A4034

Soil Fertility Guidelines for Pastures in Wisconsin

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The objective of University of Wisconsin-Extension soil fertility guidelines is to help farmers maintain an adequate supply of soil nutrients that support economically optimal yield and quality of the crops grown, while minimizing nutrient losses to the environment (figure 1).

Nutrient application guidelines for pastures for the primary nutrients—nitrogen(N), phosphorus (P), and potassium (K)—and lime are:

- ✓ Based on soil sampling and lab analysis (soil testing);
- ✓ Specific to the forage species in the pasture and estimated yield goal along with the texture of the soil in the pasture;
- ✓ Reduced according to the amount of nutrients estimated to come from manure (feces and urine) deposited by the grazing livestock. If grazing is managed to allow for good distribution of the manure across the pastures, supplemental nutrient additions from fertilizer or other sources may be minimal.

Figure 1. Pasture nutrient balance.

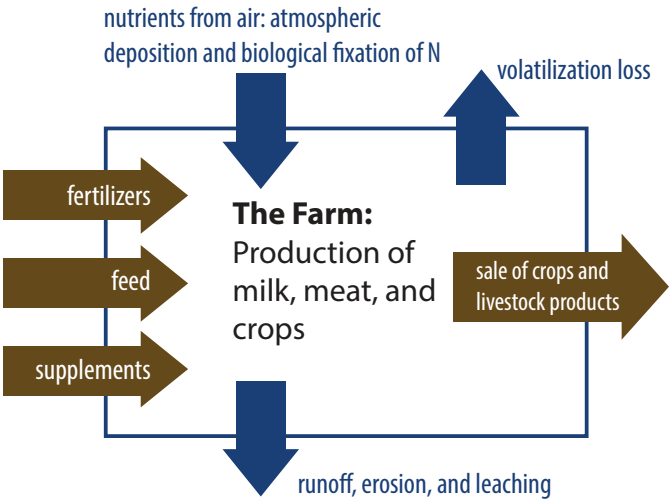
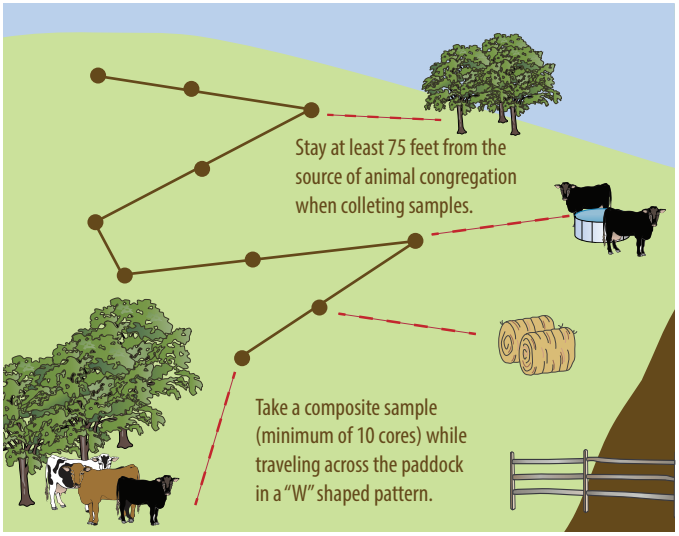


Figure 2. Soil sampling guidelines for pasture.



Soil sampling and testing

Soil fertility guidelines for crops grown in Wisconsin, including pasture forages, are based on soil testing. Soil testing measures plant-available nutrients as well as acidity levels (pH). If soil testing determines that P or K levels are potentially limiting, nutrient applications will be recommended. These nutrients can be supplied with fertilizer applications or may be met by deposition, or application, of manure. Agricultural lime applications will be recommended if soil acidity is greater than optimal (low soil pH), especially when legumes are included in the pasture mix.

Care must be taken to collect representative soil samples so that test results accurately portray the soil fertility of the pasture. Generally, one composite sample should be taken per five acres of field or paddock (management unit). If paddocks are smaller than five acres, then two or more paddocks with similar management history can be combined into one management unit for sampling. A composite sample is made up of a minimum of 10 soil cores taken to a depth of 6 inches with a soil probe. The ten cores should be collected in a "W" shaped pattern across the management unit (figure 2). Cores should be collected in a bucket, thoroughly mixed, and then placed in a labeled bag for delivery to the lab.

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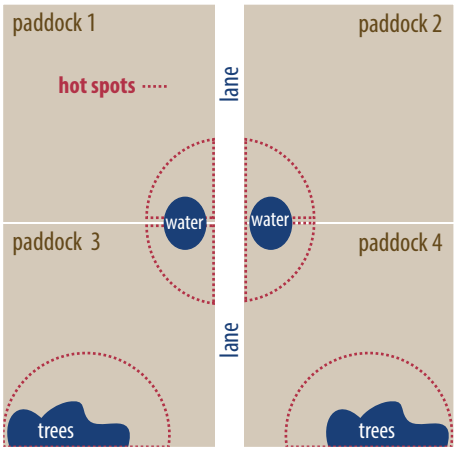
Figure 3. Soil sampling guidelines for pasture hotspots.

If you have hot spots in pastures that are similarly managed, then you can sample these areas separately and combine them into a composite sample, as long as sample density does not exceed one composite sample per five acres.



Research measuring manure distribution across pastures often shows soil nutrient gradients with higher concentrations (hot spots) near places where livestock congregate and loaf, such as near water sources, lanes, supplemental feed bunks, and trees or shade. Meanwhile, less manure deposition in other areas may result in zones of net nutrient removal and possible nutrient shortages. When sampling, avoid the hot spot areas so that overall results are not biased toward higher fertility than really exists for most of the paddock. As a general rule, stay at least 75 feet from sources of animal congregation when collecting samples. In addition, congregation areas may be sampled separately, combining similar hot spot areas into a management unit. When sampling hot spots separately from the main paddock, sample density should not exceed one composite sample per five acres (figure 3) for the hot spots or main paddock management units.

For complete information on soil sampling and submitting samples to a state-certified lab, see *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* (A2809), pages 3–8. Only soil test results from Wisconsin DATCP-certified laboratories may be used for nutrient management plans being developed with cost-share dollars. A list certified laboratories is provided at http://uwlab.soils.wisc.edu/wdatcp/.

Soil testing quick tips

1. Collect soil samples so that soil test results accurately represent the soil fertility of the pasture. **Generally, one composite sample should be taken per five acres of field or paddock (management unit).**
2. A composite sample is made up of a minimum of 10 soil cores taken to a depth of 6 inches with a soil probe. The ten cores should be collected in a "W" shaped pattern across the management unit (figure 2).
3. Samples should be collected 75 feet away from congregation areas (hot spots).
4. Hot spots may be combined into a management unit and sampled separately.
5. Soil cores for a composite sample should be collected in a bucket, thoroughly mixed, and then placed in a labeled bag for delivery to the laboratory.
6. Fill out the soil information sheet. A completely and carefully filled out information sheet will provide the most accurate nutrient recommendations.

Nutrient application guidelines

Soil pH and lime requirement

Managing soil pH is a critical component to a soil fertility program because soil pH regulates nutrient availability and influences microbial reactions in the soil. In addition, legumes have symbiotic relationships with N-fixing bacteria that are pH -dependent. Grass-based pastures that contain less than 30% of any legume species should have soil pH maintained at a target pH of 6.0. Pastures with legume-grass mixtures where the legume is more than 30% of the species, as well as red clover pastures, should have soil pH maintained at 6.3. The soil pH for alfalfa should be maintained at 6.8.

A pasture should be limed if the soil pH is more than 0.2 units below the target pH. Lime recommendations are based on soil pH as well as the buffer pH. Table 1 provides the lime recommendations for pastures with a target pH of 6.0 and 6.3, respectively. Lime recommendations are capped at 4 tons per acre (t/a) of 60-69 grade lime even though more lime may be needed to reach the target pH. This is because there is limited incorporation of the lime by bioturbation (e.g. hoof action, soil biota movement) in the pasture. Soil sampling every four years is a good way to monitor soil pH. Soil pH and lime requirement for both 60-69 neutralizing index (NI) and 80-89 NI limes will be given on a soil test report from most labs.

To adjust the lime recommendation for limes other than 60-69 grade, use the following formula:

Lime requirement (t/a) of lime being used =
(t/a of 60-69 lime recommended) x
(65 ÷ NI* of lime being used)

*When a range is given, use the midpoint (e.g., for 80-89 grade lime, use 85 in the calculation).

Table 1. Lime recommendations for pasture.

	Buffer pH*					
	6.3	6.4	6.5	6.6	6.7	6.8
	---------- tons/a of 60-69 grade lime to apply ----------					
Soil pH	Target pH = 6.0					
5.0	4.0	4.0	4.0	3.5	3.0	2.0
5.1	4.0	4.0	4.0	3.5	2.5	2.0
5.2	4.0	4.0	3.5	3.0	2.0	1.5
5.3	4.0	4.0	3.5	2.5	2.0	1.0
5.4	4.0	3.5	3.0	2.0	1.5	1.0
5.6	3.5	3.0	2.0	1.5	1.0	1.0
5.7	3.5	2.5	2.0	1.0	1.0	1.0
5.8	3.0	2.0	1.5	1.0	1.0	1.0
	Target pH = 6.3					
5.0	4.0	4.0	4.0	4.0	2.5	1.5
5.1	4.0	4.0	4.0	3.5	2.5	1.0
5.2	4.0	4.0	4.0	3.5	2.0	1.0
5.3	4.0	4.0	4.0	3.0	1.5	1.0
5.4	4.0	4.0	4.0	2.5	1.5	1.0
5.6	4.0	4.0	3.5	2.0	1.0	1.0
5.7	4.0	4.0	3.0	1.5	1.0	1.0
5.8	4.0	4.0	2.5	1.5	1.0	1.0
6.0	4.0	3.5	2.0	1.0	1.0	1.0
6.1	4.0	3.0	1.5	1.0	1.0	1.0

* If buffer pH is <6.3, apply 4.0 t/a of 60-69 lime for any soil pH if lime is needed. If buffer pH is >6.8, apply 1.0 t/a of 60-69 lime for any soil pH, if lime is needed.

Note about crops

This publication addresses the main pasture crop categories from *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* (A2809). Information on additional forage crop categories, such as red clover, alfalfa, birdsfoot trefoil, or reed canarygrass can be found in A2809.

Nitrogen

When a pasture sward contains a significant percentage of legumes such as alfalfa or clovers, nitrogen additions are not recommended. The legume species biologically fix N for their own use and provide some N to companion grasses as legume plant roots, crowns, and leaves decompose and regenerate. The grasses will generally benefit from added N, but to the detriment of the desired legumes which will not compete with the N-fed grasses. When a pasture sward is composed entirely of grass, manure and urine deposition often do not supply enough available N for optimal forage production. The guidelines in table 2 are based on the pasture's soil organic matter content (as determined by the soil test) and whether the pasture is being seeded or is already established. For legume-grass pastures, a small amount of N is recommended only at seeding.

Nitrogen applications should be split into two or three applications through the growing season. Nitrogen application will stimulate growth. Therefore split N applications in early- to mid-June and early- to mid-August will promote more even pasture production through the season. Ideally application of urea-based fertilizers should be applied ahead of rainfall to limit ammonia volitilization.

Table 2. Nitrogen fertilization guidelines for pastures.

Crop	Yield range per acre	Soil organic matter content (%)			
		< 2.0	2.0–9.9	10.0–20.0	> 20.0
		---------- lb N/a to apply ----------			
Pasture, grass[a,b]	0.5–5 ton	160	130	100	50
Pasture, ≤ 30% legume-grass, seeding	0.5–1.9 ton	40	20	0	0
Pasture, ≤ 30% legume-grass, established	2–5 ton	0	0	0	0
Pasture, > 30% legume-grass, seeding	0.5–1.9 ton	30	10	0	0
Pasture, > 30% legume-grass, established	2–5 ton	0	0	0	0
Pasture, unimproved[a]	1–4 ton	120	100	70	30

[a]Split N applications into two to three applications per year.
[b]Grass = bromegrass, orchardgrass, fescue, ryegrass, timothy (any combination).

Table 3. Soil test phosphorus (P) and potassium (K) interpretation levels for pastures.

		Soil test category					
		Very low (VL)	Low (L)	Optimum (O)	High (H)	Very high (VH)	Excessively high (EH)
	Soil group[a]	soil test K ppm					
Soil Test P	Loamy	< 10	10–15	16–20	21–30	—	> 30
	Sandy, Organic	< 12	12–22	23–32	33–42	—	> 42
Soil Test K	Loamy	< 70	70–100	101–130	131–160	161–190	> 190
	Sandy, Organic	< 45	45–65	66–90	91–130	—	> 130

[a]For more details on soil groups see *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* (A2809), Chapter 4.

Table 4. Phosphorus (P) and potassium (K) nutrient application guidelines for pastures.

		P_2O_5 rate guidelines					K_2O rate guidelines					
Crop name	Yield goal (per acre)	VL	L	O	H	EH	VL	L	O	H	VH	EH
		lb P_2O_5/a to apply					lb K_2O/a to apply					
Pasture, grass[a, b]	0.5–1.9 ton	60	50	20	10	0	115	100	70	35	20	0
	2–3 ton	80	70	40	20	0	185	170	140	70	35	0
	3.1–4 ton	95	85	55	30	0	240	225	195	100	50	0
	4.1–5 ton	110	100	70	35	0	295	280	250	125	65	0
Pasture, ≤ 30% legume-grass[b]	0.5–1.9 ton	55	45	15	10	0	110	95	65	35	15	0
	2–3 ton	75	65	35	20	0	175	160	130	65	35	0
	3.1–4 ton	85	75	45	25	0	225	210	180	90	45	0
	4.1–5 ton	100	90	60	30	0	275	260	230	115	60	0
Pasture, > 30% legume-grass[b]	0.5–1.9 ton	55	45	15	10	0	120	105	75	40	20	0
	2–3 ton	75	65	35	20	0	195	180	150	75	40	0
	3.1–4 ton	85	75	45	25	0	255	240	210	105	55	0
	4.1–5 ton	100	90	60	30	0	315	300	270	135	70	0
Pasture, unimproved[b]	1–2 ton	65	55	25	15	0	100	85	55	30	15	0
	2.1–3 ton	80	70	40	20	0	135	120	90	45	25	0
	3.1–4 ton	95	85	55	30	0	170	155	125	65	30	0

[a]Includes bromegrass, fescue, orchardgrass, ryegrass, and timothy.

[b]P_2O_5 and K_2O guidelines for pasture make no assumptions about manure/urine deposition. Nutrient credits for manure/urine deposition should be subtracted from these rates.

Phosphorous and potassium

Management intensive grazing systems with good manure distribution often result in efficient cycling of phosphorous and potassium between grazing livestock and forage production. The need for supplemental P and K inputs may be minimal, particularly when grazing livestock are supplemented with other feeds. The need for P and K additions is best determined by soil testing every four years (see *Sampling Soils for Testing* chapter in A2809 for guidelines). Applications guidelines for P and K (table 4) for each of the four pasture crop categories are based on the soil test interpretation level (table 3) and pasture forage yield goal.

Yield goals should be based on historic yields from the pasture and reasonable goals for improvement based on forage need and management level. Several methods can be employed for estimating and tracking pasture yields, including hand clipping from sampling squares, keeping records of grazing days and livestock gains, using pasture sticks (USDA-NRCS) or a pasture plate. See *Pastures for Profit* (A3529) for guidance on estimating pasture productivity.

Nutrient crediting

Nutrients deposited on pastures in manure and urine should be credited against the suggested N, P_2O_5, and K_2O application rates. Nutrient credits are based on the amount of manure deposited (t/a) and the nutrient content of the manure. Table 5 provides nutrient contents for manures from livestock species commonly grazed in Wisconsin. For these species, 40% of the total N and 80% of the total P_2O_5 and K_2O deposited should be credited each year. The N credits assume that 30% of the total N deposited is available in the year of deposition (1st year credit) and an additional 10% of total N is available in the year after deposition (2nd year credit). For P and K, 80% of the P_2O_5 and K_2O deposited are available as 1st year credits.

The availability of manure and urine nutrients will not total 100% for a several reasons:

- ✓ The deposited nutrient amounts are an estimation, not an exact amount.
- ✓ Some of the nutrients are incorporated into soil organic matter and microbial pools.
- ✓ Nutrient losses—such as ammonia volatilization, leaching and denitrification of nitrate, and surface runoff of all nutrients—can occur.

The amount of manure deposited on a pasture can be estimated according to the number of animals of a given species, their size, and the amount of time spent grazing the pasture. Daily manure production estimates for the major livestock species have been developed and are published by the Midwest Plan Service (table 6). They can also be obtained from your UW-Extension county office, county land

Table 5. Estimated total and available nutrient contents in deposited manure/urine in pasture systems.

		Total Nutrients			Available Nutrients		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
	Dry Matter %	lb/ton			lb/ton		
Beef	8	14	4	9	6	3	7
Dairy	13	10	4	7	4	3	6
Sheep	25	19	10	19	8	8	15
Goat	32	22	5	15	9	4	12
Horse	14	7	2	2	3	2	2

P and K note

Application guidelines for P and K are given in their oxide forms, P_2O_5 (phosphate) and K_2O (potash), which is how fertilizer nutrients are expressed.

and water conservation department, or from the Wisconsin Department of Agriculture Trade and Consumer Protection (WDATCP) on their farm nutrient management planning web page at http://datcp.wi.gov/Farms/Nutrient_Management/index.aspx. These manure production values, and the associated nutrient contents, are also used within the SnapPlus software for farm nutrient management planning. SnapPlus contains a Grazing Herd Setup where total daily manure production can be calculated and a Grazing Application Rate Estimator where manure deposition on a paddock-by-paddock basis can be determined (see back page).

Nutrient credits should also be taken when manure is collected from other places on the farm such as milking centers and feedlots, and then mechanically applied to pastures. In this case, the nutrient composition and availability of the collected manure will be different than feces and urine that are directly deposited on pastures; the estimated available nutrients in table 5 should not be used. To obtain more appropriate nutrient credits for mechanically applied manure, see *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* (A2809), pages 73–77.

Nutrient crediting example

	N	P_2O_5	K_2O
	---------- (lb/acre) ----------		
Soil test recommendation for a managed/rotation grass pasture (soil test = optimum for P and K, 3% OM, yield goal = 3.5 tons/acre) →	130	55	195
Credit for estimated beef cattle manure deposited in the pasture = 4.5 tons/acre @ 6-3-7 →	27	14	32
	103	41	163

Subtract the nutrient credits from the suggested nutrient application rates to get fertilizer/supplemental nutrients to apply.

Tips for good manure and urine distribution

The ability of a grazier to depend on nutrient credits from manure deposition will depend on relatively even manure distribution across the pastures and within paddocks. Practices shown to improve manure and urine distribution by grazing livestock include:

- ✓ Maintaining uniform grazing pressure in small areas for short periods of time, then rotating livestock to the next paddock. This reduces the potential for livestock to graze selectively, feeding more in some areas than in others;
- ✓ Providing water sources throughout the pasture so that livestock do not need to leave the rotated grazing areas to drink. Cattle oilers, scratchers, and supplemental feed bunks are best moved out to grazing areas for nutrient distribution purposes as well;
- ✓ Limit access to areas where livestock routinely congregate and lay when not grazing, such as shade or shelter, when these areas are not essential.

Table 6. Grazing manure application rate estimator worksheet. Source: *Livestock Waste Facilities Handbook, Midwest Plan Sevice Technical Bulletin #18.*

Animal type-weight (lbs)	Number of animals		Daily manure production (lbs/day)		Days on pasture		Percent of each day spent grazing		Total pasture manure production (tons)
Dairy									
Calf-150	( )	x	13	) x	( )	x	)	÷ 2,000 =	
Calf-250	( )	x	21	) x	( )	x	)	÷ 2,000 =	
Heifer-750	( )	x	65	) x	( )	x	)	÷ 2,000 =	
Heifer-1,000	( )	x	82	) x	( )	x	)	÷ 2,000 =	
Lact. cow-1,000	( )	x	106	) x	( )	x	)	÷ 2,000 =	
Lact. cow-1,200	( )	x	127	) x	( )	x	)	÷ 2,000 =	
Lact. cow-1,400	( )	x	148	) x	( )	x	)	÷ 2,000 =	
Dry cow-1,000	( )	x	82	) x	( )	x	)	÷ 2,000 =	
Dry cow-1,200	( )	x	99	) x	( )	x	)	÷ 2,000 =	
Dry cow-1,400	( )	x	115	) x	( )	x	)	÷ 2,000 =	
Beef									
Calf-450	( )	x	26	) x	( )	x	)	÷ 2,000 =	
High forage-750	( )	x	62	) x	( )	x	)	÷ 2,000 =	
High forage-1,100	( )	x	92	) x	( )	x	)	÷ 2,000 =	
High energy-750	( )	x	54	) x	( )	x	)	÷ 2,000 =	
High energy-1,100	( )	x	80	) x	( )	x	)	÷ 2,000 =	
Cow-1,000	( )	x	63	) x	( )	x	)	÷ 2,000 =	
Bull-1,400	( )	x	115	) x	( )	x	)	÷ 2,000 =	
Other									
Sheep-100	( )	x	4	) x	( )	x	)	÷ 2,000 =	
Horse-1,000	( )	x	5	) x	( )	x	)	÷ 2,000 =	
Goat-170	( )	x	7	) x	( )	x	)	÷ 2,000 =	

+ (Dairy)

+ (Beef)

+ (Other)

Total pasture manure (tons) ( )

÷ Total pasture size (acres) ( )

= Pasture manure application rate (tons/acre) ( )

Additional information

Midwest Plan Service, 2000. *Livestock Waste Facilities Handbook*. Publication 18, 112 pp. ISBN 0-89373-089-0. https://www-mwps.sws.iastate.edu/catalog/manure-management/livestock-waste-facilities-handbook

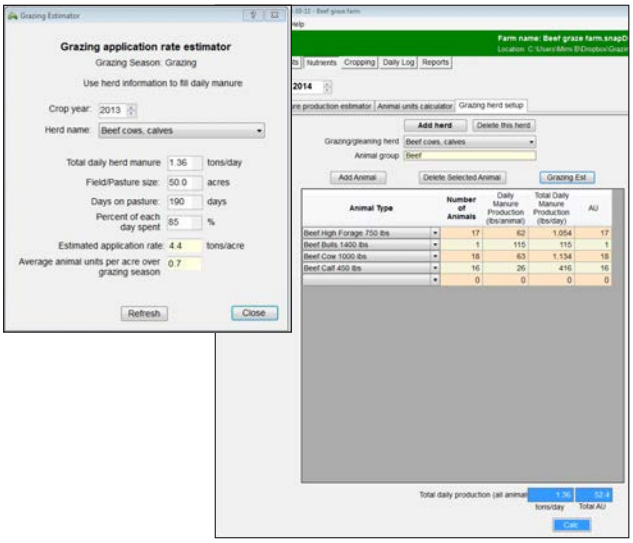
UW-Extension Team Forage website and *Grazier's Notebook Fact Sheets*. http://www.uwex.edu/ces/crops/teamforage/index.html

UW-Extension publications

Nutrient Application Guidelines for Field, Vegetable and Fruit Crops in Wisconsin (A2809). http://learningstore.uwex.edu/Nutrient-Application-Guidelines-for-Field-Vegetable-and-Fruit-Crops-in-Wisconsin-P185.aspx

Pastures for Profit (A3529). http://learningstore.uwex.edu/Pastures-for-Profit-A-Guide-to-Rotational-Grazing-P96.aspx

SnapPlus has grazing tools that estimate pasture manure amounts and application rates.



SnapPlus Software: snapplus.wisc.edu

Important note for SnapPlus users: The terminology for pastures in A2809 does not exactly match those used in SnapPlus. Use the table below to cross-reference the pasture names.

A2809 crop name	SnapPlus crop name
Pasture, grass	Pasture seeding, grass
	Pasture, rotational stocking, grass
	Pasture, variable stocking, managed continuous
Pasture, < 30% legume-grass, seeding	Pasture seeding, grass/legume
Pasture, < 30% legume-grass, established	Pasture, rotational stocking, grass/legume
	Pasture, variable stocking, managed continuous, grass/legume
Pasture, > 30% legume-grass, seeding	Pasture seeding, legume more than 30%
Pasture, > 30% legume-grass, established	Pasture, rotational stocking, legume more than 30%
	Pasture, variable stocking, managed continuous, legume more than 30%
Pasture, unimproved	Pasture, continuous stocking, high density
	Pasture, continuous stocking, low density
Idle land (no recommendations)	Pasture, dry lot, exercise area

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