WHOLE FARM CONSERVATION BEST PRACTICES MANUAL

This manual is a joint publication of Iowa State University and USDA-Natural Resources Conservation Service.

Development of this Whole Farm Conservation Best Practices Manual was led by the Conservation Learning Group at Iowa State University Extension and Outreach.

The Conservation Learning Group is a collaborative team that strives to advance training, outreach, and research across land uses and production systems to increase overall sustainability of agricultural and natural systems for multiple generations to come.

Conservation systems summit participants:

Iowa State University Extension and Outreach

United States Department of Agriculture–Natural Resources Conservation Service

United States Department of Agriculture–Agricultural Research Service

Practical Farmers of Iowa

Iowa Soybean Association

Iowa Agriculture Water Alliance

Soil and Water Conservation Society

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CLG105 February 2020

SCIENCE + SUPPORT = SOUND STEWARDSHIP

Improving water quality, soil health, and wildlife habitat while remaining productive and profitable is the focus of many conservation efforts in Iowa. There has been extensive education and outreach programming to increase awareness of whole farm water quality, soil health, and wildlife habitat practices. Confidence in practice selection and management is essential for moving from awareness to implementation. However, recommendations for practice selection and management have varied depending on the organization providing advice, leading to uncertainty among farmers and landowners.

In 2019, the Conservation Learning Group brought together a group of leading scientists and technical specialists in Iowa for a series of four conservation systems summits to **build consensus on the best management recommendations** for farmers and landowners getting started with conservation and water quality practices. This manual is the final product of those summits—a one-stop shop intended to help select and incorporate the in-field and edge-of-field conservation practices most appropriate to the decision maker's land and preferences.

This Whole Farm Conservation Best Practices Manual complements the United States Department of Agriculture–Natural Resources Conservation Service's conservation planning process. Foundational to the conservation planning process is decision makers understanding their resources, wider natural resource concerns and opportunities, and the broad effects of their land management choices. This manual provides a science-based framework to support decision makers in the conservation planning process and in adopting sound conservation practices on the land.

Conservation Practices at a Glance

Practice	ABILITY TO ADDRESS RESOURCE CONCERN: Soil Health – Impact	Soil Health – Confidence	Nutrient Loss Reduction – Nitrogen Impact	Nutrient Loss Reduction – Phosphorus Impact	Nutrient Loss Reduction – Confidence	Habitat – Impact	Habitat – Confidence
Cover Crops	Strong	Scientific Consensus	Strong	Strong	Scientific Consensus	Weak	Multiple Studies
No-tillage	Strong	Scientific Consensus	No Impact	Strong	Multiple Studies	No Impact	Scientific Consensus
Strip-tillage	Moderate	Scientific Consensus	No Impact	Moderate	Anecdotal Evidence	No Impact	Scientific Consensus
N Management	No Impact	Multiple Studies	Weak	No Impact	Scientific Consensus	No Impact	Scientific Consensus
P Management	No Impact	Multiple Studies	No Impact	Moderate	Scientific Consensus	No Impact	Scientific Consensus
Diverse Rotations	Moderate	Multiple Studies	Moderate	Strong	Multiple Studies	Moderate	Scientific Consensus
Wetlands	No Impact	Multiple Studies	Strong	No Impact	Scientific Consensus	Strong	Scientific Consensus
Saturated Buffers	No Impact *	Multiple Studies	Strong	No Impact	Scientific Consensus	Moderate	Scientific Consensus
Bioreactors	No Impact *	Multiple Studies	Strong	No Impact	Scientific Consensus	No Impact #	Scientific Consensus
Field Buffers	No Impact *	Scientific Consensus	Weak	Strong	Multiple Studies	Moderate	Scientific Consensus
Controlled Drainage	No Impact	Multiple Studies	Strong	No Impact	Anecdotal Evidence	No Impact	Multiple Studies
Terraces	No Impact *	Scientific Consensus	No Impact	Strong	Multiple Studies	Weak	Scientific Consensus
Ponds	No Impact	Multiple Studies	Weak	Strong	Anecdotal Evidence	Moderate	Scientific Consensus
Water/Sediment Control Basins	No Impact	Multiple Studies	No Impact	Strong	Scientific Consensus	No Impact	Scientific Consensus
Grassed Waterways	No Impact *	Scientific Consensus	No Impact	Moderate	Multiple Studies	Weak	Scientific Consensus
Strategically Placed Perennials	No Impact *	Multiple Studies	Moderate	Strong	Multiple Studies	Moderate	Scientific Consensus
Prairie Strips	No Impact *	Scientific Consensus	Weak	Strong	Multiple Studies	Moderate	Scientific Consensus

* Soil health improvement occurs within the practice footprint. However, no improvement is measured in the rest of the field.
# Potential habitat impact if pollinator habitat is installed above the practice.

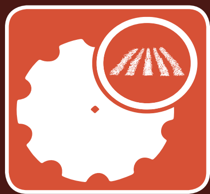
LEGEND

Strong · Moderate · Weak · No Impact

Anecdotal Evidence
Multiple Studies
Scientific Consensus

In-Field Conservation Practices That Work

This section includes:



Tillage Management

Cover Crops

Diverse Rotations

Iowa farmers constantly seek to lower production costs, protect the environment, and conserve natural resources. Adopting conservation practices works hand-in-hand with paying attention to the basics of production efficiency to achieve all three of these goals.

Conservation agriculture improves crop yields and supports the long-term environmental and financial sustainability of farming. The guidelines in this section are built upon the principles of conservation agriculture:

- √ Maintain soil cover
- √ Maximize living roots in soil
- √ Minimize soil disturbance
- √ Increase the diversity of plant species

These principles of conservation agriculture support Iowa's commitment to reduce nutrient loading through the Iowa Nutrient Reduction Strategy, developed as part of the 2008 Gulf of Mexico Hypoxia Action Plan. This comprehensive plan calls for the reduction of total nitrogen and phosphorus loadings to the Gulf of Mexico by 45 percent over the coming decades, achieved through a combination of strategically implemented practices, both in-field and edge-of-field, and high rates of conservation practice adoption statewide.

Cropping Systems for Conservation

Incorporating conservation practices in the field begins with the choices you make about crops, rotation, tillage, fertilization, and pest management. Conservation agriculture employs a cropping-systems approach that builds soil organic matter and soil structure, controls soil erosion, and conserves soil water, reducing the loss of nutrients and soil to surface and ground water. It enhances the long-term productivity of soil and maximizes economic returns.

Iowa farmers have traditionally used one of three cropping systems—the corn-soybean rotation, two years of corn followed by one year of soybean (corn-corn-soybean), and continuous corn—usually with full-width tillage of all fields. Conservation-minded Iowa farmers consider incorporating three major conservation practices in their fields, switching to no-tillage or strip-tillage, planting cover crops, and incorporating small grains into their crop rotations.

No-tillage and Strip-tillage

Full-width tillage, disturbing of the soil surface in preparation for spring planting, leaves Iowa's productive topsoil and its rich nutrients vulnerable to erosion by wind and water. No-tillage and strip-tillage systems better protect the soil from erosion by minimizing soil surface disturbance.

In a **no-tillage** system, crops are sown into undisturbed soil with plant residue on the surface. In Iowa, no-tillage is recommended for planting soybean following corn, for planting corn following soybean on well-drained soils, and for any rotation on moderately-sloped fields.

In a **strip-tillage** system, more than two-thirds of the row width is left undisturbed, and the remaining strip is tilled to create a seedbed for spring planting. In Iowa, strip-tillage is recommended for corn production in north central and central Iowa on poorly drained soils and low-sloped fields.

Consult the tillage management decision tools on pages 32 and 33 to determine whether no-tillage or strip-tillage best suits your field and cropping system.

KEY PLANTER SETTINGS WITH NO-TILLAGE AND STRIP-TILLAGE

- **Ensure adequate weight and down pressure** on the toolbar.

  50 to 100 pounds of down pressure
  Best for drier conditions and firm fields

  Reduce down pressure to avoid sidewall compaction
  Best for wetter conditions and loose seedbeds

- **Ensure adequate closing-wheel tension** to successfully close the seed furrow and provide good seed-to-soil contact.
- **Shift the planter row unit 3 to 4 inches** off the previous year's corn rows in no-tillage systems.
- **Adjust row cleaners** to move residue out of the row space with minimal soil disturbance and to avoid trenching.

Planting and Harvesting

Planting into a no-tillage or strip-tillage system requires following the same fundamental principles that maximize production efficiency in a full-width tillage system:

- Wait for conducive field conditions with a soil temperature at 50°F and rising. At a soil temperature of 50°F or warmer, there is robust seed germination and vigorous seedling emergence, growth, and establishment.

- Avoid wet conditions that are conducive to excessive soil compaction, particularly with no-tillage as remediation can be more difficult.

- When planting corn into corn residue, fall strip-tillage is preferred over spring strip-tillage, and should be delayed in the fall as late as possible. Typically, “refreshing” fall strip-tillage strips prior to planting is not needed. If spring strip-tillage is required, soil conditions must be suitable, and strip-tillage should be done at least one week before planting. Real time kinematics (RTK) guidance systems may allow for easier direct planting into the tilled zone, but are not necessary for success.

- At harvest, use controlled traffic paths, and ensure uniform residue distribution across the harvest width. For no-tillage, avoid using a chopping corn head or stalk chopper.

Fertilizing

No-tillage and strip-tillage systems do not require an increase in the total nitrogen applied for optimal crop yields. For no-tillage corn, using a split application with 20 to 30 pounds of nitrogen per acre at planting increases the potential for success.

The phosphorus and potassium fertility program under a no-tillage or strip-tillage system is similar to that for full-width tillage:

- Take composite soil samples for each zone or grid sample, and use the soil test analysis as the basis for nutrient application. In a strip-tillage system, the composite soil sample should include soil cores from between and within the strip zones.

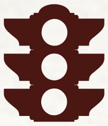
- Knifed-in phosphorus (as compared to broadcast) does not increase crop yield, but does reduce losses to surface water.

- Starter fertilizer may be beneficial in a no-tillage system.

Managing Pests and Disease

Seedling and foliar diseases may be more prevalent for pathogens that overwinter on crop residue in no-tillage and strip-tillage systems, so scout fields more frequently. Properly timed fall or spring herbicide programs will control winter annual weeds. Row cleaners in no-tillage and strip-tillage systems may create increased weed pressure when the equipment moves residue and soil away from the seedbed, especially when pre-emergence herbicides are applied prior to planting. No-tillage and strip-tillage systems reduce soil surface evaporation, allowing for better activation of certain herbicides.

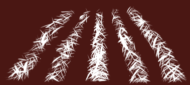
Tillage Management Guide



Use controlled traffic to minimize compaction.

Ensure residue is evenly spread across the harvest width.

Base soil fertility program on composite soil samples from uniform management zones and grid samples.

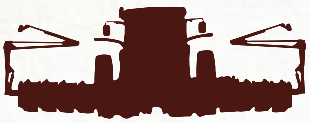


For strip-tillage, take soil cores from within and between strips.

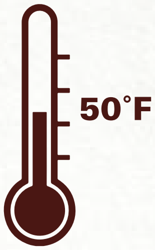
P&K

Injection of phosphorus and potassium reduces risk for loss and does not affect productivity compared to broadcast.

Starter phosphorus and potassium may be beneficial.



Follow proper maintenance and planter setup for optimum performance. Pay particular attention to row-unit down pressure, seeding depth, and closing-wheel tension.



Select corn and soybean planting dates based on ideal planting conditions (50°F soil temperatures and rising, suitable soil moisture).

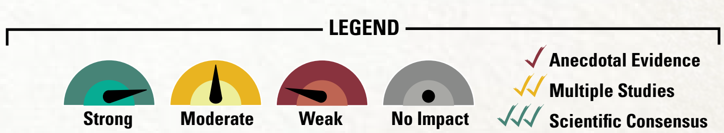
Scout fields more frequently for insects and diseases (consult ISU field agronomist or private agronomist for assistance).

Tillage Residue Management at a Glance

The table to the right summarizes common tillage management methods for corn and soybean rotations and assigns a relative success rate along with a level of confidence based on published research.

Success with tillage residue management is defined by your ability to meet both row crop production and conservation goals.

	Success Rate	Confidence
Controlled traffic to minimize soil compaction	Strong	Multiple Studies
Comparable profitability to full tillage on most soils	Strong	Scientific Consensus
Fertility program managed similarly to other systems	Strong	Multiple Studies
Scouting early and often	Moderate	Multiple Studies



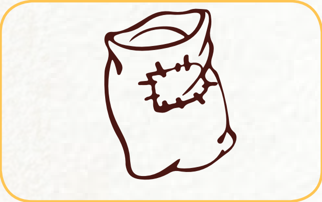
Cover crops are plant species, such as oats and cereal rye, planted to reduce soil erosion, improve soil health, and provide water quality benefits during the months of the year when crops are not actively growing on farmland. Incorporating cover crops improves soil health by:

- √ Improving soil structure
- √ Reducing soil compaction
- √ Protecting the soil surface

Cover crops are seeded in the fall, either before or after harvest. They are not harvested as grains, but can be grazed or harvested as forage. Cover crops go hand-in-hand with no-tillage and strip-tillage.

Cover crop choices and seeding specifications vary depending on crop rotation and preferences. The cover crop decision tools on pages 34 through 37 will help you choose and manage the most appropriate cover crops for your situation.

Seeding a winter cereal grain cover crop ahead of corn and soybean does not require any drastic changes in corn or soybean management practices.

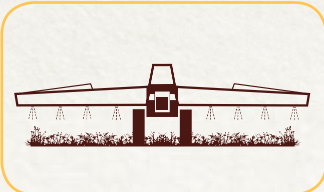


Plant Cover Crops in the Fall

- Aerial and overseeded cover crops do not interfere with harvest. Aerial overseeding a cereal grain in a corn-soybean rotation between August 20 and September 10 offers an expanded season to establish the cover crop. The recommended aerial seeding rate is 60 to 70 pounds per acre for both cereal rye and oats.

- Drilling immediately after harvest is also an option for winter cereal grains and oats. Harvest corn and soybean as soon as possible if you're planning for drilled cover crop seeding. Choose corn and soybean maturities that are within the well-adapted range for your area. Drill winter cereal grains at the seeding rate of 50 to 60 pounds per acre, ideally before October 15 and no later than November 1. Drill oats as a cover crop before September 10 at the seeding rate of 60 pounds per acre.

- Timely rainfall is critical for cover crop germination, especially for aerial or overseeded cover crops.

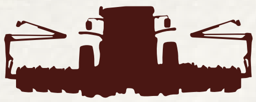


Terminate Cover Crops in the Spring

- Cover crops that survive the winter must be terminated in the spring ahead of planting, to avoid affecting corn and soybean crop yields. With corn, terminate the cover crop before it is 8 inches tall, and 10 to 14 days before planting corn. With soybean, terminate the cover crop before it is 12 inches tall, and 3 to 7 days before planting soybean. If spring weather conditions are abnormally dry, terminate cover crops earlier than otherwise recommended.
- Terminate cover crops using glyphosate. Use the full label rate, and apply when days are warmer than 60ºF and nights are above 40ºF to increase effectiveness. Avoid using high amounts of ammonium sulfate or urea ammonium nitrate tank-mixed with the glyphosate. Always read and follow herbicide label instructions.

SPRING TILLAGE OF A COVER CROP

Spring tillage of cover crop residue is not recommended. Tillage of cover crops that have been recently terminated, with minimal root decomposition, results in a rough seedbed. This creates a non-uniform seed depth and crop emergence.



Spring Planting After the Cover Crop

Planting corn or soybean after a cover crop requires minimal change. Follow best management practices for the corn or soybean crop, and the fundamental principles that maximize production efficiency:

- Plant based on soil conditions, but realize that suitable soil conditions may be a day or two later than without cover crops.
- Wait for conducive field conditions with a soil temperature at 50°F and rising. At a soil temperature of 50°F or warmer, there is robust seed germination, and vigorous seedling emergence, growth, and establishment

KEY PLANTER SETTINGS WITH A COVER CROP

- **Ensure adequate weight and down pressure** on the toolbar.

  50 to 100 pounds of down pressure
  Best for drier conditions and firm fields

  Reduce down pressure to avoid sidewall compaction
  Best for wetter conditions and loose seedbeds

- **Ensure adequate closing-wheel tension** to successfully close the seed furrow and provide good seed-to-soil contact.
- **Adjust row cleaners** to move residue out of the row space while leaving the soil undisturbed, using caution to avoid cover crops wrapping around the cleaners.

NITROGEN MANAGEMENT WITH A COVER CROP

- **Move nitrogen application to the spring** close to the time of corn planting.
- **Starter fertilizers may be beneficial** to minimize impact of nitrogen immobilization due to cover crop root and residue decomposition.
- There is **no need to adjust nitrogen rates** following winter cereal-grain cover crops.

Spring Management After the Cover Crop

- With corn following a winter cereal-grain cover crop, there is no need to change the nitrogen rate; however, wait to apply nitrogen fertilizer until after cover crop termination, to avoid the cover crop taking up the nitrogen. Starter fertilizer with 20 to 30 pounds of nitrogen per acre may be beneficial for corn following a cereal-grain cover crop.
- Corn and soybean fertility programs may need to be adjusted when adding a cover crop to the system, but many practices remain the same. The timing of phosphorus and potassium does not need to be adjusted. Apply manure based on developed manure management plans and according to best management practices; the growing cover crop will take up nutrients from the applied manure. Disturbance from manure application may be detrimental to some cover crop stands depending on the type of manure applicator injectors or disc covers used.
- Cereal-grain cover crops are typically tolerant of residual herbicides. Scout corn and soybean fields more frequently for insect and disease pressure, especially in a corn field following an overwintering cover crop.

MANURE APPLICATION WITH A COVER CROP

- **Apply following manure management plan** or Iowa State University recommendations.
- Manure application may be detrimental to cover crop stands, especially injected manure. However, cover crops are still a good option for their ability to **uptake manure nutrients** that could otherwise be lost.

Cover Crop Management at a Glance

The tables that follow summarize common cover crop species and management practices used in corn-soybean rotations, and assigns a relative success rate along with a level of confidence based on published research. Success rate with cover crops is defined by a combination of reliable emergence, biomass accumulation, and ease of termination that enables the decision maker to meet both row crop production and conservation goals.

Species

Success is defined by the ability of the species to accumulate biomass for desired cover crop benefits.

Species	Success Rate	Confidence
Oats	Moderate	Scientific Consensus
Cereal rye	Strong	Scientific Consensus
Winter wheat	Strong	Anecdotal Evidence
Vetches	Weak	Anecdotal Evidence
Clovers	Weak	Anecdotal Evidence
Rapeseed	Weak	Anecdotal Evidence
Turnips	Weak	Anecdotal Evidence
Radishes	Moderate	Multiple Studies

Seeding Method/Timing

Success is defined by reliable, uniform germination and growth of cereal grain cover crops to accumulate desired biomass.

Seeding Method/Timing	Success Rate	Confidence
Interseed	Weak	Anecdotal Evidence
Overseed (aerial)	Moderate	Multiple Studies
Overseed (broadcast)	Strong	Scientific Consensus
Drill	Strong	Scientific Consensus
Broadcast with incorporation	Moderate	Anecdotal Evidence

LEGEND

Success Rate: **Strong** · **Moderate** · **Weak** · **No Impact**

Confidence: ✓ **Anecdotal Evidence** · ✓✓ **Multiple Studies** · ✓✓✓ **Scientific Consensus**

Termination Method

Success is defined by the ability to easily terminate an overwintering cover crop ahead of corn or soybean production.

Termination Method	Success Rate	Confidence
Mow		
Herbicide		
Crimper roll		
Tillage		

Nitrogen Management

Success is defined by the ability to manage nitrogen following a cereal grain cover crop without negative impact to the following corn crop.

Nitrogen Management	Success Rate	Confidence
No change in total N rate		
Starter nitrogen		
Split nitrogen application		

Termination Timing

Success is defined by the ability to easily terminate an overwintering cover crop ahead of corn or soybean production to achieve row crop and conservation goals.

Termination Timing	Success Rate	Confidence
>14 days before corn		
7-14 days before corn		
0-7 days before corn		
>14 days before soybean		
7-14 days before soybean		
0-7 days before soybean		
0-7 days after soybean		

Crop Management

Success is defined by the ability to manage corn and soybean crops without yield penalty following a cover crop.

Crop Management	Success Rate	Confidence
Use of well-adapted maturities		
Properly maintained/ adjusted planter		
Scouting early and often		

Cover Crop Management Guide

Spring termination ahead of:

Corn

10 to 14 days prior to planting or before 8 inches tall

Soybean

3 to 7 days prior to planting or before 12 inches tall

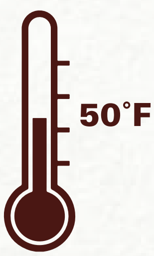
Nitrogen management for corn following cereal rye:

Move nitrogen application to the spring after cover crop termination.

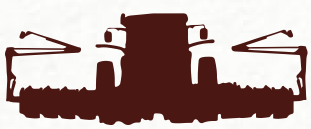
Starter fertilizers may be beneficial to minimize impact of nitrogen immobilization due to cover crop root and residue decomposition.

N

No need to adjust total nitrogen rates following winter cereal-grain cover crops.



Select corn and soybean planting dates based on ideal planting conditions (50°F soil temperatures and rising, suitable soil moisture).



Follow proper maintenance and planter setup for optimum performance. Pay particular attention to row-unit down pressure, seeding depth, and closing-wheel tension.

Choose corn and soybean maturities that are within the well-adapted range for your area.

Scout fields with cover crops more frequently for insects and diseases (consult ISU field agronomist or private agronomist for assistance).

Diverse Crop Rotations

Crop rotations use different crop species on the same piece of land from one year to the next. A typical crop rotation system in Iowa is the corn-soybean rotation. A diverse crop rotation adds small grains, forage crops, or other summer annuals into a more traditional cropping system.

In Iowa, a common diverse rotation would include a year of winter small grain interseeded with red clover following a crop of soybean. A more diverse rotation would include two to three years of alfalfa or legume-grass mixtures managed for hay production or grazing.

Diverse crop rotations are a key component in achieving the principles of conservation agriculture, improving cropping systems by:

- √ Protecting the soil surface.
- √ Enriching the soil with additional organic matter and diverse biological activity.
- √ Controlling soil erosion.
- √ Maximizing the resilience of corn-based cropping systems to weather extremes and pest pressure.
- √ Reducing greenhouse gas emissions.
- √ Possibly decreasing application amounts for nitrogen and phosphorus by reducing the loss of these nutrients.

SPRING SEEDING CONSIDERATIONS

Oats are the most reliable spring small grain in northern Iowa. Winter cereals have the potential to winter kill at northern locations.

Establishing a diverse crop rotation begins with planting a winter small grain—wheat, rye, or triticale—after the soybean harvest, by October 1 in northern Iowa and October 15 in southern Iowa. Another option is to plant a spring small grain—oats, wheat, triticale, or barley—the following spring.

Winter small grains can also be frost-seeded with red clover, or followed with a cover crop after harvest. Typically, spring small grains in Iowa can be sown alone, or companion-seeded with legumes such as alfalfa or red clover.

Some Guidelines for Incorporating Small Grains:

- Avoid using variety not stated (VNS) seed for winter or spring small grains intended for grain harvest. Rather, plant seed of named varieties, tested for germination and weed seeds.
- Oats, drilled in spring, are more reliable than winter small grains north of Interstate 80, due to the potential for winterkill. Winter small grains are more successful south of Interstate 80, drilled before October 15.
- Plant oats at a seeding rate of 80 to 90 pounds pure live seed per acre. Plant winter small grains at a rate of 60 to 70 pounds pure live seed per acre with an adequate level of soil test phosphorus. Soil phosphorus is important for winter survival of small grains.

NITROGEN MANAGEMENT WITH DIVERSE ROTATIONS

Account for nitrogen fixation legumes in the following crop.

Apply 30 to 40 pounds of nitrogen per acre to optimize small grain production.

- The extended soil surface cover by perennials like alfalfa or a legume-grass mixture in a diverse crop rotation reduces the loss of nitrogen and phosphorus. However, crop removal of phosphorus is greater with hay than with corn or soybean grain.
- Frost-seed red clover into winter small grains during the spring freeze-thaw period at 10 to 12 pounds per acre. Clip red clover and weeds one month after small grain and straw harvest.
- In general, diverse crop rotations disrupt and potentially reduce disease pressure and insect cycles. However, consider applying a fungicide to control head blight of winter small grains and rust on oats.
- Increase seed quality with post-harvest aeration of small grains.
- Test wheat, rye, barley, and hulled oats for levels of vomitoxin before feeding to livestock.

Consult the diverse rotations decision tools on pages 38 through 41 for guidance in establishing a rotation that suits your location, cropping system, and preferences.

TILLAGE MANAGEMENT WITH DIVERSE ROTATIONS

Use no-tillage for seeding small grains into corn or soybean residue.

Plant no-tillage corn or soybean into small grains or alfalfa, unless wildlife holes are problematic.

Rotation

This table summarizes common crop rotations and assigns a relative success rate along with a level of confidence based on published research.

Success is defined by the rotation's ability to meet both row crop and conservation goals.

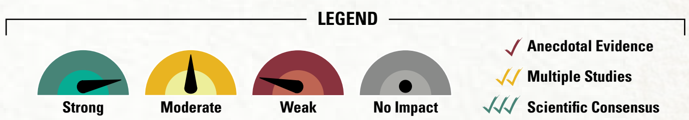
Rotation	Success Rate	Confidence
Continuous corn	Moderate	Scientific Consensus
Corn-soybean	Moderate	Scientific Consensus
Corn – soybean – small grain/red clover (3 years)	Strong	Scientific Consensus
Corn – soybean – small grain/alfalfa (5+ years)	Strong	Scientific Consensus
Energy crops	Strong	Multiple Studies

Crop Management

This table summarizes common crop management practices in relation to the use of extended rotations and assigns a relative success rate along with a level of confidence based on published research.

Success is defined by reliable crop growth to meet crop rotation and conservation goals.

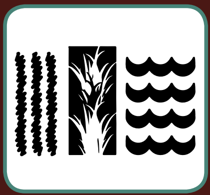
Crop Management	Success Rate	Confidence
Applying a reduced nitrogen rate to crop following legume	Strong	Anecdotal Evidence
Planting winter cereal grains in southern Iowa	Moderate	Multiple Studies
Producing oats in northern Iowa	Strong	Multiple Studies
Scouting early and often	Moderate	Multiple Studies



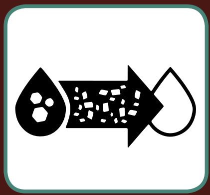
Edge-of-Field Conservation Practices that Work

This section includes:

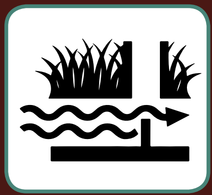
Wetlands



Saturated Buffers



Bioreactors



Controlled Drainage

Prairie Strips

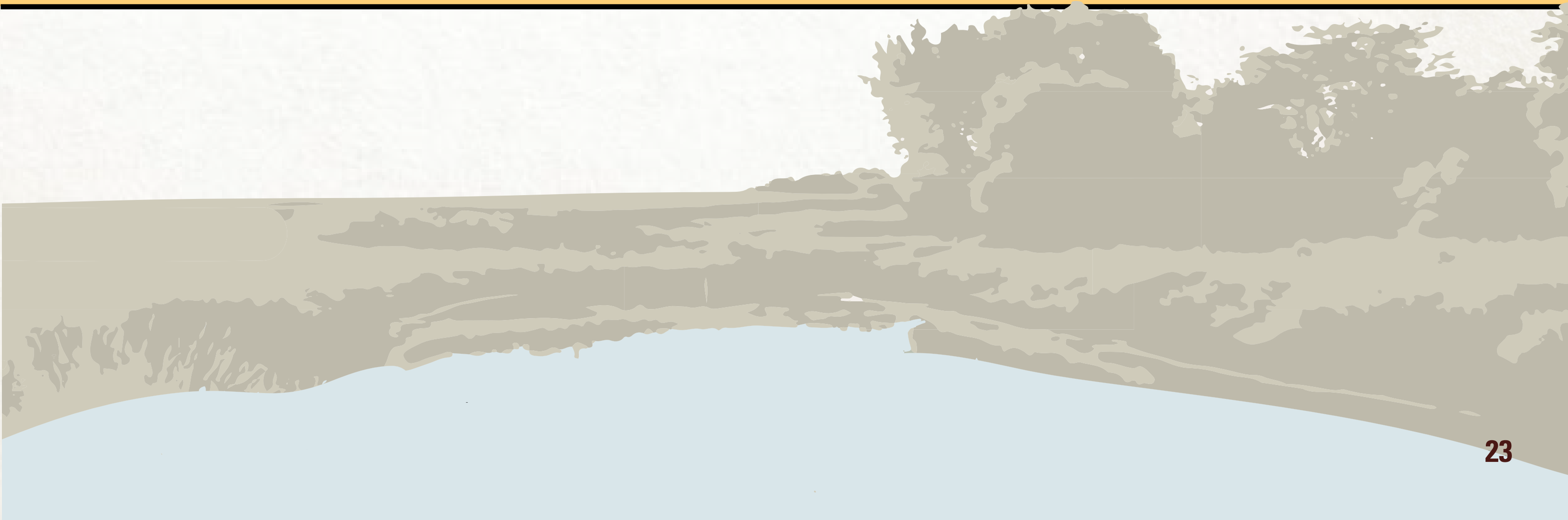
In addition to incorporating conservation practices in the field, many Iowa farmers are adopting edge-of-field practices that help to significantly improve water quality in the state by managing the loss of nitrogen from cropland.

Approximately 50 percent of Iowa cropland has subsurface drainage, based on United States Department of Agriculture Census of Agriculture data from 2012 and 2017. While this subsurface drainage makes it possible to farm previously wet soils, the drainage system also carries dissolved nitrogen from farm fields to the streams, rivers, lakes, wetlands, and other surface waters of the state.

Excess nitrogen in surface water leads to local, regional, and national-level alterations to aquatic ecosystems resulting in decreased water clarity, increased algal growth, and oxygen deficiencies that cause fish kills and reduce biotic diversity. Excess nitrogen also harms potable water supplies. Nitrate-nitrogen concentrations above the 10 mg/L NO_3-N drinking-water standard established by the United States Environmental Protection Agency are not uncommon in Iowa.

A COMMITMENT TO CONSERVATION

Iowa has made a commitment to **reduce nutrient loading in the state's waterways** through the Iowa Nutrient Reduction Strategy, developed as part of the 2008 Gulf of Mexico Hypoxia Action Plan. This calls for the reduction of nutrient loadings to the Gulf of Mexico by 45 percent over the coming decades.



Edge-of-field practices such as treatment wetlands, bioreactors, saturated buffers, and controlled drainage can significantly reduce the amount of nitrate-nitrogen that leaves subsurface drainage networks. On average, nitrate-nitrogen is reduced by:

- √ 52 percent with treatment wetlands.
- √ 53 percent with saturated buffers.
- √ 43 percent with bioreactors.
- √ 32 percent with controlled drainage.

While edge-of-field practices have the potential to remove large amounts of nitrate-nitrogen from subsurface water, there is no one practice that works well at all sites. A combination of appropriate practice implementation and high adoption rates is needed to meet the nitrogen reduction goals of the Iowa Nutrient Reduction Strategy.

This section is intended to help you determine which edge-of-field practice is best suited for your needs—a sort of "office chair" suitability analysis to help determine the appropriate practice for a given location. The edge-of-field decision tools on pages 43 through 45 guide you through the process of determining whether edge-of-field practices will work at your site and help identify the most appropriate edge-of-field practice. Practice-specific decision tools follow on pages 46 through 55.

Wetlands

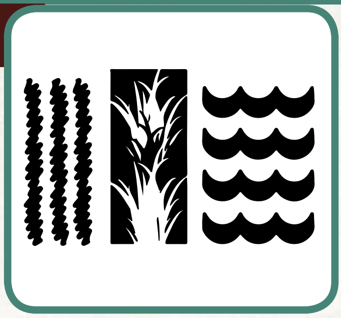
Several types of wetlands can be used in agricultural settings, depending on your goals. **If the primary goal of a wetland is for water quality improvements**, treatment wetlands help to remove nitrogen through conversion of nitrate-nitrogen to nitrogen gas by microbial activity and through plant uptake. Ideally, treatment wetlands should have a pool footprint greater than or equal to 1 percent of the watershed area to be treated. The topography of the site should allow for a drop in elevation from the tile outflow to the surface of the standing water in the wetland to prevent backflow of water into the tile drain system.

Additional land is needed to allow a diverse buffer of wetland vegetation to develop around the shallow water pool. If the wetland footprint is in an area that could experience high sediment flow, a sedimentation basin or other structure will need to be considered. It is also important that treatment wetlands remain fish-free to reduce sediment disturbance and prevent unwanted loss of sediment, phosphorus, and nitrogen from the system.

If the primary goal is to provide additional wetland habitat, identifying low-profitability wet zones within the field can reveal locations that could be planted in perennial wetland vegetation.

Some must-have pieces of information for determining if a wetland could be a suitable edge-of-field practice for the site include a soils map, profitability maps, and knowledge of relationships to district infrastructure if the site is in a drainage district.

Saturated Buffers

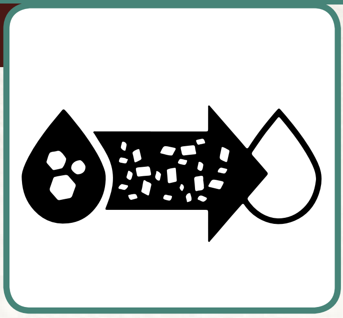


Saturated buffers are established near streams or ditches by diverting the existing tile drainage outflow so that **water passes through the subsurface of a vegetated buffer prior to entering a waterway**. Saturated buffers help to remove nitrogen through conversion of nitrate-nitrogen to nitrogen gas by microbial activity, as well as through plant uptake. In addition to improving water quality, saturated buffers also can enhance stream- and ditch-side habitat.

For this practice, it is beneficial to have a clay base layer to prevent undesired movement of water that could result in subsurface water bypassing the saturated buffer. Sites with open surface intakes in the drainage system are not ideal, as the soil and residue that may get into the drainage system via the surface intake could interfere with the movement of water into the saturated buffer. If surface intakes are present, you will need to take additional precautions to reduce sediment flow into the saturated buffer. If there are trees within the footprint of the saturated buffer, take extra care in the setting of distribution lines.

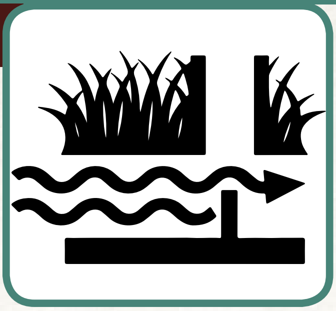
Use the USDA's Saturated Buffer Viewer (nrrig.mwa.ars.usda.gov/st40_huc/satBuff.html) to determine if a saturated buffer would work on your site.

Bioreactors



Bioreactors treat water from subsurface drainage systems by **diverting tile flow into an excavated trench filled with woodchips**. The woodchips provide carbon and attachment surfaces for microbial communities that convert nitrate-nitrogen to nitrogen gas. Ideally, bioreactors need relatively consistent tile flow to maintain saturated conditions in the bioreactor. Bioreactors cannot be placed in areas where surface flows may cause ponding of water on top of the bioreactor. It is important to keep the bioreactor footprint out of highly trafficked areas to prevent the compaction of woodchips within the trench. The presence of surface intakes requires additional consideration.

Controlled Drainage



Controlled drainage uses existing tile drainage coupled with additional water control structures to help hold subsurface water in place when full drainage isn't needed and prevent the loss of nitrogen through tile drain outflows. Water control structures are managed so that **subsurface water is drawn down** during periods of field work, such as during planting and harvesting. The **subsurface water level is then raised** outside of the growing season and after crop establishment.

Some must-have pieces of information for determining whether controlled drainage will work for your site include a drainage map, a topographic map, and a soils map. It is also helpful to have an understanding of your goals and your willingness and ability to manage such a system.

Prairie Strips

Prairie species have stiff stems and deep roots that slow down water, allow it to infiltrate, and filter out sediment and nutrients. Patches of native perennial vegetation create valuable habitat for a wide variety of birds, insects, and mammals. Prairie strips can be placed around the edge of a field, within the field, alongside or perpendicular to waterways, and in terrace channels. To provide erosion control, improved water quality, and wildlife habitat, **a minimum of 10% of the field should be converted to prairie**. Prairie strips should have a minimum width of 30' and be spaced at intervals that work with your farming equipment.

Prairie flowers and grasses take time to establish, typically requiring two to three seasons of establishment management. Annual and perennial weeds grow quickly and can outcompete prairie plants in the first two growing seasons. Mowing prairie is an essential management practice that must be done during the first year whenever the height of the vegetation reaches twelve inches. Mower height should be set to four to six inches.

SCIENCE + SUPPORT = SOUND STEWARDSHIP

Decision Tools for Conservation

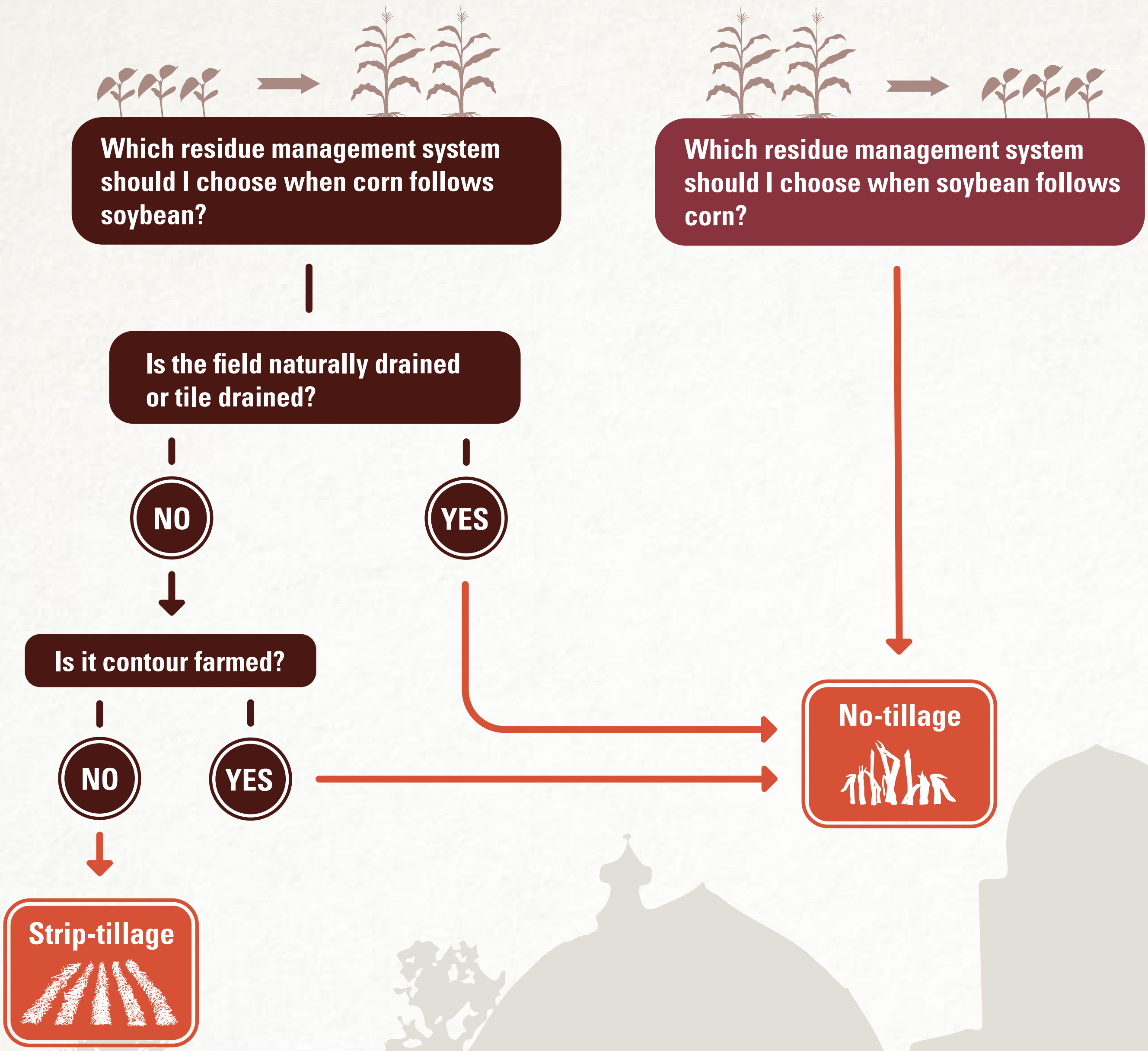
Decision tools are important step-by-step guides in the process of decision making and risk analysis. Being visual in nature, decision tools are readily comprehensible and applicable.

The decision tools that follow clearly illustrate the choices, risks, objectives, and information needs involved in the implementation of conservation practices. Further, these decision tools visually illustrate possible alternatives, probabilities and outcomes, providing clarity to the decision making process.

The conservation decision tools that follow are based on research and experience to help **decision makers (farmers and landowners)** predict future outcomes and to support rational decision making when implementing conservation and water quality practices for the first time. This icon represents decision tools developed for the decision maker.

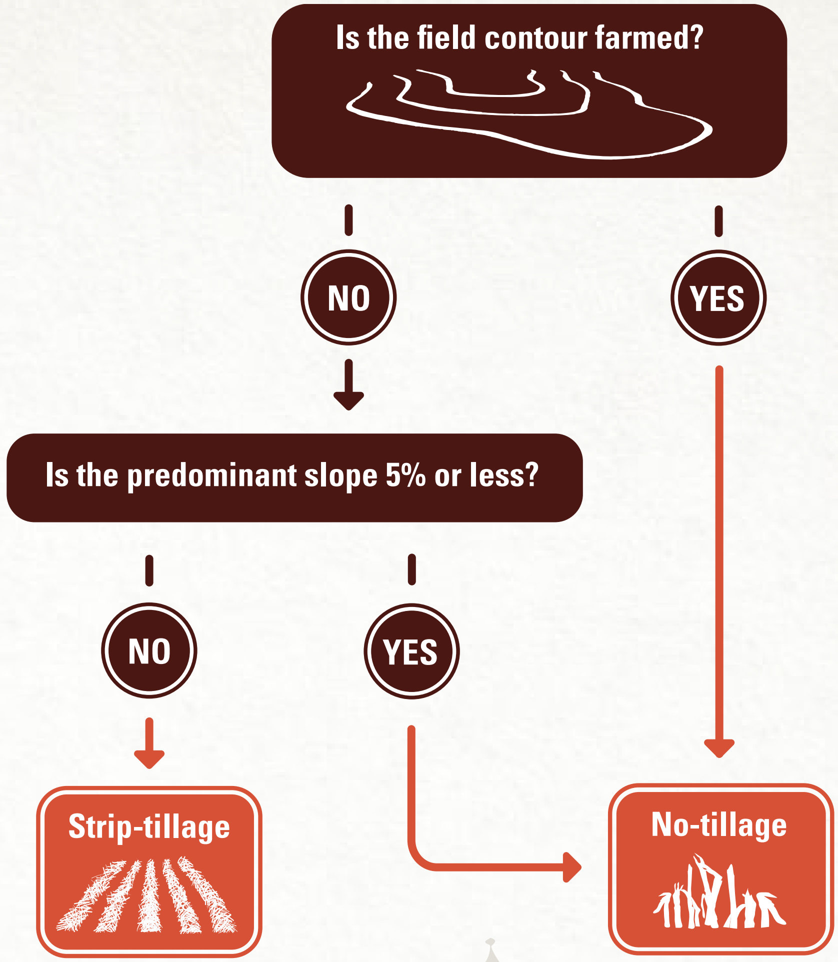
Decision tools can also be used by **conservation professionals** to help guide clients in implementing a variety of practices on their farms. This icon represents decision tools for conservation professionals advising the decision makers (mainly found in the edge-of-field section).

Tillage Management
Corn Soybean Rotation



Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.



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Cover Crop Selection and Management
After Corn

What is your next crop?

- **Corn** → **Best choice is oats**
  - **Seed oats Aug 20 — Sept 10**
    - aerial OR overseed at 60+ lb PLS/ac
  - → Pages 13–15 for spring management of cover crops
- **Soybean** → **Comfortable with spring termination?**
  - **NO** → Best choice is oats
  - **YES** → **Best choice is cereal rye**
    - **Seed rye Aug 20 — Sept 10**
      - aerial OR overseed at 60-70 lb PLS/ac
      - Best for wet conditions
    - **Seed as soon as possible after harvest, before Nov 10 — drill at 50-60 lb PLS/ac**
      - Best for dry conditions
    - → Pages 13–15 for spring management of cover crops

Pages 13–15 for spring management of cover crops

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Cover Crop Selection and Management
After Soybeans

Are you comfortable with spring termination?

NO → **Best choice is oats**

- **Seed oats Aug 20 — Sept 10**
  - aerial OR overseed at 60+ lb PLS/ac
  - Best for wet conditions

YES → **Best choice is cereal rye**

- **Seed rye Aug 20 — Sept 10**
  - aerial OR overseed at 60-70 lb PLS/ac
  - Best for wet conditions
- **Seed as soon as possible after harvest, before Nov 10 —**
  - drill at 50-60 lb PLS/ac
  - Best for dry conditions

Pages 13–15 for spring management of cover crops

Corn Crop Selection and Management

After Silage

What is your next crop?

- **Corn** → **Best choice is oats**
  - Seed by Sept 10 — drill OR broadcast at 60+ lb PLS/ac
  - → Pages 13–15 for spring management of cover crops
- **Soybean** → **Best choice is cereal rye**
  - **Are you comfortable with spring termination?**
    - **NO** → Best choice is oats
    - **YES** → Seed by Nov 10 — drill at 50-60 lb PLS/ac OR broadcast at 60+ lb PLS/ac
      - → Pages 13–15 for spring management of cover crops

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Cover Crop Selection and Management
After Small Grains Before Corn

Is fall grazing or nitrogen fixation a goal?

YES, Grazing

Plant a summer annual: millet, sudangrass, or sorghum x sudangrass

YES, Nitrogen fixation

Frost-seed or interseed red clover at 10-15 lb/ac before small grain has reached jointing

NO

Is the volunteer post-harvest stand greater than or equal to 20 plants per square foot?

- **YES**: No additional seeding needed because volunteer population is adequate to achieve benefits
- **NO**: Overseed red clover, radish, or summer annuals at reduced rates to achieve plant density

Pages 13–15 for spring management of cover crops

Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Is your farm north of I-80?

NO

Will seeding occur before Oct 15?

NO

Spring drill oats in April at 80-90 lb PLS/ac (800,000-1M PLS/ac)

YES

Fall drill winter rye, winter wheat, or triticale at 60-70 lb PLS/ac (1.5M PLS/ac)

Interested in extending beyond the corn-soybean-small grain rotation?

NO

Page 37 for seeding a cover crop following small grains

YES

Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

YES

What is this year's crop?

Corn

Soybean

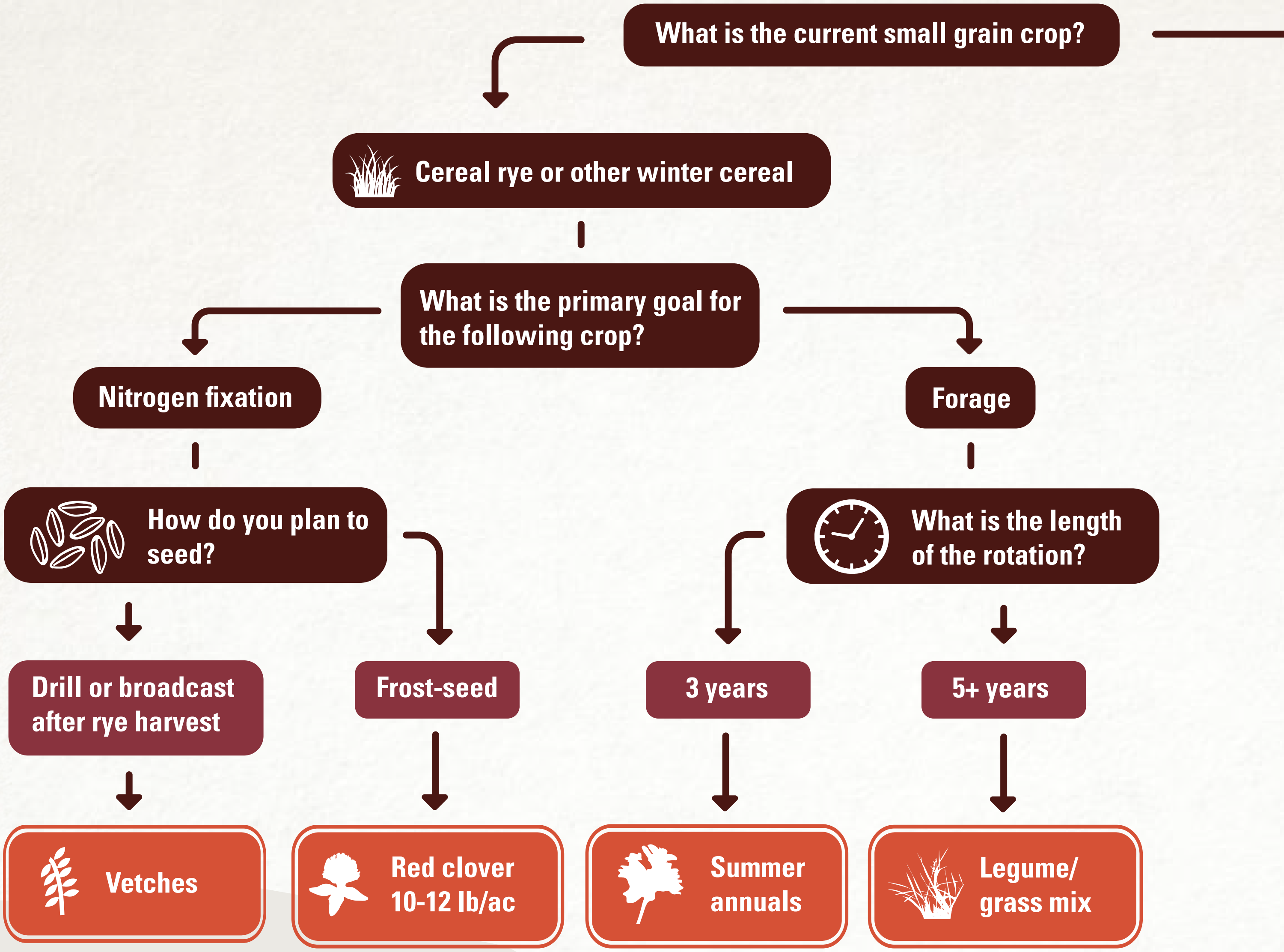
Spring drill oats at 80-90 lb PLS/ac (800,000-1M PLS/ac)

Spring drill oats in April at 80-90 lb PLS/ac (800,000-1M PLS/ac)

Fall drill winter rye, winter wheat, or triticale by Oct 1 at 60-70 lb PLS/ac (1.5M PLS/ac)

Pages 40 and 41 for 5-year rotations

Expanding Diverse Rotations



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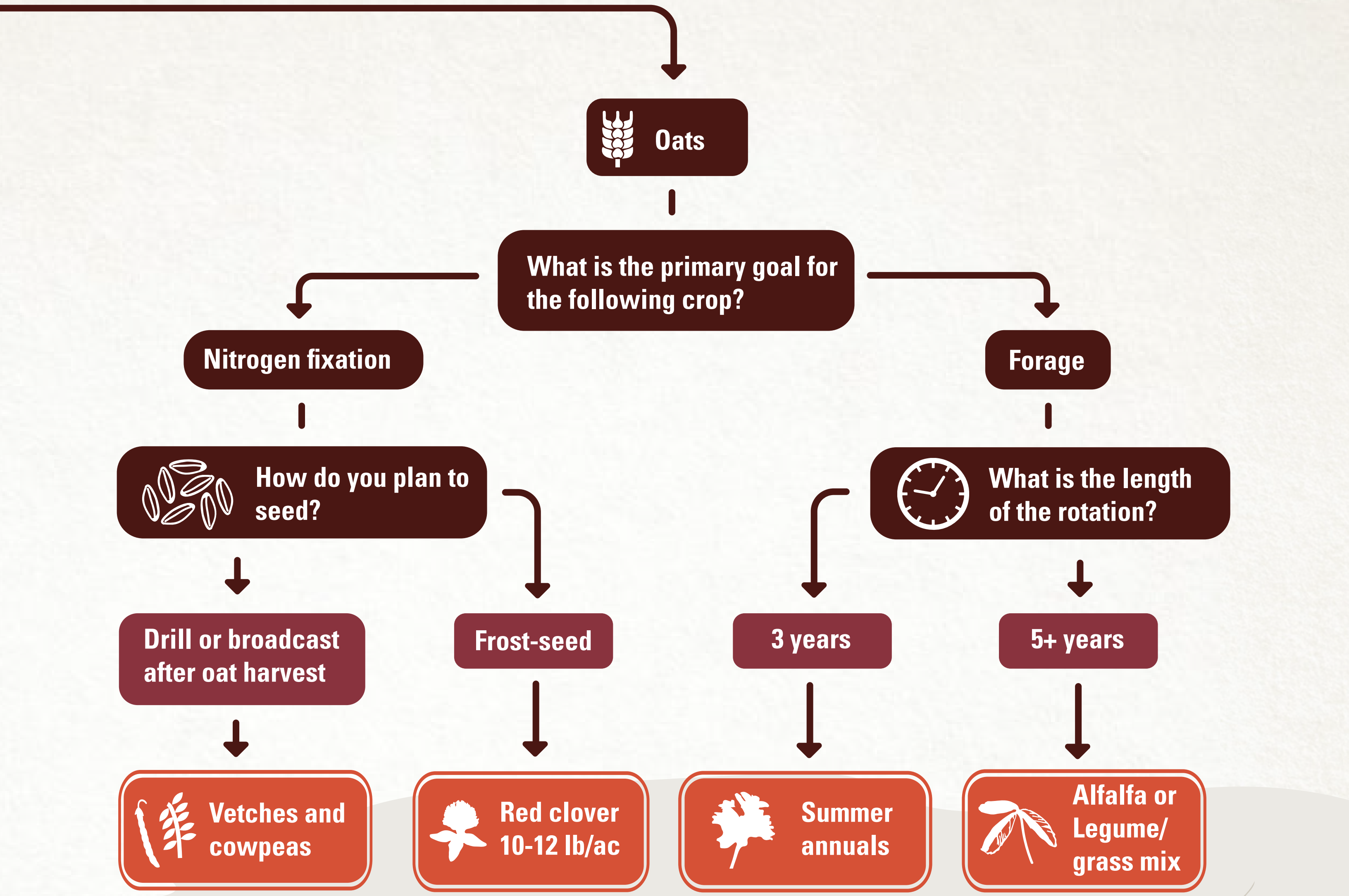
Oats
What is the primary goal for the following crop?
Nitrogen fixation
Forage
How do you plan to seed?
What is the length of the rotation?
Drill or broadcast after oat harvest
Frost-seed
3 years
5+ years
Vetches and cowpeas
Red clover 10-12 lb/ac
Summer annuals
Alfalfa or Legume/ grass mix

Helpful information for edge-of-field decision tools

It is helpful to gather background information prior to using the following edge-of-field decision tools, but collecting all the information suggested is not essential for using the tool. Ideally, the background information includes aerial photos/imagery, drainage maps (with surface inlets if present), topographic maps, soil survey information, a conservation plan, awareness of your goals, long-term site plans, profitability maps, knowledge of existing utilities, and any existing water-quality data. See the Resources section on pages 58 through 61 for information on how to find maps and aerial photos online. If you are working with a conservation technical assistance provider, additional background information includes a watershed plan and any Agricultural Conservation Planning Framework (ACPF) information for the watershed, LiDAR maps, land-use and land-cover information for the surrounding watershed, and stream and river water quality monitoring data.

This icon represents decision tools developed for the **decision maker.**

This icon represents decision tools for **conservation professionals** advising the decision makers.

Could Edge-of-Field Practices Work for You?
Considerations for Decision Makers

What is your primary goal for using an edge-of-field practice?

Water quality improvement

Choose from:
- Wetland — Page 46
- Saturated buffer — Page 48
- Bioreactor — Page 50
- Prairie strips — Page 54

Habitat

Choose from:
- Wetland — Page 46
- Saturated buffer — Page 48
- Prairie strips — Page 54

Additional water management ability and potential yield benefit

- Controlled drainage — Page 52

Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Choosing the Right Edge-Of-Field Practice for Water Quality Improvement

Considerations for Decision Makers

Are you willing to put a portion of your land into a long-term easement?

YES → **Wetland** — Page 46

NO ↓

Do you have an existing stream-side or ditch-side buffer or are you willing to install a buffer?

YES → **Saturated buffer** — Page 48

NO ↓

Do you have space available that is at least 100 ft long by 25 ft wide?

YES → **Bioreactor** — Page 50

NO ↓

Consider alternative edge-of-field, management, or land-use practices.

Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Identifying Sites for Edge-of-Field Practices in a Hydrologic Unit Code (HUC) 12 Watershed

Considerations for Conservation Professionals

Are you working in an area with a watershed plan?

- **YES** → **Do you have access to the Agricultural Conservation Planning Framework?**
  - **YES** → Use a conservation planning scenario map to determine potential locations for saturated buffers, wetlands, bioreactors, or controlled drainage.
  - **NO** → Use the Saturated Buffer Viewer at www.nrrig.mwa.ars.usda.gov/st40_huc/satBuff.html to determine suitable locations for saturated buffers.
- **NO** → Use the Saturated Buffer Viewer at www.nrrig.mwa.ars.usda.gov/st40_huc/satBuff.html to determine suitable locations for saturated buffers.

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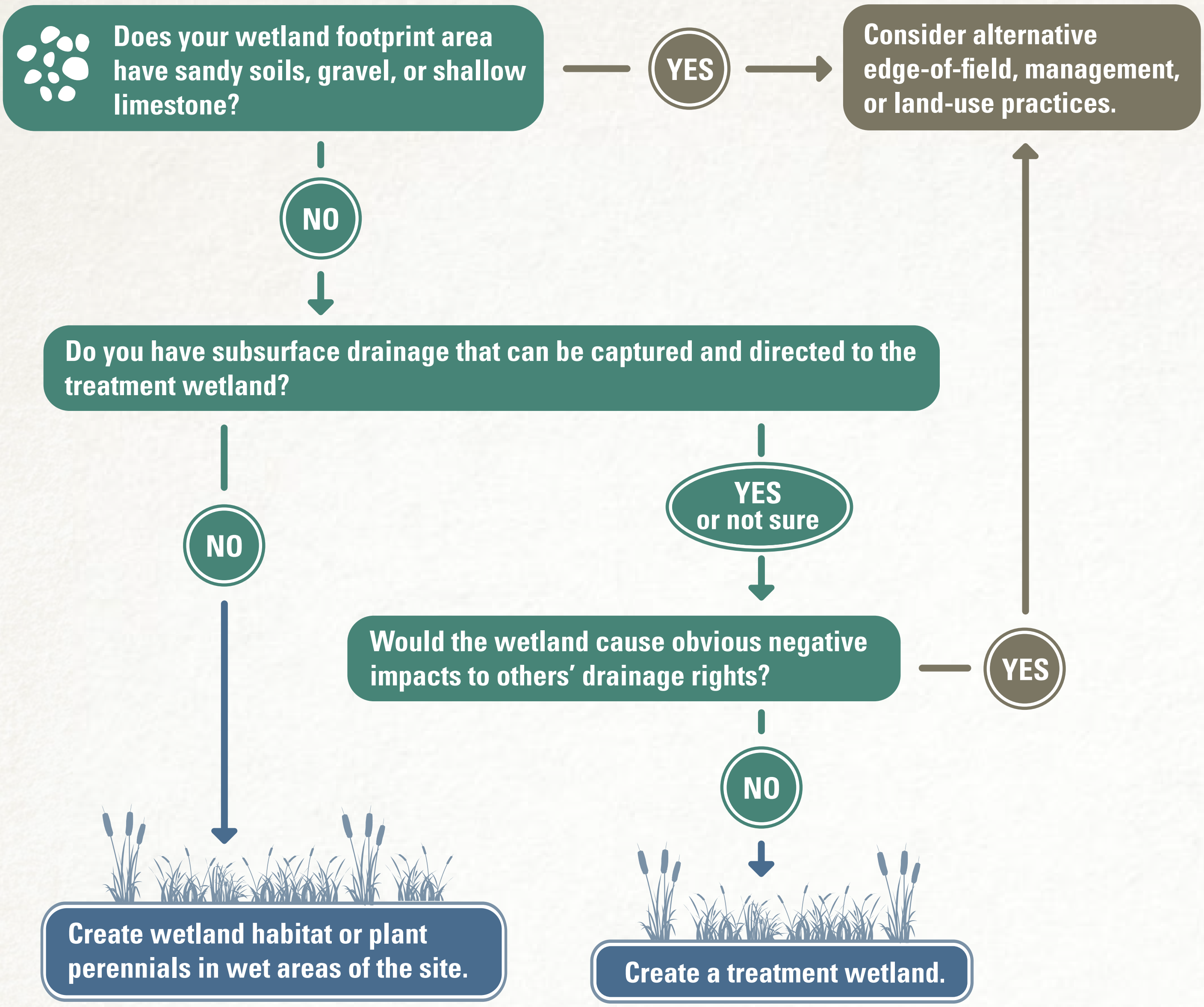
Is a Wetland Right for You?
Considerations for Decision Makers



Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Is a Wetland Right for the Site?

Considerations for Conservation Professionals

Does your wetland footprint area have sandy soils, gravel, or shallow limestone?

- **YES** → Consider alternative edge-of-field, management, or land-use practices.
- **NO** → Do you have subsurface drainage that can be captured and directed to the treatment wetland?

Do you have subsurface drainage that can be captured and directed to the treatment wetland?

- **NO** → Create wetland habitat or plant perennials in wet areas of the site.
- **YES or not sure** → Would the wetland cause obvious negative impacts to others' drainage rights?

Would the wetland cause obvious negative impacts to others' drainage rights?

- **YES** → Consider alternative edge-of-field, management, or land-use practices.
- **NO** → Create a treatment wetland.

Attend a conservation field day to learn more!

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Is a Saturated Buffer Right for You?

Considerations for Decision Makers

Do you have an existing buffer at least 30 ft wide or are you willing to install a buffer?

NO → Consider alternative edge-of-field, management, or land-use practices.

YES ↓

Are there surface intakes in your tile drainage system?

YES → Tile drainage systems without surface intakes are preferred. Sediment reduction or cleanout structures may be necessary when surface intakes are present.

- Not interested → Consider alternative edge-of-field, management, or land-use practices.
- Still interested → Contact your local watershed coordinator for more information on saturated buffers.

NO ↓

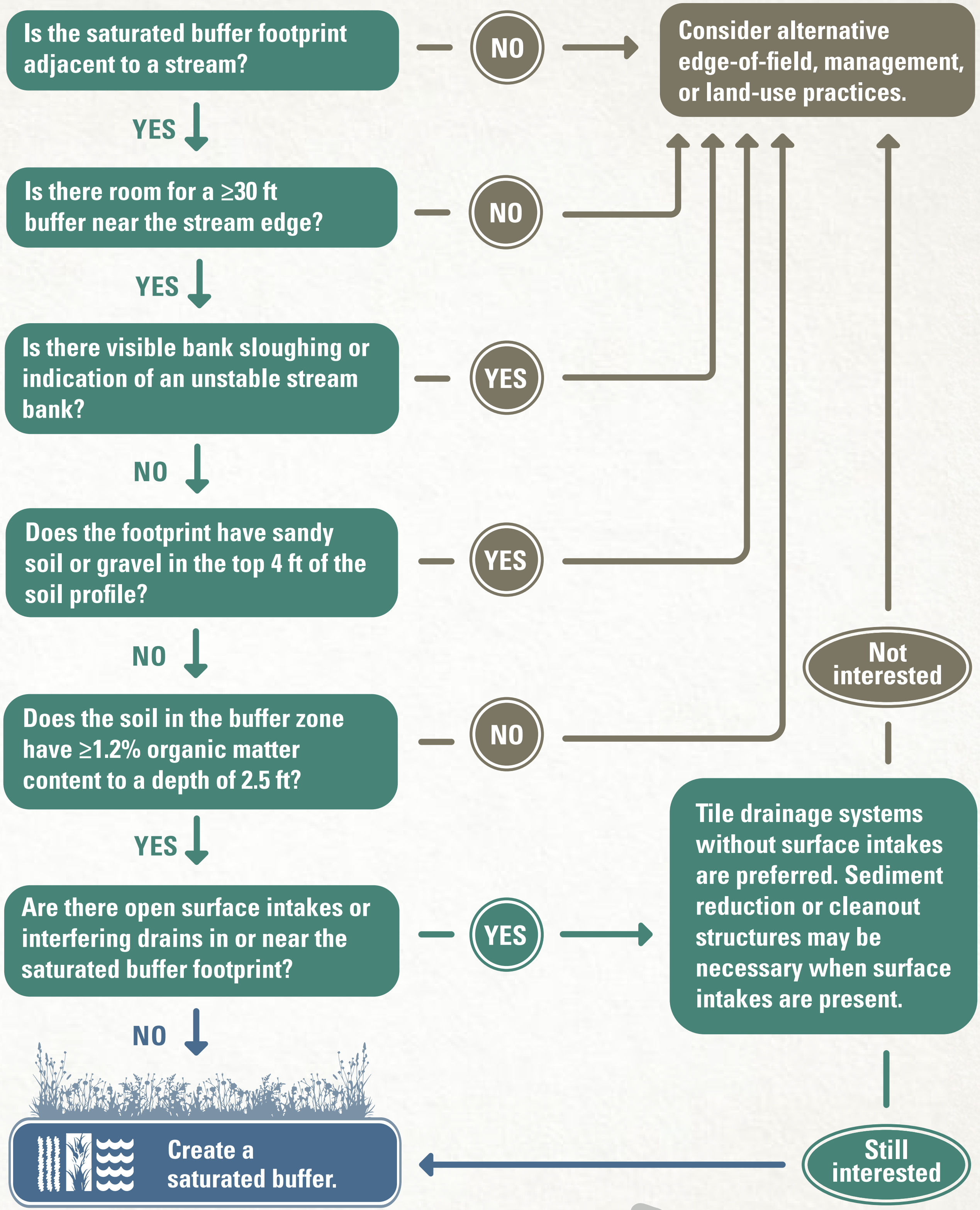
Contact your local watershed coordinator for more information on saturated buffers.

Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Is a Saturated Buffer Right for this Site?

Considerations for Conservation Professionals



Attend a conservation field day to learn more!

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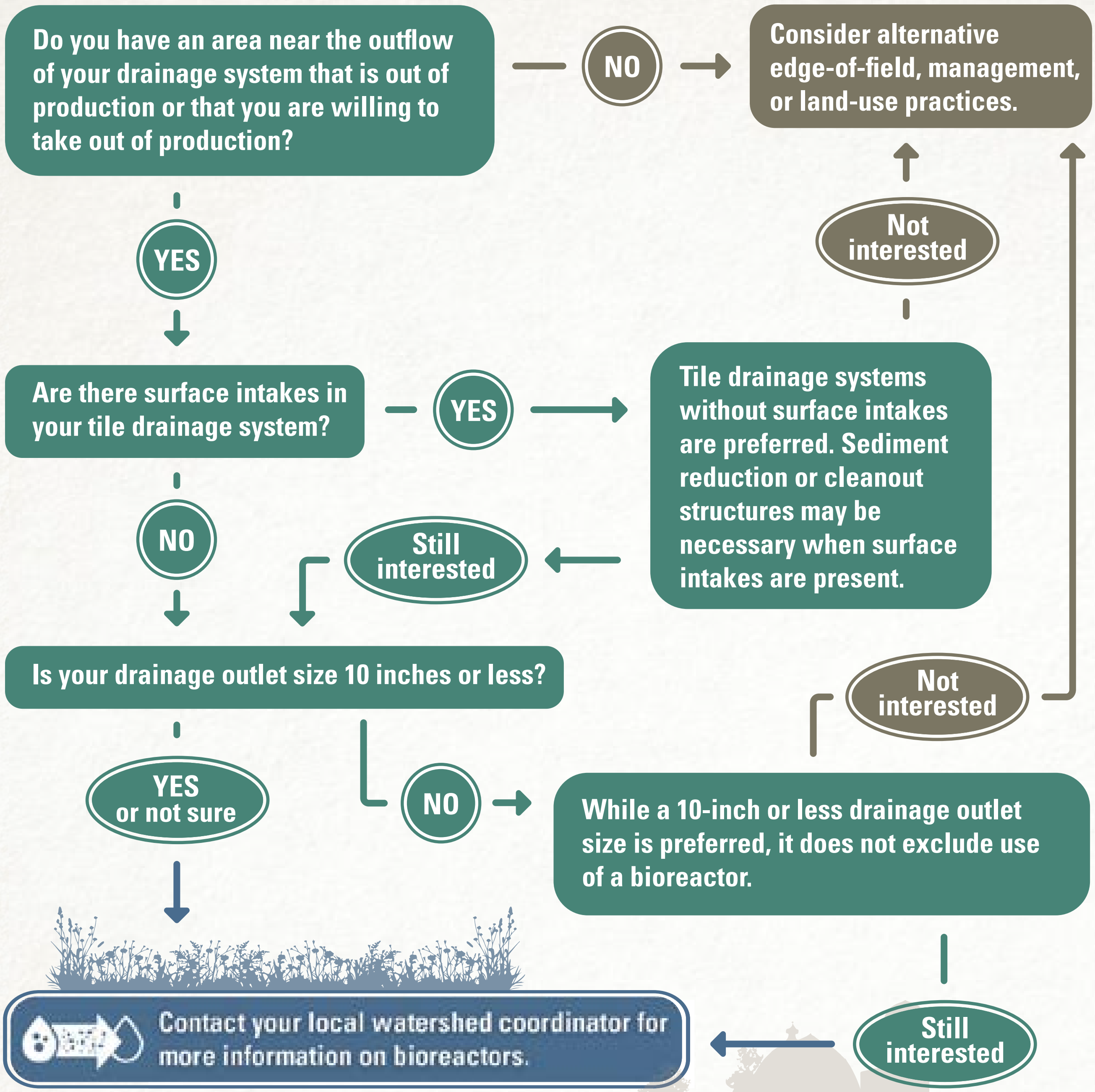
Is a Bioreactor Right for You?

Considerations for Decision Makers



Attend a conservation field day to learn more!

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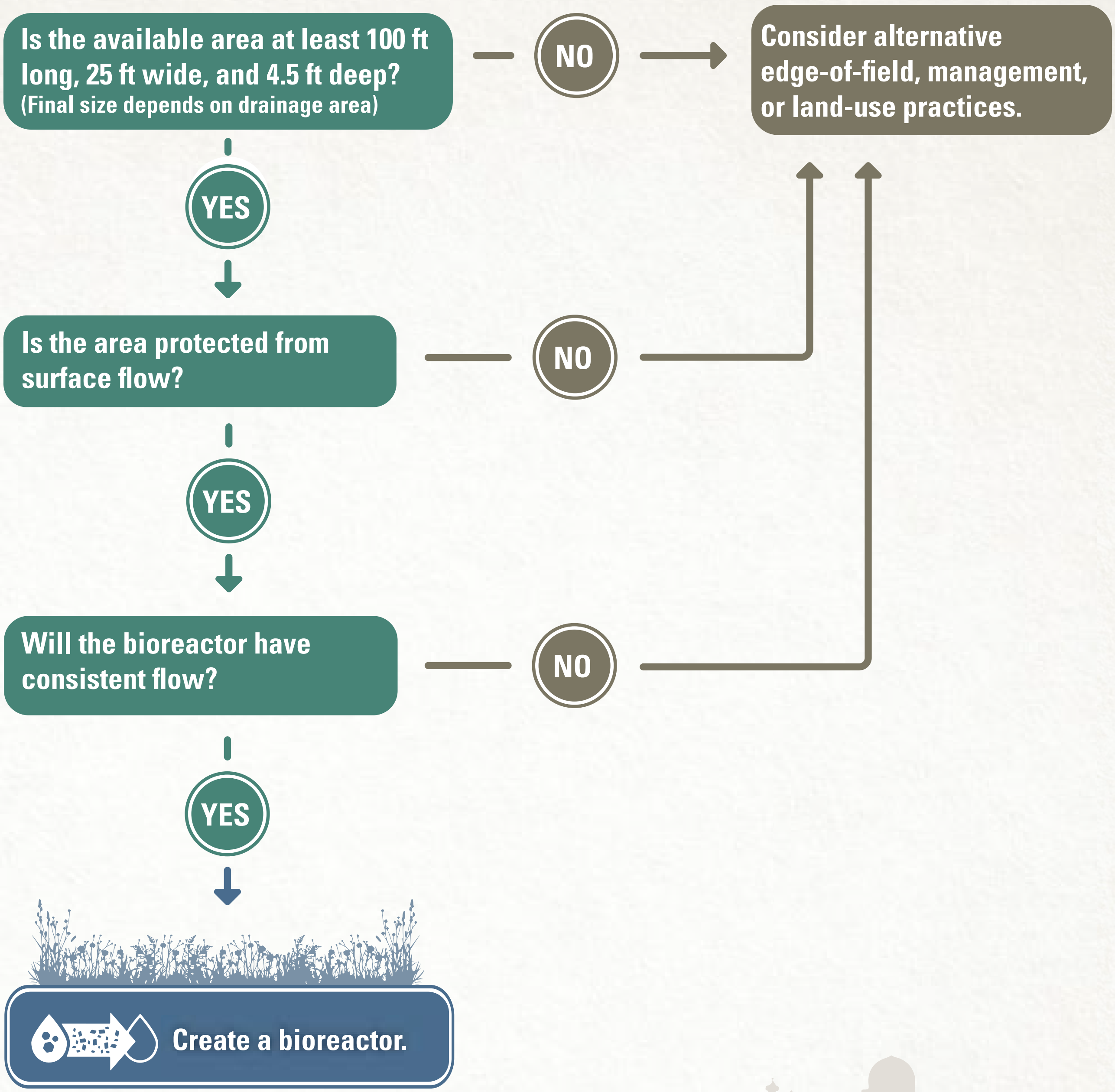
Is a Bioreactor Right for the Site?

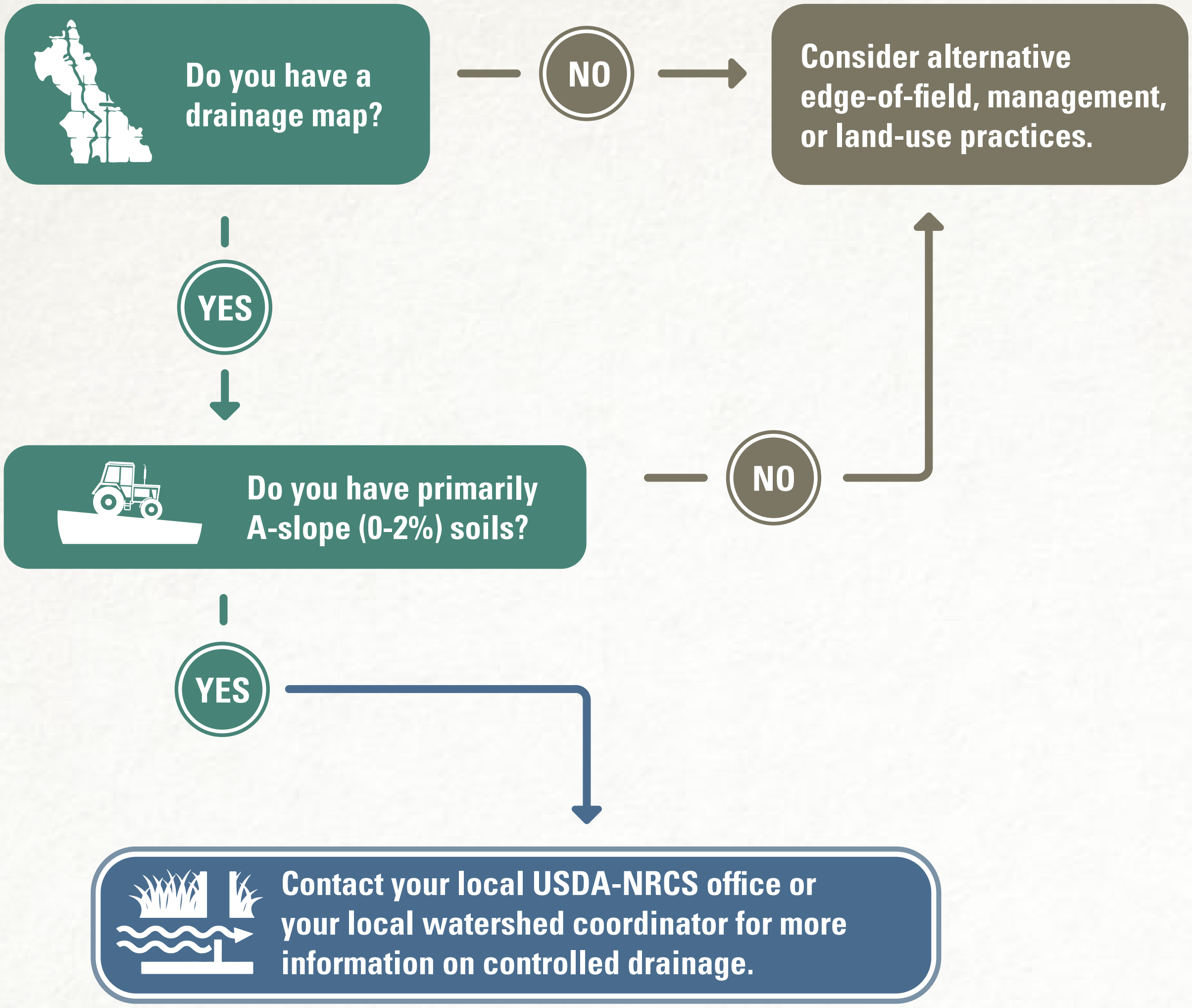
Considerations for Conservation Professionals



Attend a conservation field day to learn more!

Contact Iowa Learning Farms, Practical Farmers of Iowa, Iowa State University Extension and Outreach, or USDA-NRCS for field days near you.

Is Controlled Drainage Right for You?
Considerations for Decision Makers



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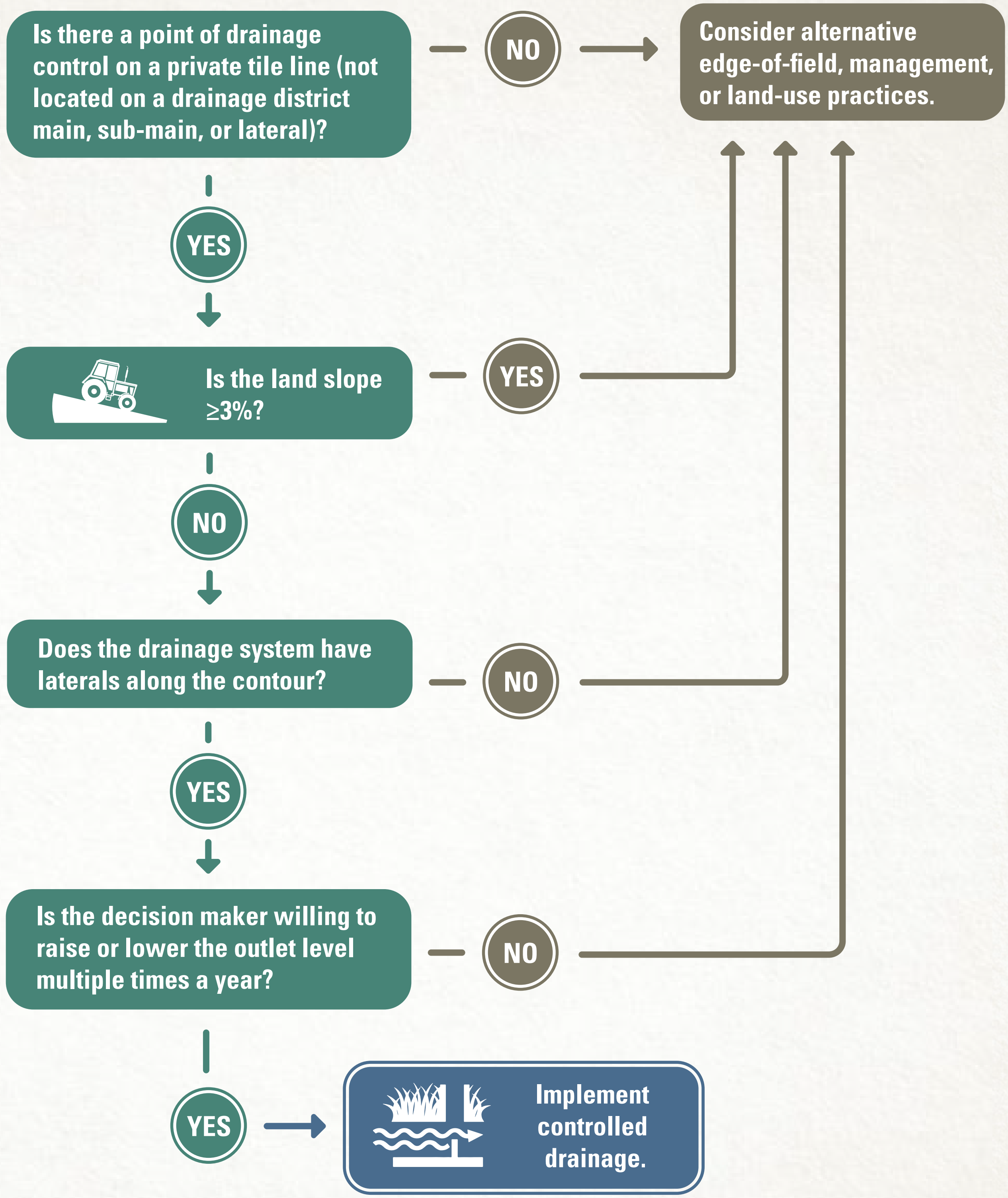
Is Controlled Drainage Right for the Site?

Considerations for Conservation Professionals



Attend a conservation field day to learn more!

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Are Prairie Strips Right for You?

Considerations for Decision Makers

Are reducing soil erosion, nitrate and phosphorus loss, AND providing wildlife habitat your primary goals?

YES

Are you willing to convert 5-10% of your field to prairie?

NO → Consider alternative edge-of-field, management, or land-use practices.

YES

Are you committed to mowing for the first two years to minimize weeds?

NO → Consider alternative edge-of-field, management, or land-use practices.

YES

Are you willing to farm around prairie strips?

NO → Plant prairie strips around the perimeter of field, on end rows, or in a terrace channel.

YES → Plant prairie strips, 30 ft or wider, through the field. Space at a distance conducive to your farm equipment.

Plant on the contour for slopes ≥5%.

Contact your local USDA-NRCS office for more information on prairie strips.

What kind of seed mix is right for your field?

Economy Mix
3:1 grass forb ratio

- **High** erosion control
- **High** weed resistance
- **Low** pollinator resources

Diversity Mix
1:1 grass forb ratio

- **Moderate to high** erosion control
- **Moderate to high** weed resistance
- **Moderate to high** pollinator resources

Pollinator Mix
1:3 grass forb ratio

- **Low** erosion control
- **Low** weed resistance
- **High** pollinator resources

Glossary

A-slope soils Nearly level soils that have an angle of 0 to 2 percent from the soil surface to the horizon.

ACPF Agricultural Conservation Planning Framework, a planning tool that uses field boundary, land use, elevation, and soil data to determine suitable locations for in-field and edge-of-field conservation practices within hydrologic units of the Midwest.

Aerial seeding Technique for sowing seeds by broadcasting them from a plane or helicopter.

Backflow Undesirable flow of water in the opposite direction from what is intended.

Broadcast seeding Technique for sowing seeds across a field by either scattering the seed by hand or mechanically, commonly using broadcast fertilizer spreaders or aerial applicators. This might occur into a standing crop or following crop harvest.

Cereal rye Cool season annual small-grain crop.

Composite soil sample Thoroughly mixed soil sample consisting of several cores taken from a particular field at a specific soil depth for analysis.

Conservation plan Natural resources management strategy for an individual farm.

Control structure Structure installed in line with a drainage pipe to raise, lower, or divert the flow of water from subsurface drainage.

Controlled traffic Conservation practice that minimizes or controls wheel traffic paths from one field operation to the next, to limit soil compaction.

Coulter Vertically mounted, circular blade that cuts crop residue and disturbs soil ahead of a planter row unit.

Cover crop A plant species that is seeded in fall, either before or after harvest, to manage soil erosion and take up nutrients to reduce nutrient losses. It is not intended for grain harvest, but can be grazed or harvested as forage.

Denitrification Microbial process that converts nitrate to nitrogen gas.

Disease pressure Level of prevalence and severity of disease.

Distribution line Tile drainage pipe that dispenses water to a desired location, such as a saturated buffer.

Diverse rotation Cropping system that has more crop diversity than the primary corn and soybean rotation.

Down pressure Amount of force transferred from one point to another point, often referred to as force from a planter toolbar to an individual row unit.

Drainage map Map that identifies the location of tile drainage lines within individual fields or a drainage district.

Drainage rights Legal ability of landowners to divert water from agricultural fields to areas of lower elevation either on or off their property.

Drainage tile Clay or concrete pipe segments, or perforated plastic pipe, buried under agricultural land to move excess water out of the soil.

Drill seeding Mechanical means of creating soil furrows at planting and metering seed into the furrows at a uniform rate.

Easement Portion of land set aside for a specific purpose.

Edge-of-field practice Structural practice located at the edge of an agricultural field.

Fall tillage Soil tillage in the fall that leaves the field rough and requires a spring finishing pass to create a smooth and clod-free seedbed.

Frost-seeding Practice of seeding a crop species in late winter when the soil surface is going through frequent (often daily) freeze-thaw cycles that help to incorporate seed.

Full-width tillage Tillage that disturbs 100 percent of the soil surface in preparation for planting.

Habitat Environment in which animals, plants, and other organisms live, eat, or breed.

Herbicide A chemical that kills plants, intended for weed control.

Hydrologic unit Area of land that drains to a common point.

Interseeding A form of early season broadcast seeding directly into an existing crop stand when it is 6 to 8 inches tall.

No-tillage Agricultural practice where crops are grown in undisturbed soil and plant residue at the surface.

LiDAR Light Detection And Ranging, a surveying method that uses laser light reflected off the land surface to form an elevation map.

Nutrient load Amount of a nutrient lost from a given area over a defined period of time.

Nutrient stratification The natural occurrence of nutrients, such as phosphorus and potassium, in layers or bands of different concentrations in the soil.

Overseeding A form of broadcast seeding directly into an existing crop stand without incorporating the seed.

Overwintering The process of a crop species surviving freezing winter conditions.

Pathogen A bacterium, virus, or other microorganism that causes disease.

Pest An organism (plant or animal) that causes damage to field crops.

Pesticide Any substance or mixture of substances used to repel, kill, or prevent pests.

Post-harvest aeration Blowing air through stored grain to reduce the rate of grain deterioration.

Potable water Water that is fit for human consumption.

Practice footprint The space or area of land that an edge-of-field practice occupies.

Pure Live Seed (PLS) The percentage of viable seed that has the potential to germinate within a measured one-pound weight of any seed lot. Seeding rates are based on Pure Live Seed expressed in pounds per acre.

Row cleaner Toolbar-mounted adjustable equipment for clearing crop residue away from the intended seedbed.

Sedimentation basin Water-holding structure that slows the flow of water and allows soil particles to settle out of the water column.

Seeding rate Amount of seed required at planting to achieve optimum yield goals.

Soil organic matter The organic component of soil that includes plant and animal residue at various stages of decomposition, biomass of soil microorganisms, and substances produced by plant roots and other soil organisms.

Soil erosion The detachment and transport of soil at the land surface by water, ice, wind, and gravity.

Soil sampling Collecting soil cores at specific soil depths from the field for analysis.

Starter fertilizer Fertilizer applied near the seed at planting to supply readily available nutrients to seeds before the plant root system develops.

Stream bank sloughing Erosion of soil down a stream bank toward or into the stream channel.

Strip-tillage A system with less than one-third of the row width tilled to create a seedbed. The strip-tillage system leaves more than two-thirds of the row width undisturbed between tillage zones.

Strip freshening Second tillage pass to prepare fall strip-tillage strips for warming before planting.

Subsurface tile drainage In-field, below-ground drainage tiles or pipes that convey excess water in the soil profile away from agricultural land.

Surface intake Surface drain that allows surface runoff to be diverted into a subsurface tile drainage line.

Unstable stream bank Stream bank that is prone to erosion or sloughing.

Vomitoxins A family of mycotoxins, also known as deoxynivalenol (DON), that infect wheat, barley, oat, rice, and corn.

Resources

Strip-Tillage and No-Tillage

Iowa Learning Farms Soil Conservation Resource Page:
iowalearningfarms.org/page/soil-conservation

Al-Kaisi, M. (2012, February 13). *Strip-tillage concept and management.* Retrieved from Iowa State University Extension and Outreach website:
crops.extension.iastate.edu/cropnews/2012/02/strip-tillage-concept-and-management

DeJong-Hughes, J., & Vetsch, J. (2018). *On-farm comparison of conservation tillage systems*. Retrieved from University of Minnesota Extension website:
extension.umn.edu/soil-management-and-health/farm-comparison-conservation-tillage-systems

Iowa Soybean Association. Strip-tillage research. Retrieved from:
iasoybeans.com/upl/downloads/publications/strip-tillage-research.pdf

Nowatzki, J., Endres, G., & DeJong-Hughes, J. (2017, June). *Strip-till for field crop production* (Publication AE 1370). North Dakota State Extension Service and University of Minnesota Extension. Retrieved from:
ag.ndsu.edu/publications/crops/strip-till-for-field-crop-production/ae1370.pdf

Mallarino, A., & Sawyer, J. (2016, December). *Take a good soil sample to help make good fertilization decisions* (Publication CROP 3108). Retrieved from Iowa State University Extension and Outreach website:
store.extension.iastate.edu/product/Take-a-Good-Soil-Sample-to-Help-Make-Good-Fertilization-Decisions

USDA-NRCS Residue and Tillage Management Iowa Job Sheet:
efotg.sc.egov.usda.gov/references/public/IA/Residue_and_Tillage_Management_329_345_JS_2017_06.pdf

Cover Crops

Iowa Learning Farms Cover Crop Resources and Research:
iowalearningfarms.org/cover-crops

Practical Farmers of Iowa Farmer-Led Research on Cover Crops:
practicalfarmers.org/research

Basche, A., Roesch-McNally, G., Clay, R., & Miguez, F. (2016, June). *Iowa Cover Crop Resource Guide*. Retrieved from Iowa State University Extension and Outreach website:
store.extension.iastate.edu/product/Iowa-Cover-Crop-Resource-Guide

Sustainable Agriculture Research and Education. (2012). Crop rotation with cover crops. *Managing cover crops profitably,* Third Edition. SARE USDA. Retrieved from:
sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition/Text-Version/Crop-Rotation-with-Cover-Crop

USDA-NRCS Cover Crop Iowa Job Sheet:
efotg.sc.egov.usda.gov/references/public/IA/Cover_Crop_340_JS_2016_04.pdf

Crop Rotations

Practical Farmers of Iowa Farmer-Led Research on Small Grains:
practicalfarmers.org/research

Baldwin, K. B. (2006). *Crop rotations on organic farms* (AG-659W-05. E06-45788). Center for Environmental Farming Systems, North Carolina Agricultural & Technical State University. Retrieved from:
carolinafarmstewards.org/wp-content/uploads/2012/12/7-CEFS-Crop-Rotation-on-Organic-Farms.pdf

Klinkenborg, V. (2012, November 3). Did farmers of the past know more than we do? *New York Times*, Sunday Review.

Ohde, N. (2016, April 7). *Five reasons why diverse crop rotations are good for Iowa*. Retrieved from Practical Farmers of Iowa website:
practicalfarmers.org/2016/04/5-reasons-why-diverse-crop-rotations-are-good-for-iowa

Union of Concerned Scientists. (2014, July). *Healthy farm practices: Crop rotations and diversity*. Retrieved from:
ucsusa.org/food_and_agriculture/solutions/advance-sustainable-agriculture/crop-diversity-and-rotation.html

USDA-NRCS Conservation Crop Rotation Iowa Job Sheet:
efotg.sc.egov.usda.gov/references/public/IA/Conservation_Crop_Rotation_328_JS_2015_05.pdf

Whole Farm Economics

Ag Decision Maker: An agricultural economics and business website:
extension.iastate.edu/agdm

Duffy, M. (2012, August). *Value of soil erosion to the land owner* (A1-75). Retrieved from Iowa State University Extension and Outreach website:
extension.iastate.edu/agdm/crops/html/a1-75.html

Edge-of-Field Practices

Baker, J.L., Melvin, S.W., Lemke, D.W., Lawlor, P.A., Crumpton, W.G., & Helmers, M.J. (2004, March). Subsurface drainage in Iowa and the water quality benefits and problem. In R. Cooke, Ed., *Drainage VIII: Proceedings of the Eighth International Symposium*, Sacramento, California, USA (Publication No. 701P0304, pp. 39-50). American Society of Agricultural Engineers.

Christianson, L.E., Frankenberger, J., Hay, C., Helmers, M.J., & Sands, G. (2016). *Ten ways to reduce nitrogen loads from drained cropland in the Midwest* (Pub. C1400). University of Illinois Extension. Retrieved from: northcentralwater.org/files/2018/03/Ten-Ways-to-Reduce-Nitrate-Loads_IL-Extension-_2016.pdf

Frankenberger, J., Kladivko, E., Sands, G., Jaynes, D., Fausey, N., Helmers, M., Brown, L. (2006). *Drainage water management for the Midwest: Questions and answers about drainage water management for the Midwest* (WQ-44). Retrieved from Purdue University Extension website: extension.purdue.edu/extmedia/WQ/WQ-44.pdf

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STRIPS Team. (2017, June). Prairie strips: small changes, big impacts. (Publication AE 3610). Retrieved from Iowa State University Extension and Outreach website: store.extension.iastate.edu/product/Prairie-Strips-Small-Changes-Big-Impacts

USDA-ACPF Watershed Database Saturated Buffer Viewing: nrrig.mwa.ars.usda.gov/st40_huc/satBuff.html

USDA-NRCS Contour Buffer Strips Iowa Job Sheet: efotg.sc.egov.usda.gov/references/public/IA/Contour_Buffer_Strips_332_JS_2016_09.pdf

USDA-NRCS Drainage Water Management Iowa Job Sheet: efotg.sc.egov.usda.gov/references/public/IA/IA_job_sheet_554_Jul2010.pdf

Iowa Nutrient Reduction Strategy

Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, Iowa State University College of Agriculture and Life Sciences. (2013). *Iowa Nutrient Reduction Strategy: A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico*. Retrieved from: nutrientstrategy.iastate.edu/sites/default/files/documents/NRSfull-130529.pdf

Map Resources

Iowa Geographic Map Server

ortho.gis.iastate.edu

LiDAR Maps
Open a Map Layer in ArcGIS Web App -> Elevation Maps -> Shaded Relief

US Topographic Maps
Open a Map Layer in ArcGIS Web App -> Elevation Maps -> USGS Topographic

Summer Aerial Photos
Open a Map Layer in ArcGIS Web App -> Summer Orthophotos 2004-2017

Spring Aerial Photos
Open a Map Layer in ArcGIS Web App -> Spring Orthophotos 2004-2018

Land Use Land Cover
Open a Map Layer in ArcGIS Web App -> 2002 IDNR Landcover

USDA-NRCS Web Soil Survey (Soil Survey information):

websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Multi-Resolution Land Characteristics Consortium (National Land Cover Database):

mrlc.gov/data