Figure 5.1 Good winter wheat stands can be achieved by planting into a rough, cloddy seedbed. Excessive tillage during fallow buries residue and pulverizes the soil, and leaves young wheat seedling defenseless against the ravages of wind erosion.
Wheat- Fallow Systems
Tillage has been an integral part of conventional fallow management to control weeds and conserve seedzone moisture over the dry summer months by creating a dry soil mulch. Maintaining adequate seedzone moisture enables farmers to establish winter wheat stands by late summer. This early stand establishment provides green cover by mid-to-late fall, and increases crop yields. The tillage mulch layer conserves seedzone moisture by preventing capillary water flow from the seedzone to the surface, and by insulating the seedzone from high day time surface temperatures. Lowering the seedzone temperature reduces water loss by reducing upward vapor flow.

While the principle goal of conventional fallow is to create a dry soil mulch, it may not always be compatible with the preservation of clods and crop residues on the soil surface. The fact is that conventional fallow, with its numerous tillage operations destroys clods and aggregates in the surface soil and buries residue. Consequently, at the end of the fallow period the soil surface is often deficient in clods and residue cover. The goal of the BMPs is to maximize surface cover and roughness throughout the fallow period until the grain crop is established without impairing moisture conservation, early fall wheat establishment, and crop yields. Wind barriers and strip cropping can be used to complement tillage-based control measures.

Wind barriers and strip cropping can be used to complement tillage-based control measures.

Figure 5.2 Coil packing summer fallow just before winter wheat can improve stand establishment, but should not be practiced when residue is lacking.

Tillage Mulch-depth Combinations
A deep tillage combination can significantly increase surface cloddiness during wet or dry fallow cycles, without impairing surface residue retention and fall wheat stand establishment, compared with more shallow tillage (Figure 5.1). For example, a soil mulch depth created by primary spring tillage with a non-inversion implement at a 6-inch depth followed by secondary tillages with a rodweeder at a 4-inch depth, increased surface clods (>2 inches in diameter) by at least 50 percent compared with a combination of primary tillage at a 4-inch depth and rodweeding at a 2-inch depth. Moreover, during a dry fallow cycle when soil drying can layer, the deeper tillage helps to ensure stand establishment, and increase grain yields and residue production. Planting into the deeper tillage mulch with a deep-furrow drill also increases the height of the furrow ridges. Tall furrow ridges create a rougher surface than short ridges and are more effective for wind erosion control. A disadvantage of deep tillage mulching is the need to reduce tractor speed when planting to avoid pushing soil in front of the drill.

The following management practices are recommended:
1. Use V-shaped sweeps or similar non-inversion tools for primary spring tillage to maximize surface residue retention and clod formation.
2. Finely divided soil aggregates within the soil mulch are effective in suppressing water loss during fallow. However, additional tillage to create such a mulch should be avoided because it tends to destroy or bury surface residues and break down soil clods needed for soil protection against wind erosion.

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3. Slower tractor speeds during rodweeding (e.g., < 4 miles/hr versus > 6 miles/hr) helps to maintain surface clods. However, fast versus slow speeds has little or no effect on surface residue retention.
4. Use slower tractor speeds, preferably no more than 2 to 3 miles/hr when planting with deep furrow drills. This helps to retain more of the residues on the surface and maintain ridge furrow height during the sowing operation.

### Packing Summer-fallow

Some growers pack summer fallow just before sowing winter wheat to improve stand establishment and fall green cover (Figure 5.2). Packing reduces the thickness of the dry surface mulch and, thus, allows deeper penetration of the deep-furrow drill openers into wetter soil, and less cover over the seed. It also can increase the soil bulk density in the seedzone which helps to improve seed-soil contact, and consequently, improves germination, plant emergence, and establishment of plant cover. A note of caution—under some conditions, packing may increase the wind erosion hazard before green cover is established by reducing surface cloddiness and residue cover.

The following management practices are recommended:
1. If used, packing should be done just before sowing to achieve maximum agronomic benefits for wheat establishment and to minimize the time between packing and establishment of green cover.
2. On finer-textured soils and where conservation tillage has been used to retain residue and clods, packing may provide agronomic benefits without increasing the risk of wind erosion.
3. Packing summer fallow should not be practiced on fallow when surface residue and clods are lacking, or on poorly aggregated, coarse-textured soils having low potential for residue production.

### Early Fall Planting

Green cover produced by late summer/early fall seeded wheat can reduce wind erosion significantly from fields that lack protection from surface clods or residue (Figure 5.3). Early stands can also increase the yield potential of wheat by 50 percent or more in the low precipitation areas and therefore produce economic as well as environmental benefits. Early establishment of winter wheat on fallow is most often limited by insufficient seedzone moisture. However, soil temperature and depth of soil covering are also important. In dry years, seeds must be placed as deep as 8 inches below the soil surface with a deep furrow drill to reach adequate seedzone moisture, and seedlings must emerge through 6 inches of dry soil. The time from seeding to plant emergence increases with decreased soil moisture content and soil temperature, and increased seeding depth. Any delay in emergence increases the risk of stand loss from soil crusting caused by showers and followed by rapid drying after the wheat is sowed. Sowing in late summer using wheat varieties that can emerge rapidly from deep planting offer the best potential for successful stand and green cover establishment in the drier areas, and under low moisture conditions when the hazard of fall wind erosion is the greatest.

The following management practices are recommended:
1. Fallow management should emphasize maintaining maximum amounts of residue and soil roughness throughout the fallow period.
2. In the drier areas, sowing should be done as early as possible, no later than the end of August or early September, and deep enough to place seed in a zone of soil moisture that is adequate for rapid germination and

### Table 5.1

<table>
<thead>
<tr>
<th>Date</th>
<th>Traditional tillage</th>
<th>Minimum tillage</th>
<th>Delayed minimum tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>Sweep - 1.0 ft Shank spacing for post-harvest control of Russian thistle</td>
<td>Herbicide - Landmaster @ 2.7 qt/acre in 1993; Roundup @ 1.8 qt/acre in 1994 and 1995</td>
<td>Herbicide - dmaster@ 2.7 qt/acre in 1993; Roundup @ 1.8 qt/acre in 1994 and 1995</td>
</tr>
<tr>
<td>October</td>
<td>Chisel – 2 ft shank spacing</td>
<td>Chisel or subsoiler – 4 ft shank spacing</td>
<td>Chisel or subsoiler – 4 ft shank spacing</td>
</tr>
<tr>
<td>February</td>
<td>Herbicide - Roundup @ 0.7 qt/acre</td>
<td>Herbicide - Roundup @ 0.7 qt/acre</td>
<td>Herbicide - Roundup @ 0.7 qt/acre</td>
</tr>
<tr>
<td>March</td>
<td>Primary tillage - cultivator + harrow (two passes)</td>
<td>Primary tillage - undercutter + rolling harrow</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>Anhydrous NH injection @ 40 lbs/acre</td>
<td>First rodweeding</td>
<td>First rodweeding</td>
</tr>
<tr>
<td>May</td>
<td>First rodweeding</td>
<td>First rodweeding</td>
<td>Primary tillage - undercutter + rolling harrow</td>
</tr>
<tr>
<td>June</td>
<td>Second rodweeding</td>
<td>Second rodweeding</td>
<td>First rodweeding</td>
</tr>
<tr>
<td>July</td>
<td>Third rodweeding</td>
<td>Third rodweeding</td>
<td>Second rodweeding</td>
</tr>
<tr>
<td>September</td>
<td>Planting</td>
<td>Planting + anhydrous NH injection @ 40 lbs/acre</td>
<td>Planting + anhydrous NH injection @ 40 lbs/acre</td>
</tr>
</tbody>
</table>
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Minimum Tillage
Minimum tillage systems substitute herbicides for traditional tillage, and use undercutters for primary spring tillage (Figure 5.4). This helps to maintain higher levels of surface residue and soil roughness during fallow. Surface residue is often the only defense against wind erosion on coarser-textured soils where roughness and structure are difficult to maintain during fallow (Figure 5.5). With delayed minimum tillage the initial or primary spring tillage operation which is usually carried out in March is delayed at least until May. Delaying tillage tends to benefit surface residue retention.
Examples of minimum and delayed minimum tillage systems were compared in an experiment conducted by Washington State University with grower cooperation as outlined in Table 5.1. The results of this study and related research provide the basis for recommending these systems as BMPs for wheat-fallow production systems in the drylands of the Columbia Plateau. Among the most significant findings of this study are the following:
1. A higher percentage of the precipitation was consistently stored in the soil during the fallow period of the minimum tillage systems compared with conventional fallow because more stubble remained standing overwinter. Thus, the minimum tillage systems had a higher fallow efficiency.
2. Surface residue remaining at the end of fallow was always significantly higher with the minimum tillage systems than with conventional fallow.
3. Surface cloddiness, which is especially important where residues are limited, was always greatest with the minimum tillage systems.
4. Grain yields were not significantly affected by the tillage system but tended to be slightly higher with minimum tillage.
5. Seedzone moisture content at the time of planting and wheat emergence were not affected by the tillage system.
6. Production costs during a two-year crop-fallow cycle were slightly higher with the minimum tillage systems compared with conventional tillage.

The slightly higher cost of the minimum tillage systems compared with conventional post-harvest sweeping was due to post-harvest herbicide application to control Russian thistle in the minimum tillage systems. However, the extra costs can readily be offset and justified by the gains in soil water storage, and long-term erosion control benefits associated with the minimum and delayed tillage systems.
The minimum tillage treatments applied in this field experiment are flexible and can be readily modified to fit individual farms. For example, it may be possible in some situations to eliminate fall tillage or reduce the number of rodweeding operations. A possibility is to use herbicides for weed control following the initial spring or primary tillage after the moisture line is set. In

Minimum and Delayed

Figure 5.4 Long-term research at Lind, Washington, shows that delayed minimum tillage produces a rough, cloddy seedbed with adequate surface residue, and is economically compatible with conventional tillage fallow.

Figure 5.4 Early fall wheat stands such as on this field near Pasco, Washington, can significantly reduce wind erosion through the fall and winter seasons. Early planted wheat can also increase winter wheat yields in the drylands by 50 percent for economic gain by growers.
addition, a grower may wish to incorporate a deep tillage combination (see section on “Tillage Mulch-Depth Combinations” on page 33) with the minimum tillage system to increase surface residues and cloddiness.

Agronomic, environmental, and economic benefits from using minimum tillage are being documented by growers in terms of increased soil organic matter, less wind and water erosion, and improved soil quality and moisture conservation. USDA’s Natural Resources Conservation Service (NRCS) in cooperation with the Adams County Conservation District conducted a case study on introduction of new wide-blade sweeps (18 to 32 inches wide) into the dryland crop area (11-inch precipitation zone) south of Ritzville, Washington. In the fall of 1994, the grower left standing stubble overwinter on a 160-acre field. The downy brome was treated with herbicide in early spring prior to any tillage. In early April the wide-blade sweep with fertilizer attachment was used as the primary tillage implement. The first secondary tillage with a rodweeder was performed May 24.

Large clods (6 to 8 inches in diameter) remained on and near the surface after rodweeding. These were attributed to a broken tillage pan and also to sweeping earlier than usual in the spring when the subsurface soil moisture was high. Because of concern that the clods would allow excessive moisture loss from the fallow, a skew treader set to run backwards was used to break the clods. Only two rodweedings were needed in summer 1995. Winter wheat was seeded the last week of August with an average of 740 lb./acre of residue on the soil surface. The result was a very healthy stand of wheat. Yields in the summer of 1996 were average and above average compared with the grower’s traditionally-tilled fields.

An economic analysis showed that the variable costs for this minimum tillage system were about $63/acre. This was almost identical to the cost of conventional tillage. Assuming a price of $4.25/bu wheat and a 43 bu/acre average yield, the average annual return was about $60/acre. The long-term effect on soil quality and sustainability should also be considered as a positive benefit. With conventional tillage six inches or more of topsoil could be lost by wind and water erosion within 50 years. Under a high level of residue management with minimum tillage, less than an inch of topsoil would be lost.

### Summer Fallow with High Residue Levels

Winter wheat residue levels in the low-rainfall areas occasionally exceed 5,000 lb./acre under favorable growing conditions. These unusually high amounts can interfere with subsequent fallow tillage and seeding operations. In this situation additional tillage may be required during fallow, especially to avoid residue plugging during planting with deep furrow drills in late-summer. However, care must be taken so that surface residue levels are not overly reduced by excessive tillage.

The BMPs for conservation management of high residue levels in the low precipitation zones are based primarily on grower experience and practices may vary somewhat among different growers and the areas where they farm. Where soil freezing is not a concern, all stubble should be left standing during the first winter after harvest to maximize storage of overwinter precipitation. If water runoff from frozen soils is a problem, tillage channels should be created on wide (e.g., 3 to 6 feet) spacings with a heavy chisel or subsoiler to a depth of at least 12 inches. The rotary “sharks tooth” subsoiler is also effective for establishing deep pits for water infiltration with little disturbance to the standing stubble.

Even under high residue conditions, growers should consider using minimum spring tillage or delayed minimum spring tillage employing a wide-blade undercutter sweep or similar implement. Harrowing prior to any tillage is advisable to help break up long stemmed wheat straw and reduce the intensity of tillage required for subsequent soil preparation. In addition, harrowing after harvest will help fall germination of downy brome weed seeds, and reduce residue levels the following spring (Figure 5.6). If the surface residue level...
by late summer is still excessive for planting with a deep furrow drill, a coil packer, skew treader, rotary hoe, or empty grain drill can be used to flatten and bury some of the excess residue prior to planting. An additional benefit of packing summer fallow just before planting winter wheat is firming of the tillage mulch which increases seed-soil contact and reduces sloughing of loose soil into the drill furrow. It should be emphasized is that while it is easy to bury and reduce surface residue with tillage operations, it is impossible to replace it.

Harrows, tandem discs, or other traditional implements can often be used safely and effectively for primary spring tillage under heavy residue conditions. However, since these implements can bury up to 60 percent of the residue, they should be used judiciously and only in situations where ample surface residue will remain to protect the soil from wind erosion during the entire fallow period and through the winter of the crop cycle.

Flail mowing. Often residue production may be ample and not necessarily excessive, but it is in a form, such as very long straw, or mature Russian thistle skeletons, which plugs minimum till equipment and drills. Traditionally growers will find themselves discing the soil once or even twice, not to produce a good fallow, but only to cut the residue into pieces which will not plug the equipment. Long straw may be more effective than short straw for wind erosion control; however, if reducing straw length is necessary mowing can dramatically reduce the cultivation necessary prior to seeding. Mature Russian thistle plants, and skeletons may be the majority of residue on a field that is deficient in straw. Flail mowing will greatly reduce the number of thistles that blow off the field as well as obviate the need to disc a low residue field. Mowing may also be necessary for no-till seeding if Russian thistle control fails. Flail mowing is labor intensive, and adds to the management costs, but timing for the operation is quite flexible.

**Shift to a Higher Residue Crop**

Some growers have successfully switched some of their highly erodible land to the production of higher residue crops as a way to achieve better wind erosion control. This can be especially important in low rainfall years when residue levels from traditional wheats can be very low with the wheat-fallow system. Planting a mid-tall hard red winter or white wheat instead of a semidwarf wheat (Figure 5.7), or planting triticale or tetraploid rye (i.e., Tetra-Petkus rye) will result in faster early growth for quicker green cover, and higher residue production. This is especially helpful if early seeding is not possible due to low moisture levels or other problems, and fall precipitation is late.

Rye usually sells at a discount to barley and has a lower yield potential than wheat except under severe drought. Since rye cross pollinates and an ordinary diploid rye is a weed in the dryland wheat area, pure tetraploid rye seed is critical when planting rye as a crop. One difficulty growers often encounter is that clean seed is usually hard to find. On the positive side, rye is very competitive, often very winter hardy, pest and drought resistant, and usually results in lower herbicide costs and less weed problems than wheat. Rye is capable of producing usually large amounts of residue.

Triticale has excellent yield potential, yet will produce high residue under drought conditions. Triticale covers the soil quickly and is generally less susceptible to damage by pests than wheat. The grain provides excellent poultry and swine feed and it’s price usually depends on the availability of the supply.

Mid-tall wheats emerge and cover the soil faster than semidwarf wheats and produce more residue. Yield potential is less than semidwarf wheats, but in dry years there may not actually be any yield loss because the yield potential of semidwarf wheats depends more on higher amounts of precipitation.

**Figure 5.6** Using a harrow after harvest will help sprout downy brome seeds and reduce surface residue in high-residue years.
Chemical Fallow

Chemical fallow substitutes herbicides for tillage to control weeds during the non-crop period. Because the soil is not disturbed and there is continuous stubble cover on the soil this practice will essentially eliminate wind erosion (and water erosion) in a wheat-fallow sequence. Although chemical fallow is practiced in some dryland situations it has gained little acceptance by growers. Chemical fallow generally requires two to three applications of a non selective contact herbicide to achieve satisfactory weed control. Late summer weeds such as Russian thistle are difficult to control and may require an additional application of herbicide.

The major drawbacks to grower use of chemical fallow are largely related to economics. The cost of chemicals for weed control can be considerably greater than for tillage. With marginally low yields typical of dryland production, weed control costs can significantly reduce profits. In tilled fallow, the soil moisture depth is generally maintained at the rodweeding depth, and can be reached with a deep furrow drill. In chemical fallow, the absence of a loose, dry tillage layer results in a more diffuse moisture zone, with moist soil deeper than where the seed can be placed with most existing drills. Consequently, fall planting in chemical fallow must often be delayed until rains wet the surface layers. Such a delay can reduce wheat yields by up to 50 percent. In some cases, chemical fallow may create hard soil conditions which require an expensive heavy-duty no-till drill to sow seed and apply fertilizer.

The reliance on herbicides for weed control with chemical fallow has raised some questions about potential adverse environmental and off-site impacts that can result from this practice. Excessive or improper chemical use can pollute surface and groundwaters, increase chemical drift, and endanger wildlife safety and health. For example, atmospheric herbicide drift has been a concern to fruit and grape growers downwind of wheat farmlands. Whether greater use of chemical fallow would increase this, or other hazards has not been established. However, because of erosion control and soil improvement benefits associated with no-till, chemical fallow is listed as a BMP option. With judicious chemical use and proper application methods the practice should be encouraged in wheat-fallow systems where the wind erosion potential is particularly high, e.g., coarse-textured, poorly-aggregated soils that do not readily form and retain clods, and where only small quantities of surface residues are available. In less hazardous conditions, a combination of tilled and chemical fallow such as minimum and delayed tillage may prove to be most practical.

Alternative Management Systems

There are many optional farming systems and adaptations that should be tried and tested which could simultaneously enhance environmental benefits, crop production and grower profits. Some new and improved methods recently tested by researchers and innovative growers include the following.

Increased Cropping Intensity with Fallow

Erosion control is enhanced by reducing the frequency of fallow in the rotation. One proposed rotation for the low precipitation zone is winter wheat-spring barley-fallow. Thus, fallow which has the greatest potential for wind erosion occurs one year out of three rather than one year out of two as in the traditional wheat-fallow system. Adoption of a 3-year rotation in the low precipitation zones and others that intensify spring cropping has been limited because the grain yields...
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with recropping (crops grown in succession) is highly variable, especially using traditional or conventional tillage systems. This is mainly due to the limited moisture supply.

To reduce economic risk, one-pass no-till seeding of spring barley into winter wheat stubble is proposed as an environmentally friendly, and agronomically feasible method for recropping (Figure 5.8) Since no preplant tillage is required, soil water is conserved and seeding can be considerably earlier compared to using tillage to prepare a seedbed. This can increase the potential for grain and residue production because the earlier plantings would have lower water demand by the crop and therefore be subjected to less water stress than traditionally later-planted crops.

Increasing cropping intensity as a BMP is not limited to the 3-year rotation with spring barley. Rotations can be made longer and barley can be replaced by other spring-planted crops, e.g., wheat, canola, yellow mustard, or safflower. For example, the rotation can be lengthened by growing spring crops two years in succession before the fallow cycle. Growers need to search for alternative crops that can be adapted to their specific environments and cropping system (Figure 5.9). The key point with this BMP is to reduce the frequency of fallow and promote spring no-till as a way to keep more cover on the land, and maintain or increase farm profitability.

The following key points should be emphasized:

1. Residue amounts produced by the alternative spring crop(s) grown just before the fallow cycle may be limited and, thus, must be carefully managed to ensure adequate retention of surface residues and sufficient roughness during fallow. For example, chemical fallow, or delayed minimum tillage fallow, following the spring crop, should be strongly encouraged under conditions where the wind erosion potential is high.

2. Growers should keep their farming options flexible to take advantage of opportunities for spring cropping, such as after a wet winter.

Annual Cropping with Conservation Systems

Crops grown every year leave sufficient surface residue and/or roughness for wind erosion control during the short period between crops and during crop establishment. This system with proper residue management can essentially eliminate wind erosion at all times of the year.

Continuous cropping with tillage. Growing a crop every year provides for more opportunity to maintain cover on the land compared with fallowing during times when there is high potential for wind erosion. Annual cropping with tillage does not require any additional equipment that growers do not already have for use in fallowing. Consequently, the practice can be implemented on short notice and effectively control wind erosion on critical areas by eliminating fallow. Another advantage is that tillage can be used to control weeds. One pass with an undercutter after harvesting wheat will control Russian thistle. Another pass in the spring prior to planting will reduce the required rate of pre-plant herbicide and make fertilizer placement much less critical than it is with no-till. If the soil is very sandy, one or all of the cultivations may be omitted from year to year by using herbicides for weed control. The grower applies fertilizer and seeds conventionally. A drawback to this practice is that fall tillage to control Russian thistle may result in loss of residue and less overwinter water storage from the thistle plants blowing away. Another major downside is that the potential benefits to the soil from continuous no-till cannot be realized and these might be necessary in order for continuous cropping to replace summer fallow as the dominant system in the region. Another drawback is that the required tillage takes time when time is critical and labor is in short supply. While the question of the long-term feasibility of continuous cropping in the dryer areas of the region is being researched this practice is being used successfully by some growers to control wind erosion on highly erodible areas.

Continuous no-till spring cropping. In this case a spring crop is no-till seeded every year in a monoculture system (e.g., wheat-wheat) or crop rotation. Without no-till, the probability of success with continuous spring cropping may be lower except in years with above normal precipitation, because no-till conserves water that is lost in the spring through cultivation. No-till crops can be planted early in the spring into optimal soil moisture which enhances plant growth and vigor. This helps to minimize water stress by avoiding the higher temperatures later in the growing season, and increases the yield potential by enabling the plants to grow and mature ahead of the hot and dry summer weather. Planting into surface residues also prevents soil crusting and subsequent loss of stand. This eliminates the need for replanting which is often a major expense with tillage systems. Moreover, spring seeding with tillage usually results in planting

Figure 5.8 Sowing spring barley into winter wheat stubble with a commercially available hoe opener no-till air drill. Spring cereal yields with no-till can equal those from conventional tillage practices that are less effective for wind erosion.
later than optimum and into drier seedbeds. This can reduce grain and residue production because of increased water stress late in the growing season. Continuous no-till spring cropping has not been adequately tested for its economic and agronomic feasibility. Although it qualifies as a BMP for wind erosion control on the basis of effectiveness, it should be used with discretion by growers until there is a better understanding of the unknowns and risks, especially those that are weather related, that might be associated with this farming system.

Some limited research has been carried out with no-till in the dryland environments. Two years of small-plot experiments in the Horse Heaven Hills on both a shallow and deep soil showed good potential for no-till annual cropping of spring wheat and barley. Yields of Butte 86 spring wheat (hard red) grown successively on the same plots ranged from 20 to 25 bu/acre. Yields of Baroness barley ranged from 0.6 to 0.8 tons/acre. All planting and simultaneous fertilizer applications were made with a John Deere 9400 Series hoe drill. A word of caution is that both years (1995 and 1996) were wetter than normal and that further testing needs to be carried out to evaluate risks under drier conditions.

A long-term continuous spring cropping experiment now into its third year is being conducted near Ralston, Washington (11.5-inch precipitation zone) to compare optimal cropping systems including continuous no-till spring wheat, spring wheat-spring barley, and spring wheat-fallow with conventional winter wheat fallow (Figure 5.10). Weather, agronomic and economic data are being collected and analyzed to help growers evaluate these systems for possible adoption on their individual farms. After two years, both with good moisture, results indicate that continuous no-till spring wheat is very competitive agronomically and economically compared with the conventional winter wheat-fallow system which, on erodible soils, is much more susceptible to wind erosion. The no-till plantings were made with the John Deere 9400 Series hoe drill.

**Including winter wheat in annual cropping.** To increase the flexibility of annual cropping systems winter wheat (or winter barley) can be readily incorporated in an annual cropping system for various reasons including agronomic, economic, or weather conditions. Winter wheat can follow most any crop with very few problems except for some barley varieties that overwinter and become a potential weed in wheat. The inclusion of winter wheat in an annual cropping system is likely to be most successful with no-till for reasons of water conservation and protection against winter-kill enhanced by surface residues. Weed infestations may present some risk with winter wheat, especially in a dry fall when there is little or no opportunity to control winter annual grassy weeds. Therefore, a grower should exercise careful judgment in deciding whether to include winter wheat in an annual cropping system, especially in fields that have a history of weed infestations including downy brome, jointed goat grass, or bulbous blue grass. However, growers can minimize winter annual weeds in winter wheat by increasing the number of spring crops grown before winter wheat.

### Conservation Tillage

#### Weed Management Systems

Weed control is an ongoing and necessary agronomic objective on all dryland farms. In most cases, maintenance or preventative control is practiced to prevent a low-density weed population from developing into dense stands. However, situations may arise which could lead to increased weed infestations and, if not aggressively controlled, can cause substantial yield...
loss or crop failure. For example, weeds can be devastating during the transition from traditional tillage-based systems to conservation tillage systems that depend on alternative control methods. When this occurs, reclamation, or emergency strategies are needed to bring weeds under control. Many growers may resort to additional tillage to reduce severe weed infestations to manageable levels. However, intensive tillage can be counterproductive by destroying surface residue cover and roughness which are needed for controlling wind erosion and dust emissions.

Two of the most troublesome weeds in wheat-fallow rotations are downy brome and Russian thistle. Based on research and grower experience, management strategies are available that will effectively control these weeds, and at the same time conserve soil and water and maintain or increase farm profitability. BMPs for control of other problem weeds in the cropping system can be designed following the same principles and methodology used to control downy brome and Russian thistle.

**Downy Brome Control**
Research has shown the best long-term management practice to control downy brome should focus on the following three strategies:
1. Facilitate seed germination.
2. Prevent seed production in fallow.
3. Minimize seed production in the crop

**Maintenance control strategies.**
Among the recommended management options for controlling low-level infestations and preventing the development of a severe downy brome problem in fields are the following:
1. Beginning with crop harvest the chaff and straw should be spread uniformly to facilitate weed seed-soil contact and maximize germination. This is best achieved with combine straw/chaff spreaders followed by light tillage to further distribute the seed and mix it with the soil to enhance germination with the first fall precipitation. Time harrows or skew treadsers by their shaking, mixing and vibrating action can improve weed seed-soil contact with little disturbance to the residue cover. Discs set at low angles can perform similarly without burying significant amounts of residue, but are less desirable because of additional tillage and soil compaction.
2. Next in the management sequence is to kill the weed seedlings resulting from the facilitated germination. A late fall application of a non-selective herbicide can prevent sod formation by downy brome and volunteer wheat, and improve weed seed-soil contact with little disturbance to the residue cover. Discs set at low angles can perform similarly without burying significant amounts of residue, but are less desirable because of additional tillage and soil compaction.

3. A non-selective herbicide should be applied by early to mid-March so that the primary fallow tillage operation can be delayed until late April or early May. Little germination of downy brome occurs after early March in the low precipitation zones. The number of secondary tillage operations (i.e., rodweeding) should be minimized (preferably no more than two operations) to conserve surface residues and roughness. Only those areas of the field where weeds are a problem should be tilled and sprayed if the dry soil mulch is intact.
4. Because nitrogen and phosphorus fertilizer stimulates both weeds and the crop it should be managed to minimize weed growth while being of maximum benefit to the crop. Nitrogen fertilizer should be limited to recommended rates. Broadcasting and excessive applications should be avoided. Deep banding of nitrogen fertilizer applied early in the fallow period rather than near planting, can improve winter wheat yield potential and competitiveness over downy brome. Deep banding or starter placement of phosphorus fertilizer, especially when available soil phosphorus is low, also helps wheat to compete against downy brome. Winter wheat fields with downy brome infestations
should not be spring top dressed with nitrogen fertilizer. All of these fertilizer management factors aim to maximize fertilizer use by the crop and limit its use by weeds.

5. Early fall planting with deep-furrow drills to enhance early wheat growth and vigor can help to prevent significant yield losses from light to moderate downy brome infestations. Earlier wheat emergence also allows the crop to reach critical growth stages needed for safe application of some-post emergence herbicides to control later emerging downy brome. Late seeding into moist soil should be avoided because wheat and downy brome will emerge at the same time. This makes selective weed control (control of weed without crop damage) extremely difficult if not impossible. Research shows that moderate infestations of downy brome emerging within 10 days of wheat emergence can reduce grain yields by about one-third (Figure 5.11).

Reclamation control strategies.
There are situations when downy brome infestations in a winter wheat-fallow rotation can reach levels where crop loss plus cost of control measures are greater than the returns from a substitute spring wheat crop. Factors contributing to increased weed populations in winter wheat are mostly related to reduced crop competition. This can be the result of winterkill, disease and insect infestations, drought, soil crusting, late emergence, and excessive nitrogen fertilization.

The main reclamation approach is to switch to spring cropping for at least one or two crop cycles to deplete the downy brome seed bank in the soil. For example, a rotation of winter wheat-fallow-spring wheat-fallow would allow opportunity for aggressive downy brome control through three successive fall seasons. However, this sequence as with other fallow rotations is not recommended for shallow soils (depth less than 40 inches) because these normally do not have adequate water storage capacity for two seasons of precipitation. With fallow on shallow soils not only is water wasted but mobile nutrients such as nitrate nitrogen may leach downward out of the root zone and become a groundwater pollutant.

The following conservation management options with a spring crop are recommended:
1. As with the maintenance control strategy, harrowing or other light tillage of winter wheat stubble after harvest will help to facilitate seed-soil contact and germination of downy brome seeds. A soil-active herbicide should be fall-applied for control of winter annual grassy weeds. Because of lower amounts of residue with the spring crop, a minimum or delayed minimum tillage system should be used through the fallow season in preparation for a winter wheat crop.
2. Burning crop stubble, moldboard plowing or other inversion tillage should not be used as weed control measures on highly erodible land.

Russian Thistle Control
Russian thistle is most damaging to crops where crop competition is limited by drought, poor stands, inadequate fertility, and late growth. Spring wheat, because of its late start and less aggressive growth habit, is considerably less competitive against thistle than winter wheat which grows vigorously from early spring until maturity. The main weed control strategy centers on reducing thistle seed production and depleting the soil seedbank because Russian thistle seed has both limited dormancy and longevity in the soil. Working against these factors are the weed’s prolific capacity for seed production and efficient mode of distribution. One undisturbed plant can
produce 150,000 to 200,000 seeds and can release thousands of these seeds across miles of fields by its tumbling action in the wind.

Management strategies. Preventing seed production throughout the crop rotation with conservation tillage will reduce weed populations to manageable levels and simultaneously control wind erosion. One weed control goal during fallow in a winter wheat-fallow system is to prevent weed seed production for a second year, while conserving seedzone moisture and maintaining surface residue and roughness.

1. If weeds are present, a herbicide application is recommended 10 to 14 days after winter wheat harvest to minimize Russian thistle water use and seed production. Non-selective herbicides applied post-harvest generally result in dry, brittle Russian thistle skeletons which facilitate their management in subsequent operations. Other herbicides can leave plant residue that is tough, leathery and difficult to manage.

2. If a post-harvest herbicide is not applied, tillage may be used for weed control. Tillage should be limited to sweep or undercutter implements that sever roots without excessive loss of crop residue. The main concern with tillage for weed control is that the severed plants tend to blow away which results in a loss of vegetative residue where it may be needed for wind erosion control. Thistles killed with post-harvest herbicide application remain anchored and contribute to the surface residue supply which is important in low residue situations Figure 5.12).

3. If needed, chiseling or subsoiling may be performed in the fall to increase infiltration of frozen soil runoff. Wide shank spacings (4 to 6 feet) does little disturbance to Russian thistle plants and standing stubble which helps to trap snow and reduce overwinter evaporation.

4. A minimum, or delayed minimum tillage system should be used through the remainder of the fallow season. A non-selective herbicide applied after the first heavy flush of emerging Russian thistles in the spring can allow delaying the primary fallow tillage for at least 3 to 4 weeks. This helps to conserve more surface residues during the remainder of the fallow period and through fall planting.

5. The control strategies should be repeated in crop and fallow year 2. After the Russian thistle seedbank has been significantly reduced more rigorous control measures may be necessary only on parts of the field as spot treatments and along field borders. It may also be helpful to monitor and treat adjacent fields and noncropped areas to reduce the potential for reinfestations.

Strip Cropping for Wind Erosion Control

Strip cropping is a system of farming with alternating strips of crops or stubble with erosion-susceptible fallow positioned at right angles to the prevailing winds (Figure 5.13). In effect, the system produces a series of parallel fields with limited distance across which saltation can occur during a wind event. Strip cropping has proved to be very effective for wind erosion control in the northern Great Plains across large tracts of land. Therefore the practice is recognized as an effective BMP. Strip cropping is used extensively by growers as a BMP for water erosion control in the intermediate precipitation zones of the Pacific Northwest. However, its use for wind erosion control has been very minimal in the dry areas of the Columbia Plateau.

The design of a strip cropping system for wind erosion control takes into account wind speeds and prevailing wind direction, machinery size, soil type, soil loss tolerance, and the effectiveness of other practices in the conservation management system. Generally other conservation measures such as surface residue and roughness management, and early fall planting of wheat for green cover are carried out in combination with strip cropping to maximize its effectiveness for wind erosion control. Topographic features such as irregularity, length, steepness, and exposure of the

Figure 5.13 Wind strips positioned at right angles to prevailing wind help to reduce downwind saltation by reducing the field width. Although used extensively in areas of the Great Plains its use in the Columbia Plateau has been minimal.
slope in relation to the direction of prevailing winds are also factors that will influence the effectiveness of strip cropping for wind erosion control. Growers should consult with the USDA’s Natural Resource Conservation Service field personnel on details for designing a field strip cropping system for their specific farm. Refer especially to Soil Conservation Service Conservation Practice Standard “Cross Wind Stripcropping” Code 589B, and Washington State Supplement to National Standard 589, Wind Stripcropping. WA-589-2.

Conservation Reserve Program (CRP)

The CRP allows growers who qualify to retire highly erodible fields from crop production and establish either a grass or tree cover on the land to control wind and/or water erosion. The lands cannot be used for grazing or haying except in emergency situations such as occurred during the 1988 drought. Grass is the most practical choice for growers on the Columbia Plateau. Soil covered by a permanent grass stand is virtually immune from wind erosion and dust emissions (Figure 5.14). Living plants or their residues dramatically slow the wind speed at the soil surface so there is little opportunity for erosion to occur.

Establishing CRP Grass Stands

The USDA/NRCS has developed a comprehensive set of guidelines for establishing perennial grass seedings to provide cover for erosion control on cropland removed from crop production. The information includes a list of drought tolerant grasses and legumes for long-term ground cover in Washington State. There is also information on parameters for stand establishment, selection of species, seeding rate, time of year to seed, and requirements for stand maintenance.

The sources of information and practice specifications do not specifically address the issue of erosion control during grass stand establishment for conservation plantings. However, the Plant Materials Center 1988 Annual Report, Pullman, Washington presents no-till as a seeding option. Where feasible no-till seeding should be strongly encouraged to conserve moisture and provide ground cover for erosion control. Because of the diverse conditions throughout the Columbia Plateau, growers should consult with their local NRCS field office for information on recommended practices for establishing CRP grass stands on their individual farms.

CRP Take-out

“Take-out” is the removal of the permanent vegetative (grass) cover from the CRP land and usually entails putting the land back into crop production use. The recommended management practices for take-out of CRP grasslands are based on results from large scale replicated field trials conducted by Washington State University with farm-scale equipment operated by growers. The goal was to identify management strategies that optimize agronomic performance and profitability of the first crops following CRP take-out, while providing effective soil erosion control and preserving soil improvements accrued during the CRP. The studies were designed to evaluate fall versus spring take-out management practices for winter wheat-fallow, and spring CRP take-out for spring cereals. Criteria used to evaluate the relative success of different CRP take-out practices included: soil water storage efficiency; crop establishment and development; soil erosion potential; pest incidence; crop yield and quality; and economics.

Winter wheat-fallow system. The combination of fall or spring undercutter or sweeps used as the initial or primary tillage implement, with minimal summer rodweedings, provides one of the best fallow management systems for erosion control without reducing agronomic performance of the wheat crop (Figure 5.15). These primary tillage tools cut the grass roots but do minimal disturbance to the surface soil and residue. Thereby, these implements allow the establishment of minimum tillage summer fallow after CRP, retaining more surface residues and roughness, and seedzone water than intensive tillage systems. A non-selective herbicide application before spring tillage is important to obtain complete kill of the cover grass by reducing grass re-establishment that would occur with tillage only, particularly under wet spring conditions.

The use of inversion type implements (e.g., moldboard plows, heavy discs) and burning is not warranted nor recommended because residue levels on CRP land that was planted mainly to crested wheatgrass in the crop-fallow region are similar to, or less than an average winter wheat crop. Moreover, the wheatgrass residues break down considerably faster than wheat crop stubble. Intensive tillage also pulverizes the soil, and with little or no residue cover makes CRP take-out fields highly susceptible to blowing. Loss of residue can also result in less water storage and thus, impair stand establishment of the wheat crop. Harrowing, or flailing with a flail mower or combine when the grass residue is dry in late summer or fall, followed by an undercutter or sweep in the fall or spring may help minimize problems with long-stemmed grass residue and reduce the intensity of tillage required.

Chemical fallow with no-till planting is another option for CRP take-out (Figure 5.16). It is highly effective for erosion control because the soil and grass cover is only minimally disturbed. A fall or spring undercutter or sweep operation can improve grass kill with minimal surface disturbance in a chemical fallow-direct seed system. However, these
no-till systems have not been tested for CRP take-out with fallow-winter wheat. **Spring crops.** The BMP options for CRP take-out with spring crops are much the same as with the winter wheat-fallow system. Minimum tillage could include a sweep or undercutter in the fall or spring ahead of direct spring seeding. This non-inversion tillage improves grass kill, allows for reduced rates of a non-selective herbicide, and reduces root disease potential compared with direct seeding without use of the sweep/undercutter implements. Like with the winter wheat-fallow system, harrowing/flailing in the late summer or fall when the residue is dry can facilitate residue management in CRP take-out with spring crops.

Field experiments on CRP take-out with spring crops showed similar yields and profitability between direct seeding and traditional tillage take-out systems. Moreover, direct seeding, because it does little soil disturbance, allows greater retention of soil quality benefits accrued in the CRP as well as improved erosion protection. An important part of the success of direct seeding depends on using a drill that can effectively penetrate the grass residue and sod for good seed-soil contact and achieve accurate seeding depth. Deep banding of fertilizer below or near the seed row can reduce the impacts of root diseases and increase the yield potential of spring crops. As with the winter wheat-fallow system, intensive, inversion tillage and burning should be avoided because these destroy surface residues and greatly increase the erosion potential during crop establishment.

**Economic Results for CRP Take-out Trials**

Detailed economic analysis was performed on the various CRP take-out field experiments conducted in eastern Washington during 1994-96. Enterprise budgets were developed for on-farm trials at eight sites. Each trial compared costs and returns for various take-out methods followed by a variety of cropping systems. Complete descriptions of these trials, economic results, and potential impacts on wind erosion control are reported in Pacific Northwest Conservation Tillage Handbook Series No.16, Chapter 2, titled “Returning CRP Land to Crop Production” (see section at the end of this chapter). Because of the importance of economic impacts the results for each CRP take-out trial is briefly summarized. Many of the trials were run for only one or two years and were conducted at a large number of sites with varying agroecological conditions. Caution must be exercised in generalizing results beyond the sites without due attention to prevailing weather conditions and specific site characteristics.

**Adams County: fall versus spring take-out, 1994-96.** CRP take-out was followed by summer fallow in 1995 and soft white winter wheat in 1996. Primary tillage and residue treatments included 1) fall disc, spring cultivate; 2) fall harrow twice and chisel, spring sketread and cultivate; 3) fall flail with combine, spring sweep; 4) spring disc, cultivate; and 5) spring sweep, disc. Treatments 1 and 2 had the lowest surface residue levels as well as the lowest annual returns over total costs, making them both economically and environmentally inferior. Treatment 3 had the highest residue level at 15% cover, which is still rather low. Treatments 3, 4, and 5 had average annual returns of about $8 per acre more than treatments 1 and 2 due to both yield and cost differences.

**Franklin County: fall versus spring take-out, 1994-96.** CRP take-out was followed by summer fallow in 1995 and hard red winter wheat in 1996. Primary tillage and residue treatments included 1) fall disc, spring disc; 2) fall harrow twice, spring disc; 3) fall flail with combine, spring sweep; 4) spring burn, sweep; and 5) spring disc twice. Treatment 3 had the highest surface residue level of the five treatments, although it was still quite low at 9% cover. The intensive tillage in treatment 1 caused about 2 inches of soil water to be lost by evaporation; consequently, grain yield was significantly lower resulting in the lowest returns which averaged $32 per acre per year. Yields for the other treatments were not significantly different. The highest return was from treatment 4 due to its relatively lower.
costs. However, returns for treatments 2 and 5 were not significantly different from treatment 4.

**Lincoln County: fall versus spring take-out, 1994-96.** Summer fallow and soft white winter wheat followed CRP take-out. Fall and spring tillage treatments were similar to those used in Franklin County. The spring burn system had the lowest surface residue in July 1995 and at planting but the highest surface random roughness after seeding. Yields and profitability across systems were similar, although the spring flail, disc system had the lowest profit ability, averaging $50 per acre annually due mainly to higher costs associated with flailing.

**Columbia County: spring take-out followed by soft white spring wheat, 1994-96.** Tillage systems evaluated in 1994 included treatment 1) plow, disc; treatment 2) burn, sweep; treatment 3) sweep, disc; and treatment 4) disc, disc. Surface residue levels for treatments 1 and 2 were only about one-fourth of that for treatments 3 and 4. Yields averaged about 4 bushels per acre higher for treatments 1 and 2 during a very dry growing season compared with the other treatments. Due to the poor growing conditions, all systems had negative returns over total costs. However, the burn, sweep system was the least negative due to $5 to $11 per acre lower production costs than the other systems. The spring wheat crop was followed by fallow and soft white wheat in 1995 and 1996. Average annual returns over the three-year period were similar across systems except for treatment 4, disc, disc, which had slightly lower returns due to slightly lower yields. Treatment 3, sweep, disc had equivalent profitability to the higher intensity tillage treatments and a more acceptable surface residue level for erosion protection.

At the same Columbia County site, spring CRP take-out followed by spring wheat was repeated in 1995 under much better growing conditions and treatment yield differences were only 2 to 5 bu/acre. Average annual returns were highest for the two higher intensity tillage systems, i.e., treatments 1 and 2, averaging $71 and $75 per acre per year over the two years compared with $53 and $58 per acre for treatments 3 and 4. These results were attributed to slightly higher yields for treatments 1 and 2, and lower costs for the burn, sweep system. Recropped spring wheat was planted in 1996 at the same site and yields were not significantly different following the initial 1995 CRP take-out practices.

**Adams and Douglas Counties: direct seeding.** Trials at three sites examined the impact of different direct seeding systems for hard red spring wheat production. All systems had negative returns over total costs because of high productions costs and low spring precipitation. Annual spring cropping in the low rainfall areas is subject to economic risks from vagaries of the weather. Compared with conventional tillage systems, all of the no-till systems had much higher surface residue levels.

At a 10- to 12-inch annual precipitation site in Adams County, crested wheatgrass was chemically killed in the spring two weeks prior to planting. Direct seeding with a Yielder drill was compared with a conventional tillage system seeded with a conventional drill. Three grass residue systems were evaluated under direct seeding: 1) undisturbed standing grass residue, 2) flailed grass residue, and 3) burned residue. The burned residue treatment and the conventional drill treatment both had significantly lower surface residue levels. Net returns over total costs were least negative for the conventional drill treatment, although these net returns were not significantly different from returns for direct seeding into standing grass residue. Returns were significantly lower for the flailed grass residue direct seeding treatment due to higher costs associated with flailing. Two additional treatments with lower fertilizer rates compared direct seeding into standing residue and direct seeding following discing and coil packing. Yield and profitability were significantly
improved with the additional tillage prior to direct seeding, primarily due to improved CRP grass kill and higher associated yields.

In the next two trials, a number of no-till drills including prototype models were tested at Adams County and Douglas County sites. In Douglas County, grass residue treatments included 1) cutting and flailing with a combine and 2) standing grass residue. Very low precipitation resulted in soil moisture levels with a spring wheat yield potential of just 8 to 11 bu/acre. In the flailed residue trial, the conventionally-tilled treatment and the Concord drill had a slight yield advantage over the other four no-till drills, likely a result of a lower grass population. Net returns over total costs were least negative for two of the direct seeding systems, the Concord drill and the Flexi-Coil 5000. This result was attributed to higher yields and lower production costs associated with the direct fertilizer placement feature of these drills. In the standing residue trial, the Concord drill performed slightly better than the other systems including the conventionally-tilled treatment mainly because of lower production costs and relatively higher yields. While the conventionally-tilled treatment had about a 2 bu/acre higher yield, production costs were higher because of the additional tillage operations. An additional sweep-seed drill was also evaluated at the Douglas County site for profitability of recropped spring wheat rather than spring wheat following CRP take-out. Again, yields were very low due to lack of spring moisture. Yields were not significantly different across treatments, but production costs were lower for the Concord, the Flex-Coil 5000, and the reduced tillage treatment (sweep-seed), resulting in less negative returns for these three seeding systems.

Another no-till drill comparison was conducted at a second Adams County site near Ritzville, also in a 10- to 12-inch rainfall zone. Yields were within about 2 bu/acre for all systems. Production costs were lowest for the Concord and Flexi-Coil 5000 drills due to their direct fertilizer placement capability. Net returns over total costs were least negative with the Flexi-Coil 5000, though differences were small and not statistically significant.

Lincoln County: spring take-out of tall wheatgrass followed by barley. One trial in the 13-inch precipitation zone examined tillage treatments for barley production following spring take-out of tall wheatgrass. There was about 14,000 lb/acre of grass residue, about 2 to 3 times that obtained from crested wheatgrass in the other trials. Tillage treatments included 1) flail, sweep twice; 2) disc twice; 3) spring burn, sweep twice; and 4) spring disc (shallow), burn, sweep twice. Surface residue cover was lowest for treatment 3 and highest for treatment 2. Yields were nearly 600 lb/acre higher for burn treatments 3 and 4. Treatments 3 and 4 resulted in higher yields and had less negative returns than treatments 1 and 2. The higher residue levels resulted in increased temporary immobilization of nutrients from microbial decomposition, causing decreased nutrient availability and yield potential.

A number of conclusions can be drawn from the economic studies of the CRP take-out trials. In general, practices that enhance the agronomic and environmental performance of the first crops following CRP take-out will also maintain farm profitability and retain the soil improvements accrued during the CRP period. In some cases there were some economic gains with certain practices that could increase wind erosion and/or reduce soil organic matter. For example, burning costs less than flailing for residue management and thus reduces grower’s costs. However, burning stubble produces smoke which adversely affects air quality, and destroys surface cover and organic matter. It also results in the loss of certain plant nutrients and thus, adds to the fertilizer bill. Additional tillage may in some cases achieve a better grass kill and make more water available for the crop. However, the tillage also destroys surface cover and soil structure, and accelerates the oxidation of soil organic matter. Both practices could increase wind erosion and reduce water use efficiency from increased evaporation losses. Any economic gains from these practices could be offset by increased wind erosion and/or adverse effects on soil quality. An important conclusion from the agronomic and economic studies on CRP take-out is that the application of practices that support good soil and water conservation will most likely be the ones that best maintain long-term farm profitability.

Alternatives to Whole Field Take-out of CRP Lands
In some situations the benefits of CRP for wind erosion control and other uses (e.g., wildlife habitat and buffer zones) can be extended or enhanced by modifying the take-out practice. Two such methods developed by the NRCS adaptable for the Columbia Plateau are presented as possible alternatives.

Wind strips for CRP land use conversion. This practice consists of taking the CRP field out in strips rather than as a block. Advantages are reduced wind erosion and PM10 emissions, increased flexibility for alternative crops, and greater ease of getting into crop rotations. In addition to erosion and air quality control, wind strips also protect crops by reducing damage from saltation. In the dryland areas wind strips usually consist of alternating strips of crop and fallow perpendicular to the prevailing wind direction. Strip width is determined by wind intensity and soil erodibility with a maximum of about 660 feet. Implementing this method of CRP take-out is to put half of the CRP field into cropped strips the first year and the other half into cropped strips the second year. Leaving the grass undisturbed over
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winter during the first fallow conserves additional water for the subsequent winter wheat crop. Similarly, using timely herbicide applications with tillage in the spring will increase the available soil moisture during summer fallow.

In a typical winter wheat-fallow area, wind strips can reduce wind erosion by 4 to 7 tons/acre/year depending on the level of residue management. Crop production may increase by 5 to 15 percent from increased available moisture, reduced disease and insect damage, decreased fire damage, and reduced erosion. The strips can also enhance soil quality and wildlife habitat.

There is also greater opportunity for cropping flexibility with the use of wind strips. Annual alternative crops can be planted between strips during years of increased moisture and better prices. There are no extra costs associated with installing wind strips during CRP take-out. The NRCS reports that, depending on field shape, variable costs may increase by 5 to 15 percent to allow for extra turning or overlap. Some additional herbicide may be needed for weed control along strip edges as well as overlapping tillage once a year to prevent the formation of a soil berm.

The following economic scenario was developed by the NRCS for wind strips. A winter wheat-summer fallow rotation in a 10-inch precipitation zone produced average yields of 40 bu/acre with variable costs of $71.35/acre. Without additional operations, net returns are increased by a 5 to 15 percent increase in production. At $4.00/bu wheat, increased net returns are $8.00 to $24.00/acre. To break even over the increased 15 percent variable costs of $10.70/acre at $4.00 wheat, requires 2.67 bu/acre or a 6.7 percent production increase. This is well within the increase in agronomic benefits. Grower experience in the low precipitation areas has indicated good success with wind strips in their farming operations for CRP take-out.

Grass field borders for CRP land use conversion. This practice consists of leaving a strip of grass along the border of the field during CRP take-out. Advantages include water conservation by trapping snow, buffer for chemical use, reduced wind erosion, turn areas for equipment, prevention of weed infestations, and increased wildlife habitat. The width of the strip depends on the purpose of the field border. For example, on erodible fields, a 20-foot grass border would be effective in stopping the movement of saltating particles whereas a border 50 to 100 feet wide may be sufficient for stopping heavier suspended particulates. In addition to wind erosion and air quality control, the grass field borders are useful as a buffer or trap area near streams or water impoundments, or other environmentally sensitive areas. Grower experience in the NRCS study indicates that “grass borders are very effective in eliminating soil powdering effect and reducing soil blowing.”

The field border is simply left out of crop production and maintained in grass when the CRP field is converted back to crop use. Growers should consider extra wide borders around critical erosion sites and riparian areas. There is no cost for establishment because the entire area is already in grass. Crop production is reduced because of non-planted acreage. However, additional benefits will be increased moisture from trapped snow surrounding the border, and reduced loss of topsoil from the field. Some maintenance is required. Annual mowing or harrowing after the grass seed matures will help scatter seed and invigorate the stand. Annual weeds can generally be controlled with herbicides. Grass stand health can be maintained with proper fertilization.

Sources of Information and Suggested Reading


Best Management Practices For Dryland Farms


Soil Conservation Service Conservation Practice Standard
c) Residue management, seasonal 344. 6/1994
d) Mulching Washington State Supplement 484. 7/1988
e) Wind strip cropping WA 589. 9/1990
f) Cross wind trap strips 589C. 6/1994
g) Cross wind strip cropping 589B. 6/1994
h) Cross wind ridges 589A. 6/1994
i) Conservation cover WA 327. 2/1993
j) Conservation crop rotation 328. 6/1994
k) Conservation tillage WA 327. 2/1993
l) Miscellaneous Washington State Supplement 484. 7/1988
m) Residue management, no-till and strip till 329A. 6/1994


