Design Specifications and Nutrient Accounting for Cattle Exclusion

Practice Description and Utility

Purpose: This chapter defines the practice of cattle exclusion with nutrient management, provides design criteria and implementation specifications, and provides nutrient credit assignments used for compliance with Nutrient Management Strategy Rules developed for Falls Lake and Jordan Lake watersheds.

Applicability: This practice is developed to provide nutrient reduction credits for cattle exclusion from intermittent and perennial streams. This practice is applicable towards compliance with Existing Development rules. This practice applies to any lands that best available information substantiates supported grazing cattle as of the baseline period for the applicable nutrient strategy. This practice establishes to-stream load reduction credit for use in meeting nutrient rules with comparable load requirements. Cattle exclusion for purposes of meeting collective agriculture nutrient loss reduction targets shall follow credit guidance and methods determined by Basin or Watershed Oversight Committees.

This practice standard establishes the technical basis for nutrient credits associated with cattle exclusion. Approval of this credit by the Division of Water Resources (DWR) will be contingent upon development of a acceptable trading framework for the exchange of credits between parties affected by the respective Agricultural Rule and parties not affected by the Agricultural Rule. This development process will be initiated by DWR, with full participation of the Watershed Oversight Committee and other regulated stakeholders in the respective watersheds. Credits will not be issued for this practice to any party until the processes governing these exchanges have been established.

Method: Cattle Exclusion includes fencing along a stream as a physical barrier to animals entering open water and degrading stream banks. This practice prevents trampling of stream banks and cattle-induced erosion, reduces direct deposition of animal waste in the stream, and allows for re-establishment of a buffer zone. A decrease in stocking rate paired with cattle exclusion may enhance water quality improvements. This crediting method provides nutrient reduction credits associated with cattle exclusion with or without reductions in stocking rates. Implementation of this practice must comply with existing local, state, and federal laws including buffer protection rules, and erosion and sediment control ordinances. In order to receive credit, cattle exclusion must be implemented and maintained to comply with the following North Carolina NRCS or NC Agriculture Cost Share Program (ACSP) practice standards: Access Control (472), Fencing (382), and Nutrient Management (590). This management practice will promote long-term, continued improvements of streams, riparian areas, and water quality as long as these specifications are maintained. The party awarded credit shall ensure ongoing maintenance of the practice.

Nutrient Credit Overview
Nutrient credits for cattle exclusion vary based on the animal stocking rates before and after exclusion. The nutrient credit is specified as mass per area per year (lb/ac/yr) and applies to the area of pasture affected by the exclusion fencing (i.e., the area that had access prior to exclusion). The crediting method is based on percent mass reductions reported in the literature and factors of safety that vary depending on the post-exclusion animal stocking rates. To account for the uncertainty associated with this approach, safety factors are applied to the percent mass reductions with higher safety factors applied to pastures with higher post-exclusion stocking rates. Cattle exclusion practices that are installed to meet the minimum standards set out in this document shall be credited using the methods described herein. Nutrient crediting for this practice is available for pastures with stocking rates post treatment of no more than 1.2 au/ac/yr. (One animal unit (au) is equal to 1 adult, 1000 lb cow.) Depending on the pre-exclusion and post-exclusion stocking rates, nitrogen credits range from 1.7 lb-N/ac/yr to 3.9 lb-N/ac/yr, and phosphorus credits range from 1.1 lb-P/ac/yr to 2.6 lb-P/ac/yr.
Relative Confidence in Credit Assignments
Cattle exclusion credit estimates are considered to have low to moderate confidence because a single study was used to inform the loading rates and percent mass reductions that form the basis of this credit. Factors of safety are applied to all sites.

Minimum Design and Operation Criteria

To receive nutrient credits, practice implementation shall meet the following minimum standards, based on NC NRCS or NC Agriculture Cost Share Program (ACSP) practices:

- Access Control (472)
- Fencing (382)
- Nutrient Management (590)

While the minimum design criteria are based on NC NRCS or NC Agriculture Cost Share Program (ACSP) practice standards, it is not a requirement to obtain cost share funds or technical assistance to be eligible for this credit. Nutrient management plans must be developed by a Certified Nutrient Management Planner. Documentation including, but not limited to, site photographs and nutrient application rates compared to those provided in the Nutrient Management Plan shall be maintained for record keeping purposes.

The party seeking credit shall provide best available information toward substantiating that the acreage and stream proposed for exclusion was cattle-grazed pasture with open stream access during the baseline period of the applicable nutrient strategy.

The party awarded credit shall ensure that the practice is inspected at least annually, maintained as necessary, that inspection and maintenance actions are documented by photographic and written means, and that the Division will be provided access to the practice with proper notice. Annual inspections shall include review of documentation by a Certified Nutrient Management Planner to verify compliance with the Nutrient Management Plan. Continuation of credit requires substantiation of ongoing practice function at minimum 5-year intervals based on written verification of ongoing operation and provision of inspection and maintenance records for the latest period.

Nutrient Credit Estimation and Relative Confidence

A. Summary of Nutrient Load Reduction Credit Method

This section summarizes the nutrient credits awarded towards compliance with Existing Development requirements associated with Nutrient Management Strategies. Credit is assigned for the area of pasture from which cattle are excluded from streams or waterbodies (i.e., the area that had access prior to exclusion). Pastures with animal stocking rates greater than 1.2 au/ac/yr after implementation of this practice are not eligible for this credit.

Nutrient credits are calculated based on the change in nutrient loading to the stream channel after cattle are excluded. An eight year study (Line et al. 2016) found reductions in nutrient loading associated with cattle exclusion paired with nutrient management to be 33 percent for total nitrogen and 47 percent for total phosphorus (Table 1). When post treatment stocking rates are less than 0.6 au/ac/yr, a factor of safety of 10 percent is applied to the percent mass reductions. If the post treatment stocking rates are between 0.6 au/ac/yr and 1.2 au/ac/yr, a 20 percent factor of safety is applied. The lower factor of safety is an incentive to achieve recommended stocking rates. The resulting percent mass reductions are shown in Table 1.

Table 1. Factors of Safety and Assumed Percent Mass Reductions Associated with Cattle Exclusion Based on Post-Exclusion Stocking Rate

Post-Exclusion Stocking Rate (au/ac/yr)	Reported Percent TN Mass Reduction[1]	Reported Percent TP Mass Reduction[1]	Factor of Safety Applied to Percent Reduction (%)	Assumed TN Percent Mass Reduction (%)	Assumed TP Percent Mass Reduction (%)
<0.6	33[1]	47[1]	10	30	42
0.6 to 1.2	33[1]	47[1]	20	26	38

[1]Line et al. 2016

These assumed percent mass reductions are applied to the pre-exclusion nutrient loading rates to calculate the nutrient credits. Table 2 summarizes the pre-exclusion nutrient loading rates associated with varying stocking rates. Table 3 applies the assumed percent mass reductions to calculate the post-exclusion nutrient credits. Multiplying the pre-exclusion nutrient loading rate by the assumed percent mass reduction provides the area-based (i.e., per acre) nutrient credits for nitrogen and phosphorus.

Table 2. Pre-Exclusion Nutrient Loading Rates

Pre Exclusion Stocking Rate (au/ac/yr)	Pre-Exclusion Nitrogen Loading Rate (lb/ac/yr)	Pre-Exclusion Phosphorus Loading Rate (lb/ac/yr)
< 0.6[1]	5.7	2.7
0.6 to 1.2	8.6	4.1
> 1.2	12.9	6.2

[1] The data for <0.6 au/ac/yr are from Line et al. (2016).

Table 3. Nutrient Credits Associated with Cattle Exclusion and Reduction in Animal Stocking Rates

Pre-Exclusion Stocking Rate (au/ac/yr)	Post-Exclusion Stocking Rate (au/ac/yr)	Pre-Exclusion Loading Rate (lb/ac/yr)		Assumed Mass Reduction (%)		Nutrient Credit (lb/ac/yr)[1]	
		N	P	N	P	N	P
< 0.6	< 0.6	5.7	2.7	30	42	1.7	1.1
0.6 to 1.2	< 0.6	8.6	4.1	30	42	2.6	1.7
	0.6-1.2	8.6	4.1	26	38	2.2	1.6
> 1.2	< 0.6	12.9	6.2	30	42	3.9	2.6
	0.6-1.2	12.9	6.2	26	38	3.4	2.4

[1]Multiply the pre-exclusion loading rate by the percent mass reduction to calculate the nutrient credit. For example, 5.7 lb-N/ac/yr times 30% = 1.7 lb-N/ac/yr.

B. Reductions Obtained with Practice

The ranges of reductions in annual nutrient loads associated with cattle exclusion depend on the pre- and post-exclusion stocking rates, where additional credit is provided if a reduction in stocking rates is achieved along with cattle exclusion. As shown in Table 3, nitrogen credits for this practice range from 1.7 lb-N/ac/yr to 3.9 lb-N/ac/yr, and phosphorus credits range from 1.1 lb-P/ac/yr to 2.6 lb-P/ac/yr.

C. Cattle Exclusion Example Calculations

The following is an example of how to calculate the nutrient load reduction credits for cattle exclusion when the stocking rate is decreased. The example 10-ac pasture with access to the stream has a pre-exclusion stocking rate of 1.2 au/ac/yr and a post-exclusion stocking rate of 0.5 au/ac/yr. The following steps are required to calculate the nitrogen and phosphorus credits:

1. Select the row in Table 3 that corresponds to the pre-exclusion stocking rate (1.2 au/ac/yr) and the post-exclusion stocking rate (0.5 au/ac/yr). Record the nitrogen and phosphorus area-based credits (2.6 lb-N/ac/yr and 1.7 lb-P/ac/yr, respectively).
2. Multiply the area-based credits by the acreage of the pasture affected by cattle exclusion (10 acres for this example) to get the total nitrogen and phosphorus credits (26 lb-N/yr and 17 lb-P/yr, respectively).

If, for this example, the stocking rates are not reduced, the credits are calculated as follows:

1. Select the row in Table 3 that corresponds to the pre-exclusion stocking rate and the post-exclusion stocking rate (both are 1.2 au/ac/yr for this example). Record the nitrogen and phosphorus area-based credits (2.2 lb-N/ac/yr and 1.6 lb-P/ac/yr, respectively).
2. Multiply the area-based credits by the acreage of the pasture affected by cattle exclusion (10 acres for this example) to get the total nitrogen and phosphorus credits (22 lb-N/yr and 16 lb-P/yr, respectively).

These values may be used toward compliance with Existing Development Nutrient Management Strategies.

D. Relative Confidence in Reduction Estimates

Overall, relative confidence in the reductions estimated for the practice is low to moderate. To evaluate relative confidence in the measure's estimated reduction, Division staff considered a range of factors outlined in the document "*DWR Approval Process for Alternative Nutrient Load-Reducing Measures.*"

The primary factor is that both pasture loading rates and load reduction efficiency values are based on a single field study (Line et al. 2016). While for several reasons there is high confidence in the values produced by the study - it was conducted in Piedmont North Carolina in the Jordan watershed by faculty at North Carolina State University who served as subject matter expert advisors to the development of this document; it used a paired watershed design; it involved eight years of data collection; it established a strong relationship between control and treatment watersheds; it was largely free from confounding effects; and a manuscript on the study has been published in a peer-reviewed journal - the study nevertheless represents only a single dataset.

A second, related factor is that the study did not involve the higher stocking rates that are allowed and credited under this practice standard. As a result, this credit method used linear extrapolation of loading rates developed in the study, which adds uncertainty to the resulting loading assignments.

To address the uncertainties recognized here, the credit method includes an adjustment factor of 10 percent that increases in magnitude to 20 percent for the higher stocking rate scenario. These factors provide some compensation for these uncertainties.

Three other studies conducted in the piedmont of NC were considered for this practice but were problematic. One study (Line et al. 2002) was not applicable because the pasture was located on recently converted cropland and there was no stream feature on the site. Another study (Line 2015) was not applicable because it had additional treatments such as restoration of riparian buffers that would confound the use of those data for estimating the percent mass reductions associated with this practice. The third study (Line 2000) had site conditions that were closer to feedlots than typical pastures, and recognized another potential confounding effect in the presence of unlined waste lagoons upslope from the monitored stream segment.

Confidence in sustained load reductions is reasonably high given that the design criteria for cattle exclusion is based on existing technical guidance published by the NC NRCS and the NC Agriculture Cost Share Program (ACSP). The methods associated with cattle exclusion are straight-forward and are aimed at maintaining post-exclusion conditions over the long term. Maintaining exclusion fencing and controlled access areas and implementing nutrient management are required to ensure the long-term water quality benefits associated with this practice.

Co-Benefits

In the case of cattle exclusion, additional benefits may include reducing other pollutants including total suspended solids (TSS) and pathogens. This practice may also result in stabilization of streambanks once cattle are removed and vegetation establishes.

Other Technical Information

This supporting technical information is provided for the cattle exclusion nutrient crediting document. Development of the nutrient credit document for this practice included input from representatives from the following organizations. Input by these individuals does not necessarily indicate agreement with all aspects of the final document:

- North Carolina Department of Environmental Quality Division of Water Resources: Rich Gannon, MEM, CPM; John Huisman; Trish D'Arconte; and Amin Davis, PWD
- North Carolina State University, College of Agriculture and Life Sciences, Department of Crop and Soil Sciences, Deanna Osmond, PhD
- North Carolina State University, College of Agriculture and Life Sciences, Department of Biological and Agricultural Engineering, Dan Line
- North Carolina Farm Bureau Federation, Anne Coan and Keith Larick
- Several members of the Falls Lake Watershed Oversight Committee
- Upper Neuse River Basin Association: Forrest Westall, PE
- Cardno: Alix Matos, PE
- The Center for Watershed Protection, Inc: Neely Law, Ph D

The representatives met several times to review the literature and evaluate approaches to develop a crediting method. Three studies conducted in the Piedmont of NC were evaluated for developing the crediting method for this practice.

The percent mass reductions in nitrogen and phosphorus loading associated with cattle exclusion with nutrient management are based on field studies conducted by Osmond and Line (2014), with updated data in Line et al. (2016). Because pastures with stocking rates greater than 3.0 au/ha (1.2 au/ac) are overgrazed, this crediting method limits eligibility to pastures with a post-exclusion stocking rate of not more than 3 au/ha (1.2 au/ac). To provide incentive for reductions in stocking rates post-exclusion, higher factors of safety are assumed for the percent mass reductions as summarized in Table 1.

The other NC studies either did not monitor the effects of treatment or had additional treatments such as restoration of riparian buffers that would confound the use of those data for estimating the credit associated with cattle exclusion. Table 4 summarizes the nutrient loading data from applicable control sites and 'before treatment' sites to develop loading estimates from pastures without cattle exclusion (i.e., the pre-exclusion loading rates provided in Table 2).

The major findings from these local and other national studies indicate the following:

- Based on the available scientific data, percent load reduction appears to be the preferred crediting method for nitrogen and phosphorus credits.
- Pasture slope and animal stocking rate likely affect the benefit of this practice. In the literature reviewed, sites with higher stocking rates (2 au/ha to 5 au/ha

(0.8 au/ac to 2.0 au/ac)) had higher pre-treatment nutrient loading rates compared to sites with lower stocking rates (less than 1.5 au/ha (0.6 au/ac)) (Line et al. 2000, Line et al. 2002, Line 2015, Line et al. 2016). However, the studies with higher stocking rates also had confounding issues that were discussed earlier, and were not used in establishing the credits for this practice. This crediting method does not offer credits for sites with post-exclusion stocking rates above 3 au/ha (1.2 au/ac).

- A number of other studies were excluded due to either their geographic location (the Meals 2001 and 2002 papers were conducted in Vermont on glacial till soils that are very different than Piedmont soils) or due to the study focus being on something other than nutrient reduction (i.e., Carline and Walsh 2007 who focused on suspended sediment reduction). Additionally, many studies have cattle exclusion coupled with riparian restoration or stream stabilization, which makes it difficult to isolate study observed benefits (Line et al. 2000, Line 2003, Meals 2001, Carline and Walsh 2007).

The study conducted by Line et al. (2016) found reductions in annual nutrient loading associated with cattle exclusion to be 33 percent for total nitrogen and 47 percent for total phosphorus. To address the uncertainty with varying ranges in stocking rates and the effects of cattle exclusion on post-exclusion nutrient loading rates, safety factors of 10 percent and 20 percent were applied to the percent mass reductions with lower factors of safety assigned to incentivize lower post-exclusion stocking rates (Table 3).

This approach results in assumed TN percent reductions ranging from 26 percent to 30 percent. For comparison, this range of assumed TN percent mass reduction is similar to that assumed under the Falls Lake Agriculture Rule pasture accounting methodology. That methodology assumes a 30 percent reduction based solely on the reduction of direct deposition of animal waste to the stream but does not quantify the additional benefits of cattle exclusion including reduced bank trampling and improved buffer zones or the effects of nutrient management which is also required under this crediting method. This system offers a point of reference for the establishment of this credit and is based on currently available research.

Table 4. Nutrient Loading Rates Reported in the Literature from Control Sites and Before Treatment Sites Used in Setting the Credits

Source	Site	Stocking Rate au/ac/yr	TN kg/ha/yr	TN lb/ac/yr	TP kg/ha/yr	TP lb/ac/yr
Line et al. 2016	Control-pre	0.5	4.65	4.14	2.20	1.96
Line et al. 2016	Treat-pre	0.5	7.09	6.31	3.67	3.27
Line et al. 2016	Control-post	0.5	7.33	6.53	3.23	2.87
Representative (average) loading rates for pastures with less than 0.6 au/ac/yr			*6.2*	*5.7*	*3.0*	*2.7*

References

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