NUTRIENT MANAGEMENT PLAN IDENTIFICATION

Operator
Kim Hatfield
117 Dealba Ln
Seaford, VA 23696
757-869-0350

Integrator:*None*

Farm Coordinates
Easting: 0, Northing: 0, zone: 17

Watershed Summary
watershed: CB21
county: York

Nutrient Management Planner
David Dutton
1764 S. Military Hwy
Chesapeake VA, 23320

Certification Code: 763

Acreage Use Summary
Total Acreage in this plan: 4.5

Cropland:	0.
Hayland:	0.
Pasture:	4.5
Specialty:	0.

Livestock Summary

Beef Cattle	0
Dairy Cattle	0
Poultry	0
Swine	0
Other	6

Manure Production Balance

	Imported	Produced	Exported	Used	Net
kgals	0.	0.	0.	0.	0.
tons	0.	0.	0.	0.	0.

Plan written 6/22/2015
Valid until 7/22/2018

Signature: _____ (Planner) 7/28/15 (date)

Riverfront Riding Center Narrative

This plan was developed for **Riverfront Riding Center** which is a facility that keeps approximately six horses on site for the purpose of riding giving lessons. There are three pastures and a riding ring on the property at this time totaling approximately 4.5 acres. The pastures contain Bermudagrass, Fescue and Orchardgrass and are contained/separated by a combination of board fence, T-posts/electric fencing. None of the soil types present is environmentally sensitive. However, care should be taken to fence animals out of any areas prone to errosion, wash outs, gully etc.

Manure Storage/Managment

An 1100# horse can produce as much as 57# of waste per day. Manure should be stored a minimum of 25' from ditches and minimum of 100' away from surface water. No manure is currently being spread on any of the pastures. All of the pastures and the riding ring are mucked on a monthly basis. The stock piled manure is hauled off every four to six weeks by a landscaping company. A silt fence barrier is maintained around the outside of the manure storage area.The manure I observed on the property at the time of my visit was stored on top of a tarp as a further containment measure. A tarp or another means to keep rain water off the manure should be used. More detailed information on manure management can be found in the VA Coop Ext Pub.406-208 included in this plan.

Pasture Management

The last application of seed and fertilizer was applied in March of 2014. The primary summer grasses will be berudagrass and fescue. We discussed overseeding in the fall with a mix of cool season grasses such as fescue, orchardgrass and ryegrass. The profiles and management practices for each as well as bermudagrass are included in this plan from the VA Tech Agronomy Handbook. A copy of the Forage Crops Guide is also included. For cool season grasses in Tidewater it is recommended that seeding occur between September 1st and October 15th. 1.3 tons of lime is recommended to adjust the soil pH. Lime may be applied ASAP or at seeding time at a rate of no more than 60#/1000sqft per application. Applications should be made four months apart and total the 1.3 tons called for on the soil sample. A product called Solu-Lime could also be used at rate of 12#/1000sqft. It is recommended to split up field/paddocks so that they can be rotionally grazed to maximize the health and productivity of the pastures. Specific information can be found in the Publications 418-101,104, 103 found in this plan.

Farm Summary Report

Plan: **Riverfront Riding Center** **Summer, 2015 - Winter, 2019**

Farm Name: **Riverfront Riding Center**
Location: York
Specialist: David Dutton
N-based Acres: 5.0
P-based Acres: 0.0

Tract Name: **Riding Center**
FSA Number: 0
Location: York

Tract Narrative:

Field Name: **Back Paddock**
Total Acres: 0.60 Usable Acres: 0.60
FSA Number: 0
Tract: iding Center
Location: York
Slope Class: A Hydrologic Group: C

Riparian buffer width: 0 ft
Distance to stream: 0 ft

Conservation Practices:
Pasture (50%-75% cover)

P-Index Summary
N-based
Phosphorus Limit method: Phosphorus Environmental Threshold (PET) method
Field Narrative:
Over-seeding the bermudagrass in the fall is recommended with ryegrass, fescue and/or orchardgrass. One species or a combination of the three will give fall, winter and early spring forage and ground cover. 30 units of N

should be applied at the time of seeding.

Soil Test Results:

DATE	PH	P	K	Lab
Su-2015	5.6	H(94 P ppm)	M(83 K ppm)	A&L MIII

MOST RECENT LIME: Summer-2015 1.5 tons/acre

Soils:

PERCENT	SYMBOL	SOIL SERIES
100	1	Altavista

Field Warnings:

Crop Rotation:

PLANTED	YIELD	CROP NAME
2015-Su	1.0 acres/AU	Bermudagrass pasture, maint. - No Till
2016-Sp	1.0 acres/AU	Bermudagrass pasture, maint. - No Till
2017-Sp	1.0 acres/AU	Bermudagrass pasture, maint. - No Till
2018-Sp	1.0 acres/AU	Bermudagrass pasture, maint. - No Till

Field Name: Main Field
Total Acres: 3.00 Usable Acres: 3.00
FSA Number: 0
Tract: iding Center
Location: York
Slope Class: A Hydrologic Group: C

Riparian buffer width: 0 ft
Distance to stream: 0 ft

Conservation Practices:
Pasture (50%-75% cover)

P-Index Summary
N-based
Phosphorus Limit method: Phosphorus Environmental Threshold (PET) method
Field Narrative:

The same overseeding is recommended as in the back paddock.

Soil Test Results:

DATE	PH	P	K	Lab
Su-2015	5.6	H(94 P ppm)	M(83 K ppm)	A&L MIII

MOST RECENT LIME: Summer-2015 1.5 tons/acre

Soils:

PERCENT	SYMBOL	SOIL SERIES
50	13	Dragston
50	33	Tomotley

Field Warnings:

Crop Rotation:

PLANTED	YIELD	CROP NAME
2015-Su	5.7 acres/AU	Bermudagrass pasture, maint. - No Till
2016-Sp	5.7 acres/AU	Bermudagrass pasture, maint. - No Till
2017-Sp	5.7 acres/AU	Bermudagrass pasture, maint. - No Till
2018-Sp	5.7 acres/AU	Bermudagrass pasture, maint. - No Till

Field Name: **Rented Field**
Total Acres: 0.87 Usable Acres: 0.87
FSA Number: 0
Tract: iding Center
Location: York
Slope Class: A Hydrologic Group: C

Riparian buffer width: 0 ft
Distance to stream: 0 ft

Conservation Practices:
Pasture (50%-75% cover)

P-Index Summary
N-based

Phosphorus Limit method: Phosphorus Environmental Threshold (PET) method

Field Narrative:

The same overseeding is recommended as in the back paddock.

Soil Test Results:

DATE	PH	P	K	Lab
Su-2015	5.6	H(94 P ppm)	M(83 K ppm)	A&L Mill

MOST RECENT LIME: Summer-2015 1.5 tons/acre

Soils:

PERCENT	SYMBOL	SOIL SERIES
25	2	Augusta
75	33	Tomotley

Field Warnings:

Crop Rotation:

PLANTED	YIELD	CROP NAME
2015-Su	10.0 acres/AU	Bermudagrass pasture, maint. - No Till
2016-Sp	10.0 acres/AU	Bermudagrass pasture, maint. - No Till
2017-Sp	10.0 acres/AU	Bermudagrass pasture, maint. - No Till
2018-Sp	10.0 acres/AU	Bermudagrass pasture, maint. - No Till

Field Name: Riding Ring/Dry Lot

Total Acres: 0.50 Usable Acres: 0.50
FSA Number: 0
Tract: iding Center
Location: York
Slope Class: A Hydrologic Group: C

Riparian buffer width: 0 ft
Distance to stream: 0 ft

P-Index Summary

N-based

Phosphorus Limit method: Phosphorus Environmental Threshold (PET) method

Soil Test Results:

DATE	PH	P	K	Lab
[NO TEST]				

Soils:

PERCENT	SYMBOL	SOIL SERIES
100	13	Dragston

Field Warnings:

Crop Rotation:

PLANTED	YIELD	CROP NAME

Field Productivities for Major Crops

Tract Name	Tract/ Field	Field Name	Acres	Predominant Soil Series	Corn	Small Grain	Alfalfa	Grass Hay	Environmental Warnings
Riding Cente	0/0	Back Paddock	1	Altavista	Ia	I	II	I	
	0/0	Main Field	3	Dragston	IVa	III	Not Suited	IV	
	0/0	Rented Field	1	Tomotley	IVb	V	Not Suited	Not Suited	
	0/0	Riding Ring/	1	Dragston	IIa	I	Not Suited	II	

Yield Range

Field Productivity Group	Corn Grain Bu/Acre	Barley/Intensive Wheat Bu/Acre	Std. Wheat Bu/Acre	Alfalfa Tons/Acre	Grass/Hay Tons/Acre
I	>170	>80	>64	>6	>4.0
II	150-170	70-80	56-64	4-6	3.5-4.0
III	130-150	60-70	48-56	<4	3.0-3.5
IV	100-130	50-60	40-48	NA	<3.0
V	<100	<50	<40	NA	NA

Soil Test Summary

Tract	Field	Acre	Date	P2O5	K2O	Lab	Soil pH	Lime Date	rec. lime tons/Ac
Riding Center	Back Paddock	1	2015-Su	H (94 P ppm)	M (83 K ppm)	A&L Mill	5.6	2015Su	1.5
Riding Center	Main Field	3	2015-Su	H (94 P ppm)	M (83 K ppm)	A&L Mill	5.6	2015Su	1.5
Riding Center	Rented Field	1	2015-Su	H (94 P ppm)	M (83 K ppm)	A&L Mill	5.6	2015Su	1.5
Riding Center	Riding Ring/Dry Lot	1	[No Test]						

Application Summary Report

2015: Bermudagrass pasture, maint.

Tract	Field	Acres	Manure Rate and Type (Season)	Broadcast Commercial	Banded Commercial	Topdress Commercial	Lime (tons)
Riding Center	Back Paddock	.6		30-0-0(Fa)			1.5 (Su)
	Main Field	3.0		30-0-0(Fa)			1.5 (Su)
	Rented Field	.9		30-0-65(Fa)			1.5 (Su)

2016: Bermudagrass pasture, maint.

Tract	Field	Acres	Manure Rate and Type (Season)	Broadcast Commercial	Banded Commercial	Topdress Commercial	Lime (tons)
Riding Center	Back Paddock	.6		60-0-70(Sp) 60-0-70(Su) 60-0-0(Fa)			
	Main Field	3.0		50-0-40(Sp) 50-0-45(Su) 50-0-45(Fa)			
	Rented Field	.9		0-0-65(Sp) 30-0-0(Fa)			

2017: Bermudagrass pasture, maint.

Tract	Field	Acres	Manure Rate and Type (Season)	Broadcast Commercial	Banded Commercial	Topdress Commercial	Lime (tons)
Riding Center	Back Paddock	.6		60-0-55(Sp) 60-0-0(Su) 60-0-0(Fa)			
	Main Field	3.0		50-0-65(Sp) 50-0-0(Su) 50-0-0(Fa)			
	Rented Field	.9		0-0-65(Sp) 30-0-0(Fa)			

2018: Bermudagrass pasture, maint.

Tract	Field	Acres	Manure Rate and Type (Season)	Broadcast Commercial	Banded Commercial	Topdress Commercial	Lime (tons)
Riding Center	Back Paddock	.6		60-0-10(Sp) 60-0-0(Su) 60-0-0(Fa)			
	Main Field	3.0		50-0-65(Sp) 50-0-0(Su) 50-0-0(Fa)			
	Rented Field	.9		0-0-65(Sp)			

Nutrient Management Plan Balance Sheet
(Summer, 2015-Winter, 2019)
Riverfront Riding Center
Planner: David Dutton (cert. No. 763)

Tract: Riding Center **Location: York**
(N = N based, 1P = P based, 1.5P = P based at 1.5 removal, 0P = No P allowed)

Field CFSA No. /Name	Size (ac) Total/ Used	Yr.	Crop	Needs N-P-K (lbs/ac)	Leg /Man Resid	Manure/BioSld Rate & Type (season)	IT (d)	Man/Bios N-P-K (lbs/ac)	Net = Needs - appld N-P-K (lbs/ac)	Sum P rem cred	Commercial N-P-K (lbs/ac)	Notes
0/Back Paddock(N)	1/1	2015	Bermudagrass pasture	200-0-65	0/0				200-0-65	N/A	30-0-0(br)	
		2016	... ...	200-0-65	0/0				200-0-130	N/A	60-0-70(br) 60-0-70(br) 60-0-0(br)	1
		2017	... ...	200-0-65	0/0				200-0-55	N/A	60-0-55(br) 60-0-0(br) 60-0-0(br)	
		2018	... ...	200-0-65	0/0				200-0-65	N/A	60-0-10(br) 60-0-0(br) 60-0-0(br)	
0/Main Field(N)	3/3	2015	Bermudagrass pasture	150-0-65	0/0				150-0-65	N/A	30-0-0(br)	
		2016	... ...	150-0-65	0/0				150-0-130	N/A	50-0-40(br) 50-0-45(br) 50-0-45(br)	2
		2017	... ...	150-0-65	0/0				150-0-65	N/A	50-0-65(br) 50-0-0(br) 50-0-0(br)	
		2018	... ...	150-0-65	0/0				150-0-65	N/A	50-0-65(br) 50-0-0(br) 50-0-0(br)	
0/Rented Field(N)	1/1	2015	Bermudagrass pasture	0-0-65	0/0				0-0-65	N/A	30-0-65(br)	
		2016	... ...	0-0-65	0/0				0-0-65	N/A	0-0-65(br) 30-0-0(br)	3
		2017	... ...	0-0-65	0/0				0-0-65	N/A	0-0-65(br) 30-0-0(br)	
		2018	... ...	0-0-65	0/0				0-0-65	N/A	0-0-65(br)	

Commercial Application Methods:
br - Broadcast ba - Banded sd - Sidedress

Notes:
1 Split Total N recommendation into three applications - April, June, and July
2 Split total N recommendation into three applcations-May, June and Augusts.

3 A spring topdress of 30-50 units of N/arce can be applied.

Report Number: 15-176-0516
Account Number: 71323

SOUTHERN STATES
Farmer owned since 1923.

Send To: SOUTHERN STATES ASS'N IN
Cliff Carr
1764 S MILITARY HWY
CHESAPEAKE VA 23320

Grower:
KIM HATFIELD
117 DEALBA LANE
SEAFORD VA 23696
869-0350

Farm ID:

SOIL ANALYSIS REPORT

Analytical Method(s):
Mehlich 3

"Every acre...Every year.™"

Date Received: 06/25/2015 **Date Of Analysis:** 06/26/2015 **Date Of Report:** 06/26/2015

Sample ID / Field ID	Lab Number	Organic Matter			Phosphorus			Potassium		Magnesium		Calcium		Sodium		pH		Acidity	C.E.C
		%	Rate	ENR lbs/A	Mehlich 3 ppm	Rate	Reserve ppm	Rate	K ppm	Rate	Mg ppm	Rate	Ca ppm	Rate	Na ppm	Rate	Soil pH	Buffer Index	H meq/100g	meq/100g
PASTURE	19648	5.5	H	146	94	H			83	L	134	M	1266	M			5.6	6.70	2.3	10.0

Sample ID / Field ID	Percent Base Saturation					Nitrate		Sulfur		Zinc		Manganese		Iron		Copper		Boron		Soluble Salts		Chloride		Aluminum
	K %	Mg %	Ca %	Na %	H %	NO_3N ppm	Rate	S ppm	Rate	Zn ppm	Rate	Mn ppm	Rate	Fe ppm	Rate	Cu ppm	Rate	B ppm	Rate	SS ms/cm	Rate	Cl ppm	Rate	Al ppm
PASTURE	2.1	11.2	63.3		23.3																			

Values on this report represent the plant available nutrients in the soil. Rating after each value: VL (Very Low), L (Low), M (Medium), H (High), VH (Very High). ENR - Estimated Nitrogen Release. C.E.C. - Cation Exchange Capacity.

Explanation of symbols: % (percent), ppm (parts per million), lbs/A (pounds per acre), ms/cm (milli-mhos per centimeter), meq/100g (milli-equivalent per 100 grams). Conversions: ppm x 2 = lbs/A, Soluble Salts ms/cm x 640 = ppm.

This report applies to sample(s) tested. Samples are retained a maximum of thirty days after testing.

Analysis prepared by: A&L Eastern Laboratories, Inc.

by: Pauric McGroary

Pauric McGroary

USDA Natural Resources Conservation Service

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Area of Interest (AOI) | Soil Map | Soil Data Explorer | Download Soils Data | Shopping Cart (Free)

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Map Unit Legend

James City and York Counties and the City of Williamsburg, Virginia (VA695)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Altavista fine sandy loam	0.7	12.2%
2	Augusta fine sandy loam	0.2	3.2%
3	Axis very fine sandy loam	0.1	1.6%
13	Dragston fine sandy loam	1.6	28.5%
33	Tomotley fine sandy loam	3.0	54.4%
W	Water	0.0	0.2%
Totals for Area of Interest		5.5	100.0%

Soil Map

Scale (not to scale)

Warning: Soil Map may not be valid at this scale.

You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mappi
The soil surveys that comprise your AOI were mapped at 1:15,800. The design of map units and the le
map are dependent on that map scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mappi
The maps do not show the small areas of contrasting soils that could have been shown at a more detai

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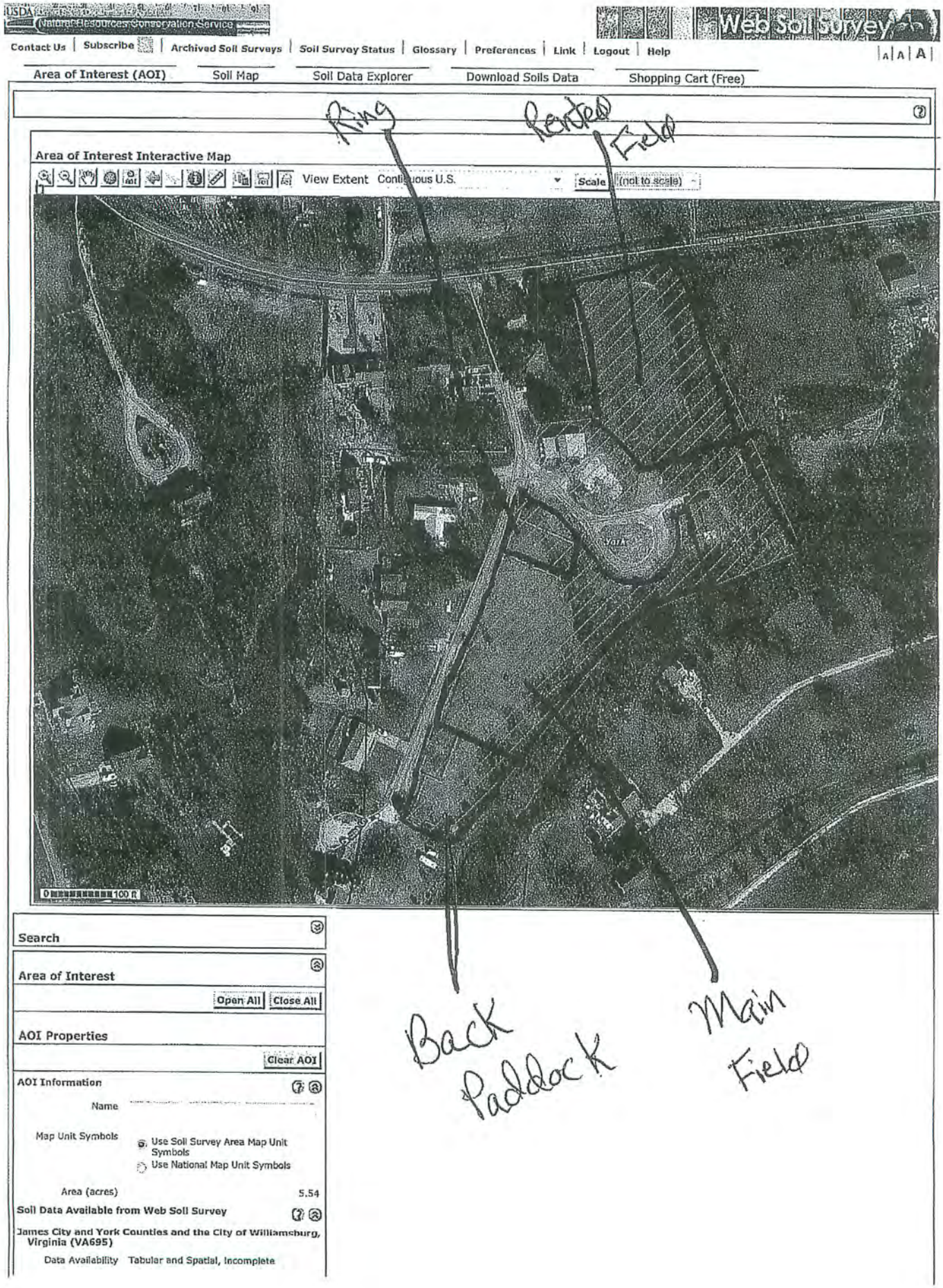
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Search
Area of Interest
Open All
Close All
AOI Properties
Clear AOI
AOI Information
Name
Map Unit Symbols
Use Soil Survey Area Map Unit Symbols
Use National Map Unit Symbols
Area (acres)
5.54
Soil Data Available from Web Soil Survey
James City and York Counties and the City of Williamsburg, Virginia (VA695)
Data Availability
Tabular and Spatial, Incomplete
Back Paddock
Main Field

Virginia Cooperative Extension

PUBLICATION 406-208

Horse Manure Management

Crystal Smith, Extension Agent, Warren County
Carrie Swanson, Extension Agent, Albemarle County

Introduction

Manure management is a vital part of modern day horse ownership. Many horses spend a significant portion of their day in stalls, accumulating large amounts of manure and stall waste. Horse owners generally have a limited amount of time to spend caring for their equine charges; thus, efficient manure removal and disposal is crucial. Additionally, horse facilities are often managed on relatively small acreage, limiting manure storage and application options.

The intent of this publication is to educate horse owners on the effective management of horse manure. Horse owners will first gain a thorough understanding of the quantity and characteristics of manure produced by horses. Finally, on-site options for handling, storing and treating manure will be discussed, keeping sound facility management and environmental stewardship in mind.

Managing horse manure can be a complex topic, and the principles presented here should be tailored to your specific situation. Please contact your local Extension agent or Natural Resources Conservation Service Field Office for technical support.

Horse Manure Production and Characteristics

Horses produce large amounts of manure. In fact, if the manure produced from one horse were allowed to pile up in a 12-foot-by-12-foot box stall for one year, it would accumulate to a height of six feet! On any given day, the average 1,000-pound horse will produce approximately 50 pounds of manure. This amounts to about eight and a half tons per year!

Manure is not the only material being removed when stalls are cleaned. Wet and soiled bedding material must also be removed, and can equal almost twice the volume of the manure itself. The amount of bedding material removed will vary by type (shavings, sawdust, straw), but on average totals between eight and 15 pounds. Total stall waste produced averages between 60 and 70 pounds per day, which amounts to approximately 12 tons of stall waste per year!

When managed properly, horse manure can be a valuable resource. Manure is a source of nutrients for pasture production and can be utilized as part of a pasture management strategy to improve soil quality. The fertilizer value of the eight and a half tons of manure produced annually from a 1000-pound horse can amount to 102 pounds of nitrogen (N), 43 pounds of phosphorous (P_2O_5), and 77 pounds of potash (K_2O). Nutrient values for manure vary widely. The type and quantity of bedding material included also affects the overall fertilizer value. If a more accurate measure of nutrient content is needed, contact your local Cooperative Extension office for a list of laboratories that perform manure analysis.

Environmental and Health Impacts

Many horse owners do not have enough land or vegetative cover to properly apply large amounts of manure and nutrients. If not managed properly, manure can deposit excess nutrients into the environment via surface runoff or as leachate (water contaminated with manure) from improper manure storage and land application. This can negatively impact water quality and subject landowners to investigation, and in some cases, legal action under the Virginia Agricultural Stewardship Act. For these reasons, horse operations are encouraged to use best management practices and develop a nutrient man-

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VIRGINIA STATE UNIVERSITY

agement plan. Nutrient management plans describe the farm's manure production, soil fertility, and recommended manure application and removal rates. For more information on designing a plan specific to your farms needs or identifying other conservation resources contact your local Cooperative Extension office.

Internal parasites, insects, rodents, and odors can be manure related health concerns on horse farms. These issues can be minimized through carefully planned manure storage and handling. Internal parasites may be found in horse manure and can compromise the health and welfare of the horses stabled or grazing the land. Composting manure and properly timed land application can limit the risk of parasite exposure. Insects, especially flies, become a nuisance on farms where stockpiled manure serves as the fly larvae habitat. Flies breed when spring temperatures rise above 65°F. Flies deposit their eggs in the top few inches of moist manure and these eggs can hatch in as little as seven days under optimal temperature and moisture conditions. Therefore, fewer flies will develop if you remove manure from the site or make it undesirable for fly breeding (through processes such as composting) within a maximum seven-day cycle. Naturally occurring fly predators can also be used to limit the fly population at the manure pile, but are no replacement for sound management practices. Rodents can be a problem when manure is stockpiled for extended periods of time; providing a warm, safe environment. Additionally, nuisance odor from manure piles can result in strained relationships with neighbors. Composting or timely removal of manure piles will help keep odors to a minimum. Finally, keep in mind that large piles of manure are not aesthetically pleasing to your neighbors or those visiting your farm. Keeping the manure storage site screened with vegetation, fencing, or by location will help to enhance the beauty of your farm.

Horse Manure Storage and Utilization

The average horse produces between 60 and 70 pounds of stall waste per day. Multiply this by several horses, and it is easy to see the importance of having methods in place to manage the manure produced on a daily basis. Letting manure pile up in stalls and paddock areas leads to a host of problems. It is not only unhealthy for your horse, inviting for pests and odors, and aesthetically unpleasing, but the sheer amount of manure produced will overwhelm you! Many handling and storage options exist, but it's up to you to choose the method that best suits your horse operation.

Horse operations with available land may choose to apply stall waste to pastures as fertilizer. This should be done based on soil-test results and nutrient needs. A soil analysis is needed to determine the fertility needs of a pasture. Soil analysis is provided through the Virginia Tech Soil Testing Laboratory for agricultural operations (which includes horse farms) free of charge. Contact your local Cooperative Extension office for instructions on how to take a soil sample. There are also private laboratories that offer soil-testing services.

In many situations, manure can be picked directly from the stall, deposited into a manure spreader, applied to the pasture, and harrowed into the soil. Barns not constructed with a management scheme allowing for stall access by a manure spreader, require manure to be carted from the stall to the manure spreader some distance away. In this case, ramps or dropped spreader parking can be helpful to avoid lifting the heavy, cumbersome stall waste. Keep in mind that when spreading manure from stalls bedded with sawdust or shavings, the applied stall waste can stunt plant growth. Wood products contain carbon that soil microbes use for energy, but not enough nitrogen to build proteins. The microbes draw nitrogen from the soil to make up for this deficit to such a degree that they can actually limit plant growth. To manage this nitrogen deficiency, nitrogen fertilizer can be applied. Or, to avoid the problem completely, manure can be composted before it is applied to the land.

When direct pasture application is not an option, manure storage facilities become a necessity. The storage facility should be convenient to the barn. A general rule of thumb is to plan for 180 days of long-term manure storage. This allows operations the flexibility to store manure when conditions are not ideal for manure application (frozen or wet fields). This storage area should be accessible to the equipment that will ultimately remove the accumulated stall waste. Manure storage facilities should also be downwind and screened from nearby homes to avoid potential complaints about odors and aesthetics. The size, type, and location of manure storage facilities will vary by horse operation based on the amount of manure produced, length of time the manure will be stored, and available land area. Always be sure to contact your local authorities regarding zoning regulations and additional restrictions.

Minimum separation distances commonly recommended for composting and manure-handling activities. Source: On-Farm Composting Handbook, NRAES-54

Sensitive area	Minimum separation distance (feet)
Property line	50-100
Residence or place of business	200-500
Private well or other potable water source	100-200
Wetlands or surface water (streams, ponds, lakes)	100-200
Subsurface drainage pipe or drainage ditch discharging to a natural water course	25
Water table (seasonal high)	2-5
Bedrock	2-5

Manure Storage Construction

Manure storage should be designed to limit the chance of leachate entering surface- and groundwater resources. Ideally, storage piles should be placed on gravel, hardened clay, or concrete pads that slope inward. The construction of manure storage sites will vary based on individual situations and soil types. For instance, concrete pads may be necessary in areas with sandy soils where contaminants are more likely to reach groundwater. Storage piles should not be placed in low-lying or flood-prone areas, and care should be taken to direct water from higher elevations away from the site. The Natural Resources Conservation Service or local Soil and Water Conservation District offices can provide individualized manure storage design specifications.

Composting

Composting horse manure is relatively simple, but does involve more than simply piling the waste. While many farms stockpile their manure, few truly compost. Composting is essentially managed decomposition. Managing the process can virtually eliminate odor, flies, weed seeds, and internal parasites found in horse manure and create a valuable soil amendment for resale or for pasture application. To manage a compost pile, the following factors must be taken into consideration: carbon to nitrogen ratio, oxygen, moisture, and temperature.

The microorganisms found in compost are most active when their diet contains about 30 times more carbon than nitrogen (or a C:N ratio of 30:1). Horse manure's C:N ratio is typically 40:1 due to the large amounts of bedding mixed with it, but generally doesn't require additional nitrogen provided it has enough moisture and oxygen.

Composting is an aerobic (requires oxygen) process. If a compost pile doesn't get enough oxygen, these anaerobic conditions can result in unpleasant odors (such as those normally associated with stockpiling manure) and slowed decomposition. There are several ways to provide oxygen to a compost pile. The most common way is to turn the pile. For large piles or windrows, turning is generally done using the bucket of a tractor or front-end loader. For smaller piles, a pitchfork will certainly get the job done, but these operations may want to consider using an aerated static pile design which doesn't require turning.

Benefits of Composting

- Creates valuable soil amendment
- Stabilizes nitrogen into a slow-release form
- Avoids the problem of nitrogen immobilization
- Reduces manure volume by 50 percent
- Destroys weed seeds, fly larvae, and internal parasites
- Eliminates or reduces the cost of off-site disposal

Typical horse-stall waste tends to be dry and will need added moisture to create the ideal conditions for compost microbes. The moisture content should be about 50 percent, or roughly the consistency of a wrung-out sponge. If rainfall does not provide enough additional moisture, the pile may need to be watered periodically. On the other hand, too much water can also be detrimental, displacing oxygen inside the pile and causing anaerobic conditions. If environmental conditions (rain or snow) are providing too much water, the pile may need to be covered. Some compost-storage designs call for permanent roofs, but properly anchored plastic tarps can be just as effective.

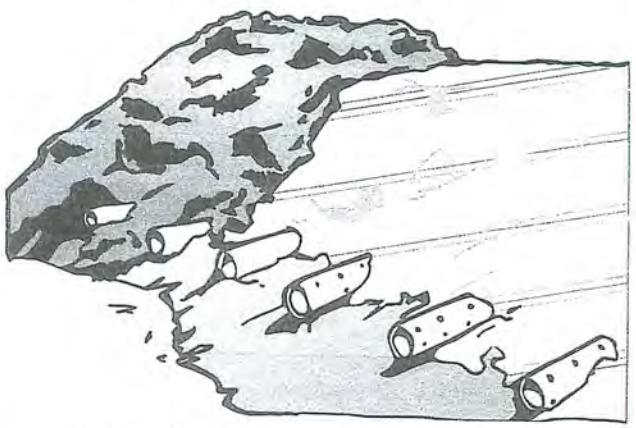
Compost Trouble-Shooting*

Problem	Possible Cause	Remedy
Fresh manure, but pile won't heat up	The pile is: 1. Too dry 2. Too wet; and/or 3. Outside temp is too cold	1. Add water evenly to pile 2. Aerate and cover 3. Wait for warmer temps and turn as needed
Pile was hot, but now temps are falling	1. Pile is settling 2. Moisture is less than 50%	1. Turn pile; and/or 2. Add water evenly to pile
Pile is more than 160°F and has gray ash-like mold	Pile is too dry	Add water evenly to pile
Pile has gone through two or more heat cycles, but still has some material that has not decomposed	Wood shavings decompose slowly.	Ensure that pile has proper moisture content; add water if needed.
Pile emits bad odor	Pile is too wet and has become anaerobic inside	Turn to aerate and increase water evaporation, apply cover to limit additional rainwater.

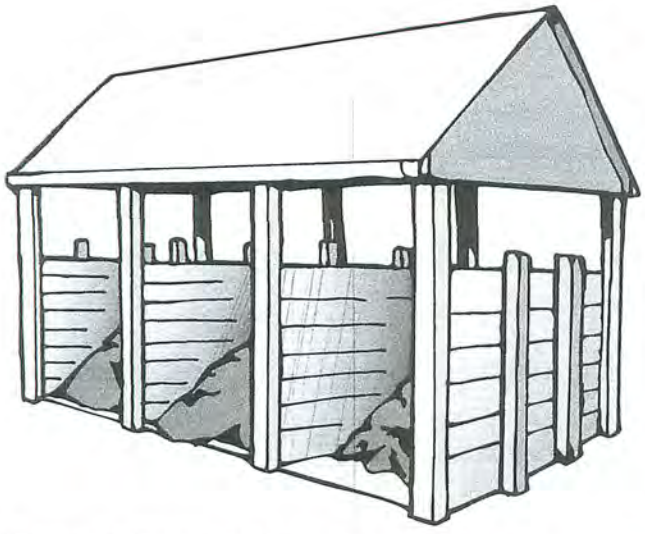
* Table does not include all scenarios; see Conclusions for more in-depth publications on the subject.

One of the best ways to monitor your compost pile is by using a thermometer. Compost thermometers should have a probe at least 36 inches long and are available through many garden supply stores. The goal is to have sustained temperatures of 130° to 150°F in the pile interior. This will optimize decomposition and also kill pathogens and weed seeds.

Compost-pile design and storage facilities will depend on the size of the operation and the equipment available. For a farm with two to six horses, small static piles, which use perforated PVC pipes to draw in air and don't require turning, may be ideal. While not necessary, the use of multiple bins can allow separation of distinct "batches." In this situation, horse manure should be piled approximately five to eight feet high with a base that is two times the width and length of the height. For example, a 10-foot-by-10-foot bin could accommodate a pile that is five feet high. PVC pipes should be placed after the pile is about one foot high and so that the ends remain visible as more manure is added.



Aerated static pile with perforated PVC pipes.



Example of bins suitable for small farms – doors and roof are optional.

For larger farms with access to bucket loaders, manure spreaders, and/or specialized composting equipment, larger piles or windrows may be the most efficient design options. These piles may be slightly larger in height and width and considerably longer, but will require periodic turning.

Compost will decompose more efficiently if the mix is uniform. Starting with a uniform mix is even more important in the case of static piles, since they will not be turned during the decomposition process. Some farms utilize a temporary storage and mixing area to aid in this process.

Example of mixing/storage area with buck wall.

Conclusion

With careful planning, proper manure management not only protects the environment and increases the efficiency and aesthetics of your farm, but might also save you money while enhancing your pastures. The following resources provide more information on composting and additional facility design specifications:

Field Guide to On-Farm Composting and the On-Farm Composting Handbook, available from the Natural Resource, Agriculture, and Engineering Service (NRAES) at *www.NRAES.org*.

Horse Facilities Handbook, available from the MidWest Plan Service at *www.mwpshq.org*.

The Virginia Tech Agronomy Handbook contains information on soil production, soil sampling, nutrient management, utilization of organic waste and more; available at *www.ext.vt.edu/pubs/agronomy/index.html*.

Acknowledgments

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Barley– Annual – (*Hordeum vulgare*) *(cont.)*

Method of Planting:	Planting with a grain drill is best; but broadcast disk-in to a depth of 1-1 1/2 inches can be successful.
Harvesting:	Combine grain when fully ripe and 12-14% moisture. Cut for silage in the soft dough stage or boot stage depending on forage requirements.
Approximate Harvest Dates:	Grain: June 1-June 20; Silage: May 1-June 1
Approximate Yields:	80–120 bushels grain or 6-12 tons 35% dry matter silage/acre

Bentgrass – Creeping – Perennial (*Agrostis paulustris*)

Description:	A stoloniferous grass used for golf greens; high maintenance is required; some varieties can be seeded while others must be vegetatively planted.
Seeds per lb:	7,800,000
Rate of Seeding:	Seeds 1/2 to 1 lb
Germination time:	10-14 days
pH Range:	6–6.5
Stolonized Bents:	2-7 bushels of stolons per 1,000 sq ft
Time of Planting:	Early spring or late summer

Bermudagrass – Perennial – (*Cynodon dactylon*)

Description:	Spreads by soil surface runners (stolons) and underground modified stems (rhizomes); stems 6-12 in tall; flowers are slender spikes, usually with 3 per cluster, similar to crabgrass; ligule a fringe of hairs.
Uses:	A warm-season grass which makes most of its growth during June, July, and August in Virginia; pasture, hay, silage, and turf. Greatest forage potential in the Southern Piedmont and Coastal Plain.
Types and strains:	Common-Occurs naturally in Virginia and throughout the South. Propagated by sprigs (rhizome and stolon pieces) and seed. Can be major weed in crop fields. Hybrid Forage Types-Improved strains which are high yielding, leafy, and cold-tolerant enough for use in Southern Piedmont and Coastal Plain. Midland, Tifton 44, and Quickstand have more cold tolerance then Coastal. All must be established using vegetative sprigs. Fine-Textured Bermudagrass—Developed for athletic fields, lawns, golf greens, fairways, etc. All improved varieties propagated by sprigs or sod. Seed is available for common bermudagrass.
Seed weight per bushel:	35-36 lbs
Seeds per lb:	1,800,000
pH Range:	6.0-6.5
Soil adaptation:	Will grow on all types of soil, but is better suited to sandy and droughty soils than other grasses. Prefers well drained soils.
Time of planting:	April 1-June 1
Rate of planting:	For pasture use 15-20 bushels of sprigs per acre, in rows or 30-40 bu/acre if broadcast. For turf, use 1 lb of seed, or 2-7 bushels of sprigs per 1,000 sq ft
Fertilizer:	At planting, 70 lbs N, plus 70-90 lbs. P_2O_5, and 70-90 lbs K_2O for medium testing soil. For turf, see Turfgrass Section. For Hay, 175-300 lbs N, 80 lbs P_2O_5 and 80-205 lbs K_2O annually, based on soil test levels . Lower rates required when used as pasture.

Bermudagrass – Perennial – (*Cynodon dactylon*) (cont.)

Method of planting: Seed broadcast by hand or seeder. Sprigs planted in rows manually or with planter. May be broadcast, disked in, and cultipacked. Cover sprigs with 2-4" of soil.

Harvesting (hay): Cut when 8-12" tall before heading, or every 35-45 days.

Harvesting (pasture): Can be continuously stocked if grazed no shorter than 2-3". Rotational stocking is preferred; turn in at 6-8"; move cattle at 2-3". Minimize seed production to maintain quality and growth rate. Don't graze during establishment year; cut for hay instead.

Approximate yield: 4-8 tons hay/A

Uses: A warm-season grass which makes most of its growth during June, July, and August in Virginia; pasture, hay, silage, and turf. Greatest forage potential in the Southern Piedmont and coastal Plain.

Birdsfoot Trefoil – Perennial – (*Lotus cornicalatus*)

Description: A fine-stemmed legume with a branching taproot. Adapted to higher elevations in Virginia. Grows 12-30" or more in length from a branching crown; flowers are orange-yellow in groups of 4-8 at end of stems; leaves consist of 5 leaflets alternately arranged, two are at the base near the stem; several seed pods attached to a single point give appearance of bird toes. Short-lived perennial that can reseed.

Uses: Hay or pasture (non-bloating)

Varieties: No varieties have been developed for Virginia conditions. The erect or European types have been most satisfactory. These varieties include Viking, Granger, Cascade, and Mansfield. The Empire variety is a decumbent pasture type.

Weight Per Bushel: 60 lbs

Seeds Per lb: 375,000

Germinating Time: 7 days

Fertilizer: Zero N—medium soil test levels; apply 40-70 lbs P_2O_5 and 50-80 lbs K_2O.

pH Range: 5.8-6.5

Soil Adaptation: Does best on well drained soil, but can be grown with impervious subsoils.

Inoculation: Essential. Does not cross-inoculate with other legumes.

Planting: March 1-April 15 or August 1-September 1. Should be sown with a grass such as orchardgrass or Kentucky bluegrass. In mixtures 4-8 lbs; alone 8-10 lbs.

Method of Seeding: 6-8" rows or solid seeded. Well prepared, compact seedbed is needed. Cover not more than 1/2" deep. Use cultipacker if surface-seeded. Can also be no-till drilled or frost seeded on killed sod. Poor seedling vigor.

Management: Permit seedlings to become well established before grazing or harvesting. Clip weeds. Use rotational or moderate continuous grazing for pastures.

Harvesting (hay): When in-bloom. Avoid clipping close if extremely dry.

Bluegrass – Kentucky – Perennial (*Poa pratensis*)

Description: A low-growing, sod-forming, perennial grass that spreads by underground rhizomes; the narrow leaves have tips shaped like the bow of a boat and reach a length of 7"; sheath flattened; short ligule.

Uses: Permanent pasture and lawns. Requires several years to become well established. Good early grazing, goes dormant in summer, revives in fall to furnish good grazing.

Weight Per Bushel: 14 lb

Seeds/lb: 2,200,000

Germinating Time: 14 days

Dallisgrass—Perennial—*(Paspalum dilatatum)*

Description:	Leaves broad and flat; grows in clumps of a few to many stems; extremely short rhizomes; stems slender and usually drooped from weight of flower clusters; flowers arranged in 2 rows along tip of seed stalk. Grows 10-20" tall.
Uses:	Dallisgrass is a hay and pasture grass in the more southern states, but is not generally recommended for Virginia. It is a slow-starting grass and usually takes 2 or more years to establish a stand.
Weight per bushel:	12-15 lbs
Seed per lb:	340,000
germinating time:	21 days
Fertilizer:	40-60 lbs N, 30-40 lbs P_2O_5 and 30-60 lbs K_2O at medium soil test levels.
pH Range:	5.8-6.2
Soil adaptation:	Well drained to somewhat poorly drained soils.
Planting:	Spring at 10-15 lbs per A alone; 3-5 lbs in mixtures

Eastern Gamagrass (*Tripsacum dactyloides*) Warm-season Perennial

Description:	3 to 8 feet tall, erect bunch grass. Stem flattened at the purplish base and growing from stout, scaly rhizomes. The blades are wide with rough and sharp margins. The inflorescence with 1-3 spikes, sometimes a foot long. It has both male and female parts in the same spike (male spikelets above and female spikelets below the spike). Crowns of established plants can be 3 feet across.
Uses:	Primarily for grazing, but also for hay, silage, erosion control and wildlife.
Fertilizer:	Responds well to N. Apply 100-150 lbs N/A/Yr, in split applications. Maintain P and K in medium range.
pH Range:	5.8-6.5
Soil Adaptation:	Grows in fertile bottomland, swamps, and along stream banks.
Time of Planting:	Seed dormancy is high, so special treatment is needed before planting. Plant wet chilled seed about 1 to 1.5" deep after the soil temperatures reaches 60 to 65°F. Alternatively, dormant seed can be sown in November-December.
Rate of Planting:	8-10 lbs/A
Method of Planting:	Best stands are obtained when planted in 6 to 10 inch rows using conventional or no-till drill. Alternatively, a corn planter can be used to seed in 30-36" rows.
Harvesting:	Harvest 2-3 times per year in vegetative to early head stages. Can harvest to.5" (hay and silage) stubble.
Harvest (pasture):	Use rotational stocking; turn in at 18-24", graze to 8" residual.
Approximate Yield:	3-7 tons hay/A

Fescue—Meadow—Perennial—*(Festuca Elatior)*

Description:	Tufted, deep rooted, long lived, with dark green leaves; no rhizome but forms strong sod; small auricles; short ligule.
Uses:	Pasture. Found in many native pastures in Virginia, but not usually seeded.
Weight per bushel:	10-15 lbs
Seeds per lb:	230,000
Germinating time:	21 days
Soil adaptation:	Prefers rich, moist soils; does not do well on sandy soil.

Fescue—Creeping Red—Perennial—*(Festuca rubra)*

Description:	Narrow leaves that are folded with a very short ligule; base of stem is usually red.
Uses:	Primarily for lawns in shade. Very similar to sheep's fescue except leaves are bright green instead of bluish and it spreads by underground-modified stems (rhizomes).
Weight per bushel:	10-15 lbs
Seeds per lb:	400,000
Germinating time:	14 days
Fertilizer:	*See Turfgrass section.*
pH Range:	5.0-6.2
Soil adaptation:	Well drained to moderately well drained soils. Does best on sandy soils. Will tolerate shade and low pH better than ryegrass or bluegrass.
Planting:	September or early spring at 3-5 lbs per 1000 sq ft for turf.

Fescue—Sheep's—Perennial—*(Festuca ovina)*

Description:	A long-lived bunch grass which forms dense turf; numerous stiff, rather sharp, nearly erect, bluish-gray leaves; a tough grass, eaten eagerly by sheep but to a lesser degree by cattle.
Uses:	Pastures, seldom seeded.
Weight per bushel:	10-15 lbs
Seeds per lb:	530,000
Germinating time:	21 days
Fertilizer:	40-60 lbs N, 30-40 lbs P_2O_5 and 30-60 lbs K_2O
pH Range:	5.0-6.2
Soil adaptation:	Most well drained soils. Does better than most grasses on sandy soils.
Planting:	August or early fall is best, but may be sown in spring at 25 lbs along; 10-12 lbs in mixtures.
	Note: Commercial seed comes from Europe.

Fescue—Tall—Perennial—*(Festuca arundinacea)*

Description:	Long lived, tufted, deep-rooted; noted for early spring and late fall growth; leaves are dark green, shiny, and barbed along the edges, making them feel rough; leaves rolled in bud, very short ligule, sheath reddish pink below ground. Most existing tall fescue stands are infected with a fungal endophyte that induces fescue toxicosis in cattle. Varieties: Endophyte-free varieties are somewhat less hardy than endophyte-infected tall fescue, requiring more careful management. Modern endophyte-free varieties are stronger than earlier varieties. Endophyte-enhanced varieties have potential.
Uses:	Pasture, hay, and turf. Excellent when seeded at high rates for turf. Widely used for winter grazing.
Weight per bushel:	24 lbs
Seeds per lb:	220,000
Germinating time:	14 days
Fertilizer:	Establishment – 40 lbs N, 120-140 lbs P_2O_5 and 120-140 lbs K_2O at medium soil test levels. Pasture topdressing 30 lbs P_2O_5 and 30-60 lbs K_2O annually or 40-125 lbs P_2O_5 and K_2O every 3-4 years. (For winter grazing, apply 60-75 lbs N in mid-august). Hay topdressing –120-200 lbs N, 40-90 lbs P_2O_5 and 85-185 lbs K_2O. For turf, see Turf section.

Orchardgrass – Perennial – *(Dactylis glomerata)*

Description:	Long-lived, deep-rooted bunch grass; leaves light green and folded and flat at the base; tufted seed heads; long ligule. Flowers only in spring. Regrowth is vegetative with no stem or seedhead production.
Uses:	Pasture, hay, and silage.
Weight per bushel:	14 lbs
Seeds per lb:	590,000 unhulled, 625,000 hulled
Germinating time:	10 days
Fertilizer:	At medium soil test levels. Establishment—When seeded alone, 40-50 lbs N, 120-140 lbs P_2O_5 and 120-140 lbs K_2O. Maintenance (hay)—120-200 lbs N applied 1/2 in early spring and the other 1/2 after 1st cutting plus 40-90 lbs P_2O_5 and 85-185 lbs K_2O. When seeded with clover, nitrogen rate should be reduced to 20 lbs. For maintenance where there is more than 35% clover, no nitrogen is needed.
pH Range:	5.8-6.2
Soil adaptation:	Does best on well drained, loam soil.
Planting:	In eastern Virginia, seed after first good rain in September and up to October 15, or during February or early March. In the Piedmont and west of the Blue Ridge, seed after first good rain in August and up to September 15, or from March 1-April 15. Plant 8-12 lbs alone; 3-6 lbs in mixtures
Harvesting : (hay and silage)	Cut in boot to early head stage. Fiber percentage increases rapidly after blooming.
Harvesting (pasture):	Do not graze below 3". Rotational stocking with 1-4 day grazing periods is best.
Approximate first harvest dates:	Hay, May 15-June 1, seed, June 1-July 1
Approximate yield:	Hay, 2-5 tons/A/year; seed, 200-600 lbs/A

Peanuts – Annual – *(Archis hypogeae)*

Description:	Legume plant native to South America. Growth habit varies from prostrate to upright. Bright yellow flowers on either the main stem or lateral branches. Flowers contain both male and female parts and are self-fertile. Following fertilization a "peg" bearing ovaries in its top elongates from the leaf axil and penetrates the soil. The peg then turns horizontally and pod and seed formation takes place. Seed per pod varies from 1-5 depending on market type. A pod will most often have two seeds.
Uses:	Food for humans and livestock.
Weight per bushel:	18-22 lbs in shell; 48-52 lbs shelled
Seeds per lb:	Virginia-type, 500-800; runner-type, 700,000; Spanish-type, 1,000-1,400 lbs in shell
Germinating time:	7-10 days
Fertilizer:	Direct fertilization not recommended. Increase the fertilizer application on the crop that precedes peanuts in rotation by 50-100 lbs P_2O_5 and 10-60 lbs K_2O. Apply 900 lbs gypsum broadcast or 600 lbs banded over the row as plants begin to bloom.
pH Range:	5.8-6.5
Inoculation :	Cross-inoculates with lespedezas, cowpeas, and kudzu.
Soil adaptation:	Best quality peanuts are produced on well drained, light, sandy soils. May be produced anywhere east of mountains, but yield and quality are usually poor on heavier soils. Rotate peanuts with other non-legume crops.
Planting:	April 20-May 10. Soil temperature should be at least 65°F for three consecutive days.
Rate of planting:	Peanuts should be planted 3-4" apart in 30-36" rows. This requires approximately 75-175 lbs of shelled nuts, depending on seed size. Plant 1 1/2-2" deep.

Ryegrass – Perennial – (English Ryegrass) – *(Lolium perenne)*

Description:	Similar to Italian in use, adaptability, and all other ways, but can be distinguished from Italian by flowers being awnless and leaves folded in the bud, not rolled. Special varieties adapted for turf purposes.
Use:	Pasture. High yielding during first year, but decreased yields in subsequent years due to poor persistence.
Planting:	In mixtures, 10 lbs; alone, 20-30 lbs
Approximate yield:	2-6 tons hay/A

Sorghum, forage – Annual – *(Sorghum bicolor)*

Description:	Sorghum is very similar to corn in the vegetative stage. Leaves tend to be more narrow than for corn. Heavily covered with a white waxy coating that can be rubbed off the leaf sheath. Flowers are perfect in that both male and female parts are produced in a panicle type head on top of the plant. Forage sorghum is 6'-10' tall with large stem, medium-size grain head.
Uses:	silage, hay, grazing.
Weight per bushel:	56 lbs
Seeds per lb:	13,000-20,000
Germinating time:	10 days
Fertilizer:	60-80 lbs each of N, P_2O_5 and K_2O
pH Range:	5.8-6.2
Soil adaptation:	Well drained to somewhat poorly drained soils
Planting:	1-2 weeks after corn. Soil needs to be warm (at least 60° F). Plant 5-20 lbs in rows with a drill or corn planter.
Harvesting:	Do not graze until 30" tall. Cut for hay or wilted silage no later than early head emergence. Cut in dough stage for direct ensiling.
Approximate yield:	Hay or wilted silage, 3-5 tons dry matter. Silage, 14-18 tons 35% dry matter/A

Sorghum, Grain – Annual – *(Sorghum bicolor)*

Description:	See forage sorghum. Same genus and species except plant types that are shorter and producelighter grain have been bred Plant height 3-5' with high grain yield. Will recover from high temperature and drought better than corn.
Uses:	Grain and silage
Weight per bushel:	56 lbs
Seeds per lb:	13,000-20,000
Germinating time:	10 days
Fertilizer:	Apply approximately the same amount that would be applied to corn when grown under comparable conditions.
pH Range:	5.8-6.2
Soil adaptation:	Well drained to somewhat poorly drained soils
Planting:	1-2 weeks after corn. Early-medium maturing hybrids can be planted following small grain harvest in eastern Virginia. Plant for grain at 5-7 lbs in rows; forage alone, 7-10 lbs. Increase seeding rate 10-20% with late seedings. Grain sorghum should be planted in rows as narrow as possible. Seed 1-1 1/2" deep.
Harvesting:	Harvest grain with combine when seed is mature and shells easily from head. Chop for silage when grain is in the dough stage. Artificial drying can be a problem because the small seed size reduces air flow through the grain.
Approximate yield:	Grain, 80-90% of adapted hybrid corn yield. Silage, 11 tons 35% dry matter/A

Virginia Cooperative Extension

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Virginia's Horse Pastures: Forage Species for Horse Pastures

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Virginia is located in the transition area between the cool temperate and subtropical zones of the United States. Thus, Virginia can produce a wide range of pasture plants, but varying temperatures and soil conditions require that different pasture species be grown in various parts of the state. Total moisture availability and temperatures are favorable to productive pasture, but short-term drought combined with high temperatures often limits forage growth during the summer months. Choosing the correct forage species is the first step in successful pasture management. Forages used in Virginia's horse pastures should be:

- Adapted to the region where they will be used.
- Adapted to the soils on which they will be grown.
- Tolerant of environmental stresses, such as high temperatures and drought.
- Tolerant of close and frequent grazing.
- Productive when pasture is needed.
- Free of antiquality factors that may restrict use by horses.
- Easily managed in horse pastures and matched to the management level of the horse owner.
- Matched to the animal's nutritional requirements.

Horses can be susceptible to health problems when allowed to overgraze lush pastures, particularly when high volumes of clover are available. The consumption of excessive soluble and rapidly fermentable carbohydrates may lead to colic and laminitis. It is best to limit grazing during the transition from dry feed onto pasture. This can be accomplished by allowing horses to graze for short periods and gradually increase the length of grazing time over a two- to three-week period. Allowing horses access to dry hay during this transition period will also help to limit nutritional problems.

Cool-season Perennial Pastures

Cool-season perennial grasses and legumes do not need to be seeded each year and have highest production in the early spring and fall, with significantly reduced growth during the summer months. Cool-season perennials common to Virginia include grasses such as Kentucky bluegrass, orchardgrass, timothy, and tall fescue. Perennial legumes such as white clover, ladino clover, and red clover compliment these cool-season grasses in Virginia horse pastures.

Grasses

Kentucky bluegrass forms a dense sod, tolerates close grazing, and is one of the more palatable grasses for horses. It is low-growing, up to a height of about 12 to 20 inches, having narrow leaves with tips shaped like the bow of a boat. Kentucky bluegrass does best on medium- to highly-productive soil with medium drainage. It has underground rhizomes that enable it to help cover areas where turf becomes torn. It will persist under low fertility, but grows best at a medium to high fertility level with a pH of 5.8 to 6.5. It is not tolerant of drought and high temperatures and commonly goes dormant during the summer months. Although bluegrass is well adapted for pastures in the Northern Piedmont and areas west of the Blue Ridge Mountains, it is not a suitable choice for Southside and southeastern Virginia. It has seasonal production from April to October, with limited production in July and August. When compared to orchardgrass and tall fescue, bluegrass produces less total forage.

Orchardgrass is a tall bunchgrass that grows in clumps, rather than forming a smooth sod. Its leaves are light dull green, folded at the base and may grow to a height of 40 inches. Orchardgrass is commonly used for hay and pasture. However, it does not per-

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sist under close and continuous grazing and requires a higher level of management than some of the other cool-season forages. It grows best on medium- to well-drained soils and does not tolerate wet soils, drought, or heavy trampling. Unless very closely seeded, horses will be likely to dig it up when the ground is wet. It has seasonal production from March to November, with limited growth in July and August. Orchardgrass is best adapted to medium- to high-fertility soils with a pH of 5.5 to 7.0. Although widely adapted in Virginia, orchardgrass does not persist as well as other grasses in eastern and southern Virginia, so it should be considered a semi-permanent pasture in these areas. To maintain orchardgrass pastures it is essential to rest pastures three to four weeks between grazings and to never graze closer than 3 to 4 inches.

Timothy is a tall, relatively short-lived bunchgrass that has dense, spike-like seed heads. The leaves are flat, erect, light green and taper to a point while twisting slightly. It has seasonal production from April to November, with lower production during the summer months. Timothy is most often used as hay since it does not withstand close and frequent grazing. Regrowth of timothy is variable and is especially low if temperatures are high and soil moisture is limiting. Timothy is technically a perennial, but since it is not very durable, it usually needs to be replanted each year or two in the mid-Atlantic region. The timothy root system is relatively shallow, making it very susceptible to drought stress. Timothy is commonly used for horse hay, but its production and persistence is significantly less than that of tall fescue and orchardgrass.

Tall fescue may grow to a height of 40 inches. It is the most widely grown cool-season grass in the southeastern United States. It forms a dense, long-lasting sod and withstands close grazing and trampling better than other grasses, making it useful in heavily traveled areas. Its leaves are dark shiny green, coarse textured, deeply veined, and rolled as they emerge from the sheath. It tolerates acidic and poorly drained soils and is fairly drought tolerant. It has seasonal production from March to November with a decreased rate of growth during July and August. A strong attribute of tall fescue is its ability to be stockpiled for deferred grazing. After frost, fescue becomes very palatable due to significant increases in sugars and digestible carbohydrates.

Most tall fescue plants harbor an endophyte, a fungus that grows within the plant that confers hardiness to the plant but produces a toxin that causes reproductive problems in broodmares. Documented symptoms of endophyte-related reproductive problems include prolonged gestation; inadequate physical readiness of the mare for birth; dystocia; large, weak, or stillborn foals; thickened and retained placentas; and failure to produce milk. Broodmare managers can effectively avoid these problems by removing endophyte-infected fescue from the mare's diet for 60 to 90 days before foaling. Endophyte-free fescue can be used in place of endophyte-infected fescue. However, it is more difficult to establish and does not persist well under horse grazing.

A recent advance in tall fescue is development of cultivars that contain a non-toxic endophyte that confers plant hardiness without producing the toxins associated with reproductive problems in broodmares. Research from Mississippi showed that broodmares grazing tall fescue infected with the Max-Q non-toxic endophyte showed no signs of "fescue toxicosis." Broodmares grazing tall fescue infected with the toxic endophyte exhibited traditional signs of "fescue toxicosis" including abortion, prolonged gestation, low milk production, dystocia, and retained placenta. This research indicates that there are no health risks to grazing pregnant mares on tall fescue infected with the non-toxic endophyte. *However, since limited research is available on the persistence of tall fescue infected with the nontoxic Max-Q endophyte under horse grazing, Virginia Cooperative Extension is not recommending its use in the last 60 days of gestation, unless pastures have been tested to ensure that only the non-toxic endophyte is present.*

Legumes

Legumes fix nitrogen from the air into a plant-available form that is shared with grasses. When a pasture consists of more than 25 percent legume, no nitrogen fertilization is needed. As a general rule, legumes should not make up more than one-third of the sward on a dry-matter basis. High levels of legumes can result in nutritional disorders such as colic and laminitis. Many Virginia pastures naturally contain large amounts of white clover when soil moisture is adequate, so in some cases clover seed may not be required in horse pasture mixes.

Common (dutch) white clover is a low-growing legume found in all areas of Virginia. The leaves consist of three heart-shaped leaflets and the petioles attach to stolons, or runners, that form shallow roots. Its white flowers are clustered into small heads. It does best on fertile soils with good moisture-holding capacity and has seasonal production from April to October. It tolerates close grazing and does well when planted with Kentucky bluegrass or with other cool-season perennial grasses. White clover is not drought tolerant and is often lost from pastures during dry periods. However, hard seed persists for long periods in the soil, and when moisture conditions become favorable for clover growth, white clover reappears.

Ladino clover is a large, taller-growing variety of white clover that is higher yielding. It is usually planted with taller, cool-season perennial grasses, such as orchardgrass and tall fescue. Ladino clover does best on fertile soils with good moisture holding capacity and is found in all areas of Virginia. It does not grow well in shallow, dry soil and usually lasts only three to four years without replanting.

Red clover is a tall, short-lived, legume. It can grow to a height of more that 30 inches. Its leafy stems are usually hairy, and its violet-pink flowers are clustered into large heads. Its root system is a taproot with many side branches. It has seasonal production from April to October. Red clover is fairly drought tolerant but usually does not persist due to disease. Therefore, red clover must be reseeded every two to three years. This can be accomplished by broadcasting red clover seed onto a closely grazed pasture in late winter. Red clover is usually planted with taller, cool-season perennial grasses, such as orchardgrass, timothy, and tall fescue. Red clover has frequently been associated with slobbering in horses. The slobbering is caused by a chemical compound produced by a clover disease known as black patch. Black patch most commonly affects red clover, but also sometimes white and ladino clover. Most often the slobbering is merely a nuisance, but severe cases may lead to dehydration.

Warm-season Perennial Pastures

Warm-season perennials begin to grow after the soil warms in late spring. Warm-season plants are high in productivity during hot, dry summer months but become dormant and unproductive after frost. Since cool-season plants lag in growth during the summer but flourish in the spring and fall, utilizing both cool-season and warm-season plants in separate paddocks can provide year-round grazing. Of the warm-season perennial species, bermudagrass is the best adapted for horse pastures in Virginia.

Bermudagrass is best adapted to well-drained, fertile loam soils, but will make excellent growth on deep sands when fertility and moisture are adequate. It does not tolerate wet soils and is sensitive to frost. It has seasonal production from late May until September. It is most productive between 80° to 90°F. In order to extend the grazing season, bermudagrass sods can be interseeded with a cool-season annual grass in the early fall. Bermudagrass is relatively tolerant of trampling and overgrazing. To maintain forage quality and palatability, it should be closely grazed or clipped down to a height of one to two inches, then allowed to recover to four to eight inches. Several ecotypes of common bermudagrass grow wild on farms throughout the Southern Piedmont and Coastal Plain regions of Virginia. In some cases, improved management of these bermudagrass ecotypes may be more efficient than trying to establish improved varieties. In the past, bermudagrass had to to be established vegetatively, but recently developed varieties can be seeded. For the most up-to-date information on bermudagrass varieties, contact your local Virginia Cooperative Extension office.

Summer perennials NOT recommended for grazing by horses include Johnsongrass, big bluestem and switchgrass. Johnsongrass may accumulate hydrocyanic acid, leading to cyanide poisoning, cystitis, incoordination, and sometimes fatal kidney disease. The concentration of hydrocyanic acid is highest after frost and lessened by proper curing and storage of hay. Big bluestem and switchgrass have not been shown to be toxic but are not palatable to horses. They also do not survive well under close and frequent grazing.

Warm-season Annual Pastures

Warm-season annuals provide rapidly growing, high-yielding, drought-resistant pasture during the summer months when cool-season plants slow in growth. Warm-season annuals are killed by frost and must be reseeded each spring. Although the plants are highly responsive to nitrogen fertilization, care should be taken to avoid nitrate poisoning. Nitrates can accumulate in slow-growing, drought-stressed plants that have been heavily fertilized. *Therefore, drought-stressed plants that have been fertilized with significant nitrogen should not be grazed.* Of the warm-season annual plants, dwarf pearl millet and crabgrass are the most commonly occurring species in Virginia.

Dwarf pearl millet may grow to a height of three to eight feet. It is leafy and tolerant of drought and acidic soils. It is seasonally productive from June to August. Pearl millet is tolerant of grazing with excellent recovery growth afterwards. Its thick stems make it difficult to cure for hay. For best quality, it should be periodically grazed to a height of five to seven inches then allowed to regrow to 18 inches. The regrowth is made primarily from stubble rather than the base of the plant so close grazing should be avoided. Grazing or clipping closer than five to seven inches will significantly reduce regrowth.

Crabgrass is often discounted as a weed, but could provide high-quality summer grazing for horses. It has nutritive value superior to most warm-season perennial grasses. It has seasonal production from June to September and grows 12 to 24 inches tall. It responds well to nitrogen fertilization and the small quantities of rainfall provided by intermittent summer thundershowers. In Virginia, crabgrass is best adapted to the Southern Piedmont and Coastal Plains regions. Naturally occurring ecotypes can be managed for forage, but production is variable. "Red River" is the only improved variety commercially available. Crabgrass is best adapted to a slightly acidic pH and well drained soils that do not crust or crack extensively.

Summer annuals NOT recommended for grazing by horses include sudangrass, sorghum, sorghum-sudangrass hybrids, and foxtail millet. Sudangrass, sorghum, and sorghum-sudangrass hybrids can accumulate prussic acid, especially after frost. When drought-stressed plants are grazed, they may cause cyanide poisoning, cystitis, incoordination, and sometimes fatal kidney disease. Since prussic acid volatilizes during curing, properly made and stored hay produced from these grasses may be safely fed to horses. Foxtail or German millet has been reported to have a diuretic effect in horses that may lead to kidney and joint problems. The coarse, fuzzy heads may also lodge in the tissues of the mouth and gums and create sores.

Cool-season Annual Pastures

Cool-season annual plants include small grains, such as rye, wheat, barley, and oats, and annual ryegrass. These plants are not primary horse-pasture species, but may furnish grazing in the late fall, early winter and early spring to complete a 12-month grazing program when other plants are not actively growing. *Grazing small grains may increase the risk of colic, laminitis, and founder, so horses' exposure to cool-season annual pastures should be limited and monitored closely.* It is important to remember that cool- and warm-season annuals must be replanted each year.

Small grains are adapted in all areas of Virginia and do well on soils with moderate drainage, fertility, and pH. They may be grazed continuously in the fall, early winter, and spring; however, they do not form a tight sod, so horses should be removed from these pastures when the soil is wet. **Rye** is the small grain most commonly used for grazing animals because of its ability to provide fall and early-spring growth. **Wheat, barley,** and **oats** may also be grazed. Of the small grains for pasture, oats are more palatable but generally more sensitive to cold than other grains and may be killed in the winter. The seedheads of rye, along with other small grains, and some perennial grasses can become infected by an ergot fungus, which can cause equine ergotism. Ergotism has neurological effects including tremors and incoordination, and it may cause dry gangrene and abortions. Since the seedhead is required for the ergot fungus to infect the plant, simply not allowing seedheads to be produced in horse pastures will present ergotism.

Annual ryegrass is adapted to soils with moderate drainage, fertility and pH. It has shiny, dark green, smooth leaves and may grow two to three feet tall. Annual ryegrass is both highly digestible and extremely palatable, making it a desirable species to include in forage systems. In addition, annual ryegrass has high seedling vigor, making it well adapted to either conventional or no-till establishment. Under good growing conditions, annual ryegrass can produce grazable forage in as little as 45 to 60 days after planting. In Virginia, annual ryegrass is best adapted to the Southern Piedmont and Coastal Plains regions. Most annual ryegrass is sodseeded into permanently established warm-season grasses in order to extend the useful period of this land area. A disorder called ryegrass staggers, caused by a fungal endophyte that proliferates in perennial ryegrass, can be a problem for horses. *However, this problem occurs only in perennial ryegrass, not annual ryegrass.*

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Forage Species at a Glance

- **Choose forage species that are adapted to the region and soil conditions present in the pasture.**
- **Kentucky bluegrass** tolerates close and frequent grazing and is best adapted west of Blue Ridge Mountains.
- **Orchardgrass** forms an open sod and does not tolerate close and frequent grazing.
- **Tall fescue** that is infected with the toxic endophyte fungus forms a dense sod that is tolerant of grazing and other environmental stresses, but can cause reproductive problems in late-term broodmares.
- **White clover** tolerates close and frequent grazing and mixes well with most grasses.
- **Red clover** is a tall, short-lived, legume that mixes well with pasture grasses, but must be reseeded every two to three years.
- **Bermudagrass** is a warm-season perennial grass that forms a dense sod that is highly tolerant of close and frequent grazing.
- **Crabgrass** is a warm-season annual grass that occurs naturally and can provide high-quality grazing during the summer months.

Table 1. Characteristics of forage species commonly used in Virginia's horse pastures.

				Tolerance to[3]			
Species	**Life Cycle[1]**	**Productive Season**	**Seedling Vigor[2]**	**Acid Soil**	**Poor Drainage**	**Drought**	**Grazing**
KY Bluegrass	PN	Spring & Fall	P	F	F	P	E
Orchardgrass	PN	Spring & Fall	G	F	F	F	G
Tall Fescue (EI)[4]	PN	Spring & Fall	G	G	G	G	E
Tall Fescue (EF)[5]	PN	Spring & Fall	F/G	G	G	F	G
Tall Fescue (NT)[6]	PN	Spring & Fall	G	G	G	G	E
Timothy	PN	Spring & Fall	G	F	F	F	F
Red Clover	PN	Spring & Fall	E	F	F	F	G
White Clover	PN	Spring & Fall	F	F	G	P	E
Bermudagrass	PN	Summer	F	E	P	E	E
Annual Ryegrass	AN	Late Fall & Spring	E	G	E	F	E
Rye	AN	Late Fall & Spring	E	E	F	F	G
Wheat	AN	Late Fall & Spring	E	P	P	F	G
Oats	AN	Late Fall & Spring	E	F	F	F	G
Pearl Millet	AN	Summer	E	E	P	E	F
Crabgrass	AN	Summer	G	G	P	G	F/G

[1]PN=Perennial, AN=Annual
[2]E=Excellent, G=Good, F=Fair, P=Poor
[3]E=Excellent, G=Good, F=Fair, P=Poor
[4]EI, infected with the toxic endophyte
[5]EF, not infected with an endophyte
[6]NT, infected with the non-toxic endophyte

Virginia Cooperative Extension

PUBLICATION 418-101

Virginia's Horse Pastures: Grazing Management

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Sound grazing management can decrease feeding expenses and stable cleaning and other chores, leaving more time for the recreational enjoyment of horses. In addition, pastures also help to maintain healthy horses by providing exercise and fresh air. Although properly managed pastures can be beneficial to both the horse and owner; improperly managed pastures can be a serious environmental concern. Poor grazing management results in the loss of groundcover that can lead to soil erosion, the degradation of water quality in neighboring streams and ponds, and increased weed pressure in pastures.

Proper grazing management includes allowing adequate time for the plants to establish themselves, providing adequate land area per horse, utilizing rotation and rest periods, confining horses to a "sacrifice area" or exercise lot during periods of drought or wet soil conditions, managing manure, maintaining soil fertility, and clipping the pasture to even out under-grazed areas and control weed populations.

Let the pasture become established. Do not allow new seedlings to be grazed until the plants have become well established. The root systems should be well developed to prevent the seedlings from being pulled out of the soil by grazing animals and to reduce damage by the hooves of running horses. This rule applies not only to newly seeded pastures but also perennial pastures that have been renovated. New forage stands require 18 to 24 months to become fully established. Overgrazing during this period can severely damage developing sods. On the other hand, light and infrequent grazing can be beneficial for sod formation. During the establishment period do not graze sods closer than four to six inches and allow at least 30 days rest for actively growing pastures and longer for slow growing pastures during the summer months.

Provide adequate land area. Proper pasture management begins with providing adequate area for each horse. Overstocking pasture areas will lead to the rapid loss of desirable forage species due to overgrazing and trampling. It also will encourage the growth of unpalatable and in some cases poisonous weeds. In Virginia, two to three acres of well-managed pasture should provide adequate grazing and exercise for a mature horse. However, with careful, sustainable pasture management a horse may be adequately kept on less acreage. Regardless of acreage, both the large equine business and the small hobbyist will benefit from sustainable grazing management, which is critical to a healthy sod that benefits the horse, the owner, and the environment.

Rotate and rest pastures. Even the best pasture needs rest after grazing to allow plants time to regrow and replenish food reserves. The length of the rest period will depend on the time of the year and weather conditions. It should ultimately be based on the height of the regrowing plant (Table 1). Optimally, pasture acreage should be divided into at least four to six pastures. Continuous grazing weakens and thins stands and allows weeds and poisonous plants to invade pastures. Horses should be rotated from pasture to pasture based on the height of the forage. Never allow pastures or portions of pastures to become overgrazed. *Since horses are spot grazers, rotate to a new pasture when the grazed areas reach the minimum height rather than waiting for the entire pasture area to be grazed to the minimum height.* Target heights for starting and stopping grazing of commonly used forage species are shown in Table 1. Some forage species are more tolerant of grazing than others. For more information on forage species, see *Virginia's Horse Pastures: Forage Species for Horse Pastures*, Virginia Cooperative Extension publication 418-102.

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Table 1. Starting and stopping grazing heights for forage species commonly used in horse pastures.

Forage Species	Start Grazing (inches)	Stop Grazing (inches)	Usual Rest Period[1] (weeks)
Kentucky Bluegrass + Clover	8-10	2-4	2-3
Orchardgrass + Clover	8-12	4-6	2-4
Tall Fescue + Clover	6-8	2-4	2-4
Bermudagrass	4-8	1-2	1-2

[1] Usual rest period is based on optimal growing conditions. Temperature and rainfall can dramatically impact regrowth and either shorten or lengthen the rest period significantly.

Rotating livestock in pastures. There are advantages to grazing different types of livestock in horse pastures, primarily because it allows more efficient use of the pasture. Although all livestock are selective grazers, compared to horses, cattle and sheep are less selective. Rotating different livestock through the pastures keeps them grazed more uniformly and helps maintain the high-quality leafy stage of growth. Cows and sheep will also graze around manure piles left by horses. Cattle or sheep and horses may be stocked together in the same field or alternately, cattle or sheep may follow horses in the pasture rotation system.

Utilizing a "sacrifice" or "exercise area." In cases where land is limited to less than two acres per horse, it is nearly impossible to maintain pasture sod with continuous grazing. Maintaining an exercise area, that is, an exercise lot where no plants will grow is a practical solution. Permit grazing only when the pasture has reached the target height. Proper fertilization and timely irrigation of the pasture area can significantly increase forage growth and reduce the time period between grazing events. The exercise area should be used during periods of wet soil conditions and drought—and during winter/nongrowing season. Hoof action can seriously damage even well-established pasture sods when soil conditions are wet. Do not graze pastures during periods of drought stress and slowed growth. Overgrazing during these periods will significantly weaken and eventually kill even well -established stands. Footing in exercise areas may become unsafe due to mud, so a base comprised of a geotextile (available at many agricultural or landscape supply stores) covered with six to eight inches of one- to two-inch rock capped with two to three inches ground stone dust or sand should be constructed to improve the footing and prevent soil loss. Removing and composting manure and other organic materials such as hay and bedding every three days will also improve footing, and reduce parasite and fly exposure.

Provide hay as alternate forage. During times of the year when adequate pasture is not available (e.g. winter or drought conditions), provide hay as a forage alternative to pasture. Hay fed at a rate of 1 to 2 percent of body weight will provide adequate roughage to maintain digestive tract health. Horses will graze pasture during periods of nongrowth if they have no alternative. However, limited forage availability and poor quality of nongrowing pasture do not provide adequate nutrition for horses. Also, the grazing will weaken and kill desirable pasture plants. Since horses will tend to graze even if hay is provided, hay should be fed in the sacrifice area. Hay feeders should be utilized rather than feeding hay on the ground to avoid the ingestion of soil, sand, or stone dust that can lead to colic, and impaction.

Mowing maintenance. The tendency of horses to spot graze pastures leaves some areas ungrazed. These areas need to be clipped to approximately four inches to remove mature growth and seed heads, promote new growth, increase forage quality, and encourage grazing. Mowing will also slow weed propagation by removing seed heads. Many grasses (ryegrass, fescue, bluegrass, small grains, etc.) may be susceptible to infection with an ergot mold, which may cause equine ergotism. Normally the ergot is only a problem when the forage is allowed to produce a seed head. Therefore, pastures should be clipped to avoid seed head formation.

Grazing Management at a Glance

- Allow pastures to become established before grazing.
- Do not graze pastures closer than two to four inches.
- Allow pastures to rest between grazing events.
- Graze pastures only after regrowth has reached a height of six to 12 inches.
- Do not graze pastures that are not actively growing.
- Feed hay when pasture growth is slowed or stopped.
- Do not graze pastures when soil conditions are wet.
- Mow pastures to remove mature forage and encourage grazing.
- Harrow pastures to spread manure.
- Create and utilize an "exercise area" to feed hay when pastures are not ready to be grazed.

Removing or harrowing manure. Piles of manure droppings contribute to under-grazed areas of the pasture, because horses will avoid these areas and the nutrients contained in the manure will promote rapid plant growth. Manure piles in the pasture should be scattered periodically, by dragging a chain harrow, spiketooth harrow, or other similar implement across the pasture. Harrowing the manure will promote uniform grazing. Additionally, breaking up and spreading the manure piles may also help to reduce parasite populations. A good time to harrow the manure piles is shortly after the horses have been rotated to a fresh pasture and the resting pasture has been mowed.

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Virginia Cooperative Extension

PUBLICATION 418-104

Virginia's Horse Pastures: Renovating Old Pastures

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Pasture renovation can be defined as a series of practices that result in long-term improvement in the health, productivity, and botanical composition of pastures. These practices include interseeding legumes and grasses, fertilization, liming, weed control, and improved grazing management. Successful renovation requires planning, timelines, and attention to detail. *Before reseeding pastures it is important to determine why the previous stand did not persist.* It is essential that these problems be addressed in the long-term pasture management plan.

Pasture renovation does not always mean reseeding. Weak pastures can often be improved by simply resting, fertilizing, liming, clipping weeds, and implementing rotational grazing. For this to work, desirable plant species must be present in adequate densities. Pastures that have large spaces, more than six inches, between plants may require reseeding to thicken stands.

Control weeds prior to reseeding. Weeds occur in horse pastures for a number of reasons, including poor fertility, overgrazing, and the use of forages that are not adapted to the region and soil conditions. You must address these issues prior to reintroducing desirable grasses and legumes. The best time to control weeds is the season prior to renovation. You can control perennial broadleaf weeds by using herbicides; however, this will cause severe injury to desirable legumes. Broadleaf weeds must be controlled prior to interseeding legumes. For more information on herbicides for pastures see *Pest Management Guide: Field Crops*, Virginia Cooperative Extension publication 456-016.

Adjust soil fertility prior to seeding. Soil testing is an important first step in pasture renovation. Without proper soil fertility, pasture renovation will not be successful. Apply lime and fertilizer according to soil test recommendations. Soil acidity is a major factor limiting pasture growth in Virginia. Acidic conditions reduce nutrient availability, limit root growth, and decrease nitrogen fixation in legumes. Lime applications reduce both soil acidity and the availability of toxic metals such as aluminum and manganese. Some lime sources supply only calcium, while applications of dolomitic lime supplies both calcium and magnesium. Lime should be applied the season prior to reseeding to allow adequate time for it to react with the soil. In situations where more than two tons of lime per acre are needed, apply one-half prior to reseeding and one-half after reseeding.

Suppress sod and reduce surface residue prior to reseeding. The existing sod must be suppressed and plant residue reduced prior to seeding. Sod can be suppressed by hard grazing in late fall and early winter. Overgrazing reduces the competitiveness of the sod and eliminates plant residue. This allows seed to reach the soil surface and establish good soil-seed contact, which is essential for germination and emergence. Vegetation can also be suppressed using a low rate of a nonselective herbicide, but killed pastures with high levels of residue may need clearing before seeding can be successful. For more information on sod suppression using herbicides see *Pest Management Guide: Field Crops*, Virginia Cooperative Extension publication 456-016.

Choose adapted forage species and use certified seed. Successful pasture renovation requires forage species adapted to the soil conditions present in the pasture and the region of the state where it will be grown. If the forage is not regionally adapted, the chance of maintaining a healthy sod is low. It is also important to select a forage species that will tolerate close and frequent grazing. Use certified seed or a proprietary variety which is adapted to your climatic region. This will ensure that you are getting high-quality, weed-free seed. For more information on adapted species see *Virginia's Horse Pastures: Forage*

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Species for Horse Pastures, Virginia Cooperative Extension publication 418-102. For information on varieties of adapted species contact your local Extension office.

Inoculate legume seed. Legumes form a symbiotic relationship with Rhizobium bacteria in which nitrogen from the air is fixed into a plant available form. There is no need for nitrogen fertilizer when legumes make up more than 25 percent of the stand. Legume seed should always be inoculated with the proper strain of nitrogen fixing bacteria before seeding. In many cases legume seed comes preinoculated. If the seed is not preinoculated, just prior to seeding, mix the seed with a prepackaged inoculum available from the seed dealer.

Ensure good soil to seed contact. There are a number of different seeding methods, and regardless of the method used, the objective is always the same, to ensure good soil-seed contact. This helps to ensure that the seed will germinate and emerge in a timely manner. For more information on seeding methods please see No-Tillage Seeding of Forage Grasses and Legumes, Virginia Cooperative Extension publication 418-007, available online at *http://pubs.ext.vt.edu/418-007/418-007.html.*

Frost seeding is accomplished by broadcasting seed onto the soil surface in late winter or early spring. The freezing of the soil surface during the night and thawing during the day cause small cracks to form. These cracks allow the seed to incorporate into the soil. In order for frost seeding to be successful, the seed must reach the soil surface. Therefore, it is critical to reduce plant residue on the soil surface. In addition, broadcast the seed early enough that adequate freeze-thaw cycles take place to incorporate the seed. In Virginia, frost seedings are most successful when seed is broadcast from late January to early March, depending on location. This method is most successful with clovers and annual lespedeza. It does not work as well with grasses and alfalfa. Seeding rates are shown in Table 1.

Table 1. Legume seeding rates for frost seeding.

Plant Species	Seeding Rate lb/A
Red Clover alone	8-10
Ladino Clover alone	1-3
Red Clover + Ladino Clover	4-6 + 1-2
Annual Lespedeza alone	15-20
Annual Lespedeza + Ladino Clover	8-10 + 1-2

Minimum tillage seeding is accomplished by disturbing 40 to 60 percent of the established sod. This can be done using a disk, field cultivator, or other tillage implement. The tillage implement does not need to penetrate the soil more than two to four inches. Tillage helps to suppress the sod and expose bare soil. After tillage, the seed is broadcast onto the soil surface and cultipacked. This seeding method can be used to reintroduce both perennial grasses and legumes or to overseed annual grasses and legumes into an established sod. Depending on the species being established, this seeding method can be successful in either late summer or early spring. Seeding rates are shown in Table 2.

No-tillage seeding is accomplished by using a no-till and requires more effort and attention to detail. However, it generally produces more consistent results than frost seeding. No-till seeding methods can be successfully implemented in either late summer or early spring.

Table 2. Seeding rates for minimum- and no-tillage seeding.

Plant Species	Seeding Rate lb/A
Red Clover alone	8-10
Ladino Clover alone	1-3
Red Clover + Ladino Clover	4-6 + 1-2
Annual Lespedeza alone	15-20
Annual Lespedeza + Ladino Clover	8-10 + 1-2
Red Clover + Ladino Clover + Orchardgrass	4-6 + 1-2 + 8-10
Red Clover + Ladino Clover + Tall Fescue	4-6 + 1-2 + 10-15
Annual Ryegrass	20-35
Small Grain	90-120
Small Grain + Annual Ryegrass	90 + 15

Virginia Cooperative Extension

PUBLICATION 418-103

Virginia's Horse Pastures: Forage Establishment

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Well-managed pastures can provide a relatively inexpensive and high-quality feed source for horses in Virginia. In contrast, poorly managed pastures are less adequate nutritionally and can reduce environmental quality. Proper pasture management starts with forage establishment. The establishment phase of forage production is critical since all other management practices depend on a healthy sod. Forage establishment begins long before the actual seeding. Successful forage establishment requires a great deal of planning and attention to detail.

Control weeds. Perennial weeds must be controlled prior to seeding. This is especially important if a mixture of grasses and legumes will be established. There are no herbicides available for controlling grassy or broadleaf weeds in grass-legume mixtures. In most cases, pasture herbicides are designed to kill either broadleaf weeds (legumes included) in grasses or grassy weeds in legumes. The use of herbicides and cropping sequences that include winter-annual (small grains) and/or summer-annual (pearl millet, foxtail millet) smother crops prior to seeding can prevent the accumulation of weed seed. Broadleaf weeds can be controlled in pure grass stands using selective herbicides (herbicides that affect only broadleaf plants). Reseeding restrictions need to be taken into account when applying these herbicides. In situations where both undesirable perennial grass and broadleaf weeds are present, or when a total burndown is desired a nonselective (affects both grasses and broadleaf plants), translocatable herbicide such as glyphosate should be applied prior to seeding. For more information on herbicides for pastures see *Pest Management Guide: Field Crops*, Virginia Cooperative Extension publication 456-016.

Adjust soil fertility prior to seeding. Test the soil in pastures and apply the recommended amounts of lime and fertilizer prior to seeding. Soil acidity is a major factor limiting forage production in Virginia. Cool-season grass pastures should be maintained at a pH of 6.0 to 6.2, while grass-legume mixtures should have a pH value of 6.2 to 6.4. Acidic conditions reduce nutrient availability, root growth, and nitrogen fixation of legumes. Lime not only corrects soil acidity, but also supplies calcium and magnesium while reducing the availability of toxic nutrients such as aluminum and manganese. *Lime should be applied six to 12 months prior to seeding to allow adequate time for it to react with the soil.* In conventional seedings where more than two tons of lime per acre are required, one-half should be applied and disked in before plowing and the remainder should be applied after plowing and disked in. In no-tillage seedings where more than two tons of lime per acre are required, one-half of the lime should be applied before seeding and one-half the following season. For more information on soil testing contact you local Virginia Cooperative Extension office to speak with an agricultural agent.

Choose an adapted forage species. Forage species must be adapted to the soil conditions present in the pasture and the region where it will be grown. *If the forage is not regionally adapted, the chances of successfully establishing and maintaining a healthy sod are low.* It is also important to select a forage species that will tolerate close and frequent grazing. Use certified seed or a proprietary variety which is adapted to your climatic region. This will ensure you are getting high quality, weed-free seed. For more information on forage species see *Virginia's Horse Pastures: Forage Species for Horse Pastures*, Virginia Cooperative Extension publication 418-102. For information on varieties of adapted species contact your local Extension office.

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Virginia Tech
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VIRGINIA STATE UNIVERSITY

Inoculate legume seed. Legumes form a symbiotic relationship with *Rhizobium* bacteria in which nitrogen from the air is fixed into a plant-available form. There is no need for nitrogen fertilizer when legumes make up more than 25 percent of the stand on a dry matter basis. A visual rating of clover percentage is a good estimate of clover on a dry matter basis for taller growing species such as ladino or red clover, but often overestimates common (dutch) white clover. Therefore, pastures where the predominant clover is common (dutch) white clover may require nitrogen fertilization even when a visual rating indicates more than 25 percent clover. *Legume seed should always be inoculated with the proper strain of nitrogen fixing bacteria before seeding*. In many cases legume seed comes preinoculated. If the seed is not preinoculated, mix prepackaged inoculum with the seed just prior to seeding.

Prepare the seedbed. For conventional seedings, prepare a fine and firm seedbed by plowing or heavy disking followed by other tillage tools to shape and smooth the soil. Avoid overworking the soil. A firm seedbed serves two purposes. First, it allows capillary action to draw water to the soil surface. This will provide needed moisture for seeds to germinate and help to sustain small seedlings during dry periods. Second, a firm seedbed allows for accurate seed placement. In many cases a soft seedbed allows seed to be placed too deeply, resulting in poor emergence and weak stands. A general rule is that the seedbed is too soft and should be refirmed if you walk across it and sink past the sole of your shoe.

No-till seedbeds must also be prepared by suppressing the existing sod and reducing surface residue prior to seeding. You can accomplish this with hard grazing in late fall and early spring. Vegetation can also be suppressed by using a low rate of nonselective herbicide. For more information regarding herbicides for sod suppression see the *Pest Management Guide: Field Crops*, Virginia Cooperative Extension Publication 456-016.

Ensure good soil to seed contact. Seeding methods include drilling, broadcasting and dragging or cultipacking, band-seeding, and cultipack-seeding. The type of seeding method you choose will depend on the equipment you have and whether you are preparing a conventional seedbed or doing no-till seeding. Regardless of the seeding method, the goal is to achieve good soil-seed contact. Good soil-seed contact ensures that the seed will germinate and emerge in a timely manner.

Seed on the correct date. Cool-season grasses are normally established in either early spring or late summer. Spring seedings generally have plenty of moisture, but increased weed problems. A general rule is that early-spring plantings should be made four weeks before the last average killing frost in the spring. Late-summer seedings are at more risk of failure due to a lack of

Table 1. Seeding rates and dates for horse pastures in Virginia.

Forage Species	Seeding Rate lb/A	Time of Year to Plant
Orchardgrass	10-15	early spring and late summer
Tall Fescue	15-25	early spring and late summer
Timothy	6-8	early spring and late summer
Orchardgrass + Red Clover	8-10 + 6-8	early spring and late summer
Tall Fescue + Red Clover	10-15 + 6-8	early spring and late summer
Timothy + Red Clover	4-6 + 6-8	early spring and late summer
Orchardgrass + Ladino Clover	8-10 + 1-2	early spring and late summer
Tall Fescue + Ladino Clover	8-10 + 1-2	early spring and late summer
Annual Ryegrass	20-35	early spring and late summer
Small Grains	90-120	early spring and late summer
Pearl Millet	20-30	late spring-early summer
Bermudagrass with clay coating	8-12	late spring-early summer
Bermudagrass without clay coating	4-6	late spring-early summer
Crabgrass	3-6	late spring-early summer

moisture, but generally have fewer weed problems. It is critical to allow seedlings time to reach adequate size before winter, therefore late-summer plantings should be made at least four to six weeks before the first average killing frost in the fall. Plantings of warm-season grasses should be made in late spring or early summer after the soil has reached a temperature of 65°F. This usually occurs when night time temperatures remain in the 60s.

Seed at the proper rate. It is not uncommon for less than one-third of the sown seed to produce viable seedlings and only half of those to survive the first season. Therefore, seed must be applied at higher rates to obtain the desired stand densities. *It is important to remember that raising seeding rates above reasonable levels will not compensate for a rough seedbed or poor seeding methods.* Having approximately 20 plants per square foot at the end of the seeding year will result in a stand density of six plants per square foot the year after establishment. Seeding rates for commonly used forages are shown in Table 1.

Seed at the proper depth. Small-seeded forages have very little energy stored in the seed. Therefore, seed that is placed too deep will germinate, but not have enough energy to make it to the soil surface. On the other hand, seed that is placed too shallow may not have adequate moisture to germinate. In general, best results are obtained with a seeding depth of one-quarter to one-half inch. As a general rule, never place small-seeded forages deeper than one-half inch. *It is important to remember that proper seed placement cannot be obtained on poorly prepared seedbeds.* Seedbeds that are too soft will result in the seed being placed too deep.

Control weeds during establishment. Newly emerged forage seedlings are extremely susceptible to weed competition. Weeds compete for water, nutrients, and light. In pure grass stands, broadleaf weeds can be controlled with herbicides once grass seedlings have at least four leaves. No herbicides are available for mixtures of grasses and legumes. You can use frequent clipping to control weeds during establishment. Clip weeds down to a height of just above the desired forage seedlings. For clipping to be successful, it must be implemented in a timely manner and on a regular schedule until seedlings become established.

Do not graze new stands too early or frequently. Newly established forage stands do not develop into a fully mature sod until the second growing season after establishment. New stands should be grazed only after plants are well anchored. *Light and infrequent grazing can encourage the development of a healthy sod, but avoid overgrazing.* Feeding hay in a sacrifice/exercise area and limiting animal access to new stands is a good way to avoid overgrazing during the establishment period.

Fertilize newly established stands. Plants require nutrients to grow and persist. Apply lime, phosphorus, and potassium as needed according to the soil test. Pure grass stands will also require nitrogen fertilization. Nitrogen, along with proper defoliation management,

Forage Establishment at a Glance

- Control weeds prior to establishment.
- Soil test and adjust fertility six to 12 months prior to establishment.
- Choose a forage species that is adapted to the region, soil conditions in the pasture, and grazing.
- Always inoculate legume seed before planting.
- Prepare a fine and firm seedbed for conventional seeding.
- Suppress the sod and reduce surface residue prior to no-till seeding.
- Seed at the appropriate time of year.
- Never place seed deeper than one-half inch.
- Control weeds during establishment.
- Do not graze stands too early, closely, or frequently during the establishment period.
- Sods require 18 to 24 months to become fully established.
- Fertilize new stands to encourage the development of a healthy sod.

Virginia Cooperative Extension

PUBLICATION 442-305

Nutrient Management for Small Farms

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Introduction

The principles of nutrient management on small farms are similar to those of large farms. However, small farms may have a greater challenge when it comes to managing manure nutrients because of (1) the different characteristics of manure from the multiple animal species they keep, (2) the limited land area available to apply manure, and/or (3) a lack of equipment for manure management and spreading. The purpose of this publication is to outline how to quantify and determine use of manure nutrients in small farms as a crop fertilizer in order to prevent environmental damage that may be caused by nutrient losses.

What Is a Small Farm?

Small farms are diverse, ranging from retirement and residential farms with few off-farm sales to commercially oriented farms with annual sales approaching $250,000.

What Is Nutrient Management?

Nutrient management is the process used to handle the application of nutrients to crops, including their quantity, form, placement, and timing. On most farms, the nutrients predominantly come from manure and commercial fertilizer, but other sources, such as compost, can also be important. The purpose of nutrient management is to supply sufficient plant nutrients for optimum forage and crop yields, and thus prevent excess applications that can contaminate water quality. A nutrient management plan (NMP) documents the source, rate, method, and timing of nutrient applications.

Movement of Nutrients on a Farm

To manage manure effectively, it is important to consider the entire farm's nutrient balance. Figure 1 provides an overview of nutrient cycling on a farm. Usually, there is a tendency to focus on manure management alone, which may only account for a small part of the total nutrients. Nutrient dynamics include inputs, outputs, what is lost, and what is stored on the farm. It is necessary to consider the big picture in order to understand and identify the sources of nutrients potentially associated with environmental issues and how to develop solutions to deal with the problems they create.

Farm nutrient inputs include purchased animals, feed, fertilizer, legume nitrogen, and bedding. **Farm nutrient outputs** are products that are moved out of the farm through sales or given away, including animals, milk, meat, eggs, manure, and crops. Recycling of nutrients occurs on the farm when manures from livestock are used for crop fertilizer, and then the crops are harvested and fed to the livestock. The optimal goal is to have a situation whereby the farm can balance the inputs with crop and animal needs to minimize risk of environmental damage.

The major nutrients of interest are nitrogen (N) and phosphorus (P). Losses of N occur via leaching of nitrates to groundwater, volatilization of ammonia to the atmosphere, and phosphorus (P) runoff into the surface water. Phosphorus may also accumulate in the soil to levels greater than crop needs and cause excessive losses in runoff. Nutrients may leave the farm when manure is used for off-site energy generation (thermal and biological processes) and composting.

Estimating Manure Quantity and Nutrients on a Farm

In general, the quantity and nutrient content of manure depend on the species, breed, and age of the animal and the composition of feed in their diet. Table 1 presents quantity and nutrient content of freshly excreted manure from different animal species, usually referred to "as excreted."

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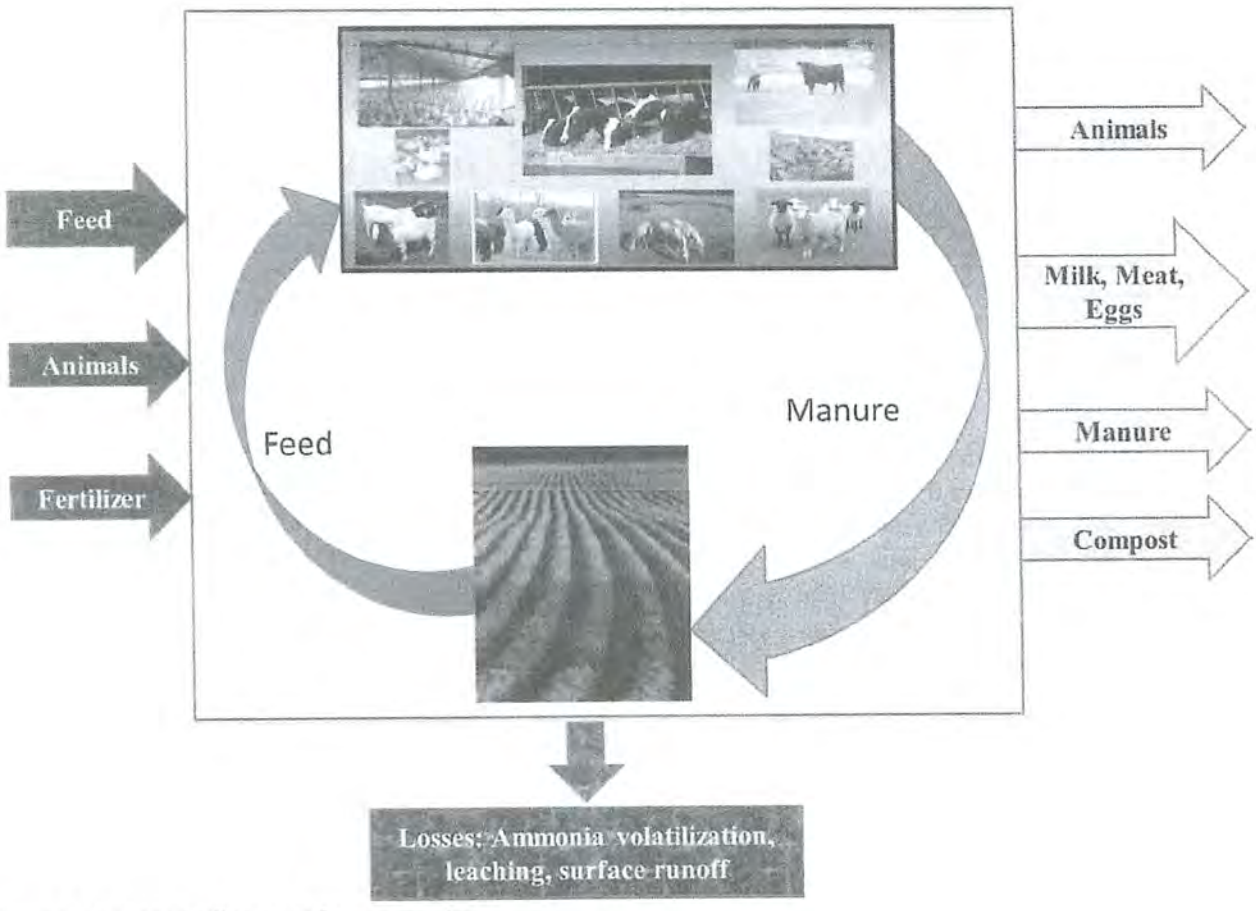

Figure 1. Nutrient cycling on a farm operation

The composition of manure applied to cropland is usually different from that of freshly excreted manure because of decomposition and losses during storage. The amount of loss depends on the climate, transformation of nutrients, storage period, and type of manure handling system used. Major losses are from N volatilization and leaching of soluble nutrients. Some studies have indicated that as much as 50 to 70 percent of N may be lost from manure (depending on how it is stored), due to ammonia volatilization and denitrification to dinitrogen gas (N_2). Phosphorus and potassium (K) losses are less likely except for manure not contained properly. Tables 2 and 3 present the nutrient content of stored manure for the common animal species in Virginia.

Manure quantities in table 1 are suitable for planning short-term storage and nutrient application where there is no manure storage on the farm. Tables 2 and 3 are useful in estimating the amount of nutrients that will be available for application to cropland after storage. The data in tables 2 and 3 also include standard deviations, which show how the nutrients in manure vary and how close individual manure samples are to the average value. These values should be used as a guide and only when manure analyses for your farm are not available.

Manure composition can vary widely, so testing is the most accurate way to determine nutrient content. Taking a representative sample from your manure is important because manure composition is not consistent. For example, manure on the surface of a pile will contain less N because of ammonia loss than that deeper in the pile. To learn how to take a representative sample, see the publication by Maguire, Hodges, and Crouse (2009), available online at *www.sera17.ext.vt.edu/Documents/P_Methods2ndEdition2009.pdf* (pages 72-75).

Also, all phosphorus in manure is considered plant-available. This is not the case for N because it is so mobile and exists in many forms. The total N and ammonium-N in manure are used to calculate the plant-available component, as described in *Soil Test Note No. 5: Fertilizing with Manures*, Virginia Cooperative Extension (VCE) publication 452-705 (*http://pubs.ext.vt.edu/452/452-705/452-705.pdf*). The example below shows how to estimate the nutrients on a farm with several animal species.

Table 1. Quantity of manure produced daily and nutrient concentrations as excreted by different animals.

Animal type	Weight (lb)	Quantity produced per day: Weight (lb)	Quantity produced per day: Volume (gal)	Moisture content (%)	Nutrients (lb/day per animal): Total N	Nutrients (lb/day per animal): Total P (P_2O_5)	Nutrients (lb/day per animal): Potassium (K_2O)
Dairy							
Lactating	Mature	150	18.00	87	0.99	0.39	0.28
Dry	Mature	83	9.72	87	0.50	0.15	0.40
Heifer	970	48	5.83	83	0.26	0.10	0.33
Calf	250	22	2.60	87	0.11	0.04	0.09
Beef							
Finishing	975	58	6.9	88	0.36	0.11	0.30
Cow (confined)	Mature	64	7.80	88	0.42	0.22	0.36
Calf (confined)	500	29	3.5	88	0.29	0.13	0.23
Horses	1,100	57	6.80	85	0.34	0.17	0.25
Poultry							
Broilers	2.5	0.2290	0.0265	74	0.0025	0.0017	0.0017
Layers	2.5	0.1900	0.0232	75	0.0035	0.0025	0.0016
Turkey							
Male (toms)	17	0.5850	0.0730	74	0.0090	0.0062	0.0051
Female (hens)	10	0.3620	0.0430	74	0.0054	0.0034	0.0029
Sheep	63	3.1800	0.4190	70	0.0319	0.0089	0.0316
Goats	64	3.4200	0.3800	64.5	0.0412	0.0092	0.0367

Source: ASABE 2005; MWPS 1993; Barker, Zublena, and Walls 2001.

Table 2. Average nutrient content (± standard deviation) of liquid manure for different animal species at the time of application in Virginia.

Animal	Samples (#)	Moisture content (%)	Nutrient (lb/1,000 gal): Total N	Ammonium-N	Total P (P_2O_5)	Potassium (K_2O)
Beef	59	93.1 (±2.3)	22.11 (±3.30)	9.51 (±1.52)	12.50 (±3.51)	19.61 (±3.42)
Dairy	1,181	94.0 (±1.3)	21.19 (±3.94)	9.18 (±0.52)	9.18 (±1.11)	21.25 (±9.79)
Swine	617	98.9 (±0.5)	9.06 (±0.93)	6.61 (±0.73)	4.20 (±1.32)	12.28 (±0.98)

Source: Virginia Department of Conservation and Recreation.

Table 3. Average nutrient content (± standard deviation) of solid manure for different animal species at the time of application in Virginia.

Animal	Samples (#)	Moisture content (%)	Nutrient concentration (lb/ton): Total N	Ammonium-N (NH_4-N)	Total P (P_2O_5)	Potassium (K_2O)
Dairy	384	65.8 (±2.6)	19.78 (±10.94)	2.99 (±0.72)	7.93 (±1.58)	17.98 (±9.87)
Beef	142	59.6 (±4.8)	23.81 (±10.98)	2.34 (±0.43)	12.71 (±2.50)	26.08 (±11.69)
Swine	6	46.1 (±27.1)	29.45 (±13.04)	7.80 (±1.98)	24.35 (±18.34)	10.75 (±5.93)
Broiler	2,025	27.8 (±0.6)	66.58 (±3.49)	11.05 (±0.61)	48.09 (±8.50)	54.25 (±2.26)
Layer (breeders)	436	30.7 (±2.0)	48.68 (±3.98)	8.45 (±0.54)	57.85 (±8.92)	44.77 (±2.72)
Turkey	1,017	29.5 (±1.0)	66.54 (±6.44)	13.5 (±0.41)	49.74 (±7.42)	41.73 (±5.31)
Turkey (breeders)	107	24.4 (±2.6)	59.18 (±5.60)	11.91 (±1.76)	57.45 (±9.72)	38.02 (±6.12)

Source: Virginia Department of Conservation and Recreation.

Example: Estimating Quantity and Nutrients in Manure

A farm has 50 lactating cows, five dry cows, 45 heifers, 40 goats (1-year-olds), 1,000 broilers, and five horses. Estimate (1) the amount of manure generated per year; (2) the nutrient content (nitrogen, phosphorus, and potassium) in manure excreted by each of the animals; and (3) the total nitrogen, phosphorus, and potassium produced on the farm annually.

The answers to this example can be obtained by using table 1.

1. Estimate the amount of manure generated in a year.For each animal species, estimate by multiplying "volume of manure produced per day" by the number of animals on the farm and the number of days in a year.

Lactating cows:
18 gal/animal-day × 50 animals × 365 days/year = 328,500 gal

Dry cows:
9.72 gal/animal-day × 5 animals × 365 days/year = 17,739 gal

Heifers:
5.83 gal/animal-day × 45 animals × 365 days/year = 95,758 gal

Goats:
0.38 gal/animal-day × 40 animals × 365 days/year = 5,548 gal

Broilers:
0.00265 gal/bird-day ×1,000 birds × 365 days/year = 9,673 gal

Horses:
6.8 gal/animal-day × 5 animals × 365 days/year = 12,410 gal

2. Estimate the amount of nutrients in the manure that are generated in a year.

For each animal species, estimate each nutrient — nitrogen, phosphorus, and potassium — by multiplying pounds of the nutrient in manure produced per day by the number of animals on the farm and the number of days in a year. The calculations for nitrogen values are presented below. You can estimate phosphorus and potassium using the same method and compare with the answers given in table 4.

Lactating cows:
0.99 lb N/animal-day × 50 animals × 365 days/year = 18,608 lb N

Dry cows:
0.5 lb N/animal-day × 5 animals × 365 days/year = 913 lb N

Heifers:
0.26 lb N/animal-day × 45 animals × 365 days/year = 4,271 lb N

Goats:
0.0412 lb N/animal-day × 40 animals × 365 days/year = 602 lb N

Broilers:
0.0025 lb N/bird-day ×1,000 birds × 365 days/year = 913 lb N

Horses:
0.34 lb N/animal-day × 5 animals × 365 days/year = 621 lb N

3. Estimate the total amount of manure and nutrients in the manure generated in a year.The total amount of manure and nutrients generated on the farm in a year is the sum of all the manure produced by each species, as shown in table 4.

Table 4: Total manure and nutrient production in a year.

Animal	Manure (gal)	N (lb)	P_2O_5 (lb)	K_2O (lb)
Dairy: lactating	328,500	18,608	7,118	5,293
Dairy: dry	17,739	913	274	730
Dairy: heifers	95,758	4,271	1,643	5,417
Goats	5,548	602	134	536
Broilers	9,673	913	621	621
Horses	12,410	621	310	456
Total	469,628	25,385	10,009	10,052

How To Decide Location and Nutrient Application Rates

Conduct a farm risk assessment using a farm map to determine appropriate areas for spreading. Consider slope, distance to water sources, erosion potential of the land where manure might be applied, and soil nutrient tests. Soil testing is the basis of good nutrient management, and soil samples should be taken regularly. Details regarding sampling procedures and laboratory methods are available at *www.soiltest.vt.edu*.

A soil sample should be taken every three to five years. From the soil test data, knowledge of the soil type, and the crop to be grown, nutrient and lime application rates can be determined for optimum crop growth. A three-year sampling interval is recommended for row crops and hay systems where nutrients are removed in harvested crops; a five-year sampling interval is acceptable for forage systems where grazing animals return nutrients to the soil through their manure. Soil pH must be kept within a specific range for each crop, and your soil test report will include the lime requirement (if any) along with nutrient recommendations. Lime supplies calcium, but the main benefit is to increase the pH of the predominantly acidic soils we have in Virginia.

Source of Nutrients

Once your soil test tells you the quantity of nutrients required in each field, the next step is to decide what source of nutrients to use. If you have manure on the farm, it is normally cheapest to use this before purchasing any commercial fertilizer. The problem with manure is that its ratio of nitrogen to phosphorus is low compared to crop requirements, so applying manure to meet crop nitrogen needs overapplies phosphorus (unless soil test phosphorus is low) and applying to meet crop phosphorus needs underapplies nitrogen. The solution to this is either (1) apply manure according to crop phosphorus needs or supplement with commercial nitrogen fertilizer; or (2) apply according to crop nitrogen needs once every three years, track soil test phosphorus, and use no phosphorus fertilizer or manure in the intervening two years.

Once you have decided where to use your manure, the remaining nutrient needs can be made up through commercial fertilizers. There are various fertilizers available that can be mixed to provide the correct quantities of the primary nitrogen, phosphorus, potassium, and other secondary and micronutrients. Common commercial fertilizers and how to calculate application rates are covered in *Fertilizer Types and Calculating Application Rates*, VCE publication 424-035 (*http://pubs.ext.vt.edu/424/424-035/424-035.pdf*).

Summary

Step 1: Estimate the total nutrients on your farm. Use manure analysis data for your farm if available. Otherwise, use local book values or general book values provided by professional organizations whose work involves manure.

Step 2: Test soils in the fields where manure is to be applied. This test will tell you the amount of nutrients needed for the planned crops for that field.

Step 3: Determine how much of the nutrients required by the crops in step No. 2 will come from manure. Plan use of manure based on the nutrient (phosphorus or nitrogen) that limits manure application.

Step 4: Determine how much supplemental commercial fertilizer is needed to meet crop nutrient needs for optimum production.

When and How to Apply

Lime takes time to react in the soil, so it should be applied several months in advance of planting or at the start of the growing season for perennials, if possible. Nutrients — especially nitrogen, which is very mobile in soil — should be applied as close to planting as possible or at the start of the growing season for perennials. This will maximize nutrient use by the crop and minimize unwanted losses through runoff and leaching that can be economically and environmentally damaging.

When deciding how to apply the nutrients, there are several factors to take into consideration, including manure and equipment availability and cropping system. Losses of nutrients in runoff are generally less if they can be placed under the soil surface, either through injection or incorporation. However, special equipment is needed for injection, while incorporation through tillage conflicts with forage and no-till systems and can increase soil erosion. Therefore, surface applications of manure or fertilizer are most common.

Record Keeping

Keeping good nutrient management plan records is critical for demonstration of good environmental stewardship. Records should include the necessary items

to help with proper development/improvement and implementation of the nutrient management plan. The records may be kept in various ways, ranging from a simple handwritten logbook to a detailed, computer-based spreadsheet. Records should document the quantity and location of nutrients on the farm.

The basic components of a record book consist of:
- Number and type of animals.
- Manure generated and inventory.
- Manure applied to land or used on the farm.
- Any manure (excess or otherwise) moved off the farm through sales or given away.
- Any other change that affects quantity of manure produced on the property that is not listed above.

Records should be maintained for a period of five years for other beneficial uses, which include making important business decisions that affect farm income; improving efficiency of production by evaluating the yields, soil tests, manure nutrients, and usage as a fertilizer; and using other commercial fertilizers. Although not a desirable situation, records provide the potential to reduce liability for producers should they be accused of environmental mismanagement. The records will help document responsibility and show the practices in place on the farm to manage nutrients.

Manure Records

Where animals are housed or confined, manure accumulation will occur, making manure collection and storage necessary. It is important to know the quantity and nutrient content of the manure to plan for its use. It is a good practice to collect and send manure samples for analysis.

Manure records should include:
- Sampling date.
- Sampling protocol.
- Name of the person who took the samples.
- Name of the analytical laboratory.
- Analytical results.

If manure is to be moved off the property, the records to keep include:
- Amount (volume or weight) of manure produced or handled.
- Date of manure transfer.
- Volume or weight of manure transferred.
- Name and address of person to whom manure is given or sold.

Storage

The two critical issues or questions one should consider about storage structures are their capacity and maintenance. Manure storage structures should have enough capacity to allow for the environmentally safe utilization of the manure and wastewater generated by an operation. "Environmentally safe utilization" means that manure and wastewater are not land-applied at times or under conditions that increase the likelihood of nutrients to enter surface water.

These conditions or periods include:
- High precipitation.
- Frozen or snow-covered ground.
- Saturated soil (with water and nutrients).
- Floods.
- Near the end of or after the growing season, when crops cannot take up applied nutrients.

Adequate capacity will provide the operator with the flexibility to make changes to the NMP, especially if manure storage for a longer time is required. Details on how to site, size, and maintain a storage structure can be found in *Selection and Location of Poultry and Livestock Manure Storage*, VCE publication 442-307 (*http://pubs.ext.vt.edu/442/442-307/442-307.pdf*); and *Poultry and Livestock Manure Storage: Management and Safety*, VCE publication 442-308 (*http://pubs.ext.vt.edu/442/442-308/442-308.pdf*).

Specific records to keep for manure storage are:
- Animal numbers (monthly or weekly).
- Storage capacity.
- Storage volumes or levels recorded weekly.
- Any changes to the storage structure.
- Dates and quantities of any discharges from storage and corrective measures taken to manage the discharges.
- Notes on weekly or regular inspections of the storage structure's integrity, including the liquid depth marker.
- Other information.

Land Application

Records concerning land application activities that the farmer is to maintain should be specified in the plan. Land application records are critical because they enable farmers to demonstrate that they are applying manure and wastewater in accordance with a site-specific NMP. Land application records will demonstrate that the manure and wastewater are being applied in accordance with the requirements of the NMP.

Specific records for land application include:

- Location and description of land where manure is applied.
- Area of land where manure is applied.
- Date the manure is applied.
- Volume or weight of manure applied.
- Application rates of manure nutrients and fertilizer by field and year.
- Manure incorporation methods.
- Weather conditions at the time of application and 24 hours before and after application.
- Explanation of the basis for determining manure application rates.
- Calculations showing the total nitrogen and phosphorus to be applied to each field, including sources other than manure, litter, or process water.
- Total amount of nitrogen and phosphorus actually applied to each field, including documentation of calculations for the total amount applied.
- Methods used to apply the manure, litter, or process water.
- Dates of manure application equipment inspection.
- Expected crop yields.
- Soil test results.
- Conservation practices to reduce nutrient losses.

Other Records

- Mortality management.
- Manure and wastewater analysis.
- Soil tests.
- Crop yields.
- Equipment inspections and calibrations.
- Handling, use, and management of chemicals on the farm.

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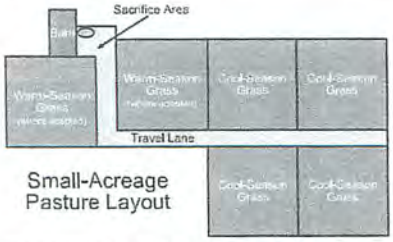
Maintaining Healthy Horse Pastures

C.D. Teutsch, Virginia Tech, and S.R. Smith, University of Kentucky

Well-maintained pastures can serve as an economical and high-quality feed source. Here a mature pleasure horse grazes contently in a field of annual ryegrass.

Horses can graze very closely. In this photo a horse grazes a bermudagrass sod too close.

Close and frequent grazing weakened this sod, resulting in a pasture that is less productive and more susceptible to erosion and weed encroachment.



This is an example of a small-acreage pasture layout for pleasure horses. The inclusion of a warm-season grass provides grazing during the summer.

Pasture Management

Once pastures have been established (18-24 months after planting), sound pasture management is critical for maintaining a healthy and vigorous sod that benefits the horse, owner, and environment.

SOIL TEST PASTURES. Pastures should be soil tested every 2-3 years in order to provide a baseline for tracking changes in pH and fertility.

MAINTAIN ADEQUATE SOIL PH. Soil pH can dramatically affect nutrient availability and plant growth. Maintain pH between 6.2 and 6.5 for grass-legume pastures by applying lime according to the soil test.

MAINTAIN ADEQUATE PHOSPHORUS AND POTASSIUM. Phosphorus and potassium should be maintained in the high range as determined by soil testing.

DISTRIBUTE DUNG PILES. Drag pastures to distribute dung piles and encourage uniform grazing.

PROVIDE 2-3 ACRES PER HORSE. If land area is limited, grazing must be controlled to maintain healthy pastures.

SUBDIVIDE PASTURES. Establish four or more pastures and graze them rotationally.

REST PASTURES BETWEEN GRAZING EVENTS. Resting pastures allows plants to replenish food reserves. Allow pastures to regrow to a height of 8-10". In the spring when cool-season grasses are growing rapidly, rest periods will be shorter. In midsummer when plant growth is slower, rest periods will be longer.

LEAVE PLENTY OF LEAF AREA. Do not graze closer than 2-4". Leaving plenty of leaf area results in faster regrowth and helps maintain a vigorous sod. Horses tend to graze some areas closer than others, so rotate horses to a fresh pasture when heavily grazed areas are at 2-4". Clip ungrazed areas of the pasture.

DO NOT GRAZE PASTURES WHEN PLANTS ARE NOT GROWING. Feed hay in a sacrifice area to avoid overgrazing pastures during the winter and summer.

REMOVE HORSES FROM PASTURES DURING WET WEATHER. Hoof action can seriously damage established sods during wet periods of the year. Place horses in the sacrifice area and feed hay when the soil is soft.

Pasture Layout and Design

Proper pasture design allows horse owners to control grazing. In some cases it is advisable to establish a permanent perimeter fence and cross-fence with temporary fencing until a suitable layout is found.

INDIVIDUAL PASTURES SHOULD BE SQUARE. Long and narrow or odd shaped pastures are not uniformly grazed.

PASTURES SHOULD BE UNIFORM. Pastures should contain similar forage species, soil types, slopes, and aspects.

HORSES SHOULD HAVE ACCESS TO FRESH WATER AND SHADE. Ideally, each pasture should contain water and shade. In some cases lanes can allow access to the barn from all pastures (see small-acreage example).

LIMIT ACCESS TO TREES. Trees should be fenced out to prevent girdling.

ESTABLISH A SACRIFICE AREA. Allow 600 to 1,000 sq ft per horse of well-drained area located near the barn. In most cases a rock pad will be required to keep area from becoming muddy (see diagram of rock pad).

USE ELECTRIFIED POLYTAPE TO CONTROL GRAZING. For this type of fencing to be effective, it must be electrified at all times.

Healthy pasture sods supply a safe exercise surface for growing foals.

Sacrifice areas often become muddy and require the construction of a rock pad.

Rock pads are constructed by placing geotextile fabric over the soil, covering it with 4-6" of No. 4 rock, and capping the rock with 2-4" of sifted lime.

Trees must be fenced out to avoid girdling by horses. In this photo an unfenced tree has been fatally injured.

For more information on maintaining healthy horse pastures, contact your local Virginia Cooperative Extension Office or visit the Virginia Cooperative Extension website at http://www.ext.vt.edu/resources/.

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