to be spot-checked for maintenance should be between 5 and 10 years old because this is the period between establishment and re-enrollment when the least number of inspections occur. Most maintenance issues are easily detected, and state protocols should describe typical maintenance violations that need to be checked. If statistical sampling design help is not available, states can recommend other means of spot-checking to reach an 80% confidence level.

3. Special attention is needed at the end of contract life (10 or 15 years), to determine if a new contract will ensure continuation of the buffer or if the buffer will be maintained voluntarily without a contract. In lieu of confirmation that the buffer will still be on the landscape, it will need to be removed from NEIEN after the contract expires.

- This action is recommended to encourage the conservation of existing buffers. CREP contracts expire after 10 or 15 years, and a record amount of sign-ups in 2001-2007 are due to expire in the next few years. There are three likely scenarios when a contract is ending: 1) the landowner re-enrolls the buffer into another 10 or 15-year contract; 2) the landowner does not re-enroll, but plans to keep the buffer; or 3) the landowner does not re-enroll and plans to get rid of the buffer. Actions taken now by CREP partners can lead to more landowners being in the re-enrollment category (#1), and to knowing what to expect for those lands coming out of contract (#2 or #3). To re-enroll, CREP partners must determine that the buffer still meets the practice standards (survival/stocking rate). To facilitate the re-enrollment process (and thus retain functioning buffers), the following actions are recommended:
    a. CREP partners conduct outreach/technical assistance to landowners with expiring contracts.
    b. CREP partners field check buffer sites in the last 2-3 years of contract to assess whether buffers meet standards and will be continuing after contract expiration, either through re-enrollment in CREP or voluntary retention of buffer.
    c. Acres of buffer that do not meet the practice standard or will not be retained should be removed from NEIEN/CB model. FSA will assign a unique identifier to each project in the future so it can be tracked better and doesn't become double-counted when re-

enrollment occurs.

4. Implementation strategies should include approaches to conserve existing forest buffers so that newly planted buffers represent a net gain in overall buffers for a county or watershed segment. The following examples support this point:

a) Laws or ordinances that encourage conservation of existing buffers are in place.
b) Monitoring and maintenance occurs on both newly planted buffers and also on existing buffers.
c) Periodic sampling of total buffer area to indicate that overall riparian buffer canopy in the county or watershed segment is increasing (Part 3 below).

- CREP partners should establish a baseline for total riparian forest buffer acreage in a given county using high resolution aerial imagery to be able to determine whether there has been a loss in riparian forest cover. A number of software tools and geospatial programs are available to help with this. For example, every 5 years, the reporting agency will sample the three counties in each state that have experienced the most development or increase in agriculture (per agriculture census) to show there has not been a loss in total buffer cover—this is not information that is "entered" in the model, but a way of assuring that what is reported is a net gain. If a loss in overall riparian forest buffer coverage in these counties is detected, it would result in county-wide removal of buffers reported as a "net gain" for those years. The theory is that if a state can show that it is maintaining buffers in the counties with the most threat, then it is assumed that buffers are being protected in less critical counties.

5. *Where agricultural riparian forest buffers are being planted voluntarily and reported by farmers or non-governmental organizations, jurisdictions may give them credit for an initial four years without inspection, only if such plantings represent a small portion of the total acreage of buffer plantings reported in a given year.*

- To credit riparian forest buffers installed voluntarily by a landowner or non-governmental organization, the reporting agency must obtain information (e.g., description of the project plan and photographs) to verify that the buffer has been installed, and has the characteristics of an effective buffer (at least two tree species and a minimum width of 35 feet). In addition, credit requires the same tracking information as described for cost-shared practices.
- When voluntary riparian forest buffers account for 5% or less of a state's reported buffer acreage, initial verification does not require a site-inspection. Practices that are inspected at the 4-5 year mark can remain in the NEIEN record if the site visit shows that the buffers are established, and they are included in the spot check protocol (similar to cost-share practice) outlined in Part 2.

7 Future Research and Management Needs

The Panel considers this report to improve upon the riparian buffer information in the CBWM, but it also acknowledges that significant gaps still exist in our understanding and modeling of riparian functioning across the watershed. The foremost issue that arose is the improved understanding and incorporation of subsurface flow paths and how they benefit or detract from buffer efficiencies. The Panel agreed that these efficiencies should be reconsidered only when flow paths are better understood and can be accounted for in a CBWM. In other words, future research needs to measure water flux in the buffer to determine what water is actually passing through and being processed by the buffer.

The following are some examples of flow questions that should be addressed:

- How much stream flow in a given area is from groundwater discharge?
- How often is surface runoff channelized in grass and forest buffers limiting their effectiveness?
- How does surface runoff behave at high flow where a floodplain is present?
- Where are the low areas in a floodplain? These can be important areas for forest buffer restoration.
- What nutrient and sediment removal on floodplains can be attributed to overbank flooding?
- Aquifers range in permeability, thickness, and hydraulic gradient, all of which can control groundwater flow. Which groundwater flow paths through aquifers are likely to have high nitrate and which are not likely to be processed by a buffer?
- Where are the toe slopes where groundwater discharges to land surface in the floodplain? Buffering these can be effective for improving both surface-runoff and groundwater quality.
- What conditions lead to the development of seeps that can flow perpendicularly across a buffer with little potential for processing?
- Other than vegetation at or near the surface, what sources of organic carbon could be aiding denitrification?
- Does flow modeling include hydrogeology and the geochemical conditions associated with a particular hydrogeologic setting, which have been mapped, explained, and are available as GIS coverages?
- What is the potential impact of engineered stream channels on nutrient transport (focus on the Eastern Shore)?

Other issues to be addressed:

- Research is needed on the hydrology and biogeochemistry of grass buffers in the region.
- More research is needed supporting recommended efficiencies by HGM regions such as ranges in effectiveness, standard errors, and measures of dispersion among the estimates.
- How much nutrient uptake is attributed to vegetation? What is the long-term fate of nutrients sequestered in vegetation?
- What is the additional water quality benefit of targeting the buffer practices? How can this be incorporated into the CBWM?
- There is a need for better models of buffer function.

- More data are needed on instream processing values both dependent and independent of riparian forest buffers. Just how much instream processing is denitrification and how much is uptake by algae? What is the long-term fate of nutrients taken up by algae?
- Need more site-specific data on hot spots and adjacent land use effects on buffer and connection/disconnection to flow paths.
- Need to determine the average width of grass buffers reported to CBWM.

Mid-Point Assessment-- A mid-point assessment of the TMDL is scheduled for 2017. As part of the MPA, there will be new land use layers, including new agriculture layers and an improved accounting for existing forests which will differentiate upland from riparian/floodplain forests. These riparian forests will likely be given a unique loading rate in the CBWM. This will be a separate process from the BMP establishment and crediting addressed here, but the distribution of loadings across the landscape can be expected to change.

Ancillary benefits and considerations:
Certain aspects of the riparian buffer practice make it unique among other BMPs and, while they were not the focus of this report, are important to note:

- There are many ancillary reasons for doing this practice in addition to water quality (e.g., habitat, bank stabilization, natural stream channel maintenance, temperature moderation, etc.).
- Compared to many other BMPs, the water quality benefits of this practice have been well-researched over a long period of time.
- Riparian buffers are usually a permanent (regenerative) practice with the average life span of initial planting that is greater than 40 years.
- Buffers are a less expensive, more aesthetic, and more natural practice compared to many other types of BMPs. Furthermore, it may be risky to continue to promote the singular value of water quality improvement, when forest buffers could be designed to maximize a range of ecosystem goods and services without additional cost.

Going forward, it was suggested that a group such as the Panel continue to meet and share information apart from CBWM needs.

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Appendix A:

Notes from Meetings

Riparian Buffer Expert Panel Call – March 26, 2012
Participants:
Sally Claggett, USFS Chesapeake Bay Liaison
Cully Hession, Virginia Tech
Harry Campbell, Chesapeake Bay Foundation, PA Office, sitting in for Dave Wise
Ken Belt, USFS Northern Research Station
Ken Staver, University of Maryland
Mark Southerland, Versar
Peter Groffman, Cary Institute of Ecosystem Studies
Judy Okay, consultant for Virginia Department of Forestry
Gary Speiran, USGS, Richmond
Jeff Sweeney, EPA Chesapeake Bay Program

Objective of Panel: To investigate forest and grass riparian buffers to determine the most appropriate credit in the Chesapeake Bay model.
Several Panelists provided suggestions for additional literature resources and panel members. The literature resources should be provided to Tetra Tech for upload to the Panel's SharePoint site. Literature can be sent to Aileen Molloy at aileen.molloy@tetratech.com
Judy suggested that the research should include a focus on biological nutrient uptake processes from vegetation, since the existing literature seems to cover only nutrient processing related to hydrology and flow.
Jeff Sweeney from the Chesapeake Bay Program gave a presentation on scenario builder. The presentation is provided on the SharePoint site.
Ken Staver asked whether the forest buffer BMP is a mechanistic change or just an efficiency. Jeff indicated that the BMP areas are converted to forest as a land use change and the upland acres of crops receive an efficiency, which varies by hydrogeomorphic (HGM) region, to account for the buffer-groundwater interaction.
There are many factors that affect efficiencies, but the states largely do not collect the site information (soils, slope, site conditions) and the location information, when available, is not used in the model. We can start to ask the states for this type of information to add more details to the efficiencies.
Sally reminded the Panel that to qualify for credit, the buffer must contain at least 2 tree species and must be at least 35 feet wide. Grass buffers are currently calculated as 70% of the forest buffer efficiency for TN. Grass buffer TP and TSS are equivalent to the efficiencies on forest buffers.
Peter – Should the Panel push ahead to get a finer breakdown of the HGM classifications? Each could be stratified by impervious area in a watershed because floodplains get disconnected from the stream at a certain impervious coverage. Some landscape scale HGM classifications are more conducive to efficiencies than others (e.g. the presence of seeps).
Sally –It may be that practitioners would need to report impervious cover data when the practice is reported to the model.
Peter – Need to use widely available data, such as the level of imperviousness and/or soils information. SURGO coverage is available.
Jeff – You can get very specific but it needs to be data that can be reported and specific questions may need to be answered about conditions at the buffer site.
Sally – Most things we ask for will have repercussions at the field level in terms of data collection, but it could still be worth pursuing. Targeted buffers allow credit for buffers applied to the most needed areas. If targeted buffers have a higher efficiency, the team may need to lower the efficiency on all other buffers.
Panelist – Pennsylvania has LIDAR data that can be incorporated into prioritization
Peter – LIDAR shows stream incision, which could be better than impervious estimates.
Cully – LIDAR isn't available everywhere yet.
Jeff – If the details aren't there, there needs to be a default value efficiency that can be applied.

Judy – We need to back up the data with scientific technologies, but also need to remember to do a reality check on what's possible during monitoring and verification.
Sally – We have until 2015 before practices need to go into the model, so there's time to get used to new data collection requirements.
Jeff – The model does not use paired watersheds, in coming up with efficiencies, you need to think of an average farmer, in an average year, with average precipitation. These are not research conditions, and a lot of these efficiency estimates come down to best professional judgment. Review what is currently in the model. Are the efficiencies high, low or ok? If a mechanistic representation would be better, that can be changed in the future.
Sally – What are hot button issues that were not included in the 2008 review? Think about those that should be addressed. Some of them include:

Targeting (or finer scale than HGM)—include flow/hydrology and concentration of nutrients

- Buffer width – currently the same credit for all buffers over 35', should there be different credits for different widths
- Instream nutrient processing
- Temporal –longevity of the practice and the lag time to full efficiency
- Upland acres are credited at 4 acres to 1 acre of buffer, is that still the best science?

Ken – With respect to monitoring. You can use research methodology to see how you are progressing and to answer questions of implementation over time. Could also get at cost efficiency.
Judy – MD has been monitoring, so has Bern Sweeney, so it's possible to get that information.
Sally – Review the lit search to see if grass buffers are incorporated sufficiently.
Ken Staver – I do not see grass buffer studies because most buffers are on existing floodplains and they don't have a natural grass buffer area. All grass research is on new systems on existing agricultural lands.
Judy – What about wetland studies. Do grass buffers act the same as a wetland buffer?
Peter – We are not changing the hydrologic environment, so we need nutrient reductions related to this vegetation. The existing literature is from existing buffers not these newly created buffers that are on land that was good enough for agricultural use. Grass buffers are not doing anything unless there's a flow spreader because the water would flow to the buffer and flow along it until it hits a gully and then enters the stream.
Judy – Grass can trap sediment as well or better than forests.
Peter – But that's in a controlled study.
Sally – For the next call, review the literature search. We need enough studies for each category we address. Prioritize the lit review from Bern Sweeney. The next meeting will be in about 3 weeks. Subgroups should be formed to review the hot topics during the next call.

- Targeting buffer placement – Don Weller (?) and Gary Speiran
- Buffer Width – Gary Speiran
- Instream Processing – David Wise, Bern Sweeney
- Sediment – Cully
- Upland efficiency credit – Judy

Riparian Buffer Expert Panel Call – April 25, 2012
Attendees:
Sally Claggett, USFS Chesapeake Bay Liaison
Dave Wise, Chesapeake Bay Foundation, PA Office
Ken Staver, University of Maryland
Mark Southerland, Versar
Peter Groffman, Cary Institute of Ecosystem Studies
Judy Okay, consultant for Virginia Department of Forestry
Gary Speiran, USGS, Richmond
Anne Strang, Maryland DNR

Objective of Panel: To review the current riparian buffer BMP efficiencies /land use changes and determine whether they are appropriate or if there are adjustments that should be made.
Key Issues:
1. How do we break out the practice? Do there need to be component parts? Do there need to be separate classifications for targeted buffers and non-targeted buffers?
2. The BMP representation for the model needs to be simple because it's going to be applied by a wide range of people. It should be easily understood, identifiable, practical and trackable.

Targeted Buffers: buffers that are intentionally placed where there will be more water quality benefits than other locations.
What are the options for adjusting the practice?
1. No changes from existing efficiencies and upland treatment area
2. Redefine the practice more narrowly, there could be multiple definitions of the practice with different efficiencies, depending on buffer and landscape characteristics
3. Modify existing options - the upland treatment area and efficiencies

Instream Processing Findings – Dave Wise
Presenting the results of "Riparian Deforestation, Stream Narrowing, and Loss of Stream Ecosystem Services" by Bernard Sweeney, et al. (2004).
Most studies have addressed what's happening upslope of buffers; this research addresses the instream processing.
Key Findings: Comparison of 16 good quality forest and grass buffered streams
- Forest buffered streams are twice as wide as grass buffered streams, they have a slower velocity are rougher
- Ammonium uptake in forest buffer streams is up to 9 times greater than in grass buffer streams
- Atrazine degradation is twice as fast in forest buffer streams
- Dissolved organic carbon (DOC) concentrations do not exhibit much difference between grass and forest buffers
- Net metabolism is 2 times greater in forest buffer streams

Issues:
- What is the magnitude of instream reduction in comparison to the land-based buffer reduction?
- How much retention is denitrification versus uptake through primary production?
- How efficient is nutrient spiraling such that it doesn't flow downstream?
- What is the magnitude of nutrients in instream processing compared to the magnitude of nutrients flowing downstream? In degraded streams, relative to the downstream flow of nutrients, the instream processing probably doesn't make much of a difference.

- Should instream processing be a distinguishing factor separating forest and grass buffers? Should they be treated separately? Sweeney et al. showed a clear difference, but other studies are inconclusive.
- Stream ecology: if stream ecology is accounted for, there is a much bigger difference between forest and grass buffers
  - The data support stream ecology differences, but not as much with nutrients.
  - Need to consider the model, if there is only an opportunity to revise efficiencies and land use, there's no place to account for stream ecology. Needs to be stated, but don't inflate nutrient reductions because of ecology.

Questions regarding the Model:

- How does the model treat nutrient spiraling? Is it accounted for?
  - The model is empirical; does not treat nutrient spiraling mechanistically. Loads are estimated for terrestrial sources and reconciled with monitoring data. Any instream loss is accounted for by closing the loop between land-based loads and monitoring data.
- Instream processing of nitrogen attributable to forest and natural systems is valid, this Expert Panel should weigh in on how the model could tackle this.
  - Can instream processing be quantified? It's already being used to make adjustments in the model, can these be better represented?
  - LINX studies could provide some insight.
  - There are a lot of variables, such as carbon input and stream morphology that are going to change on a case-by-case basis. There are too many variable and there may not be enough data when reporting on the ground practices to accurately capture instream processing.

Need to be careful not to push up the nitrogen or phosphorus efficiencies without sufficient science to support it. **The Panel needs to stick to the science as close as possible but come out with a strong statement on the ecological significance of buffers.**

Upland Acres Treatment – Judy Okay

The model currently applies a ratio of 1 acre of buffer to 4 acres of upland area treated. There were no references for this decision in past Panel work, other than this is the ratio that was used previously.

Brief Summary of Ratios used in research:

- Correll and Weller (1992) Rhode River: the ratio of buffer to upland was 1:1.75, this showed an 80% N reduction from surface and 85% reduction from subsurface, TSS was a 90% reduction and TP was not addressed
- Lowrance et al. (2001): using the REM model a 1:15 ratio yielded 5% N removal, a 1:1 ratio showed 95% N removal. This study was a simulation at Gills Farm
- Newbold (Stroud Water Research Center) (2000): field study of 3 subwatersheds, using a 1:16 ratio, subsurface N was reduced by 31% and TSS by 55%
- Dillaha et al. (1989): at a 1:2 ratio, 73% reduction in N, 80% reduction in TSS and 79% reduction in TP; at 1:4 ratio, 54% reduction in N, 70% reduction in TSS and 61% reduction in TP
- Lee et al. (2000): simulated watershed: 1:1.3 ratio for grass buffer N is reduced by 64% and P by 72%; 1:1.3 ratio for grass and woody vegetation N is reduced by 80% and P by 93%; 1:2 ratio for a grass and shrub buffer is 95% N reduction and 91.7% P reduction.
- Mankin et al. (2007): 1:2 for grass and shrub, 95% TN reduction, 91.8 TSS reduction and 97% TP removal.

- See Judy Okay's summary report for more details.

It is difficult to find in-field studies that will give you the data to find the ratio of buffer to upland area, simulations tend to provide more information.

- Should recommendations be based on simulations or in field studies?
- The land use in the studies was all row crops.
- As the ratio increases the efficiency decreases.

The Dillaha et al. 1:4 ratio yields results pretty close to what's already in the model.

- Do the existing efficiencies include a factoring in of the loss of efficiency as the ratio changes?
- The nature and extent of connectivity between the upland and stream isn't accounted for, in the model the only limitation is the stream segment.
- If there are seeps or deep bypass flow, there's no reduction
- The flow path determines effectiveness
- In setting the effectiveness: for all the situations where the buffer is not effective, there needs to be situations with higher efficiencies to balance it out, on average

Simulated Studies:

- How were the buffer/ streams simulated? What's the physical system that's being simulated? It's limited by the groundwater/surface water gradient.
- Do certain settings have seeps? Seep areas can be critical.
- Simulations do have caveats about seeps and concentrated flows
- In most studies the reduction are much higher that what's current being used in the Bay model
- In the current model, the N efficiency was lowered to 65% because of flow issues such as seeps.
- Do groundwater and surface water flows need to be separate?

Can there be an intro to the recommendation that discusses the mechanistic process of how a buffer treats nutrients? In the model, the only thing that is changing is the vegetation, not the hydrology.
Targeted Buffers:

- Does buffer placement really consider all these factors when deciding on a location?
- Pragmatically, the approach is to just put buffers as many places as possible. Funding for buffers is not an issue. In PA they are targeting Plain Sect farms and production areas, rather than targeting certain hydrologic or landscape features.
- It's important to remember that to include more specific information in the model, this information needs to be collected at the field level in order to put it in the model.
- Using high resolution data is it possible to implement at the farm or watershed scale and then use known features and combine them in such as so that people on the ground would recognize an area as a targeted buffer area? Could a checklist be developed to define a targeted buffer area?
- The MD CREP program uses a walk-in signup process; the state is not targeting locations.

Next Meeting: Further discussion of targeting and a recommendation based on the literature review summaries.

Riparian Buffer Panel Call May 23, 2012

Attendees:
Sally Claggett, USFS Chesapeake Bay Liaison
Dave Wise, Chesapeake Bay Foundation, PA Office
Ken Staver, University of Maryland
Mark Southerland, Versar
Judy Okay, consultant for Virginia Department of Forestry
Greg Noe, USGS
Ken Belt, USFS Northern Research Station
Cully Hession, Virginia Tech
Don Weller, Smithsonian Environmental Research Center

Objective: Start looking at the bigger picture, instead of the individual variables and decide on a direction.
Targeted Buffers – Don Weller
There are two definitions of targeted buffers:

1. Buffer placement in locations that intercept nutrients from sources – this type of buffer placement requires GIS analysis of topography, land use, stream location, drainage paths, etc. Only source-stream paths are considered. Nutrient calculations are based on the stream side(s) with sources. This method addresses the function component of rather than just proximity to stream. Only accounts for surface pathways, however.
2. Buffer placement in more effective physiographic provinces – buffers have been found to be more effective in the coastal plain than the Piedmont or Appalachian regions.

One obstacle is that there is often more money than willing landowners to install buffers
One consideration for assigning extra credit to targeted buffers is that it wouldn't be representative unless there is an opposite effect to devalue less effective buffers
An analysis of HUC12s in the Chesapeake Bay for buffer coverage indicated that pre-existing buffers (including natural ones) are not accounted for in the model. Only restored buffers receive credit.
Sally – Pre-existing buffers are bigger than the Riparian Buffer Panel's task. All beneficial land uses are not getting credit, not just buffers. The Panel write up can discuss existing beneficial features but adding them to the model is beyond the scope of work for this Panel.
Have the impacts of existing buffers been identified? – The HUC 12 study quantified buffer gaps. The coastal plain has more buffers but there's also more cropland in this region.
Can they predict the nitrate yield that has been taken out by existing buffers and what could be taken out by additional buffers? This type of discussion would be good to include in the Panel recommendation prologue.
In PA there is a shortage of willing land owners, but if efficiencies are highest in the coastal plain, it would be important to target outreach there. Installing buffers where they do the most water quality good is important, but also relevant to consider other benefits
If more efficient buffers had a higher incentive would that change landowner willingness?
It would, but there are more powerful tools like asking for buffers along with other BMPs with funding opportunities
If the buffer isn't connected to the nutrient source, but your only metric is nutrients, that may incentivize putting buffers elsewhere.
The Bay model isn't mapped to target locations downstream of nutrient sources. The model relies on data from the Ag Census, which isn't geographically-based.
Most effectiveness differences are across bigger areas, there is not a lot of county-level variation.
Buffer Width
Existing buffers are around 30+ meters wide, but in the Bay model anything over 10 meters counts.

All the Bay Model literature addresses 100 ft buffers, but was brought down to 35feet in the model for consistency with the USFS minimum buffer requirements.
The Model tracks buffer acres not buffer width, the impact of the buffer is scaled down based on buffer width.
Acre units are not necessarily unreasonable. If someone installs a 20 ft buffer, there's still a benefit, since the first few feet of a buffer are the most important. Depending on location, narrow buffers can make a big difference, so the practice shouldn't be discouraged. Studies have shown that accounting for buffer width didn't predict water quality any better than buffer presence/absence since there is little difference in effectiveness beyond 100 ft.
The model tracks acres, NRCS tracks acres, going through width documentation would add a whole other process. Accounting only for acres of buffer would simplify data collection at the local level.
Decision Point: Panel agrees to leave buffer width alone and continue to credit buffers based on acreage.

Riparian Buffers and Sediment – Cully Hession
Buffers can alter channel flow and morphology. Upslope trapping efficiencies are in the literature. There is some data on overbank flooding events. Literature addresses effects of buffers on other ecosystem services (channel width, temperature, leaf litter) Articles will be sent out.
The AWRA Proceedings on instream processing contain data on buffer treatment from upland acres.
This issue is complicated to get into the model. Upstream source studies will have efficiencies that can update the model. Deposition rates are also available if floodplain trapping can be included in the model.
Channel morphology can predict sedimentation rates, but LIDAR data would be needed.
There has been a huge effort to reduce cropland erosion. Slowing and trapping works well reducing sediment tonnage. At the edge of field, there is a high level of inorganic sediment that doesn't have a lot of N and P. The smaller organics are still moving through the system and aren't being trapped. The less you till, the more dissolved P that is lost. Dissolved nutrients are the critical component for downstream water quality.
Does the model have an enrichment value where the ratio of dissolved to total sediment increases as it moves to the stream?
All the other benefits of buffers aren't accounted for, only N, P and TSS. If the nutrient values are too low, buffers might be deemphasized. The panel should insist on a disclaimer that buffers shouldn't be cast aside just because there is a less favorable model representation.
Does the model integrate instream processes? Bern Sweeney's belief in high instream processing is affected by use of overall low load streams. Instream processing becomes a bigger proportion of these types of streams.
Other groups are addressing instream processing. Secondary services are important since that is where the ecological benefits are.
How does all of this integrate? What's the bigger picture?

Riparian Buffer Panel Call – February 15, 2013
Attendees:
Sally Claggett, USFS Chesapeake Bay Liaison
Greg Noe, USGS
Judy Denver, USGS
Judy Okay, consultant for Virginia Department of Forestry
Anne Hairston-Strang, Maryland DNR
Mark Southerland, Versar
Denis Newbold, Stroud Water Research Center
David Wise, Chesapeake Bay Foundation
Ken Staver, University of Maryland
Don Weller, Smithsonian Environmental Research Center
Gary Speiran, USGS
Peter Groffman, Cary Institute of Ecosystem Studies

Quick review of paper and charge:
Experts were convened to talk about the riparian buffer practice. We need to take the next step to make the practice applicable to the Chesapeake Bay model. It's not always possible to have such refinement in the model as experts know exist in the science. We have to ask does the current efficiency seem about right; do we have data to support the efficiencies?
Status Paper distributed during the call was developed by Sally. The current efficiencies established were in 2008. Riparian buffers are #10-12 in per acre efficiencies of all practices, showing the relative importance the buffers to the states in meeting their goals.
Denis Newbold and Bern Sweeney lit review, summarized by Denis:
The report will be submitted to JAWRA at end of March and will not be available to share until after that time.
Research question – How wide should buffer be?
The paper addresses removal efficiencies for nitrogen and sediment, as a function of width. Phosphorus was not addressed. In addition to nutrient and sediment removal they looked at what width means for temperature control, fish, macro inverts, channel morphology, wood debris, etc.
It doesn't make much sense given the fuzziness of the data to start fine tuning width to address specific factors. The approach was to go as simple as possible. Buffer should be 100 ft wide for a variety of benefits. Nitrogen is removed via subsurface flow, very little is overland. Studies and lit reviews use well transects and observe the decline of nitrogen as you get near the stream. Few studies identify how water got to the stream. USGS is the exception. How much of the actual stream water is coming through well transects? All studies put together are very optimistic - high efficiencies and narrow buffers.
Sweeny and Newbold didn't use studies unless there was a discussion of stream flux. Once the studies that didn't address stream flux were weeded out, they found very few narrow buffer studies report flux. 29 studies had good flux to stream data. Median nitrogen removal was 90%, but below 80% for buffers narrower than 30 meters. Really high removal efficiencies with narrow buffers only occur where the water flow to the stream isn't from the buffer pathway and is not sufficient to support the stream. The large buffers only have high efficiencies over 40 meters wide. Under 40 meter buffers efficiencies tend to be less than 60%. There was only 1 study with buffers less than 20 meters wide. If buffers tend to be 100 ft wide, 50% reduction seems reasonable.
Sediment studies were primarily experimental stations with plumes and plots to see how effective buffer width is. These show high removal in short distances. Sweeney and Newbern only looked at studies without highly constrained flow and ruled out studies without realistic loading (how much water is coming through buffer). Experimental plot source areas tend to be too small. TSS removal is lower. A 10 m buffer = 50% removal. At 130 meters, efficiencies average around 80%. There is a wider is better result and a reasonable result for narrow buffers.

Temperature – when a buffer is over 100 ft, temperature in stream is protected. A 5m buffer is effective in some cases. Lots of variation in the 10-20 m range.
Efficiencies in the Chesapeake Bay model seem to be realistic. Given how much uncertainty there is and how few studies there are, there's no empirical basis for making a fine distinction based on the HGM classifications. The efficiencies can be tweaked based on best professional judgment, which is how the efficiencies are adjusted now. They aren't empirically based values though. There's just not enough precision in the data.
Forest v. Grass Buffers – Other stream factors showed at 100 ft or more you get an effective buffer. Most studies in natural landscapes are forest buffers, but grass buffers weren't excluded. Many sediment studies were grass buffers. There's not enough information to make a distinction between grass and forest.

Discussion

- Sediment was the same for forest and grass in the past. Only TN has a forest advantage. Realistically phosphorus will follow the sediment.
- Phosphorus moves with finer sediments. Large particles tend to be measured, leading to high efficiencies.
- Not sure data supports TN benefit in forest over grass.
- Can't make a definitive statement one way or the other on TN between grass and forest. One other caution, there are high denitrification rates in historically forested buffers. Does reforestation rehab the soil structure? It may take a long time to get back up to forested denitrification rates.
- Why is there a discount for TN removal in grass?
- The most defendable data on effectiveness are landscape scale studies; these are all forest studies and show improvements in water quality. If you want to be conservative about the hard evidence, the hard evidence is only from forest buffers.
- Should grass and forest be more equal on TN?
- Organic matter is the limiting element in the denitrification process. Turf grass people say grass puts organic matter into the soil, but realistically a mature forest will have a much higher organic matter content.
- There were no differences between grass and forest down to a meter in Baltimore studies. Grass has high productivity and don't have a carbon limitation.
- We need to consider that grass longevity isn't always there, esp without management. Forests probably get added removal through first 15 years where grass will go down.
- If we're looking at model credit, one of the big questions is that we don't really know how wide the buffers are. Of the buffers that are 100 ft wide, how many are forest and how many are grass?
- Buffer width average was 105 ft in looking across the states.
- Most grass buffers are narrow.
- On the eastern shore, grass buffers can be very wide. In the model, treatment area is scaled for the width issue. A narrow buffer might have high efficiency, but a smaller buffer gives a smaller treatment area. There is only credit for a small area.

We need an approach, 100 ft is the best, but is any buffer good enough to count? That's a question that's in the status paper. Width presents difficulty in tracking. It might be nice to deal with acres, but that's not what the science is saying? Do we go with the model or the science?

- Efficiency per unit area. You could argue that the first 50 ft are more effective than the next 50 ft; the return on the effectiveness goes down at some point. The model isn't ignoring width. It's not the effectiveness on the whole load that's being credited, just on the actual buffer width. Land uses are treated with the % reduction, based on the different land uses. An acre of buffer will take a load from 4 acres of land and reduce it by the given percentage. Is the number at the end of it all around the average across all buffers?

- Contributing watershed area efficiencies, what is the net effect? The model makes a conservative estimate since it's not applied to the entire contributing area.
- Gibbs farm had a 1:1 ratio of buffer to farm. All this effort to normalize the data into 1 number is hard.
- There is upslope gradient collection through entire upslope area, but the model is only counting a limited fraction of the upslope collection area. You may be getting a low-ball estimate of the actual reduction.
- Looking at table in doc. Peterjohn and Correll upland area is not calculated correctly. Total study area was 40 acres not just upland area. Agrees that the unit area treated creates a scaling factor, but we don't have evidence that it's the correct way or value.
- 40 acres was the area that was treated. Listed study area as cropland or pasture

We need to circle back and talk about HGM provinces. Coastal Plain – if the buffer doesn't get a chance to treat the water, is there enough evidence to support a reduction in efficiencies?

- Surprised that Coastal Plain has so much bypass
- Coastal Plain can't be thought of as the Coastal Plain. In the inner coastal plain in previous studies, there's a high potential for interception.
- Doesn't the contributing area within the 4 acre treatment area generate surficial flow?
- Thickness of aquifer matters – if buffer is on a streamside levy – there's' limited effectiveness.
- What do we want to do about coastal plain?
- It's possible that coastal plain is pushing high nitrate water into the buffer, so it's treating groundwater, and isn't bypassed.
- Table is premised on understanding of flow paths. Is it a reasonable approach to use the HGM because we think they fundamentally affect efficiencies?
- The outer coastal plain is poorly drained. It's already at a reduced efficiency in the model. Is it reasonable?
- Nitrate in Morgan Creek is influenced by deeper water not impacted by nitrates.

Soils/Vegetation/Landscape

- Need to map where high organic content exists.
- We're talking about efficiencies for newly installed buffers. All the existing buffers are already accounted for. Only concerned about buffers on lands formerly suitable for farming. So we're only changing the plants.
- Can't give credit for tile drainage areas – since we know buffers won't work.
- Tile drainage had little impact in the piedmont.
- If it's not really about the buffer, it's about the landscaping, could we add a request for mapping?
- Soil maps for riparian zone. If we had this info, soil series lookup table could help with efficiencies by describing likelihood of flow paths, nitrate, and functional process drivers. Much richer source of information than HGM.
- We could infer about deep flow paths if you know the soil series. If you know about the parent material and landscape condition, there are relationships between these and deep flow paths.

- Jeff Sweeney would have to generalize the data. 1m data is too fine for the model. We could get modelers feedback on incorporating a SURRGO overlay with HGM.
- SURRGO caution – Base soil surveys were done at dramatically different times. There are county line differences due to timeframe when work was done. It will be a nightmare for predicting efficiencies.
- Agree with Peter that there's valuable info in soil series but can't be used effectively until there's a physically based model. There's the potential to do explicit spatial analyses that could feed into the model. This should be a recommendation. Info can be summarized and fed into the model, but until that kind of commitment is made, we're stuck with the HMG
- We need some evidence that explains more of the variability than we can explain now. If Don could do more research using the soil mapping data to show that makes a difference and is worthwhile to go to this level, it could be useful, but there's not enough data to support it right now.
- We need to empirically verify that we can exploit SURRGO data to make efficiency estimates.
- MD has geologic data that could help supplement the SURRGO data and show potential for deeper flow. It is worthwhile to do more research.
- Rosenblatt et al 2001 – SURRGO coverages in the riparian zone. Could you map narrow bans of hydric soils in the riparian zone? SURRGO indicated presence of hydric soils in riparian zones. Don't forget tile drainage stuff. If a hydric soil maps as agriculture, it raises a red flag that there's subsurface drainage.
- Buffers are mostly on non-croppable land in some states and not others.
- In areas with higher water tables, ag is converted to grass buffers. Eastern Shore likes grass buffers over forest buffers.
- In CREP areas that are taken out of cropland, do they have subsurface drainage?
- No, Eastern Shore is ditch drains, not subsurface tile drains
- Will SURRGO data influence width discussion?
- Judy Denver – SURRGO will inform width.
- If you have hydric soil, you don't need lots of buffer width to get good reduction
- What's the mechanism to create this big interception if all you do is change the vegetation?
- If you take areas out of cropland, these are wet areas. They will denitrify. If it's not wet, it won't denitrify.
- Perennial vegetation is actually drier.
- Getting into highly mechanistic issues.

Do we have any new information since the 1990s, really?

- In 2002, the lit review efficiency was a baseline of 85%. In 2008, we said this was way too high. Almost arbitrarily lowered to 65% as a baseline, and then lowered it again across the HGMs. There is still no empirical evidence, just best professional judgment. What data do we have now that we didn't have 2008?
- Denis says the 2008 values weren't that far off and may have even been too conservative. There's not a lot of new evidence.
- There's not a lot of new evidence. There's a lot of scope for additional research, but there's not a lot of justification to change the efficiencies.

- We need to come up with what we know NOW that will affect the numbers we've been using.

What's reasonable for grass vs forest?

- There is good evidence to discount lag time in forest development. Grass buffers could go either way. Too low or too high. Both have been heard. This makes Sally think the current value is about right.
- Paul Mayer – meta-analysis around the globe looked at width and vegetation type – grass was lower than forest because surface flow was looked at more frequently, but subsurface flow is the same between the two.
- One of the future data needs – study grass and forest in the same conditions to determine if there are differences.
- What's the likelihood that grass will be managed correctly and won't be overwhelmed by excess sediment to continue to function in the long term? The efficiency discount reflects these uncertainties.
- PA CREP – Grass buffers on cropland are not having longevity due to commodity prices driving reconversion.
- We don't have as much data on grass. This is a key point that we need the same level of data on grass, so we can verify the grass practice efficiencies.

Next Steps/Conclusions

Provide Sally more written comments about the paper. Sally will try to come up with recommendations. Given the fuzziness and new stuff we want to start incorporating, there's nothing new enough right now. There were good points about the way the model already tweaks stuff. Area efficiency basis is already accounted for. There's more to work through.

We keep having the same discussions over and over again for 20 years. The discussion is constrained by what's in the model. The new ideas aren't going to fit within the existing model approach. The approach isn't improving and keeping us focused on tweaking table 2. Other issues aren't addressable within the model framework. The model limits the extent to which science based information is brought in. We talked about changing how the model deals with the buffers. Can we capture spatially variable data in the model? This is something for the future. Need to work towards it as a future goal.

Buffers Expert Review Panel
May 31, 2013

Participants: Bern Sweeny, Anna Stuart Burnett (note taker), Mark Southerland, Sally Claggett, Denis Newbold, Don Weller, Judy Okay, Peter Groffman, Judy Denver, Julie Mawhorter,

Any edits to the previous minutes? No response.
There is a section in the report for acronyms.

Objective of call:
Sally: look over draft report during this call with highlighted decision points. Either give her input now or send her a document with track changes.
Mark: looked over the document and has no significant changes.
Peter: thought it was good and sent in his comments.
Buffer Width Section
Peter: section was a little confusing. Reorganize the section to make it flow better. See comments he provided. Have the recommendation at the end. Suggested order: current regulations and credits, what does the research base show, what are the unresolved issues, what does the panel recommend.
Mark: should that be the organization of the whole document not just that section?
Sally: will look at both options.
Judy Okay: in second paragraph, need to better cite the average buffer width. Other citations need to be revised. Will forward recommendations in track changes.
Don: Too many unsupported statements, especially in the first paragraph.
Denis: might want to send out requests to get help documenting all citations.
Sally: will need support from the panel to volunteer to work on sections and finish the report by fall.
Denis: would like to try to add some specific text in the first paragraph in Buffer Width section.
Ken: the amount the buffer is effective depends on the size of the buffer. Model calculation is based on buffer area not width.
Don: delete the first sentence from paragraph and make recommendation to change the way that the buffer is calculated in the model.
Ken: general benefits from moving the agriculture away from the water, don't want to discourage even small buffers, even though we prefer more.
Denis: agree that we don't want to discourage narrow buffers.
Sally: fencing, filter strips, are all possible practices.
Judy: willing to take on the buffer with section
Ken: Will have to be a major overhaul of the model to handle buffers. Because of the way they are tracking the progress, they don't want us to change the accounting process in a big way.
Sally: this report is not recommending radical changes.
Judy: adjacent land use is critical for efficiency and benefits as well.
Denis: How important is the shading effect?
Sally: what is the order of priorities? Need to update sections in the next two to three weeks.
Loading Rates Section
Don: didn't actually investigate buffer width in research.
Sally: this section is OK?
Hydrologic Flow Paths
Sally: Get rid of the AKA and just refer to hydrogeomorphic regions
Sally: separate out surface and sub-surface. Will work with Judy to get relevant graphics.
Judy: if we are talking about infiltration, should we just come out and say it?
Sally: reorganize it about surface vs. subsurface flow and treatment.
Sally: anyone interested in taking a stab at this section?
Judy: I do have some comments on this section and can send them

Sally: will share Gary's comments with the group and include his comments into the future suggestions. Anyone else willing to work on this section?

In stream processing section

Sally: work done by the urban stream restoration panel; draft panel recommendation was approved by the Water Quality GIT.

Panelist: a fair amount of ideology that goes beyond the research here. Shouldn't just jump on because another expert panel likes it.

Sally: referencing Kushal. Algae are just a temporary uptake of N.

Don't discredit it. 50% of all N entering a river system is used before it gets to the Bay.

Sally: want to add info about area of stream bed and amount of N per area stream bed.

Judy: Philip Vidon (?) is the cited author 2010 American Water Resources Journal. Will find some references to send to Sally.

Large discussion of instream processing.

Sally: what is the suggested bump in efficiency in table one numbers?

Panelist: Hard to get any defensible number.

Is there a prediction as to what would happen as you move to a smaller stream?

Denis: volunteers to come up with an instream removal number.

Practice Longevity Section

Sally: don't want to keep getting stuck with 15 year lifespan of buffers.

Lag time section

Sally: Do we need to wait until after the forest is established (5-10 years) until they get credit? What is the best way to represent the first 5 years? Credit it as a grass buffer then bump it up to a forest buffer at 5 years?

Julie: run the model every year and show progress every year.

Gary: The model is viewed as ultimately what will be the effect on the water when all is said and done. Need to be consistent on lag times (can't do it for some and not others). Need to address them all the same.

Grass Interface Zone Section

Sally: Grass filter strip will be counted as a separate credited process in the model

Grass Buffers Section

Sally: not very well researched.

Denis: didn't get this far in his review.

Judy: Mayer has a lot of research on vegetative cover and buffer width. Good reference.

Ken: history of riparian buffer, studies were done in existing floodplain areas, existed because they weren't suitable for farming. Thinking to credit new buffers on farmland.

Denis: there wasn't much left after looking through the experimental plot studies.

Sally: does this section need a substantial reworking?

Denis: will take a look at it and will work on it if need be.

Sally: Please send input in track changes. Not recommending changing amounts (Credits and Rates table 1) from 2009. Any last questions or comments?

Ken: burden of proof, but burden of proof to change than just coming up with new numbers.

Judy: came up short on research to make changes. Important that we support more research that is needed.

Don: supports what ken says. Don't think we can change the numbers without identifying 10-15 new studies since the last analysis. In 3 years at the next evaluation, if trying to change the numbers, not worth doing. But if we are trying to change the way buffers are credited/ represented, then we can convene a panel.

Judy: keep a cohesive group of people together to continuously work on this over 5-7 years so there is some continuity in the group and a buffer panel for the Bay Program.

Judy Denver: more of a broad hydrogeomorphic panel that buffers are a part of.

Judy Okay: can't forget ecology

Appendix B:

Summary of Expert Panel Interviews

QUESTIONARIE—Riparian Buffers Expert Review Panel & State Representatives – Aggregate Responses from Panel

Please answer all questions to the best of your knowledge. The primary purposes for this questionnaire are to:

- Obtain information on the applicability and effectiveness of riparian buffers.
- Obtain information on ways to track and characterize implementation of riparian buffers.
- Obtain literature references and other information for review by Expert Panel members.

Please feel free to provide documentation that helps to answer any of the questions. If you do so, please identify where to find the information in the document. We can use the document to summarize the information and answer the question for you to save you time.

General Comments

Ken Belt

Denitrification requires a different set of conditions than if you're just using the buffer as a filter. Long term conditions deserve to be paid attention to.

All Panelists

1. Definitions and efficiencies of riparian buffers in the model are included in Attachment A. Please review them before completing the interview. Are the definitions clear and specific enough to you?

Mark Southerland

These are pretty good. They are clear and specific. Overall, there are improvements that should be made if possible, but this is a good starting point.

Ken Belt

Riparian Forest/Grass Buffer Definition:

Maybe expand beyond the linear constraint? There are important "satellite" aquatic resources that should be considered part of the drainage system... that need the same riparian centric protection. When you are in the field or have very high resolution cover imagery, there are lots of bogs, seeps, wetlands that require protection. Although these are in some sense "away" from the linear stream they are a direct route for pollutants washing off and so are effectively "riparian". Besides being areas where groundwater intersects the surface, they are also areas (hotspots) where removal takes place (e.g., denitrification... N removal) and would benefit from a riparian zone area of protection

Same for ponds, small lakes and reservoirs (although reservoirs may be a stretch); they (as well as the streams they might discharge to) benefit from riparian buffers? Farm ponds would be an especially vulnerable lentic resource.

I suspect that if the total "shorelines" for these lentic features were summed they might be important to nutrient and sediment removal in some areas.

Land Uses:
Are aquaculture operations included in "agriculture"? Nurseries? Silviculture?
Why are AFOs excluded; these are real hotspots for runoff, and potential runoff (why couldn't riparian forests buffers be used to guard against containment failures, as well as ameliorate atmospheric ammonia exports to the landscape? They are also hotspots for groundwater contamination… riparian forest buffers could well help there too? This kind of protection follows on the above discussion of "satellite" aquatic resources… it is different in that these are away from the stream but it makes sense to get the biggest bang for the buck and not be too constrained by linear thinking.

Reduction Representation:
Might want to lay this out a little more clearly, with some introductory text…. I am not sure what the purpose is (but do vaguely remember the discussions!)

Landscape Position.. Buffers
It would be helpful to have some way to apply modifiers here… topography matters, and where the water table is matters?

Typo?: the grass buffer table says "forest"?

Existing Buffers: There has been some discussion of this… I think that, if you are working with a long-term process, it is important to consider the resources that are already in place. This way we have some feeling for the ecological services that these (areas of which are greater than for what we are "managing"). This knowledge also facilitates the targeting process for where to do riparian planting, monitoring and mgt. It would be useful to have a definition here too?

Greg Noe

The existing definitions and efficiencies are clear.

I've spent about two hours online trying to find a table of the N and P loading rate of the various land-use types in the Watershed Model. I have not been successful. Modeling buffers in the model includes both the efficiency tables (which were clear) and the change in load due to land-use change. The loading table needs to be easily accessible

Peter Groffman

Forest and grass definitions are ok. Peter has trouble with the land use reduction representation. Uniform acreage says nothing about how well connected it is to buffer/upland. Tile drainage could eliminate the connection.

The frontier in buffer zone research is getting the hydrology right. You need to get the water right.

HGM efficiencies are fine, it starts to get at the spatial variability, but the data is old. Since those values were put forward, science has learned more about soil and hydrology. There are new tools (remote sensing, GIS) and the panel should push to have a more sophisticated picture of soil and hydrologic conditions.

Judy Okay

The definition given is simple and acceptable. The width is recommended to be 100ft rather than being required. People get caught up in width in the model 100 ft.is used, USDA does 35ft. 25-35ft gives you a little bit of everything in terms of benefits, 100 ft is better, but even a narrower forest buffer makes a difference, just the land change alone is positive. It would be nice if everyone used one value or the other, but it's not likely to change.

Don Weller

Regarding the 35 ft minimum width – Does this mean that all buffers considered in the CBP model runs are 35 ft wide or greater?

Why are afos excluded from the land uses on which buffers can be applied?

Can the logic and supporting citations behind the upland acres be supplied?

Regarding the HGM regional efficiencies, to support these it would be helpful to present information on the variability among the studies that were summarized. Do you have information on the ranges, standard errors, or measures of dispersion among the estimates for each region and material?

What's the logic and supporting citation behind grass being only 70% as efficient as forest buffers in TN removal?

Judy Denver

For what they are, it's clear. Not particularly keen on the efficiencies.

Newbold and Sweeney

The definition is clear, but it needs to be read a few times to understand it.

Where did the upland ratio come from?

The upslope distance above the buffer to ridge should be the area treated. The contributing area should be based on how far it is from the stream to ridge. Bern and Denis don't see a problem with the existing acre ratio. The average distance from a 1^{st} order stream to ridge is about 800 feet. Based on an average drainage density of 2 km/km2, the average distance to ridge is 250 m or 820 feet. This means the 4:1 ratio is not too liberal, even for the 100 foot buffer.

Buffer System: The concept uses the grass as a level spreader in front of the forest buffer to prevent gullies. This is especially useful if the grass buffer is specifically contoured to perform this function. There should be more credit if there's a system of buffers: grass and then forest. Forest buffers should be 100ft, with 20ft of upslope grass. Even a 35ft forest buffer should have an upslope grass buffer. There should be a minimum forest buffer of 35 feet. If the grass is going to count towards the 35ft of buffer, it's better not to use it and stick with the full forest buffer. The upland grass should be in addition to the forest buffer.

There needs to be a grass interface upslope of the forest buffer. Minimum of 55 ft, at least 35ft of forest, and 20ft of grass.

Gary Speiran

The current write up mixes the definition and the practice. The definition should be separate from the practice. Buffers have multiple functions beyond pollutant reduction; some of the functions should be included in the definition of buffers. Identify what buffers do. Efficiencies get covered in other areas.

Eric Sprague

Definitions are fine. One confusing thing; however, is that there's a 35ft minimum width but no discussion of width crediting after that. It's unclear how width fits into the efficiencies.

Ken Staver

The definitions are clear enough. Regarding the minimum width, it's unclear why there needs to be a minimum, since the buffer efficiency is calculated on an area basis. It's only treating an area equal to the multiplier. If we're talking about water quality and calculating load reduction on an area basis, no minimum is needed. Narrow buffers have small land conversion and small treated area, but no reason it would be less efficient on an area basis than a wider buffer. In fact, the consensus is there is a decline in impact after the first 10ft (in regards to water quality). This could open the door to narrower buffers, strictly as a water quality practice.

David Wise

Suggested amendment to the buffer definition: Forest buffers help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater, and surface water by instream processes. The recommended buffer width for riparian forest buffers (agricultural) is at least 100 feet, with a 35 feet minimum width required.

The existing definition misses the instream processing functions which are critical, especially for nitrogen. Instream processing is less of a concern for TP and TSS.

100 feet is a good minimum buffer width. 35ft is clearly a USDA and Bay Program programmatic decision, but a preferable minimum is 100 feet.

A Georgia literature review also ended up with a minimum recommended width of 100 ft.

Cully Hession

Only part that's confusing is why is TN upland acres are 4 times and TP and TSS are only 2 times the riparian area. This is not clear. Cully noted that he's not a nitrogen guy.

Anne Hairston-Strang

Don't recall having run into problems with definitions. Width doesn't always make sense, but good enough. 300 feet max isn't in there, may want to add a suggested maximum width.

Is there a better term than linear area?

Buffer land uses – some land is not agricultural.

2. During the Riparian Buffer Expert Panel call on March 26, 2012, several "hot button" issues were identified as important to address: targeted buffer placement, buffer width, instream processing, sediment, and upland efficiency credit. Are there any topics that you consider high priorities that should be addressed before making efficiency recommendations?

Ken Belt

Upland efficiency credits make sense in principle... it is almost always important and more cost effective to go to the source, both in prevention and in "buffering", I think. Also, in this respect it would make sense to consider upland-riparian "tweeners"… i.e. those aquatic systems that are riparian (wet areas, seeps, etc). It may be more effective to consider these as part of any stream restoration efforts (see attached Filosa pub)… meaning there needs to be a riparian component to that aspect (more program overlap...!) So a stream restoration credit would be accompanied by a riparian buffer credit…

Greg Noe

Greg came on the panel after March and was brought on for floodplain expertise. Floodplains with overbank flow perform additional riparian functions and need to be treated differently than those that only intercept upland flow.

The TMDL is based on load, and the current efficiency tables deal with a percent load reduction, but what's important is the actual load reduction not the percent reduction of the load. A buffer downstream from a land use with high load may not have the same percent reduction of the load as the same ecosystem downslope of a lower intensity load. There is not a linear relationship to load reduction efficiencies.

To account for this, it would require tracking the load delivered to the buffer. You could modify reduction efficiencies by a scaling term that incorporates a loading rate associated with different land uses. Actually knowing the loading to a given buffer is difficult in the current model and may not be feasible, but state of science recognizes that percent reduction relies on the loading rate to buffer.

Peter Groffman

Maybe the same as targeted buffer placement but the hot topic is – hydrologic connection between upland and buffer.

If there's tile drainage that goes under buffer, then the buffer isn't doing anything. If there are natural seeps in the buffer, there's perpendicular flow, and buffer isn't doing anything.

When there's upstream urban land use, stream incision is due to impervious surface upstream. Agricultural streams could be showing urban stream effects, and there would be a disconnect from the buffer.

Judy Okay

For what's being done, most hot button issues have been hit on. Hydrology, GW and slope are important, if you're going to be targeting and assigning higher efficiencies. Width is a key factor, since it costs money for land owners to increase width. Targeted Placement – good concept.

Don Weller

To me, the least supported assumption in the current calculations are the upland areas treated (TN: 4x buffer acres, TP: 2x buffer acres, and TSS: 2x buffer acres), and refining this presents the greatest opportunity to improve the calculations. For the width issue, recent meta-analysis could be used to develop functions of efficiency vs. width (e.g., Zhang et al 2010; .JEQ 39:76-84; Mayer et al. 2007, JEQ. 36:1172-1180; Sweeney and Newbold, 2014). I think the issue of instream processing should be considered separately from the effects of restored buffers.

Judy Denver

Huge gap in defining coastal plain by HGM. Way too general. Lots of info on hydrogeology that hasn't been incorporated that is important to understanding the potential for buffers to efficiently treat nitrate in groundwater. SPARROW model info isn't considered either. Coastal Plain dissected uplands on east and west shore are totally different.

Need to reflect hydrogeology. (See PowerPoint) Eastern Shore and Western Shore of the Chesapeake Bay have entirely different hydrologic impacts. Coastal efficiencies are based on work that is primarily focused on the Western Shore, which is generally not transferable to the Eastern Shore. Eastern Shore efficiencies should be much lower than what is in there now.

Power Point - 200 sampled streams in coastal plain for a nitrogen study. Groundwater provides the majority of flow to coastal streams because of permeability. Up to 90% of flow is from groundwater. Almost all nitrate comes from NPS through groundwater. Very little nitrate instream production.

Look at large-scale hydrogeologic features that affect GW/nitrate. In Chesapeake Bay Eastern Shore, there are thick coarse sediments and thicker aquifers, so a lot of water bypasses the groundwater. On the Western Shore there is middle coastal plain fine sediment, clay near the surface and areas of lots of dissection of the surficial aquifer. Streams dissect down to a clay layer and there is more opportunity for nutrient removal prior to stream discharge.

Smithsonian studies, for example - results for the Coastal Plain are based on efficiencies from the higher efficiency on the Western Shore.

Ator and Denver (in press, JAWRA) estimated loadings based on 1st order watersheds. Chesapeake Bay Eastern Shore nitrate flux base flow to streams is 12,400 kg/day, Western Shore is 10x less because of hydrogeology and land use. For the entire coastal plain (Long Island through North Carolina), over half the nitrate flux is from Chesapeake Bay Eastern Shore.

Eastern Shore needs to be included in the efficiencies of buffers.

***11% of applied N makes it out in base flow. Accounts for entire N cycling. Important to think about credit reductions.

SPARROW models – On the Chesapeake Bay Eastern Shore 77% of N flux is from base flow, regardless of riparian zones or not, based on 1st order streams.

Efficiency needs to be improved by considering subsurface conditions. Can't just look at topography and geomorphology. Need to look at Eastern Shore specifically.

In NC and GA the aquifer is much thinner, so efficiencies are better. Much of the riparian zone work from that area has been done in areas without a thick, sandy aquifer beneath the buffer.

Use a hydrogeomorphic/hydrologic regional setting distinction. Need to separate eastern and western shores. Refer to **USGS Paper 1680** for a hydrogeologic framework that could be used. (Use because Virginia is included.) For the lack of anything better, it would be helpful to consider potential buffer efficiencies with respect to these subregions.

The flux data will show that most nitrate is through groundwater, regardless of buffers.

Newbold and Sweeney

Targeting

Some buffers work better than others, but to have certainty about a given buffer, you have to spend substantial money to prove it. We don't know enough to get it right without spending a lot of money on each site. One size fits all is preferable. In the worst case scenario, people will hire consultants to prove their riparian area shouldn't be targeted for buffers due to its low potential for high efficiency.

Buffer width

In looking at the data, most studies may need to be thrown out because either the subsurface water flux was unknown or very small. If the flux is small, the water is getting to the stream, but not through the site that was being examined. These studies aren't actually looking at the flow path of the water in question.

In the studies with sufficient flux to supply stream flow, high N reduction efficiencies (>80%) are limited to those buffers that are wider than 30 m. There is a range of 35-80% efficiency in buffers less than 30m.

Sweeney and Newbold (2014) suggest the evidence that buffers work only applies to those that are 100 ft or wider.

Sediment studies are similar; high removal efficiencies are based on unrealistic plot studies with confined flow, artificial flow, etc. Once these types of studies are eliminated, the ones that remain show the efficiency approach 80% at around 30m. At 10m efficiency is under 60%.

Liu et al. find the average efficiency up at 85% at 10 m because of artificial plots.

Looking at the model efficiencies, they aren't as unreasonably high as the literature. They are more reasonable, especially if the buffer is wider. The existing efficiencies should be applied for the 100 ft buffer, but are too high for the 35 ft buffer.

Newbold/Sweeney found that at a width of 35ft, the sediment removal efficiency was 55%, and increased to 80% at 100 ft. There are so few studies on narrow buffers, we just don't know what's going on and can't say with confidence what the N effectiveness is.

Instream Processing

Instream processing is important, but most buffer data do not incorporate instream processing into the efficiency. It should not be considered as part of the buffer. Instream processing should be considered as a separate issue from the buffers.

The kind of buffer determines the instream processing. In comparing a grass buffer and a forest buffer there's greater potential for instream processing adjacent to a forest buffer because the stream with a forested buffer will be wider, more than twice as wide for first- and second-order streams (Sweeney et. al. 2004 PNAS). For first and second order streams, forest buffer should yield instream processing at twice the grass buffer instream processing credit, with a smaller credit for larger streams. This is still a separate issue though.

Gary Speiran

A lot gets tied into hydrology and hydrologic setting, which are so important. The hot topics can't be addressed unless we understand how buffers hydrology and hydraulic setting are intricately linked. Gary's AWRA Buffer Conference Paper addresses where the buffer is in the hydrologic setting.

If a stream has developed a valley with a floodplain, it will start to get a natural levee next to stream. If the prescribed buffer is 100 ft, the primary active area is the toe slope. Flow will be routed through breaches in the levee. A buffer back on the toe slope is more active than the stream edge for surface and groundwater efficiency.

Different geologies and functions vary: Valley and Ridge with karst – stream flow is variable in groundwater/surface flow proportions. In VA, conductivity probes have been used to separate GW/SW based on water quality, and hydrograph separation. In VA, 50-80-90% of flow is groundwater discharge. Only 10-50% is surface runoff. When you're in karst system, less than 10% of annual flow is surface runoff. In this condition, buffers don't have a lot of benefit and introduces the question of how much sediment is from instream sources.

Buffers are good for bank stabilization, but efficiencies are totally different. In a predominantly GW system, how can you increase efficiency by linking to hydrology. In karst systems, so much flow is GW recharge. The pathway to recharge is the solution channels and springs, and there's not a lot in the surficial aquifer. Any trees around springs would have minimal opportunity to affect water quality. Need to consider these issues for practical terms and in modeling values.

Eric Sprague

Would be good to have a document about key questions about buffers.

STAC workshop – instream processing – when there's an unhealthy stream, there is little instream processing due to saturation, but in healthy streams it's pretty important. You can't make the same assumptions about instream processing in healthy and unhealthy streams.

Grass vs. forest issue – Grass buffers can get overloaded with sediment more easily than forest buffers and this isn't accounted for in the efficiency rates.

Are the grass efficiencies too high? There's anecdotal evidence that it's too high. How strong is the review of grass buffers?

Ken Staver

Vegetation types should be more specific than grass/forest.

There needs to be some consideration from the source area. What is the buffer buffering? Corn and pasture get the same credit. If there's rotation, it might not matter, but buffer on permanent pasture may be of less use. You can't reduce a load that's not there.

Cully Hession

Landscape position – can the buffer intercept runoff or not. May be a data resolution issue to give acreage credit. May be improved upon with graphic indices.

Mark Southerland

No missing topics were identified. All have some importance. Targeted buffer may be most important.

Anne Hairston-Strang

No other topics that aren't addressed above or below.

David Wise

Nothing

3. What are the three main factors that determine the efficiency of a riparian buffer? What are the key factors that determine whether the practice is likely to be as efficient as we are giving credit for? (e.g. placement in the flow path, buffer width)

Mark Southerland

- Type of vegetation
- Width
- Hydrologic circumstance

Flow path is most important, but also hard to get at. Root zone flow is key to determining efficiency.

Grass v forest buffers – grassy ones work well sometimes, but depending on microtopography, they can create shortcut channels.

Greg Noe

- Load
- Connectivity of buffer to load (upland area)
- Residence time within buffer

Peter Groffman

- Hydrological connection between the upland and riparian zone
- Soil wetness (hydric soils)
- Soil organic matter levels

Judy Okay

- Loading (there's going to be a limit to what a buffer can treat)
- topography (slope/infiltration)
- width

Monitoring data indicate after 8 years, 70% of forest buffers are surviving. 100 trees/acre, that's a good buffer. There is opportunity for regeneration to increase that density. The average width reported to the Bay Program is about 105 ft. It's a reasonable efficiency that's assigned right now. Hydrogeographic provinces cover the efficiency reductions due to groundwater/hydrology. If we start assigning lower efficiencies down to 10-15% it will be perceived that there's no point in installing buffers.

Don Weller

Connection to a source area is always important. Other dominant factors depend on the material considered and mechanism of retention. For nitrogen, there must be a hydrologic connection (usually subsurface) that delivers nitrogen from a source to the rooting zone of the forest.

Judy Denver

- How well they trap water moving across land surface (related to topography)
- Thickness of underlying aquifers, and chemical composition (aquifer might be doing things that buffer is getting credit for)

- Connectivity of floodplain and the stream (in coastal plain, if there's a ditch, there's much less chance for benefit.)

Newbold and Sweeney

- **Width**
- Water flux
- Flow path (for nitrogen)

The main factor that determines efficiency is buffer width. It's the only aspect where there's good data to show a difference.

Efficiency implies that twice the load in will give twice the load reduction out. This is not necessarily true.

A buffer on a headwater stream is more likely to be efficient. There should be a credit or preference for this. Most of the water will go through 1st and 2nd order streams.

Subsurface flow paths have good data to show they are important; however you can't measure them without intensive study. For practical purposes, this wouldn't work in implementation, because you'd have to drill wells. There is not enough known to make it practical.

Soil type is important too. You can make a lot of predictions based on soil type (e.g. Rosenblatt et al. 2001). Sweeney is a little skeptical about whether this really works. Width is the important factor.

Rosenblatt, A. E., A. J. Gold, M. H. Stolt, P. M. Groffman, and D. Q. Kellogg. 2001. Identifying riparian sinks for watershed nitrate using soil surveys. Journal of Environmental Quality **30**:1596-1604.

Gary Speiran

- Geology
- Soils
- Topography

Efficiency goes back to hydrology; having a surficial aquifer is important. There is a very big difference in thickness of the surficial aquifer in coastal plain. If it's closer to the surface, there's an opportunity to interact with the buffer. It can get confusing regarding whether a buffer or other natural aquifer aspects are creating/affecting the efficiency. Thick aquifers and deep water have longer residence times, more likely O_2 will be removed causing denitrification.

Carbonate rocks and shales show differences, shale has high organic content. Little dissolved O_2, natural denitrification.

Eric Sprague

- Flow path,

- width,
- buffer design

Buffer Design – Refer to USFS Riparian Forest Buffers Function and Design report. The three zone buffer: 15ft trees, managed forests, grass buffer, yields greater reductions through better design than any of these components individually.

MD DNR – Riparian Forest Buffer Design and Maintenance
http://www.dnr.state.md.us/forests/download/rfb_design&maintenance.pdf.
Guide lists what makes buffers better for WQ : taller the tress the better the reductions, instream processing, wider is better, 100 ft is better; Wetter the better - low slopes, placement on the landscape; Managed forest is better than unmanaged forest, etc.

Bern Sweeney says native trees are better, MDNR says diversity is better at allowing for more resiliency over time.

Is there a different efficiency for healthy vs unhealthy forest? A healthy forest will be more resilient and last longer.

Ken Staver

If you have a field draining to a stream, then buffer width is important, but that's not how the model works. Efficiency means load reduction/buffer. In this sense, width isn't important. Buffer area times 4 acres and then apply an efficiency based on how well it treats the 4 X area. Per unit of buffer

- Nature of surface water (is there surface runoff, is it channelized, etc)
- Depth to GW
- Vegetation type

David Wise

- Width
- Vegetation type
- Context (adjacent land use, displaced land use, site specific details, such as groundwater and concentrated flows)

Cully Hession

- Landscape position
- Flowpath: how water is passing through – subsurface vs surface flow through buffer
- Age of buffer (in the beginning a forest buffer is like a grass buffer and will take 20 years to reach forest efficiency.

Anne Hairston-Strang

- Nutrient loading on flow path
- fluctuation wet/dry condition

- flow paths within rooting zone (~10feet)

Efficiencies - if you have optimal conditions, it will be a lot more effective than given credit for, but using the average is appropriate.

Ken Belt

Other folks are covering this pretty well, I think. Some things I have not heard though… With respect to the above factors (e.g. positioning to maximize connecting the root zone) are there enough considerations of ecohydrological traits of species (trees, shrubs, etc)? Transpiration and water efficiency considerations may be important "modifiers"; although they would require more consideration the gain in efficiency may make this extra step worthwhile.

Are phyroremediation methodologies worth thinking about? There is a USFS researcher who develops tree cultivars from a small spp pool to maximize the rate of extraction of contaminants from brownfields and landfields (see attached). I have to wonder if this approach would be useful in developing regionally tailored stock for riparian buffers.

Along this same thought path… Is there any way the riparian buffers might themselves be agricultural products? See Zalesny pdf. Maybe engineering fast growing cultivars that are harvested as smaller trees can be part of a riparian forestry industry? I suspect harvesting 2 " DBH trees might be done with minimal impact to water quality, especially when done in a selective manner in a diverse riparian buffer system with patches different-aged trees.

Same path… Are there considerations for how ecohydrological functions change over time? Do young and old trees do as well accessing that groundwater pool of N/P ? Do different spp exude different amounts of DOC in there roots…that might be needed as a carbon source for denitrification? Should there be a planned diversity component to planting plans?

4. How effective are forest and grass riparian buffers in load reduction? Are the existing efficiencies reasonable for an average condition?

Mark Southerland

Existing efficiencies are reasonable. Mark was thinking about 50% and the values are around that number. Mark hasn't done research on it and is relying on other studies and what seems reasonable.

Greg Noe

The existing efficiencies are reasonable for an average condition.

Judy Okay

Paul Mayer (EPA) – Annotated bibliography – Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations (2005). In the forward, Mayer goes on record to say there is not a difference in nutrient reduction between vegetation types.

Literature says grass is good for sediment and by extension TP, but for N it's not nearly as effective as a forest buffer. There are seasonal issues with grass only being active part of the year. No real above ground structure for grasses in the winter. Forests can slow water down and add organic matter so there's denitrification occurring even in the winter.

Judy provided factsheets with references on width controversy and forest vs grass

Don Weller

See comments in on existing definitions

Gary Speiran

Gary's gut feeling is they are incorrect because many instances viewed as removal may not be. From the GW perspective, GW recharge isn't considered in many papers, and that doesn't make any sense. Paired WS studies have shown higher GW recharge in forested watersheds.

High nitrate GW can be deeper in the system. Further you go into the forest, you measure less nitrate because it's deeper, but not gone. It's still delivered from deeper groundwater flows to the streams though. The studies are essentially switching from sampling agricultural recharge areas to forest recharge, so concentrations appear lower. The studies measure the wrong thing by not following the same flow path that the high nutrient ag water is taking.

In karst systems efficiencies should be lower, if you look at sediment sources. There's not necessarily a lot of runoff sources, so much is from GW. Sediment, therefore can be derived largely from instream sources such that other practices are needed.

Ken Staver

Ken was on the 90s efficiency review panel but not on the more recent one, which was conducted by Tom Simpson.

Effectiveness depends on how you define the buffer landscape. Vegetation isn't specified. You'd have to have a definition of an average buffer setting, which doesn't exist, to determine if the efficiencies are reasonable for an average condition. There are no data on average depth to GW, the typical vegetation, or whether there is channelized runoff at the site. These factors will affect efficiencies.

Ken is having a hard time making an assessment of average efficiency. Without a definition of average condition, it's too early to tell. We need to know the universe of existing buffers to determine what average is.

In the Coastal Plain, the existing efficiencies are on the high side.

On the whole, Ken is not all that unhappy with the efficiencies.

TP reductions are too high though. Lowrance said TP reduction was possibly negligible, yet there's nothing in the averages under 30%, and that's too high. TP loss is driven by big events.

TSS may be in the same category (too high). Buffers rely on big events to be effective for TP and TSS. There are settings where these efficiencies will work, but you need offsetting, especially in the coastal plain where there's little erosion to start with.

David Wise

David noted that he's not an academic and not working on the model. He is a field practitioner and program manager and not in a position to assess efficiencies.

There are widely disparate views on instream process and its benefits. When there are widely disparate views of the same reality, there's value in pushing a little harder on instream processing to find out why people are conflicted about the situation. Are studies looking at newly established buffers where functionality hasn't kicked in? David doesn't know how to explain these differences of opinions. Based on Stroud's work, the model runs the risk of substantially underestimating the efficiencies of forest buffers, especially with regards to N removal if instream processing is ignored.

Anne Hairston-Strang

Existing efficiencies are reasonable. Some are low, but there's a variety of conditions. There are so many buffers where further from the stream, the buffer may be in a more upland condition and provide less denitrification. Denitrification is the pathway to removing nitrogen.

LINX experiments – research network addressing these questions (Mulholand) Once pollutant gets into denitrification pathway, it's important that it goes all the way to N2, rather than NOx. N uptake to trees gets redeposited as part of N cycle, and won't take away nutrients in the same way as a buffer promoting denitrificaiton. Uptake will get returned in an organic form.

Newbold and Sweeney

Studies that met criteria on effectiveness were mostly forested watersheds or forest/grass combinations, not grass alone.

There is weak evidence that grass buffers are good for TN removal.

Sediment – There is little known about forest removal. Newbold and Sweeney only identified a few studies. Peterjohn and Correll (1984) found 90-94% sediment removal from forest buffers. All the other studies were grass only or grass plus forest. Evidence suggests that you can get eroding channels in the forest without a protective grass buffer, so you can't be confident in sediment removal all the time.

Sweeney/Newbold don't know the numbers well enough to make a statement about the existing efficiencies. There may be more data underlying these values, but they are either guesses or based on few data sources. The efficiency table seems inappropriately detailed given the level of available information.

Cully Hession

We don't know. Research isn't out there. There are things here and there. But more research needs to be done.

Judy Denver

Don't know, very variable depending on situation

Peter Groffman

No evidence that grass areas are less efficient than forests in removing N. Grass tends to be higher, not lower.

Average efficiencies mean nothing unless you know something about how the buffer is connected hydrologically to the stream

Ken Belt

Aren't grass buffers only effective with respect to the filtering function?

Eric Sprague

No response

5. Should forest and grass buffers be considered separately? Currently, grass buffers are represented as equally efficient at TP and TSS reductions but only 70% of the forest buffer TN reduction.

Mark Southerland

Yes. Grass is more dependent on microtopography. Forest buffer efficiencies maybe could be higher. Mark defers about changing the specific grass efficiency, but TP and TSS should probably be some percentage of forest rather than 100%.

Ken Belt

Combined, designed systems make sense. Grass filters outside the forest buffer as a filtering mechanism for runoff before it gets to the riparian forest, which will have a litter layer based surface that is good for through fall rain interception and erosion control, but is not effective for laterally entering flows (which just find a way under the litter layer.)

Peter Groffman

For N, P, TSS, grass and forests shouldn't be considered separately. There are multiple other benefits provided that are different between them, but for nutrients they should be considered together.

Judy Okay

The way grass is considered now is marginal. Could be more work done on it. May or may not be worthwhile. Grass at 70% of forest buffer effectiveness may be ok.. Peter Groffman did a study of efficiencies of forest alone, grass alone, and a mixture of the two. He shows forest buffers as more effective than grass but a combination (3 zone) to be the most effective..

Woody debris and structure maximize the value of any buffer. Grass doesn't stabilize as well because of a weak root mass– more serious undercutting can occur and thus more sediment in streams.

Could consider them separately if people are willing to do that. The current way is the easy route.

Don Weller

See comments in on existing definitions

Judy Denver

Probably. It depends on roughness of buffer and depths of roots. If some grasses have deep roots equivalent to trees, they may be just as good.

Newbold and Sweeney

Grass buffers lack strong evidence for working on TN reduction. It makes sense to reduce credit.

Gary Speiran

Yes, because the nature of the functions are very different. Foresters say if you're going to see a decrease in nitrate from A to B in GW, the roots would have to go into the water, remove nitrate and let water go by. That just won't happen. Trees have a high water demand. Trees prefer to have roots in zone of aeration, above the water table. With regards to nitrogen uptake from GW, grasses may function differently.

Don't know enough about grass buffer efficiencies to speak to the specific values.

Eric Sprague

Yes. From the instream processing aspect, forested streams are wider and shallower, which yields more instream processing. 10-40% more instream processing in streams with forest rather than grass buffers. This is because wider, shallower streams generally have slower flows and more surface area.

Ken Staver

Yes for nitrogen. No for TP and TSS, if you are talking about reductions related to subsurface flow. Grass buffers shouldn't have different efficiencies, except for TN. Grass efficiencies can vary widely. Forest buffers will be less diverse (more uniform vegetation type). Some grass buffers have cool season non-native grasses, but there could also be native warm season grass buffers. On average, since we know there are some grass buffers that are shallow rooted, it's ok on average to have the TN be lower than the forest efficiency. This accounts for grass buffers that don't do anything with GW. This is only because of the subsurface component. If we are just talking surface runoff, efficiencies should be the same for forest and grass buffers.

David Wise

Sally talked about how it'd be hard to increase efficiency for forest buffers. If there's intent to favor forest buffers, maybe we need to reduce grass buffer efficiency.

Considering grasses to be 70% of forests efficiency value for N removal is a generous assessment.

Grass and forests are different and should be separate and not equal.

Cully Hession

It is ok to consider forest and grass buffers separately. There does need to be an assessment of age of forest buffers though.

Not sure forest should get so much extra TN credit. TP and TSS being equal in forest and grass is ok.

Anne Hairston-Strang

Yes. Reasonably comfortable with current efficiencies, relative tree and grass efficiencies vary significantly. Biomass matters, but it isn't the most controlling condition. Fast growing trees add organic carbon that drive denitrification and more rooting mass. You'll get more biomass with trees. It's good to have organic carbon in wet/dry flux areas.

Soil infiltration rates will change over time. Forest will develop more macroporosity (decayed root channels etc.) There may be a basis for distinguishing between warm season grasses (more biomass, deeper roots) than mowed fescue.

Organic carbon loading, rooting depth, infiltration rates are important facts when determining forest and grass buffer efficiency.

Greg Noe

Insufficient personal knowledge to make an assessment.

6. Would it be appropriate to develop buffer tiers to reflect high, medium and low efficiencies? If so, what would be the factors that determine those classifications?

Mark Southerland

There is enough variability to warrant tiers. They could be based on flow path and groundwater. If you could determine likelihood of shallow ground water and flat topopgraphy, that could be a high tier. Maybe two tiers based on flow and GW.

Ken Belt

This would seem to be a cost-benefit optimization problem, if the modulators were sufficiently well know… and in a long-term sense (ie what is the life cycle of a planted riparian buffer… etc.). All the factors considered above enter into these equations; the trick is to optimize the result. This depends on how much simplicity has to be built into the programmatic aspects of implementation and extension work. I would say however, that a parallel effort here might be useful. I know there is a point where complexities interfere with efficient implementation, but it makes sense to have an "experimental riparian forest" aspect to such a large, expensive program. This way designed experiments can be developed, with consortia of scientists and practitioners involved, to ask highly pertinent questions aimed at getting knowledge and data for implementation related uses.

Greg Noe

Efficiencies could be tied to the loading rate in the catchment. It is unclear how tiers would be used to improve the model, but efficiency tiers could help with the loading rate issue.

Peter Groffman

This would move away from average condition. It could be driven by new information on soil and hydrologic conditions and buffer connection to the streams.

Don Weller

I assume we are still talking only about buffers that have been added/restored as a BMP to be accounted for assessing progress in reducing loads. We do know factors that can affect efficiency (connection to a source, uphill area, width, slope, soil properties, etc.). IF information on such properties can be assembled and included in the database of implemented BMPs, then it could make sense to try to categorize the restored buffers as high, medium, or low efficiency. I don't know if it is realistic to think that such information can be included in the database.

Judy Denver

Use previously discussed factors. Topography, soil, roughness of buffer, underlying geology, connectivity, condition of stream channels. There are varying degrees of efficiencies.

The Western Shore has a higher efficiency because the aquifer is thinner, water will go through aquifer and into the anoxic zone, so there's more potential for denitrification.

Newbold and Sweeney

Maybe there should be a role for width in the tiers: possibly tiers for 35 feet, 60-65 feet and 100 feet and wider. Perhaps the credits could be prorated by width to encourage more than the minimum.

The data aren't there to assume an asymptotic pattern in efficiency related to width for sediment reductions. The problem is the fine sediments, which will require wider buffers than the data show are needed.

Gary Speiran

Yes to reflect the differences in hydrologic settings. Both in a regional sense – carbonate/noncarbonated, and also within the landscape – valley slopes, toe slopes, stream adjacent.

Tried to promote looking at whole riparian corridor as a system with each part having a different function.

Eric Sprague

It would be appropriate to develop buffer tiers. This is a good idea. The factors go back to the responses to Question 3. Factors would include width, flow path and buffer design. There could be a concern that if you look at efficiency, you may find that existing buffers aren't as efficient as originally thought.

Ken Staver

If we are going encourage best practices, then it is appropriate to develop buffer tiers. Refer to the factors identified in Question 3 for factors that determine tier classifications.

David Wise

Clearly there are differences in functionality. Factors would be those from Question #3. The delivery ratio in some ways is a manifestation of the tiered efficiencies. How does the delivery ratio affect efficiency?

If delivery ratio accounts for instream processes, then unless ratio can change, you're discounting the instream processes. If the delivery ratio can change every year, that could account for instream processes.

Cully Hession

Yes, position in landscape, flow path and actual upslope land area would determine the classifications. Should not use the standardized 4/2 acres upland credit. Need to incorporate more info than is being used now.

Anne Hairston-Strang

Already have HGM regions. Don't know that we could do better with the existing data. Not cost effective to set up a system that determines carbon levels. HGM helps account for differences. Denitrification is anaerobic process, but proceeding steps are aerobic, so the wet/dry flux is important.

We may want to place a higher value on buffers in hydric soil. This information is already mapped. We could create a new tier for hydric soil buffers. Except if a buffer is split between hydric and non-hydric, it's a tracking nightmare. Only worth it if there's good data going into it.

Judy Okay

Don't like the idea of tiers because of past experience in tracking for Bay Program, it's not too complicated now, but when you start adding different measurements and records, the quality of data will be diluted due to increased time and effort. The efficiencies already include HGM provinces. If you lower the efficiency too much, there's no value to implementing forest buffers If you can't prove they are doing a good thing, it'll be even harder to get participants.

7. What are the implications of assigning different tiers to buffer efficiencies? Is it appropriate to value certain buffers higher than others? Can you see any consequences of the tier system on implementation rates or ecosystem benefits?

Mark Southerland

It is appropriate. The question is whether we have the data to assign tiers. GW is the toughest. Topography might be obtainable.

Consequences would be that buffers are better targeted. Right now buffer placement is largely opportunistic. There would be a benefit for ecosystems, if forests received more credit.

Ken Belt

A tier system would seem to make sense, given the constraints in number 6, above.

Greg Noe

If the science supports tiers based on controlling factors, then it would be good for adaptive management to target resource allocation to activities that decrease loads the most.

Consequences would be primarily on ecosystem benefits: Ecosystems can, on their own or through management, have very high load trapping rates, which is good for downstream water quality but can have detrimental impacts on other ecosystem functions (habitat/wildlife). With high sedimentation rates the plant community diversity drops. High N and P plant communities will shift in composition (wetlands in general and also riparian buffers). The buffer will still remove lots of pollutant, but there can be negative consequences for the wider ecosystem.

Peter Groffman

Certain buffers are more valuable than others. Those with hydric soil and hydrologic connection are more valuable. It is appropriate to value them differently. Many conservation programs have moved to targeting and valuing areas as higher than others. CREP used to be available to anyone, and now it's only to higher value areas. Tiered system is well established in ag conservation.

Don Weller

We do expect buffers to vary in efficiency, and it is appropriate to try to account for more of that variation. The effects on total material removal would depend on the rates efficiencies assigned to the three categories and on the distribution of the restored buffers into the three categories. If there was intense competition for buffer restoration funds, then creating the tiers could help direct the funds to the most efficient sites. However, it seems like the reverse is true—practitioners work hard to identify any sites for restoration. In this case, creating tiers may not have an impact on implementation rates.

Judy Denver

Better able to target areas with more efficiency and areas where they aren't useful (not to negate other benefits). In thinking about WIPs, there shouldn't be credit for a buffer that's not actually functioning correctly.

Newbold and Sweeney

We should be careful that the tiers don't encourage the minimum buffer because the next tier is too far a reach.

It is appropriate to value certain buffers higher, especially if they are wider. The biggest issue in 1st order streams is they can get forgotten – contoured out of the picture. These are the most important per stream length for reducing pollutants.

One option could be to give credit based on the proportion of flow from 1st order streams (hydraulic loading). Determine how much water per stream distance gets to a 1st order stream. Effectiveness could be based on this: more credit for buffers that are getting more load in 1st order streams.

Newbold's take: I think we came up with this on the spot and, while it makes sense it suffers—like other schemes—from being hard to measure and not being well supported by data. The loading issue is important in evaluating the significance of transects studies that show nitrate removal, but this involves the question of deep versus shallow pathways as well as potentially large variations in loading over relatively small spatial scales. Thus I don't encourage pursuing this option any further.

Sweeny's take ---One option could be to: (i) give credit based on the proportion of flow in the downstream river that is provided by the various order tributaries in a given watershed (e.g., proportion contributed by 1st, 2nd, 3rd. etc); or (ii) based on hydraulic loading (i.e., how much new groundwater water is added per unit length of a given order stream. Regardless of the approach, the point is to give proportionally more credit for buffers along stream reaches which are contributing more of the river flow and hence providing proportionally more ecosystem services to the river as a whole.

Gary Speiran

You need to identify features that are key, visually, so you can find landowners with specific features. You could determine where buffers are, even on a specific property. Tools that are easy enough for land owner to understand are needed. Need to find aspects of buffer placement the landowners can relate to, to encourage buffers, i.e toe slopes are always wet anyway, so a buffer would be a good use of that area.

Eric Sprague

In general, it's best to follow the science, which says that tiers make sense because there's lots of individual variation and the efficiencies should reflect that.

Tiers could affect payments to landowners. They could get more payment for higher functioning buffers. This is appropriate.

When local governments are looking to maximize the use of their funds and trying to be strategic be doing higher efficiency buffers, they should be rewarded. Model should recognize this.

The downside consequence is that we might find out that other buffers aren't as efficient as originally thought.

Incorporating ecosystem benefits into the tiers – A healthy forest buffer (wide, native species, diverse species) could be assigned to a high tier, while a less healthy forest buffer could be in a lower tier. There should be a system to reward good buffers and incorporate other benefits.

Ken Staver

You can value buffers in certain settings. Most nitrogen reduction is a result of the groundwater contact. If there's a bluff with a drop-off, there won't be any GW contact and thus no value to WQ.

The tier system based just on nutrients is problematic because buffers are part of overall watershed restoration, not just nutrient control. If you start only valuing on WQ efficiencies, and reduce buffer implementation, you're not valuing all the other watershed restoration benefits. This is the big problem with the tier system. Holistically, there is value, but it isn't reflected in the efficiencies, and people may not install them.

Need a narrow range of efficiencies, so there's not an average covering everything. There's a better chance that numbers for a given category are more accurate. Tiering could give better resolution, but the data to support this are fairly thin.

David Wise

It is appropriate to assign higher value to some buffers than others. It would bolster targeting efforts. However, when the TMDL is so close to E3, then what is the purpose in targeting?

Targeting can be detrimental if it's overloading the resources in an area with less technical assistance and neglecting areas with sufficient technical resources/land owner readiness. Targeting can lead to decreased outcomes if it causes decreased implementation.

Bay Program hasn't assessed the availability of financial assistance and the difference in availability across areas. PA CREP has $0.5 billion/year but EQIP only has $20 million/year, yet the Bay program sets priorities blind of the economic reality.

With regards to cost effectiveness, it's been ignored that there's essentially unlimited funding for forested buffers and inadequate funding for other agricultural BMPs. If targeting exacerbates the underutilization of buffer funding, there could be negative effects. Tiering will lead to targeting. Bay Program operates on an assumption of scarcity, and there isn't one when it comes to buffer funding.

Anne Hairston-Strang

It is appropriate to value differently, but you need reliable data that is accessible. If all you have is point data, is it easy to map a small stream.

Lots of efficiencies make it difficult to predict what someone is going to get on their individual buffer, so it's hard to maintain incentives. Questions of what kind of credit will you get will arise.

Other issue is that we know the efficiency but not the load. You can get the efficiency on a reduced load from other on-farm BMPs. It further complicates the ability to do reasonable projections. But the question is how to get buffers in the right places. Target the efforts, rather than the efficiencies. Can targeted efforts be rewarded in the efficiencies? Targeted buffer v non targeted buffer? All targeted buffers would have to be reported through a verification step.

Cully Hession

Don't know. It could make people not implement if there's less credit. But any buffer is better than no buffer.

There may be consequences on implementation rates and ecosystem benefits.

Judy Okay

It is appropriate to value some buffers higher than others. Within different forests there are different values (species-wise), but should we make that into something we track? We already track the need for at least 3 species in a buffer. We're already considering grass/forest, so we already are valuing some higher than others. We are already using different hydrogeomorphic provinces.

Yes there are consequences. If you say some are valued higher than others, people might try to put the high value buffers in inappropriate places. In Piedmont, you're in a shale/karst area, you're not going to get the same value as a coastal buffer. These things are already considered. No need to add anything on top of hydrogeomorphic provinces. Slope/hydrology/geology are already included in provinces. Maybe better define what's included in the use of the provinces – better definition with all the factors that are involved – slope, soils, water table, aquifers.

8. What are the lifespans of forest and grass riparian buffers?

Mark Southerland

If grass is mowed or managed as grass, it'll stay that way. If not, it will transition to forest.

If you plant all saplings in a forest buffer, it will not be fully effective for a while. It would make sense to give more credit as a forest buffer gets older. Forest buffers are more likely to be permanent.

Ken Belt

This is a really important and often forgotten aspect; we need more of a forest managment perspective that looks more like standard forest silvicultural practices to address age structures and harvesting timing issues (although harvesting does not have to be the endpoint, necessarily… even considering "replacement" is useful.

This also brings up the idea of how to plant riparian forests that can regenerate themselves.. this is an area that I think needs much more discussion and documentation. I think it is also important to consider seed banks (both existing and maybe engineered?) in this consideration both in terms of planted riparian forests and existing unmanaged ones. It would be an important part of prudent "business plan" for long-term protection.

Greg Noe

If there's little sedimentation, it's effectively indefinite. If there's lots of sedimentation, hydrology can change, thus affecting efficiencies. As long as plants are there and soils are relatively undisturbed, the functions will be indefinite.

Peter Groffman

Depends on what happens to soil, hydrologic conditions, and buffer connection.

Grass riparian buffers in VA - When you establish a grass area next to field, you get a berm and gully, sideways flow until it breaks through the buffer. The grass buffer might look fine, but isn't doing anything because it degraded over time. Grass buffers need maintenance and flow spreader. Hydrologic connection must be maintained.

What's N fate? If it's denitrified, there's a long lifespan. If N is cycling in soil then there's concern about nitrogen saturation. Life span of a buffer is determined by the N dynamics.

Judy Okay

Forest buffers – 40-50 years, only issues would be thinning/harvesting and streambank shoring up to avoid tree lose. First 5 years are important to manage for establishment.

Grass buffers – Limited to 7 years without needing to be redone, due to sediment overload and deterioration in quality due to invasion of species. Will need to mow or something to maintain it. MD comes back to assess a cost share – if there's no management, it will start to turn into a forest buffer. Cost share will make them take out trees invading a grass buffer to get grass buffer cost share renewal. Trees are not allowed to remain in a buffer considered and cost shared as a grass buffer.

0.24 runoff value in grass, 0.8 forest runoff value. For Peak flow, forest is better; it also reduces stream thermal pollution, requires less management. It is much cheaper to put in a grass buffer , which is why there's a case made for grass buffers. In the long run forest buffers have better payoff if left for a 15 year contract time or longer.

Dillaha (1989) veg filter strips for agriculture.
www.watersheds.org/news/ There is a definition of riparian zone at this site. You have to select "riparian ecosystems".

Simpson and Weammert from review, USFS (2007)
This report is on the Ches Bay website, the topic area is BMP Effectiveness It is the review done in 2007-08.

Anne Hairston-Strang

70 years for forest but it depends on what's planted and whether there are conditions for regeneration. There may be a need for intervention around 70 years to ensure continuation. In

areas of invasive species and deer predation, these can take a toll and shorten lifespans and prevent regeneration.

Grass buffers will last 30 years, if they are maintained.

Don Weller

See answer to question 9.

Judy Denver

Forests are pretty indefinite as long as they are allowed to be natural.

Don't know much about grass buffers over time.

Newbold and Sweeney

Forest lifespan is indefinite. Grass buffer can get saturated with sediment. Our study (Newbold et al 2010) show that in 15 years, there wasn't much buildup. If the buffer is in conjunction with good upslope practices, it should last decades. Both forest and grass are vulnerable to concentrated flow and gully erosion. If those develop you have a problem and need to address it.

Newbold, J. D. N., S. Herbert, B. W. Sweeney, and P. Kiry. 2010. Water quality functions of a 15 year old riparian forest buffer. Journal of the American Water Resources Association. 46 (2): 299-310.

Eric Sprague

Can't speak to grass buffers, but they can get overrun easily.

Forests – practice is given a relatively short lifespan, but it will likely be there indefinitely. You have to be proactive about the buffer, though. If they are managed to last a long time, they will. (control deer browse, invasives, etc)

Ken Staver

Lifespans are basically indefinite, for practical purposes. Eventually they will reach a new equilibrium. The buffer will still be there for wildlife etc. but at some point in time its retention efficiency might tail off in a non-harvest situation.

Forest buffer will improve for 30 years, and will reach a peak in decades. There will only be a decline after several decades.

For all the uncertainties we have, lifespan is not an issue.
The one point I would change is in question 8 regarding changes in efficiencies over time. I think it is well established that nutrient accrual in both grass and forest settings will plateau at some point but at least for N, this does mean that N retention efficiency will go down. I don't think there is any data supporting the idea that a buffer will become less efficient at some point down the road so I don't think it is something we should be dealing with given all the other questions there are. It would mostly be weakly supported speculation.

David Wise

This is a management and use question, not a question of the lifespan of the integrity of vegetation. A change in management or use will affect the lifespan of a buffer.

These ease of conversion of grass buffers under plow and/or hoof doesn't set grass buffers up to have a trajectory towards self-preservation. E.g. In 2004 500 CREP forested buffer (CP 22) landowners were surveyed and 87% were likely or very likely to leave the practice in place when the contract ended. However, with grass practices, 2/3 are back into production after the incentives are over. More than 90% of forested buffers are installed on land that was not in crop production (was pasture, grass hay or idle). Thus the pressure to reconvert to crops is far less for forested buffers.

Cully Hession

Don't have a good answer. Gut feeling is that forest buffers will last a long time because they are harder to get rid of. Grass buffers get full of sediment and become less effective, so there is a shorter lifespan but no idea how short.

Gary Speiran

Don't have the background for this one.

9. Is there sufficient scientific data to justify different efficiencies at different stages of maturation, to account for lag time? Would forest and grass buffers differ? If there is sufficient data, what would the different stages/efficiencies be?

Mark Southerland

Would think so, but can't point to it. Defer to others. Suggested categories could be <10 years old, >10 years old.

Ken Belt

I rather doubt this… but have not done a literature search. I would expect grass and forest buffers to be very different. There is going to be change over time… not sure how well we can predict that "trajectory" given some initial conditions, especially given the dynamic nature of stream channels and floodplains. This should be given a lot of thought, and likely would benefit from a focused lit search and some discussions based on it. Also see some of the points made above.. eg., seed banks, etc.

Greg Noe

No, there is not sufficient data. This would be too difficult to model, even if there were differences.

Peter Groffman

Not aware of sufficient scientific data to account for that.

Judy Okay

No, only one report – a PhD thesis, Lisa Orzetti (2002) George Mason. Works in Eastport (Ecosystem Solutions) she studied buffers 1-15 years old. Could see a difference in first 5 years, related a lot to land use change – less erosion. Instream life improved (macroinverts) within first 5 years. The forest buffers seem to get up to functioning pretty quick considering the removal of cattle from streams as a part of the CREP practice.

Bern Sweeney has a 15 year study, but more on the trees, Nitrogen removal got messed up because farmer changed fertilizer application.

Newbold and Sweeney

There are not sufficient scientific data to make a determination.

Don Weller

This is going to be hard. There are few studies that track buffer performance through time. In general, we would expect the effects of maturation to vary depending on the material considered and the dominant mechanism of retention. For example, nitrogen can be removed from the water by forest buffers through incorporation into wood (trunks, branches, roots, and dead wood), incorporation into the soil, or by denitrification. In restoring a forest buffer, we would expect incorporation into wood to be high during early, rapid stages of forest succession and to eventually approach zero later as the standing stock of wood stabilizes. In contrast, denitrification might increase with age and could be sustained indefinitely with age.

Judy Denver

Probably some data, don't know if it's sufficient. May need to look at literature outside of riparian buffer topics.

No comment on stages/efficiencies.

Eric Sprague

Can't speak to sufficiency of data.

According to MD DNR – forest buffer function is at 50% after 5-10 years; buffers older than 15 years are much better at reducing pollutants.

Younger forests grow faster, but there's less root structure and understory layer. These qualities contribute to nutrient processing and slowing the flow of water across the buffer.

Ken Staver

Grass would reach its potential faster, but forest buffers look like grass buffers in the initial stages. Leaf litter in streams isn't a forest function for 20 years. It's good in some streams and not so good in others.

Both forest and grass buffers will work in the initial stages and would probably be about the same. If there's going to be a lower efficiency for grass buffers, then forest buffers should have a lower efficiency in the first few years, since they are like grass at this stage.

From a practical standpoint, a forest isn't a forest when you plant a seeding. Actual leaf area is minimal in the beginning.

Don't know if there's sufficient data on efficiencies to address the lag time. Stroud has a study, and maybe Lowrance on forest development stage studies.

Cully Hession

Nowhere near enough data. Grass and forest would differ. There would be no real lag time in grass buffer, but there needs to be a lag time for forest buffers.

Anne Hairston-Strang

Not enough data. Some is out there, but not robust enough to include in efficiencies. There are so many other variables that are more important. This is where biomass matters. The faster it grows, the more credit you can get. This can be measured above ground.

Grass and forests overtime will get blurred, grass buffers that aren't maintained will start to become forested.

Gary Speiran

Not sure about amount of literature. The aspect that is critical (esp for GW) is residence time, time of travel of GW to stream (age of the water). This can vary from one year to 50 years old. It's not just the buffer effectiveness that's important, but the age of the groundwater. Need to focus on removing the source, so as recharge goes into GW, the WQ gets better. It's less the buffer efficiency than lower nitrate water from forest source that's getting into the GW.

Age and flow path factor may not be considered in buffer efficiency analyses. From a surface water standpoint, the pathway matters. Efficiencies will be more evident.

David Wise

Don't have a basis for opinion.

10. Are there certain types of studies/research that do not accurately capture what is occurring in the field? In looking at the literature search provided to the Expert Panel, are there any outstanding papers that capture load reduction efficiencies well? Are there any papers that should be disregarded?

Mark Southerland

Some people are finding variability. Initial studies set the stage and then things got complicated (10-15 years ago). People are starting to come back around to recognizing the benefits of buffers. Defer to Don Weller on this issue.

Don Weller

Many analyses of buffer performance are strictly modeling exercises. As a modeler, I endorse this activity. However, until the models are evaluated against observed data, they should not be give the same credence as empirical observations or other models that *have* been tested with observed data.

Ken Belt

Not sure about certain types (what do you mean by type?). Studies are always going to be constrained.. they usually can only look at one or two things at a time effectively and originate with different motivating forces and experience on the part of the investigator. Add to that the tremendous variance in landscapes, groundwater, etc… and over time too and you see the problem. See the above discussion on experimental riparian forests.

Greg Noe

If you work on a short term time scale, long term dynamics can be missed. Most loading is during infrequent events (rainfall/flooding, etc.). If you miss rare, but large magnitude events you miss the effects.

Peter Groffman

Theo Dillaha grass buffer work in VA – very important. Other important studies focus on hydrologic connection

Vidon – mostly in Canada. Conceptual papers about buffer and upland connection

Studies on seeps (Angier) – very important, well studied site at Beltsville. Because of the groundwater flowpath, runoff water was bubbling up in seeps and discharging high N concentrations into the stream.

Judy Okay

Annotated Bibliography by Mayer – forward notes that vegetation types do matter Judy notes that everyone did not agree with this conclusion.

Approach a lot of literature with caution. Research will reflect the individual researchers objectives and have a narrow scope of data.

Judy Denver

See above discussion on Eastern Shore efficiencies and hydrogeologic setting. Good job on lit search for riparian zones. Need to acknowledge papers carefully because broad settings /sweeping statements may only apply to certain areas. Need to understand hydrogeologic system, or clearly acknowledge any limitations to the results.

USGS Professional Paper 1680; Circular 1350: Nutrients in the Nations Streams and GW – Chapter 5 GW/SW transport and talks about SPARROW, has a useful table.

Newbold and Sweeney

See above discussions. Sediment study plots with artificial sediment application do not reproduce real world conditions. In N removal studies, the big limiting factor (in terms of utility) is the lack of flow path /hydrologic loading quantification.

Many papers from European program that ended 10 years ago. This was called NICOLAS (Nitrogen Control by Landscape Structures in Agricultural Environments). It's summarized by:

Sabater, S., A. Butturini, J. C. Clement, T. Burt, D. Dowrick, M. Hefting, V. Maitre, G. Pinay, C. Postolache, M. Rzepecki, and F. Sabater. 2003. Nitrogen removal by riparian buffers along a European climatic gradient: patterns and factors of variation. Ecosystems **6**:20-30.

Other NICOLAS papers listed under Q 11 below.

Lowrance, R., L. S. Altier, J. D. Newbold, R. R. Schnabel, P. M. Groffman, J. M. Denver, D. L. Correll, J. W. Gilliam, J. L. Robinson, R. B. Brinsfield, K. W. Staver, W. C. Lucas, and A. H. Todd. 1997. Water quality functions of riparian forest buffers in Chesapeake Bay watersheds. Environmental Management 21:687-712.

Lowrance, R., R. Todd, J. Fail, O. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984. Riparian forests as nutrient filters in agricultural watersheds. BioScience 34:374-377.

Lowrance, R. R., R. L. Todd, and L. E. Asmussen. 1984. Nutrient cycling in an agricultural watershed. I. Phreatic movement. Journal of Environmental Quality 13:22-27.

Vidon, P. G. F. and A. R. Hill. 2004. Landscape controls on nitrate removal in stream riparian zones. Water Resources Research 40. (This addresses subsurface flow/denitrification)

Peterjohn, W. T. and D. C. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. Ecology 65:1466-1475.

Vidon, P. G. and A. R. Hill. 2006. A landscape-based approach to estimate riparian hydrological and nitrate removal functions. Journal of the American Water Resources Association 42:1099-1112.

Gary Speiran

Many studies don't account for recharge, residence time, and position within watershed. Sally asked Gary to look at buffer width issue; however, there's lots of uncertainty about the efficiencies. Efficiencies are very different because it's not the width; it's the hydrology that's driving efficiency of a buffer.

Example: Hill slope buffers - USGS looked at areas of deposition. They were not seeing much deposition on forested hill slopes. There's lots of noise in the efficiency data.

Gary has papers that address width; width isn't factor because hydrology is the overriding factor.

Can we look at papers to find well screen depth that goes below water table.

Anne Hairston-Strang

Paul Mayer summary (EPA paper) is a good one, except you're averaging so many conditions that you can't pull out patterns that would be seen under narrower conditions (such as soils, etc.). Meta-reviews capture the bigger patterns, but are limited in capturing finer scale impacts. Mayer didn't find a big distinction because he was looking nationally. That lack of a difference shouldn't be considered a conclusion. Differences often have to do with flow path/moisture. Too much nutrient loading can also overwhelm the capacity of the buffer. Both are bigger than vegetation type issues.

Ken Staver

There are no mature buffers on ag land to evaluate. A lot of enthusiasm came from studies of existing forest buffers in floodplain settings. Buffers were in areas where it was never suitable for farming due to the hydrologic setting. Old buffers in floodplains have high denitrification rates. Now we are trying to take well drained agricultural land and apply buffers/efficiencies. Transferability of these studies may be questionable. Studies of buffers where the buffers are in areas too wet to farm may not be representative of buffers on ag land, but these old riparian buffers are where much of the data are from. We can't recreate the hydrogelology by changing the vegetation on the land. There are different conditions in original buffers and new buffers.

Lowrance (Gibbs farm) – big floodplains with existing buffers, not new buffers on ag land.

There isn't much research on trapping efficiency in new buffers, esp for the trees that take so long to reach their potential.

Cully Hession

Already gave us a list of good ones. Stroud one is good.

A lot of early research was coastal plain and is totally different from everywhere else.

David Wise

Don't have a basis for opinion.

Eric Sprague

No response

11. Please identify any other literature or individuals whom the Panel should contact for additional information on forest or grass riparian buffers. Please provide any other information you want to provide regarding these practices.

Mark Southerland

Don Weller, Tom Jordan. Bern Sweeney – best forest stuff.

Ken Belt

Do you have a listing of the literature you have already (preferably in a literature database)? Have you looked at the ad hoc list from my own database I had sent (admittedly rough..!) How are your search resources? Web of knowledge? Have you used the USFS TreeSearch feature (free… and many free pdfs are available). Have you accessed the Long-term ecological research network (LTER) literature (lots of long-term forestry hydrological research there (Hubbard Brook, Coweeta, etc), and the USFS EFR literature (experimental forest and rangeland)… these are long-term study networks that may yield good information and or contacts, both in terms of direct riparian info and other related forestry info that could be synthesized for use here. Lastly, the USDA Agricultural Research Service (ARS) would be another good place to look.. they have done a lot of riparian work in agricultural settings, I believe.

Have we considered silvicultural research? Transpiration rates could be used, trying to move water. GW moves through riparian zone. If the trees are moving a lot of water that will slow down water and give you longer time and more treatment.

Greg Noe

Floodplains haven't been considered and they intercept upstream river loads in addition to upland loads. It's an extra load capture that non-floodplain riparian buffers cannot do. However, there's not a lot of data on floodplain efficiencies

Noe and Hupp 2009: floodplain sediment and phosphorus trapping rates. This work is not necessarily scalable to all physiographic providences.

Judy Okay

Rich Lowrance – Developed REMM model, Gibbs Farm in Georgia. REMM model hasn't been calibrated for Bay area, but it would be good to get. Have unbiased modeling information, maybe could work with Bay Program.

Mike Dosskey. – paper on soil and sediment and buffer targeting, paper on buffers and targeting.

Leslie Orzetti did the Buffer study on 1-15yr old sites. She is with Ecosystem Solutions, Inc. The phone number is 410-935- 0996. Tell her I recommended you speak with her.

AWRA Buffer Conference: Paul Mayer is the conference chair, Judy is technical program chair. Instream processing paper will be helpful.

Judy Denver

Larry Puckett papers – he is retired.

Need more information/incorporation of groundwater processes, not just the surface connection.

Newbold and Sweeney

Vidon, P. and A. R. Hill. 2004. Denitrification and patterns of electron donors and acceptors in eight riparian zones with contrasting hydrogeology. Biogeochemistry 71:259-283.

Puckett, L. J. and T. K. Cowdery. 2002. Transport and fate of nitrate in a glacial outwash aquifer in relation to ground water age, land use practices, and redox processes. Journal of Environmental Quality 31:782-796.

Puckett, L. J., T. K. Cowdery, P. B. McMahon, L. H. Tornes, and J. D. Stoner. 2002. Using chemical, hydrologic, and age dating analysis to delineate redox processes and flow paths in the riparian zone of a glacial outwash aquifer-stream system. Water Resources Research **38**.

Hill, A. R., K. J. Devito, S. Campagnolo, and K. Sanmugadas. 2000. Subsurface denitrification in a forest riparian zone: Interactions between hydrology and supplies of nitrate and organic carbon. Biogeochemistry 51:193-223.

NICOLAS papers (not exhaustive):

Blicher-Mathiesen, G. and C. C. Hoffmann. 1999. Denitrification as a sink for dissolved nitrous oxide in a freshwater riparian fen. Journal of Environmental Quality **28**:257-262.

Burt, T. P., G. Pinay, F. E. Matheson, N. E. Haycock, A. Butturini, J. C. Clement, S. Danielescu, D. J. Dowrick, M. M. Hefting, A. Hillbricht-Ilkowska, and V. Maitre. 2002. Water table fluctuations in the riparian zone: comparative results from a pan-European experiment. Journal of Hydrology **265**:129-148.

Clement, J. C., G. Pinay, and P. Marmonier. 2002. Seasonal dynamics of denitrification along topohydrosequences in three different riparian wetlands. Journal of Environmental Quality **31**:1025-1037.

Hefting, M., B. Beltman, D. Karssenberg, K. Rebel, M. van Riessen, and M. Spijker. 2006. Water quality dynamics and hydrology in nitrate loaded riparian zones in the Netherlands. Environmental Pollution **139**:143-156.

Hefting, M., J. C. Clement, D. Dowrick, A. C. Cosandey, S. Bernal, C. Cimpian, A. Tatur, T. P. Burt, and G. Pinay. 2004. Water table elevation controls on soil nitrogen cycling in riparian wetlands along a European climatic gradient. Biogeochemistry **67**:113-134.

Hefting, M. M., R. Bobbink, and H. de Caluwe. 2003. Nitrous oxide emission and denitrification in chronically nitrate-loaded riparian buffer zones. Journal of Environmental Quality **32**:1194-1203.

Hefting, M. M., R. Bobbink, and M. P. Janssens. 2006. Spatial variation in denitrification and N2O emission in relation to nitrate removal efficiency in a n-stressed riparian buffer zone. Ecosystems **9**:550-563.

Hoffmann, C. C., S. Rysgaard, and P. Berg. 2000. Denitrification rates predicted by nitrogen-15 labeled nitrate microcosm studies, in situ measurements, and modeling. Journal of Environmental Quality **29**:2020-2028.

Maitre, V., A. C. Cosandey, E. Desagher, and A. Parriaux. 2003. Effectiveness of groundwater nitrate removal in a river riparian area: the importance of hydrogeological conditions. Journal of Hydrology **278**:76-93.

Sabater, S., A. Butturini, J. C. Clement, T. Burt, D. Dowrick, M. Hefting, V. Maitre, G. Pinay, C. Postolache, M. Rzepecki, and F. Sabater. 2003. Nitrogen removal by riparian buffers along a European climatic gradient: patterns and factors of variation. Ecosystems **6**:20-30.

Gary Speiran

Floodplain deposition of sed and TP, when streams go into flood stage needs to be addressed. This is a separate function from when materials make it into the stream. So much of the nutrients get into Bay during high flows. Many of the available BMPs may not function as well during high flows. At flood stage, buffers are very important for pollutant reduction.

Eric Sprague

1. Luc Claessens, University of Delaware. Presented on instream processing at STAC meeting.
2. Amy Jacobs – DE TNC – buffer placement.

Ken Staver

Lots of buffer width papers. Alan Hill (review paper on controls on Nitrate retention), Puckett paper.

Some work in the mid-west. May not be applicable.

There's a problem trading away things that are important for watershed restoration for high TN, TP, TSS efficiencies.

David Wise

Stroud Center: Bern Sweeney brings a consistent conviction that forests are valuable. Denis Newbold is an investigator on the study of instream services.

Many instream N removal studies have a dim view on instream processes and we should talk with Bern to figure out why they think differently. Ask Newbold if he has reviewed the LINX studies. He looked into the methodologies and determined if it they were appropriate for the outcomes.

Harry Campbell – works with David, saw DEP reporting 30,000 acres of forested buffers. CREP has done 80-90% of forest buffers. Not likely to be that high since 2008. Buffers have been on the decline since 2007.

Without new enrollment and an imperfect percentage of reenrollment going back in, the actual number of CREP buffer acres is at risk of going negative in the coming years.

Cully Hession

Dan Storm –Oklahoma State, found that dissolved P is moving around in flood plains. Dissolved P is a key issue to look into. Can look up some recent papers.

Anne Hairston-Strang

LINX reports have matured enough. Focused on denitrification, a lot is instream focus rather than buffers. Instream denitrification would be a tough sell in the model. Most settings would be forest buffers naturally, and support the stream system.

Herbaceous cover can shade whole stream and be incompatible with native species. Won't support the same level of organisms as the natural system. Is a degraded buffer better than the concrete if it's covered with too many invasives?

Peter Groffman

No response

State Representatives

12. Who is responsible for tracking where and when riparian buffer practices are used?

Peter Groffman

We can get more sophisticated. There are GIS farm-level coverages. Could have more sophisticated targeting, but it depends on the answers to these questions.

Judy Okay

Judy did States' Bay tracking. Judy was looking for unreported buffer miles through grants and organizations. Found over 50 miles from last 3 years done by NGOs with grant money that were not reported to the state at all. Same thing happens in MD. Need to call all the NGOs. There's some that is sliding through the system. This is a hot issue.

In VA, there is discussion about who's responsible for tracking. DCR is the lead organization for reporting to Bay Program. DOF gets info from foresters and gives it to DCR.

David Wise

Reporting issues are huge and real. They don't report site specific CREP buffers, but report a summary tally of buffers they've done. Rough tallies may have been reported on top of CREP reporting. We don't know what measures are in place.

CREP has slowed down since 2007. FSA tracks CREP buffers.

FSA is unable to distinguish between reenrollment and new buffers. Field offices could do it, but FSA has not provided instruction to collect that data.

The Executive Order would give an impetus for measuring progress on buffers.

Anne Hairston-Strang

Forest BMPs Reporting Procedures, Final.

MD DNR Forest Service buffers (Partners for Wildlife, volunteers, landowner paid).
CREP is through MDA. Eventually all go to MDE.

CREP is the biggest acreage historically, but fallen in recent years. State lands are no longer eligible for CREP.

13. How are riparian buffers from individual farms reported to the state? What information is reported?

Judy Okay

The information is gathered primarily from NRCS and FSA cost-share programs.

Ken Staver

Data collection: people always start with "it's too hard", but if you decide it's important, you need to attempt to get the data. Often people are too quick to say it's too much information and it can't be used/collected. If we need to fix the model then fix it, let's not leave out critical data that will help in accurately assessing the impacts of practices.

GIS/GPS is so much better that before. More data can easily be collected. Figure out what we need to know, and figure out a way to know it.

Anne Hairston-Strang

MDA reports CREP a year after because it's reported off the maximum cost share. CREP incentives were reduced in 2004/05, they've increased again, but crop prices are really high so there's less incentive for buffers. (This is the biggest barrier – opportunity cost of buffers is much higher)

The Forest Service reports from forest buffer forms used by foresters (DNR FS provides the buffer/planting plan so they have all the info). Forms are in performance evaluations, so there is incentive to report.

Forest Service maintains a database and takes out CREP buffers to avoid double counting.

A separate file with buffer tracking and locations is sent to Bay Program, separate from NEIEN. State/Latlong/ Acres/Length/planting date. Geographic info from point location (county, WS)

14. Please provide any recommendations or information you have regarding tracking and reporting implementation of riparian buffer practices.

Judy Okay

States should have a team review with ag, forestry, and NGO reps before submitting data to be sure everything is captured, including voluntary efforts paid for with Federal grant money. The same beginning and end date of the reporting year should be followed by all. A strict but simple set of descriptive info fields should be developed, the Forestry Workgroup collects a set of information about forest buffers:

Date of planting by year
Site identification
Geo-coordinates
Watershed (HUC 12) or 8 digit HUC
Length of Buffer
Width of Buffer
Minimum 3 species
Minimum width (35ft?)
Sponsoring group/individual (cost share, NGO, landowner, municipality etc)

Eric Sprague – General Comments about Implementation

It's good to have 3rd party verification of installation. Adds costs, but is better in long run.

Beyond buffer implementation, monitoring buffer health over time is a big gap in implementation. Not as much known about grass buffer implementation.

Can you factor in whether the buffer has been permanently protected, vs a buffer that could be returned to previous use. A protected buffer will offer more assurances that you will actually get load reductions.

Ken Staver

What's important needs to start at the science level.

If you pull out the Lowrance table of efficiencies/existing buffer research, the efficiencies will go down, because these results are a big part of these studies.

Anne Hairston-Strang

Keep paying attention to the details. Make sure there are measures to avoid double counting.

Tried to capture non-agency buffers through online reporting system, but it hasn't really worked.

MD is trying to expand backyard buffer programs, including seedling giveaways for residential landowners.

Attachment A

Riparian Forest Buffers:
Agricultural riparian forest buffers are linear wooded areas along rivers, streams and shorelines. Forest buffers help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with a 35 feet minimum width required.

Land uses: all agricultural land uses, except animal feeding operations

Reduction Representation: There is a land use change for the buffer area from existing land use to forest land use. A reduction efficiency is applied to upland areas. The reduction efficiency varies geographically according to the table below. For each acre of riparian buffer, the upland acres to which the efficiency applies is as follows:

- TN: 4x buffer acres
- TP: 2x buffer acres
- TSS: 2x buffer acres

BMP	Hydrogeomorphic region(s)	TN reduction efficiency	TP reduction efficiency	SED reduction efficiency
Forest Buffers	Appalachian Plateau Siliciclastic Non-Tidal; Appalachian Plateau Carbonate Non-Tidal	54%	42%	56%
	Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal	34%	30%	40%
	Coastal Plain Dissected Uplands Non-Tidal	65%	42%	56%
	Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Piedmont Crystalline Tidal	19%	45%	60%
	Coastal Plain Lowlands Non-Tidal	56%	39%	52%
	Piedmont Crystalline Non-Tidal	56%	42%	56%
	Coastal Plain Uplands Non-Tidal	31%	45%	60%
	Piedmont Carbonate Non-Tidal	46%	36%	48%
	Valley and Ridge Siliciclastic Non-Tidal	46%	39%	52%

Grass Buffers
Agricultural riparian grass buffers are linear strips of grass or other nonwoody vegetation maintained between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment, and other pollutants from runoff. The recommended buffer width for riparian grass buffers (agriculture) is 100 feet, with 35 feet minimum width required.

Land uses: all agricultural land uses except animal feeding operations

Reduction Representation: There is a land use change for the buffer area from existing land use to hay without nutrients (hyo). A reduction efficiency is applied to upland areas. The reduction efficiency varies geographically according to the table below. For each acre of riparian buffer, the upland acres to which the efficiency applies is as follows:

- TN: 4x buffer acres
- TP: 2x buffer acres
- TSS: 2x buffer acres

Grass buffer are assumed to be 70% as efficient at reducing TN as forest buffers, but equal to forest buffer efficiency at reducing TP and TSS.

BMP	Hydrogeomorphic region(s)	TN reduction efficiency	TP reduction efficiency	SED reduction efficiency
Forest Buffers	Appalachian Plateau Siliciclastic Non-Tidal; Appalachian Plateau Carbonate Non-Tidal	38%	42%	56%
	Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal	24%	30%	40%
	Coastal Plain Dissected Uplands Non-Tidal	46%	42%	56%
	Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Piedmont Crystalline Tidal	13%	45%	60%
	Coastal Plain Lowlands Non-Tidal	39%	39%	52%
	Piedmont Crystalline Non-Tidal	39%	42%	56%
	Coastal Plain Uplands Non-Tidal	21%	45%	60%
	Piedmont Carbonate Non-Tidal	32%	36%	48%
	Valley and Ridge Siliciclastic Non-Tidal	32%	39%	52%

Appendix C

Conformity of Report with BMP Review Protocol

Conformity of Report with BMP Review Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT 2010) outlines the expectations for the content of Expert Panel reports. This appendix references the specific sections within the report where panel addressed the requested protocol criteria.

1. Identity and expertise of panel members*:*
Table 2 in Section 1

2. Practice name or title:
Riparian Forest Buffer BMP and Riparian Grass Buffer BMP

3. Detailed definition of the practice*:*
Section 3

4. Recommended N, P and TSS loading or effectiveness estimates:
Section 5

5. Justification of selected effectiveness estimates*:*
- List of references used (peer-reviewed, etc.)
  Section 8
- Detailed discussion of how each reference was considered.
  Section 4

6. Land uses to which BMP is applied:
Section 3

7. Load sources that the BMP will address and potential interactions with other practices:
Agricultural loads

8. Description of pre-BMP and post-BMP circumstances and individual practice baseline:
Addressed in BMP definitions, see Tables 3 and 4.

9. Conditions under which the BMP works/not works.
- *Included throughout in the discussions in Section 4.*

10. Temporal performance of BMP including lag times between establishment and full functioning.
See lag time discussion Section 4F

11. Unit of measure (e.g., feet, acres):
Acres of land use change in buffer, plus efficiency credit for additional acres of upland area

12. Locations in Chesapeake Bay watershed where the practice applies:
All qualifying agricultural acres in the Bay watershed that are in or adjacent to a riparian area

13. Useful life of the BMP: *40-120 years for riparian forest*

14. Cumulative or annual practice: *cumulative practice*

15. Description of how BMP will be tracked and reported:

See Section 6.

16. Ancillary benefits, unintended consequences, double counting:
See Sections 6 and 7

17. Timeline for a re-evaluation of the panel recommendations:
The Panel recommends that riparian buffers efficiencies should be reconsidered when, and not before, hydrologic flow paths are better understood and can be accounted for in a CBWM.

18. Outstanding issues that need to be resolved in the future and a list of ongoing studies, if any:
Section 7

19. Operation and Maintenance requirements and how neglect alters performance:
Sections 4 and 6

20. Where studies with negative pollution reduction data are found (i.e. the BMP acted as a source of pollutants), they should be considered the same as all other data.
Not encountered

21. Include results where the practice relocated pollutants to a different location. An example is where a practice eliminates a pollutant from surface transport but moves the pollutant into groundwater.
Not encountered