

**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**FORAGE AND BIOMASS PLANTING**

(Ac.)

**CODE 512**

**DEFINITION**

Establishing adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production.

**PURPOSE**

- Improve or maintain livestock nutrition and/or health.
- Provide or increase forage supply during periods of low forage production.
- Reduce soil erosion.
- Improve soil and water quality.
- Produce feedstock for biofuel or energy production

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies all lands suitable to the establishment of annual, biennial or perennial species for forage or biomass production. This practice does not apply to the establishment of annually planted and harvested food, fiber, or oilseed crops.

**CRITERIA**

**General Criteria Applicable to All Purposes**

Select plant species and their cultivars based on:

- Climatic conditions, such as annual precipitation and its distribution, growing season length, temperature extremes and the USDA Plant Hardiness Zone.

- Soil condition and landscape position attributes such as; pH, available water holding capacity, aspect, slope, drainage class, fertility level, salinity, depth, flooding and ponding, and levels of phytotoxic elements that may be present.
- Resistance to disease and insects common to the site or location.

Follow recommendations for planting rates, methods and dates obtained from the plant materials program, land grant and research institutions, extension agencies, or agency field trials.

Seeding rates will be calculated on a pure live seed (PLS) basis.

Plant at a depth appropriate for the seed size or plant material, while assuring uniform contact with soil.

Prepare the site to provide a medium that does not restrict plant emergence.

Plant when soil moisture is adequate for germination and establishment.

All seed and planting materials will meet state quality standards.

Do not plant federal, state, or local noxious species.

Apply all plant nutrients and/or soil amendments for establishment purposes according to a current soil test. Application rates, methods and dates are obtained from the plant materials program, land grant and research institutions, extension agencies, or agency field trials.

When planting legumes, use pre-inoculated seed or inoculate with the proper viable strain of Rhizobia immediately before planting.

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Exclude livestock until the plants are well established.

Select forage species based on the intended use, level of management, realistic yield estimates, maturity stage, and compatibility with other species. Verify plant adaptation to the area prior to planting.

**Additional Criteria for Improving or Maintaining Livestock Nutrition and/or Health**

Use forage species that will meet the desired level of nutrition (quantity and quality) for the kind and class of the livestock to be fed.

Forage species planted as mixtures will exhibit similar palatability to avoid selective grazing.

**Additional Criteria for Providing or Increasing Forage Supply During Periods of Low Forage Production**

Select plants that will help meet livestock forage demand during times that normal farm/ranch forage production are not adequate.

**Additional Criteria for Reducing Erosion and Improving Water Quality.**

Ground cover and root mass need to be sufficient to protect the soil from wind and water erosion.

**Produce Feedstocks For Biofuel or Energy Production**

Select plants that provide adequate kinds and amount of plant materials needed.

**CONSIDERATIONS**

In areas where animals congregate consider establishing persistent species that can tolerate close grazing and trampling.

Where wildlife and pollinator concerns exist, consider plant selection by using an approved habitat evaluation procedure.

Where air quality concerns exist consider using site preparation and planting techniques

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that will minimize airborne particulate matter generation and transport.

Where carbon sequestration is a goal select deep rooted perennial species that will increase underground carbon storage.

During and upon stand establishment planning and application of the following conservation practices should be considered as applicable; Forage and Biomass Harvest (511), Herbaceous Weed Control (315), Nutrient Management (590), and Prescribed Grazing (528).

**PLANS AND SPECIFICATIONS**

Prepare plans and specifications for the establishment planting for each site or management unit according to the Criteria, Considerations, and Operations and Maintenance described in this standard. Record them on a site specific job sheet or in the narrative of a conservation plan.

The following elements will be addressed in the plan to meet the intended purpose:

- Site Preparation
- Fertilizer Application (if applicable)
- Seedbed/Planting Bed Preparation
- Methods of Seeding/Planting
- Time of Seeding/Planting
- Selection of Species
- Type of legume inoculant used (if applicable)
- Seed/Plant Source
- Seed Analysis
- Rates of Seeding/Planting
- Supplemental Water for Plant Establishment (if applicable)
- Protection of Plantings (if applicable)

**OPERATION AND MAINTENANCE**

Inspect and calibrate equipment prior to use. Continually monitor during planting to insure

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proper rate, distribution and depth of planting material is maintained.

Monitor new plantings for water stress. Depending on the severity of drought, water stress may require reducing weeds, early harvest of any companion crops, irrigating when possible, or replanting failed stands.

**REFERENCES**

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**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**PRESCRIBED GRAZING**

(Ac.)

**CODE 528**

**DEFINITION**

Managing the harvest of vegetation with grazing and/or browsing animals.

**PURPOSE**

This practice may be applied as a part of conservation management system to achieve one or more of the following:

- Improve or maintain desired species composition and vigor of plant communities.
- Improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity.
- Improve or maintain surface and/or subsurface water quality and quantity.
- Improve or maintain riparian and watershed function.
- Reduce accelerated soil erosion, and maintain or improve soil condition.
- Improve or maintain the quantity and quality of food and/or cover available for wildlife.
- Manage fine fuel loads to achieve desired conditions.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all lands where grazing and/or browsing animals are managed.

**CRITERIA**

**General Criteria Applicable to All Purposes**

Removal of herbage will be in accordance with

site production limitations, rate of plant growth the physiological needs of forage plants and the nutritional needs of the animals.

Adequate quantity and quality drinking water will be supplied at all times during period of occupancy.

Adjust intensity, frequency, timing and duration of grazing and/or browsing to meet the desired objectives for the plant communities and the associated resources, including the grazing and/or browsing animal.

Manage kind of animal, animal number, grazing distribution, length of grazing and/or browsing periods and timing of use to provide grazed plants sufficient recovery time to meet planned objectives. The recovery period of non-grazing can be provided for the entire year or during the growing season of key plants. Deferment (non-grazing period less than one year) and/or rest (non-grazing period equal or greater than one year) will be planned for critical periods of plant needs.

Provide deferment or rest from grazing or browsing to ensure the success of prescribed fire, brush management, seeding or other conservation practices that cause stress or damage to key plants.

Manage grazing and/or browsing animals to maintain adequate vegetative cover on sensitive areas (i.e. riparian, wetland, habitats of concern, karst areas).

Manage livestock movements based on rate of plant growth, available forage, and allowable utilization target.

Develop contingency plans to deal with expected episodic disturbance events e.g.

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insect infestation, drought, wildfire, etc.

**Additional Criteria to Improve or Maintain the Health and Vigor of Plant Communities.**

Duration and intensity of grazing and/or browsing will be based on desired plant health and expected productivity of key forage species to meet management objectives.

Plan periodic deferment from grazing and/or browsing to maintain or restore the desired plant community following episodic events, such as wildfire or severe drought.

Where appropriate, soil test periodically for nutrient status and soil reaction and apply fertilizer and/or soil amendments according to soil test to improve or maintain plant vigor.

**Additional Criteria to Improve or Maintain Quantity and Quality of Forage for Animal Health and Productivity**

Plan grazing and/or browsing to match forage quantity and quality goals of the producer within the capability of the resource to respond to management.

Enhance diversity of rangeland and pasture plants to optimize delivery of nutrients to the animals by planning intensity, frequency, timing and duration of grazing and/or browsing.

Plan intensity, frequency, timing and duration of grazing and/or browsing reduce animal stress and mortality from toxic and poisonous plants.

Supplemental feed and/or minerals will be balanced with the forage consumption to meet the desired nutritional level for the kind and class of grazing and/or browsing livestock.

Dietary needs of livestock will be based on the National Research Council's Nutrient Requirements of Domestic Animals or similar scientific sources with appropriate adjustments made for increased energy demand required by browsing or grazing animals foraging for food including travel to and from pasture site.

Biosecurity safeguards will be in place to prevent the spread of disease between on-farm or ranch classes of livestock and between livestock farm or ranch units.

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Shelter in the form of windbreaks, sheds, shade structures, and other protective features will be used where conditions warrant to protect livestock from severe weather, intense heat/humidity, and predators.

**Additional Criteria to Improve or Maintain Surface and/or Subsurface Water Quality and Quantity.**

Minimize concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover.

Plan intensity, frequency, timing and duration of grazing and/or browsing to:

Minimize deposition or flow of animal wastes into water bodies,

Minimize animal impacts on stream bank or shoreline stability.

Provide adequate ground cover and plant density to maintain or improve infiltration capacity and reduce runoff.

Provide adequate ground cover and plant density to maintain or improve filtering capacity of the vegetation.

**Additional Criteria to Improve or Maintain Riparian and Watershed Function.**

Minimize concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover and riparian/floodplain plant community structure and functions.

Plan intensity, frequency, timing and duration of grazing and/or browsing to:

Provide adequate ground cover and plant density to maintain or improve infiltration capacity and reduce runoff.

Provide adequate ground cover and plant density to maintain or improve filtering capacity of the vegetation.

Maintain adequate riparian community structure and function to sustain associated riparian, wetland, floodplain and stream species.

**Additional Criteria to Reduce Soil Erosion and Maintain Soil Condition**

Minimize concentrated livestock areas, trailing, and trampling to reduce soil compaction, excess runoff and erosion.

Plan intensity, frequency, timing and duration of grazing and/or browsing to provide adequate ground cover, litter and canopy to maintain or improve infiltration and soil condition.

**Additional Criteria to Improve or Maintain Food and/or Cover for Fish and Wildlife Species of Concern**

Identify species of concern in the objectives of the prescribed grazing plan.

Plan intensity, frequency, timing and duration of grazing and/or browsing to provide for the development and maintenance of the plant structure, density and diversity needed for the desired fish and wildlife species of concern.

**Additional Criteria for Management of Fine Fuel Load**

Plan intensity, frequency, timing and duration of grazing and/or browsing to reduce hazardous fuel loads.

Plan intensity, frequency, timing and duration of grazing and/or browsing to manage fuel continuity, load and other conditions to facilitate prescribed burns.

**CONSIDERATIONS**

Protect soil, water, air, plant and animal resources when locating livestock feeding, supplementing, handling and watering facilities.

Livestock feeding, handling, and watering facilities will be designed and installed in a manner to improve and/or maintain animal distribution. These facilities will also be designed and installed to minimize stress, the spread of disease, parasites, contact with harmful organisms and toxic plants.

Utilization or stubble height target levels are tools that can be used in conjunction with monitoring to help ensure that resource conservation and producer objectives are met.

Where practical and beneficial, start the grazing sequence in a different management unit each growing season.

When weeds are a significant problem prescribed grazing and/or browsing should be implemented in conjunction with other pest management practices to promote plant community resistance to invasive species and protect desired plant communities.

Prescribed grazing should consider the needs of other enterprises utilizing the same land, such as wildlife and recreational uses.

Consider improving carbon sequestration in biomass and soils through management of grazing and/or browsing to produce the desired results.

If nutrients are being applied, Nutrient Management (590) will be applied.

**PLANS AND SPECIFICATIONS**

The prescribed grazing plan shall conform to all applicable federal, state and local laws. Seek measures to avoid adverse affects to endangered, threatened, and candidate species and their habitats.

Prepare a prescribed grazing plan for all planned management units where grazing and/or browsing will occur according to state standards and specifications.

Prescribed Grazing Plan will include:

- Goals and Objectives clearly stated.
- Resource Inventory that identifies:
  - existing resource conditions and concerns
  - ecological site or forage suitability group
  - identifies opportunities to enhance resource conditions
  - location and condition of structural improvements such as fences, water developments, etc, including seasonal availability and quality of watering sites.
- Forage Inventory of the expected forage quality, quantity and species in each management unit(s).

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- Forage-Animal Balance developed for the grazing plan, which ensures forage produced or available meets forage demand of livestock and/or wildlife.
- Grazing Plan developed for livestock that identifies periods of grazing and/or browsing, deferment, rest, and other treatment activities for each management unit.
- Contingency plan developed that details potential problems (i.e., severe drought, flooding, insects) and serves as a guide for adjusting the grazing prescription to ensure resource management and economic feasibility without resource degradation.
- Monitoring plan developed with appropriate records to assess in determining whether the grazing strategy is resulting in a positive or upward trend and is meeting objectives. Identify the key areas and key plants that the manager should evaluate in making grazing management decisions.

#### OPERATION AND MAINTENANCE

**Operation.** Prescribed Grazing will be applied on a continuing basis throughout the occupation period of all planned grazing units.

Adjustments will be made as needed to ensure that the goals and objectives of the prescribed grazing strategy are met.

**Maintenance.** Monitoring data and grazing records will be used on a regular basis within the prescribed grazing plan to insure that objectives are being met, or to make necessary changes in the prescribed grazing plan to meet objectives.

All facilitating and accelerating practices (e.g. Fence (382), Pest Management (595), Brush

Management (314), Pasture Planting (512) (etc.) that are needed to effect adequate grazing and/or browsing distribution as planned by this practice standard will be maintained in good working order and are being operated as intended.

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**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**FORAGE HARVEST MANAGEMENT**

(Ac.)

CODE 511

**DEFINITION**

The timely cutting and removal of forages from the field as hay, green-chop or ensilage.

**PURPOSE**

- Optimize yield and quality of forage at the desired levels
- Promote vigorous plant re-growth
- Manage for the desired species composition
- Use forage plant biomass as a soil nutrient uptake tool
- Control insects, diseases and weeds
- Maintain and/or improve wildlife habitat

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all land uses where machine harvested forage crops are grown.

**CRITERIA**

**General Criteria Applicable to All Purposes**

Forage will be harvested at a frequency and height that optimizes the desired forage stand, plant community, and stand life. Follow State Cooperative Extension Service (CES) recommendations for forage harvest based on stage of maturity, moisture content, length of cut, stubble height and harvest interval. The following criteria must be met:

**Stage of Maturity.** Harvest forage at the stage of maturity that provides the desired quality and quantity without compromising plant vigor and stand longevity.

**Moisture Content.** Harvest silage/haylage crops within the optimum moisture range for the type of storage method(s) or structure(s) being utilized.

CES recommendations must be followed for optimum moisture content and levels as well as methods and techniques to monitor and/or determine moisture content and levels.

Avoid fermentation and seepage losses of digestible dry matter from direct cut hay crop silage (moisture content >70%) by treatment with chemical preservatives or add dry feedstuffs.

For optimal dry hay quality, rake hay at 30 to 40 percent moisture and ted or invert swaths when moisture is above 40 percent.

To preserve forage quality and quantity, bale field cured hay at 15 – 20 percent moisture and bale force air-dried hay and 20 – 35 percent moisture.

**Length of Cut.** When harvested for ensilage forage will be chopped to a size appropriate for type of storage structure used and optimal effective fiber. The length of chop selected will allow adequate packing to produce the anaerobic conditions necessary to ensure the proper ensiling process.

A shorter chop length on very dry silage may help to ensure good packing and adequate silage density.

**Stubble Height.** Cut forage plants at a height that will promote the vigor and health of the desired species. Cutting heights will provide adequate residual leaf area; adequate numbers of terminal, basal or auxiliary tillers or buds; insulation from extreme heat or cold;

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and/or unsevered stem bases that store food reserves needed for full, vigorous recovery. Follow CES recommendations for proper stubble heights to avoid winterkill of forage species in cold climates.

**Contaminants.** Forage shall not contain contaminants that can cause illness or death to the animal being fed or rejection of the offered forage. Check CES contaminant notices, cautions, and recommendations for the specific harvest site location and area.

**Additional Criteria to Improve or Maintain Stand Life, Plant Vigor and Forage Species Mix**

**Stage of Maturity and Harvest Interval.** Cut forage plants at a stage of maturity or harvest interval range that will provide adequate food reserves and/or basal or auxiliary tillers or buds for regrowth and/or reproduction to occur without loss of plant vigor.

Cut reseeding annuals at a stage of maturity and frequency that ensures the production of ample viable seed or carryover of hard seed to maintain desired stand density.

If plants show signs of short-term environmental stress, harvests will be adjusted in a manner that encourages the continued health and vigor of the stand. Follow CES recommendations in these cases.

Manipulate timing and cutting heights of harvest to ensure germination and establishment of reseeding or seeded annuals.

**Additional Criteria for Use as a Nutrient Uptake Tool**

Employ a harvest regime that utilizes the maximum amount of available or targeted nutrients. Using this practice for this purpose may require more frequent harvests to increase uptake instead of managing for stand longevity.

**Additional Criteria to Control Disease, Insect, Weed and Invasive Plant Infestations**

Follow CES guidelines when available for control of disease, insect, weed and invasive plant infestations to forage.

Schedule harvest periods to control disease, insect, and weed infestations. When a

pesticide is used to control disease, insects or weeds, adhere to the specified days to harvest period stated on the pesticide label. Evaluate pest management options by planning conservation practice standard Pest Management (595) for all forage areas to be harvested. Also plan and schedule removal of invasive plants and noxious weeds.

Lessen incidence of disease, insect damage, and weed infestation by managing harvests to maintain a full, vigorous, dense forage stand.

Cut forages after dew, rain, or irrigation water on the leaves has evaporated.

**Additional Criteria to Improve Wildlife Habitat Values**

If client objectives include providing suitable habitat for desired wildlife specie(s) then appropriate harvest schedule(s), cover patterns, and minimum plant heights to provide suitable habitat for the desired specie(s) should be implemented and maintained.

Time harvests to benefit the desired wildlife species by following state guidelines.

Coordinate this practice with conservation practice standard Upland Wildlife Habitat Management (645) and accompanying job sheets.

**CONSIDERATIONS**

Where applicable coordinate this practice with NRCS practice standard Prescribed Grazing (528).

When nutrients or other soil amendments are applied coordinate forage harvests with NRCS practice standard Nutrient Management (590) and/or Waste Utilization (633) as appropriate. An excess or improper balance of nutrients such as nitrogen can produce plant material that causes toxicity in some animals.

Produce stored forages of the quality needed for optimum performance of the animal being fed. Legume forages too low in fiber and lead to metabolic disorders in ruminants and an economic loss to the producer due to lowered animal performance. Consider analyzing harvested forages for feed quality. Coordinate this practice with NRCS practice standard Feed Management (592).

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Direct cut grass and legume silage can create silage leachate (seepage) in storage. Consider use of practice standards Runoff Management System (570) and Waste Storage Facility (313).

In conjunction with harvest options, consider storage and feeding options that will retain acceptable forage quality and minimize digestible dry matter loss.

Where weather conditions make it difficult to harvest the desired quality of forage consider use of mechanical or chemical conditioners, forced air barn curing and/or ensile.

Consider delaying harvest if prolonged or heavy precipitation is forecast that would reduce forage quality.

In regions where rainfall and/or humidity levels cause unacceptable forage quality losses consider green chopping or ensiling the forage to reduce or eliminate field drying time. Other options are: the use of desiccants, preservatives, or macerating implements to reduce field-drying time.

To reduce safety hazards, avoid operating harvesting and hauling equipment on field slopes over 25 percent, particularly on cross slope traffic patterns.

Consider Harvesting Forages in the afternoon to optimize water soluble carbohydrates and nutritional quality.

#### PLANS AND SPECIFICATIONS

Place the detailed specifications in a site-specific job or design sheet or in the practice narrative in the conservation plan.

Plans and Specifications must include as minimum for the forage harvest operations:

1. Goals, objectives, specific purpose (such as high forage quantity and quality or nutrient uptake, etc.)

2. Forage species to be harvested

By each dominant forage species harvested show:

3. Method of harvest
4. Stage of maturity
5. Optimal harvest moisture content

6. Length of cut
7. Stubble height to be left
8. Harvest interval including late harvest if applicable
9. Contaminant avoidance recommendations.

These plans and specifications shall be available through appropriate job sheets and other materials for applying the practice to achieve its intended purpose.

#### OPERATION AND MAINTENANCE

Before forage harvest, clear fields of debris that could damage machinery or if ingested by livestock, lead to sickness (for example, hardware disease) or death.

Operate all forage harvesting equipment at the optimum settings and speeds to minimize loss of leaves.

To control forage plant diseases, insects, and movement of weeds, clean harvesting equipment after harvest and before storing.

Set shear-plate on forage chopper to the proper theoretical cut for the crop being harvested. Keep knives well sharpened. Do not use re-cutters or screens unless forage moisture levels fall below recommended levels for optimum chopping action.

Follow all agricultural equipment manufacturer's safety measures when operating forage harvesting equipment.

Regardless of silage/haylage storage method, ensure good compaction and an airtight seal to exclude oxygen and mold or bacterial formations.

Dispose of the plastic wrap or bags used to store forage in an environmentally sound manner.

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**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**NUTRIENT MANAGEMENT**

(Ac.)

**CODE 590**

**DEFINITION**

Managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments.

**PURPOSE**

- To budget and supply nutrients for plant production.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To minimize agricultural nonpoint source pollution of surface and ground water resources.
- To protect air quality by reducing nitrogen emissions (ammonia and NO<sub>x</sub> compounds) and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical and biological condition of soil.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all lands where plant nutrients and soil amendments are applied.

**CRITERIA**

**General Criteria Applicable to All Purposes**

A nutrient budget for nitrogen, phosphorus, and potassium shall be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water.

Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-products tests.

For new crops or varieties, industry yield recommendations may be used until documented yield information is available.

Plans for nutrient management shall specify the source, amount, timing and method of application of nutrients on each field to achieve realistic production goals, while minimizing movement of nutrients and other potential contaminants to surface and/or ground waters.

Areas contained within established minimum application setbacks (e.g., sinkholes, wells, gullies, ditches, surface inlets or rapidly permeable soil areas) shall not receive direct application of nutrients.

The amount of nutrients lost to erosion, runoff, irrigation and drainage, shall be addressed, as needed.

**Soil and Tissue Sampling and Laboratory Analyses (Testing).** Nutrient planning shall be based on current soil and tissue (where used as a supplement) test results developed in accordance with Land Grant University guidance, or industry practice if recognized by the Land Grant University. Current soil tests are those that are no older than five years.

Soil and tissue samples shall be collected and prepared according to the Land Grant University guidance or standard industry practice. Soil and tissue test analyses shall be performed by laboratories that are accepted in one or more of the following:

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- Laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America, or
- State recognized program that considers laboratory performance and proficiency to assure accuracy of soil test results.

Soil and tissue testing shall include analyses for any nutrients for which specific information is needed to develop the nutrient plan. Request analyses pertinent to monitoring or amending the annual nutrient budget, e.g. pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus and potassium.

**Nutrient Application Rates.** Soil amendments shall be applied, as needed, to adjust soil pH to an adequate level for crop nutrient availability and utilization.

Recommended nutrient application rates shall be based on Land Grant University recommendations (and/or industry practice when recognized by the university) that consider current soil test results, realistic yield goals and management capabilities. If the Land Grant University does not provide specific recommendations, application shall be based on realistic yield goals and associated plant nutrient uptake rates.

The planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on the following guidance:

- Nitrogen Application - Planned nitrogen application rates shall match the recommended rates as closely as possible, except when manure or organic by-products are a source of nutrients. When manure or organic by-products are a source of nutrients, see "Additional Criteria" below.
- Phosphorus Application - Planned phosphorus application rates shall match the recommended rates as closely as possible, except when manure or organic by-products are sources of nutrients. When manure or organic by-products are a source of nutrients, see "Additional Criteria" below.

- Potassium Application - Potassium shall not be applied in situations in which excess (greater than soil test potassium recommendation) causes unacceptable nutrient imbalances in crops or forages. When forage quality is an issue associated with excess potassium application, state standards shall be used to set forage quality guidelines.
- Other Plant Nutrients - The planned rates of application of other nutrients shall be consistent with Land Grant University guidance or industry practice if recognized by the Land Grant University in the state.
- Starter Fertilizers - When starter fertilizers are used, they shall be included in the overall nutrient budget, and applied in accordance with Land Grant University recommendations, or industry practice if recognized by the Land Grant University within the state.

**Nutrient Application Timing.** Timing and method of nutrient application (particularly nitrogen) shall correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions, risk assessment tools (e.g., leaching index, P index) and field accessibility.

**Nutrient Application Methods.** Application methods to reduce the risk of nutrient transport to surface and ground water, or into the atmosphere shall be employed.

To minimize nutrient losses:

- Apply nutrient materials uniformly to application area(s).
- Nutrients shall not be applied to frozen, snow-covered or saturated soil if the potential risk for runoff exists.
- Nutrients shall be applied considering the plant growth habits, irrigation practices, and other conditions so as to maximize availability to the plant and minimize the risk of runoff, leaching, and volatilization losses.
- Nutrient applications associated with irrigation systems shall be applied in a

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manner that prevents or minimizes resource impairment.

**Conservation Management Unit (CMU) Risk Assessment.** In areas with identified or designated nutrient related water quality impairment, a CMU specific risk assessment of the potential for nutrient transport from the area shall be completed.

States that utilize a threshold prescreening procedure to trigger CMU risk assessment shall follow approved procedures as recommended by the respective state or Land Grant University.

Use an appropriate nutrient risk assessment tool for the nutrient in question (e.g., leaching index, phosphorus index) or other state recognized assessment tool.

**Additional Criteria Applicable to Manure and Organic By-Products or Biosolids Applied as a Plant Nutrient Source**

When animal manures or organic by-products are applied, a risk assessment of the potential for nutrient transport from the CMU shall be completed to adjust the amount, placement, form and timing of application of nutrient sources, as recommended by the respective state or Land Grant University.

Nutrient values of manure and organic by-products (excluding sewage sludge or biosolids) shall be determined prior to land application. Samples will be taken and analyzed with each hauling/emptying cycle for a storage/treatment facility. Manure sampling frequency may vary based on the operation's manure handling strategy and spreading schedule. If there is no prior sampling history, the manure shall be analyzed at least annually for a minimum of three consecutive years. A cumulative record shall be developed and maintained until a consistent (maintaining a certain nutrient concentration with minimal variation) level of nutrient values is realized. The average of results contained in the operation's cumulative manure analyses history shall be used as a basis for nutrient allocation to fields. Samples shall be collected and prepared according to Land Grant University guidance or industry practice.

In planning for new operations, acceptable "book values" recognized by the NRCS and/or the Land Grant University may be used if they accurately estimate nutrient output from the proposed operation (e.g., NRCS Agricultural Waste Management Field Handbook).

Biosolids (sewage sludge) shall be applied in accordance with USEPA regulations. (40 CFR Parts 403 (Pretreatment) and 503 (Biosolids) and other state and/or local regulations regarding the use of biosolids as a nutrient source.

**Manure and Organic By-Product Nutrient Application Rates.** Manure and organic by-product nutrient application rates shall be based on nutrient analyses procedures recommended by the respective state or Land Grant University. As indicated above, "book values" may be used in planning for new operations. At a minimum, manure analyses shall identify nutrient and specific ion concentrations, percent moisture, and percent organic matter. Salt concentration shall be monitored so that manure applications do not cause plant damage or negatively impact soil quality.

The application rate (in/hr) of liquid materials applied shall not exceed the soil intake/infiltration rate and shall be adjusted to minimize ponding and to avoid runoff. The total application shall not exceed the field capacity of the soil and shall be adjusted, as needed, to minimize loss to subsurface tile drains.

The planned rates of nitrogen and phosphorus application recorded in the plan shall be determined based on the following guidance:

**Nitrogen Application Rates**

- When manure or organic by-products are used, the nitrogen availability of the planned application rates shall match plant uptake characteristics as closely as possible, taking into consideration the timing of nutrient application(s) in order to minimize leaching and atmospheric losses.
- Management activities and technologies shall be used that effectively utilize mineralized nitrogen and that minimize nitrogen losses

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through denitrification and ammonia volatilization.

- Manure or organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.
- When the nutrient management plan component is being implemented on a phosphorus basis, manure or organic by-products shall be applied at rates consistent with a phosphorus limited application rate. In such situations, an additional nitrogen application, from non-organic sources, may be required to supply, but not exceed, the recommended amounts of nitrogen in any given year.

#### Phosphorus Application Rates

- When manure or organic by-products are used, the planned rates of phosphorus application shall be consistent with any one of the following options:
  - ◇ Phosphorus Index (PI) Rating. Nitrogen-based manure application on Low or Medium Risk Sites; phosphorus-based or no manure application on High and Very High Risk Sites.\*\*
  - ◇ Soil Phosphorus Threshold Values. Nitrogen-based manure application on sites on which the soil test phosphorus levels are below the threshold values; Phosphorus-based or no manure application on sites on which soil phosphorus levels equal or exceed threshold values.\*\*
  - ◇ Soil Test. Nitrogen-based manure application on sites for which the soil test recommendation calls for phosphorus application; phosphorus-based or no manure application on sites for which the soil test recommendation calls for no phosphorus application. †

\*\* Acceptable phosphorus-based manure application rates shall be determined as a function

of soil test recommendation or estimated phosphorus removal in harvested plant biomass.

Guidance for developing these acceptable rates is found in the NRCS General Manual, Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy), and the National Agronomy Manual, Section 503 (to be developed).

- The application of phosphorus applied as manure may be made at a rate equal to the recommended phosphorus application or estimated phosphorus removal in harvested plant biomass for the crop rotation or multiple years in the crop sequence. When such applications are made, the application rate shall:
  - ◇ Not exceed the recommended nitrogen application rate during the year of application, or
  - ◇ Not exceed the estimated nitrogen removal in harvested plant biomass during the year of application when there is no recommended nitrogen application.
  - ◇ Not be made on sites considered vulnerable to off-site phosphorus transport unless appropriate conservation practices, best management practices or management activities are used to reduce the vulnerability.

**Heavy Metal Monitoring.** When sewage sludge (biosolids) is applied, the accumulation of potential pollutants (including arsenic, cadmium, copper, lead, mercury, selenium, and zinc) in the soil shall be monitored in accordance with the US Code, Reference 40 CFR, Parts 403 and 503, and/or any applicable state and local laws or regulations.

#### **Additional Criteria to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere**

In areas with an identified or designated nutrient management related air quality concern, any component(s) of nutrient

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management (i.e., amount, source, placement, form, timing of application) identified by risk assessment tools as a potential source of atmospheric pollutants shall be adjusted, as necessary, to minimize the loss(es).

When tillage can be performed, surface applications of manure and fertilizer nitrogen formulations that are subject to volatilization on the soil surface (e.g., urea) shall be incorporated into the soil within 24 hours after application.

When manure or organic by-products are applied to grassland, hayland, pasture or minimum-till areas the rate, form and timing of application(s) shall be managed to minimize volatilization losses.

When liquid forms of manure are applied with irrigation equipment, operators will select weather conditions during application that will minimize volatilization losses.

Operators will handle and apply poultry litter or other dry types of animal manures when the potential for wind-driven loss is low and there is less potential for transport of particulates into the atmosphere.

Weather and climatic conditions during manure or organic by-product application(s) shall be recorded and maintained in accordance with the operation and maintenance section of this standard.

**Additional Criteria to Improve the Physical, Chemical and Biological Condition of the Soil**

Nutrients shall be applied and managed in a manner that maintains or improves the physical, chemical and biological condition of the soil.

Minimize the use of nutrient sources with high salt content unless provisions are made to leach salts below the crop root zone.

To the extent practicable nutrients shall not be applied when the potential for soil compaction and rutting is high.

**CONSIDERATIONS**

The use of management activities and technologies listed in this section may improve

both the production and environmental performance of nutrient management systems.

The addition of these management activities, when applicable, increases the management intensity of the system and is recommended in a nutrient management system.

Action should be taken to protect National Register listed and other eligible cultural resources.

The nutrient budget should be reviewed annually to determine if any changes are needed for the next planned crop.

For sites on which there are special environmental concerns, other sampling techniques may be appropriate. These include soil profile sampling for nitrogen, Pre-Sidedress Nitrogen Test (PSNT), Pre-Plant Soil Nitrate Test (PPSN) or soil surface sampling for phosphorus accumulation or pH changes.

Additional practices to enhance the producer's ability to manage manure effectively include modification of the animal's diet to reduce the manure nutrient content, or utilizing manure amendments that stabilize or tie-up nutrients.

Soil test information should be no older than one year when developing new plans, particularly if animal manures are to be used as a nutrient source.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients.

If increases in soil phosphorus levels are expected, consider a more frequent (annual) soil testing interval.

To manage the conversion of nitrogen in manure or fertilizer, use products or materials (e.g. nitrification inhibitors, urease inhibitors and slow or controlled release fertilizers) that more closely match nutrient release and availability for plant uptake. These materials may improve the nitrogen use efficiency (NUE) of the nutrient management system by reducing losses of nitrogen into water and/or air.

***Considerations to Minimize Agricultural Nonpoint Source Pollution of Surface and Ground Water.***

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Erosion control and runoff reduction practices can improve soil nutrient and water storage, infiltration, aeration, tillage, diversity of soil organisms and protect or improve water and air quality (Consider installation of one or more NRCS FOTG, Section IV – Conservation Practice Standards).

Cover crops can effectively utilize and/or recycle residual nitrogen.

Apply nutrient materials uniformly to the application area. Application methods and timing that reduce the risk of nutrients being transported to ground and surface waters, or into the atmosphere include:

- Split applications of nitrogen to provide nutrients at the times of maximum crop utilization,
- Use stalk-test to minimize risk of over applying nitrogen in excess of crop needs.
- Avoid winter nutrient application for spring seeded crops,
- Band applications of phosphorus near the seed row,
- Incorporate surface applied manures or organic by-products as soon as possible after application to minimize nutrient losses,
- Delay field application of animal manures or organic by-products if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.

***Considerations to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere.***

Odors associated with the land application of manures and organic by-products can be offensive to the occupants of nearby homes. Avoid applying these materials upwind of occupied structures when residents are likely to be home (evenings, weekends and holidays).

When applying manure with irrigation equipment, modifying the equipment can reduce the potential for volatilization of nitrogen from the time the manure leaves the application equipment until it reaches the surface of the soil (e.g., reduced pressure,

drop down tubes for center pivots). N volatilization from manure in a surface irrigation system will be reduced when applied under a crop canopy.

When planning nutrient applications and tillage operations, encourage soil carbon buildup while discouraging greenhouse gas emissions (e.g., nitrous oxide N<sub>2</sub>O, carbon dioxide CO<sub>2</sub>).

Nutrient applications associated with irrigation systems should be applied in accordance with the requirements of Irrigation Water Management (Code 449).

CAFO operations seeking permits under USEPA regulations (40 CFR Parts 122 and 412) should consult with their respective state permitting authority for additional criteria.

**PLANS AND SPECIFICATIONS**

Plans and specifications for nutrient management shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s), using nutrients to achieve production goals and to prevent or minimize resource impairment.

Nutrient management plans shall include a statement that the plan was developed based on requirements of the current standard and any applicable Federal, state, or local regulations, policies, or programs, which may include the implementation of other practices and/or management activities. Changes in any of these requirements may necessitate a revision of the plan.

The following components shall be included in the nutrient management plan:

- aerial site photograph(s) or site map(s), and a soil survey map of the site,
- location of designated sensitive areas or resources and the associated, nutrient management restriction,
- current and/or planned plant production sequence or crop rotation,
- results of soil, water, manure and/or organic by-product sample analyses,
- results of plant tissue analyses, when used for nutrient management,

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- realistic yield goals for the crops,
- complete nutrient budget for nitrogen, phosphorus, and potassium for the crop rotation or sequence,
- listing and quantification of all nutrient sources,
- CMU specific recommended nutrient application rates, timing, form, and method of application and incorporation, and
- guidance for implementation, operation, maintenance, and recordkeeping.

If increases in soil phosphorus levels are expected, the nutrient management plan shall document:

- the soil phosphorus levels at which it may be desirable to convert to phosphorus based planning,
- results of appropriate risk assessment tools to document the relationship between soil phosphorus levels and potential for phosphorus transport from the field,
- the potential for soil phosphorus drawdown from the production and harvesting of crops, and
- management activities or techniques used to reduce the potential for phosphorus loss.

#### OPERATION AND MAINTENANCE

The owner/client is responsible for safe operation and maintenance of this practice including all equipment. Operation and maintenance addresses the following:

- periodic plan review to determine if adjustments or modifications to the plan are needed. As a minimum, plans will be reviewed and revised with each soil test cycle.
- significant changes in animal numbers and/or feed management will necessitate additional manure sampling and analyses to establish a revised average nutrient content.
- protection of fertilizer and organic by-product storage facilities from weather and accidental leakage or spillage.

- calibration of application equipment to ensure uniform distribution of material at planned rates.
- documentation of the actual rate at which nutrients were applied. When the actual rates used differ from the recommended and planned rates, records will indicate the reasons for the differences.
- Maintaining records to document plan implementation. As applicable, records include:
  - Soil, plant tissue, water, manure, and organic by-product analyses resulting in recommendations for nutrient application,
  - quantities, analyses and sources of nutrients applied,
  - dates and method(s) of nutrient applications,
  - weather conditions and soil moisture at the time of application; lapsed time to manure incorporation, rainfall or irrigation event.
  - crops planted, planting and harvest dates, yields, and crop residues removed,
  - dates of plan review, name of reviewer, and recommended changes resulting from the review.

Records should be maintained for five years; or for a period longer than five years if required by other Federal, state or local ordinances, or program or contract requirements.

Workers should be protected from and avoid unnecessary contact with plant nutrient sources. Extra caution must be taken when handling ammoniacal nutrient sources, or when dealing with organic wastes stored in unventilated enclosures.

Material generated from cleaning nutrient application equipment should be utilized in an environmentally safe manner. Excess material should be collected and stored or field applied in an appropriate manner.

Nutrient containers should be recycled in compliance with state and local guidelines or regulations.

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## APPENDIX II Factors used to convert metric units to English units

APPENDIX TABLE II. Factors used to convert metric values to English units.

From	To	Multiply by
<b>Length</b>		
Kilometer, km	Mile, mi	0.621
Meter, m	Yard, yd	1.094
Meter, m	Foot, ft	3.280
Millimeter, mm	Inch, in	0.039
<b>Area</b>		
Hectare, ha	Acre	2.470
Square meter, m <sup>2</sup>	Square foot ft <sup>2</sup>	10.760
<b>Volume</b>		
Liter, L	Quart, qt	1.057
Liter, L	Cubic foot, ft <sup>3</sup>	0.035
<b>Mass</b>		
Gram, g	Pound, lb	0.0022
Gram, g	Ounce, oz	0.0352
Kilogram, kg	Pound, lb	2.205
Kilogram, kg	Ton (US, 2000 lb), ton	0.0011
Megagram, Mg (tonne)	Ton (US, 2000 lb), ton	1.102
<b>Yield and Rate</b>		
kg per ha, kg ha <sup>-1</sup>	lb per acre, lb acre <sup>-1</sup>	0.893
Mg per ha, Mg ha <sup>-1</sup>	lb per acre, lb acre <sup>-1</sup>	893.0
Tonne per ha, Mg (tonne)	Ton (2000 lb) per acre	0.446
Meter per second, m sec <sup>-1</sup>	Mile per hour, mph	2.24

**APPENDIX TABLE III.** List of common and scientific names for species mentioned in the book. Scientific names are according to the USDA-NRCS PLANTS database (<http://plants.usda.gov>) except those with an asterisk for which the USDA Germplasm Resources Information Network (GRIN; <http://www.ars-grin.gov/>) was consulted.

### Crop species

1. Barley (*Hordeum vulgare* L.)
2. Canola (*Brassica campestris* L.)
3. Corn (*Zea mays* L.)
4. Cotton (*Gossypium hirsutum* L.)
5. Oat (*Avena sativa* L.)
6. Peanut (*Arachis hypogaea* L.)
7. Rye (*Secale cereale* L.)
8. Soybean (*Glycine max* [L.] Merr.)
9. Sunflower (*Helianthus* spp.)
10. Triticale (× *Triticosecale rimpaii* Wittmack)
11. Wheat (*Triticum aestivum* L.)
12. Winter pea, pea (*Pisum sativum* L.)
13. Winter rye (*Secale cereale* L.)

### Cool-season annual grasses

14. Annual poa (*Poa annua* L.)
15. Annual ryegrass (*Lolium multiflorum* Lam.)\*
16. Black oat (*Avena strigosa* Schreb.)
17. Italian ryegrass (*Lolium multiflorum* Lam.)\*
18. Short-rotation (hybrid) ryegrass (*Lolium × hybridum* Hausskn.)

### Warm-season annual grasses

19. Broadleaf signalgrass (*Urochloa platyphylla* [Munro ex C. Wright] R.D. Webster)
20. Crabgrass (*Digitaria* spp)
21. Fall panicum (*Panicum dichotomiflorum* Michx.)\*
22. Pearl millet (*Pennisetum glaucum* [L.] R. Br.)
23. Sandbur (*Cenchrus* spp.)
24. Setaria (*Setaria sphacelata* [Schumach.] Stapf & C.E. Hubb.)
25. Sorghum-sudangrass (*Sorghum bicolor* [L.] Moench nothosubsp. *drummondii* (Steud.) de Wet ex Davidse)\*
26. Sudangrass (*Sorghum bicolor* [L.] Moench ssp. *drummondii* [Nees ex Steud.] de Wet & Harlan)
27. Teff (*Eragrostis tef* [Zuccagni] Trotter)
28. Texas panicum (*Urochloa texana* [Buckley] R.D. Webster)\*

### Warm-season perennial grasses

29. Bahiagrass (*Paspalum notatum* Flueggé)
30. Bermudagrass (*Cynodon dactylon* [L.] Pers.)
31. Big bluestem (*Andropogon gerardii* Vitman)
32. Blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths)
33. Brachiariagrass cv. Mulato (*Brachiaria* spp.)
34. Buffalograss (*Bouteloua dactyloides* [Nutt.] J.T. Columbus)
35. Buffelgrass (*Pennisetum ciliare* [L.] Link)

36. Caucasian bluestem (*Bothriochloa bladhii* [Retz.] S.T. Blake)
37. Creeping signalgrass (*Urochloa humidicola* (Rendle) Morrone & Zuloaga)
38. Dallisgrass (*Paspalum dilatatum* Poir.)
39. Digitgrass (*Digitaria eriantha* Steud.)
40. Eastern gamagrass (*Tripsacum dactyloides* L.)
41. Energycane, sugarcane (*Saccharum* spp. L.)
42. Giant reed (*Arundo donax* L.)
43. Green needlegrass (*Nassella viridula* [Trin.] Barkworth)
44. Guineagrass (*Urochloa maxima* [Jacq.] R. Webster)
45. Indiangrass (*Sorghastrum nutans* [L.] Nash)
46. Johnsongrass (*Sorghum halepense* [L.] Pers.)
47. Kikuyugrass (*Pennisetum clandestinum* Hochst. ex Chiov.)
48. Kleingrass (*Panicum coloratum* L.)
49. Lehmann lovegrass (*Eragrostis lehmanniana* Nees.)
50. Limpograss (*Hemarthria altissima* [Poir.] Stapf et C.E. Hubb.)
51. Miscanthus (*Miscanthus × giganteus* Greef et Deu)
52. Old world bluestem (*Bothriochloa* spp.)
53. Palisadegrass (*Urochloa brizantha* [Hochst. ex A. Rich.] R. Webster)
54. Stargrass (*Cynodon plectostachyus* [K. Schum.] Pilg.)
55. Switchgrass (*Panicum virgatum* L.)
56. Vaseygrass (*Paspalum urvillei* Steud.)
57. Weeping lovegrass (*Eragrostis curvula* [Schrad.] Nees)
58. Wilman lovegrass (*Eragrostis superba* Peyr.)

### Cool-season perennial grasses (and sedges)

59. Creeping foxtail (*Alopecurus arundinaceus* Poir.)
60. Crested wheatgrass (*Agropyron cristatum* [L.] Gaertn.)
61. Festulolium (× *Festulolium loliaceum* [Huds.] P. Fourn.)
62. Grazing brome grass (*Bromus stamineus* Desv.)
63. Intermediate wheatgrass (*Thinopyrum intermedium* [Host] Barkworth & D.R. Dewey)
64. Kentucky bluegrass (*Poa pratensis* L.)
65. Meadow brome grass (*Bromus biebersteinii* Roem. & Schult.)
66. Orchardgrass (*Dactylis glomerata* L.)
67. Perennial ryegrass (*Lolium perenne* L.)
68. Phalaris (*Phalaris aquatica* L.)

APPENDIX TABLE III. continued.

69. Prairiegrass (rescuegrass) (*Bromus catharticus* Vahl)  
 70. Purple nutsedge (*Cyperus rotundus* L.)  
 71. Quackgrass (*Elymus repens* [L.] Gould)  
 72. Red oatgrass (*Themeda triandra* Forsk.)  
 73. Reed canarygrass (*Phalaris arundinacea* L.)  
 74. Rough fescue (*Festuca campestris* Rydb.)  
 75. Russian wildrye (*Psathyrostachys juncea* [Fisch.] Nevski)  
 76. Slender wheatgrass (*Elymus trachycaulus* [Link] Gould ex Shinners)  
 77. Smooth bromegrass (*Bromus inermis* Leyss.)  
 78. Tall fescue (*Schedonorus phoenix* [Scop.] Holub; syn, *Lolium arundinaceum* [Schreb.] S.J. Darbyshire; formerly *Festuca arundinacea* Schreb.)  
 79. Tall wheatgrass (*Thinopyrum ponticum* [Podp.] Z.-W. Liu & R.-C. Wang)  
 80. Thickspike wheatgrass (*Elymus lanceolatus* [Scribn. & J.G. Sm.] Gould)  
 81. Timothy (*Phleum pratense* L.)  
 82. Yellow nutsedge (*Cyperus esculentus* L.)

**Legumes (annual and perennial)**

83. Aeschynomene (*Aeschynomene americana* L.)  
 84. Big trefoil (*Lotus pedunculatus* Cav.)  
 85. Birdsfoot trefoil (*Lotus corniculatus* L.)  
 86. Cowpea (*Vigna unguiculata* [L.] Walp.)  
 87. Faba bean (*Vicia faba* L.)  
 88. Illinois bundleflower (*Desmanthus illinoensis* [Michx.] MacMill. ex B.L. Rob. & Fernald)  
 89. Korean lespedeza (*Kummerowia stipulacea* [Maxim.] Makino)  
 90. Kudzu (*Pueraria montana* [Lour.] Merr.)  
 91. Lablab (*Lablab purpureus* [L.] Sweet)  
 92. Leadplant (*Amorpha canescens* Pursh)  
 93. Leucaena (*Leucaena leucocephala* [Lam.] De Wit)  
 94. Lupin (*Lupinus* spp.)  
 95. Mungbean (*Vigna radiata* [L.] R. Wilczek)  
 96. Ovalifolium (*Desmodium ovalifolium* [L.] DC. subsp. *ovalifolium* [Prain] H. Ohashi), *Desmodium adscendens* (Sw.) DC.  
 97. Partridgepea (*Chamaecrista fasciculata* [Michx.] Greene)  
 98. Pinto peanut (*Arachis pintoi* Krapov. & W.C. Greg.)  
 99. Prairie clover (*Dalea* spp.)  
 100. Purple prairie clover (*Dalea purpurea* Vent.)  
 101. Rhizoma peanut (*Arachis glabrata* Benth.)  
 102. Roundhead lespedeza (*Lespedeza capitata* Michx.)  
 103. Sainfoin (*Onobrychis viciifolia* Scop.)  
 104. Sericea lespedeza (*Lespedeza cuneata* [Dum. Cours.] G. Don)  
 105. Siratro (*Macroptilium atropurpureum* [Moc. & Sessé ex DC.] Urb.)

106. Striate lespedeza (*Kummerowia striata* [Thunb.] Schindl.)  
 107. Sulla (*Hedysarum coronarium* L.)  
 108. Tickclover (*Desmodium* spp.)  
 109. Tropical kudzu (*Pueraria phaseoloides* [Roxb.] Benth.)  
 110. Velvet bean (*Mucuna pruriens* [L.] DC.)  
 111. White sweetclover (*Melilotus albus* Medik.)  
 112. Yellow sweetclover (*Melilotus officinalis* [L.] Lam.)

**Clovers**

113. Alsike clover (*Trifolium hybridum* L.)  
 114. Arrowleaf clover (*Trifolium vesiculosum* Savi)  
 115. Balansa clover (*Trifolium michelianum* Savi ssp. *balansae* [Boiss.] Ponert)  
 116. Ball clover (*Trifolium nigrescens* Viv.)  
 117. Berseem clover (*Trifolium alexandrinum* L.)  
 118. Buffalo clover (*Trifolium reflexum* L.)  
 119. Crimson clover (*Trifolium incarnatum* L.)  
 120. Kura clover (*Trifolium ambiguum* M. Bieb.)  
 121. Persian clover (*Trifolium resupinatum* L.)  
 122. Red clover (*Trifolium pratense* L.)  
 123. Rose clover (*Trifolium hirtum* All.)  
 124. Strawberry clover (*Trifolium fragiferum* L.)  
 125. Subterranean clover (*Trifolium subterraneum* L.)  
 126. White clover (or ladino clover) (*Trifolium repens* L.)

**Vetches**

127. Cicer milkvetch (*Astragalus cicer* L.)  
 128. Crownvetch (*Securigera varia* [L.] Lassen)  
 129. Hairy vetch (*Vicia villosa* Roth subsp. *villosa*)\*  
 130. Deervetch (*Vicia ludoviciana* Nutt.)  
 131. Woollypod vetch (*Vicia villosa* Roth ssp. *varia* [Host] Corb.)\*

**Medics**

132. Alfalfa (*Medicago sativa* L.)  
 133. Barrel medic (*Medicago truncatula* Gaertn.)  
 134. Black medic (*Medicago lupulina* L.)  
 135. Burr medic (*Medicago polymorpha* L.)  
 136. Little burr medic (*Medicago minima* L.)  
 137. Rigid medic (*Medicago rigiduloides* E. Small)\*  
 138. Tifton burr medic (*Medicago rigidula* [L.] All.)

**Nonleguminous forbs**

139. Annual ragweed (*Ambrosia artemisifolia* L.)  
 140. Chicory (*Cichorium intybus* L.)  
 141. Multiflora rose (*Rosa multiflora* Thunb.)  
 142. Nodding thistle (*Carduus nutans* L.)  
 143. Plantain (*Plantago lanceolata* L.)  
 144. Turnip (*Brassica rapa* L.)\*

## Animals

145. Black grouse (*Tetrao tetrix*)
146. Brown hare (*Lepus europaeus*)
147. Brown trout (*Salmo trutta*)
148. Cattle (*Bos* sp.)
149. Crested caracaras (*Caracara cheriway*)
150. Deer (*Odocoileus* spp.)
151. Eastern garter snakes (*Thamnophis sirtalis*)
152. Elk (*Cervus elaphus*)
153. Field vole (*Microtus agrestis*)
154. Goat (*Capra hircus*)
155. Grasshopper sparrow (*Ammodramus savannarum*)
156. Horse (*Equus caballus*)
157. Iberian ibex (*Capra pyrenaica* Schinz)
158. Meadow pipit (*Anthus pratensis*)
159. Mottled duck (*Anas fulvigula maculosa*)
160. Northern queen snake (*Regina septemvittata*)
161. Prairie chicken (*Tympanuchus cupido pinnatus*)
162. Sage grouse (*Centrocercus urophasianus*)
163. Sheep (*Ovis aries*)
164. Spur-thighed tortoise (*Testudo graeca*)
165. Upland sandpiper (*Bartramia longicauda*)

## Other (specific bacteria and fungi)

- Campylobacter jejuni*
- Cryptosporidium parvum*
- Escherichia coli*
- Leptospira grippotyphosa*
- Salmonella java*
- Salmonella typhimurium*
- Shigella flexneri*
- Shigella sonnei*
- Endophyte fungus (*Neotyphodium coenophialum* (Morgan-Jones & W. Gams) Glenn, C.W. Bacon & Hanlin)

**APPENDIX IV** Chemical names for pesticides mentioned in the chapter texts

**APPENDIX TABLE IV.** List of trade names and chemical names of pesticides and other chemicals mentioned in the book.

Common name	Trade name	Chemical name
<b>Herbicides</b>		
2,4-D acid plus dicamba	Outlaw	3,6-dichloromethoxybenzoic acid; 2-ethylhexyl ester of 2,4-dichlorophenoxyacetic acid
2,4-D amine	AgriStar 2,4-D amine 4	2,4-dichlorophenoxyacetic acid
2,4-D amine plus dicamba	Weedmaster	Dicamba (3,6-dichloro-o-anisic acid); 2,4-dichlorophenoxyacetic acid
2,4-D amine plus picloram	Grazon P+D	4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid; (2,4-dichlorophenoxy) acetic acid
2,4-D ester	AgriStar 2,4-D LV4 or LV6	2-ethylhexyl ester of 2,4-dichlorophenoxy acetic acid
2,4-DB	Butyrac	4-(2,4-dichlorophenoxy)butyric acid
Atrazine	Aatrex	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Benefin	Balan	N-butyl-N-ethyl- $\alpha,\alpha$ -trifluoro-2,6-dinitro-p-toluidine
Bromoxynil	Buctril	3,5-dibromo-4-hydroxybenzotrile
Clethodim	Select	(E)-2-[1-[(3-chloro-2-propenyl)oxy]imino]propyl]-5-[2-ethylthio]propyl-3-hydroxy-2-cyclohexen-1-one
Diuron	Direx	3-[3,4-dichlorophenyl]-1,1-dimethylurea
EPTC	Eptam	S-ethyl dipropylthiocarbamate
Flumioxazin	Chateau	2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzox-azin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione
Glyphosate	Roundup; Roundup WeatherMax	N-(phosphonomethyl) glycine
Hexazinone	Velpar	3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione
Imazamox	Raptor	2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-(methoxymethyl)-3-pyridinecarboxylic acid
Imazapic	Impose	( $\pm$ )-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid.
Imazethapyr	Pursuit/Thunder	( $\pm$ )-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid
Metolachlor	Dual II	2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide
Metribuzin	Sencor	4-amino-6-(1,1-dimethyl)-3-(methylthio)-1,3,4-triazin-5(4H)-one
Nicosulfuron	Accent	2-[[[4,6-dimethoxy-2-pyrimidin-2-yl]aminocarbonyl]aminosulfonyl] N,N-dimethyl-3-pyridinecarboxamide
Norflurazon	Solicam	4-chloro-5-(methylamino)-2- $\alpha,\alpha,\alpha$ -trifluoro-m-tolyl]-3-(2H)pyridazinone

APPENDIX TABLE IV. continued.

Common name	Trade name	Chemical name
Paraquat	CycloneMax	1,1-dimethyl-4,4-bypyridinium dichloride
Pendamethalin	Prowl	N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine
Pronamide	Kerb	3,5-dichloro-N-(1,1-dimethyl-2-propynyl)benzamide
Quinclorac	Paramount	3,7-dichloro-8-quinolinecarboxylic acid
Sethoxydim	PoastPlus	2-[1-(ethoxyimino)butyl]-5-[2-ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one
Siduron	Tupersan	[1-2-methylcyclohexyl]-3-phenylurea
Sulfosulfuron	Outrider	1-[4,6-dimethoxypyrimidin-2-yl]-3-[2-ethylsulfonylimidazo[1,2-a]pyridin-3-yl]sulfonylurea
Terbacil	Sinbar	3- <i>tert</i> -butyl-5-chloro-6-methyluracil
Triasulfuron	Amber	1-[2-(2-chloroethoxy)phenyl]sulfonyl-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)urea
Trifluralin	Treflan	$\alpha,\alpha,\alpha$ -trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
<b>Insecticides</b>		
Carbosulfan		2,3-dihydro-2,2-dimethylbenzofuran-7-yl (dibutylaminothio)methylcarbamate
Furathiocarb		butyl 2,3-dihydro-2,2-dimethylbenzofuran-7-yl N,N-dimethyl-N,N'-thiodicarbamate
Imidacloprid		1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine
Isofenphos		(RS)-(O-ethyl O-2-isopropoxycarbonylphenyl isopropylphosphoramidothioate)
<b>Fungicide</b>		
Mefenoxam (Metalaxyl)	Apron	N-(2,6-dimethylphenyl)-N-(2-methoxyecetyl)-DL-alanine