

SPECIFICATIONS
TREE/SHRUB SITE PREPARATION
CODE 490

Site preparation is the most important component of forest regeneration. Since it has the potential to be destructive, care must be taken to develop practice prescriptions that adequately prepare the site for regeneration while minimizing damage to the soil and other resources. Factors to consider when developing a site preparation prescription in the order of importance include: composition and density of the residual vegetation, soil limitations, terrain, quantity and distribution of logging residue, and water quality and quantity concerns. Properly planned and implemented site preparation prescriptions improve seedling survival and growth, facilitate seedling planting, enhance wildlife food and cover, reduce fire hazard, limit mammal seedling predation, and increase equipment accessibility for fire suppression and forest management activities

SITE PREPARATION OPTIONS

There are three primary practices that may comprise a site preparation prescription: herbicide applications, mechanical treatments, and prescribed burning.

Herbicide Site Preparation

An herbicide application is the only practice that effectively manipulates the composition and density of residual vegetation. Residual vegetation competes directly with newly established seedlings for soil nutrient and water resources. Herbicide applications provide the growing space necessary for enhanced seedling survival and growth by extending the period of hardwood brush, broad leaf weed, and grass suppression beyond that achieved with a mechanical practice. Herbicide applications can minimize soil disturbance, can be used on steep slopes or where equipment limitations are severe, can be used on small acreages, and can target specific vegetation problems.

Target species susceptibility and vendor availability affects application timing and herbicide selection. Spring or early summer foliar applications of contact or systemic herbicides provide adequate control of annual grasses and early season forbs but have limited impact on perennial grasses, vines and hardwood brush. Depending on formulation, soil active herbicides can be applied from spring through fall to suppress foliar and root development of the residual vegetation. Herbicide formulations can be blended and applied as tank mix prescriptions to address specific vegetation problems.

Application Methods

1. Broadcast Treatments - Broadcast and banded herbicide applications should be considered when ground cover vegetation exceeds 60% and/or hardwood sprout or stem cover is greater than 100 trees per acre.

A. Broadcast or banded spraying: Foliar systemic or soil active herbicides can be applied by air using fixed-wing aircraft or helicopter and by ground using sprayers attached to skidders, farm tractors, ATV's, or other ground equipment. If vendors are available, this is the fastest application method. The potential for spray drift onto

untargeted and/or sensitive areas should be considered during practice planning. Use of qualified and experienced applicators will help avoid this problem. A broadcast application should be considered, if mammal seedling predation is a concern.

B. Ground spot applications: Soil-active herbicides can be used to treat small acreage. Liquid and granular formulations available for this method can be applied in a strip or a grid pattern manner by hand using fertilizer distributors, spotguns, spray wands or similar equipment. Late spring (mid-March to early May) applications are more effective due to maximum water uptake into the plant leaves during hot weather. Herbicide runoff and soil leaching potential will be considered when applying soil active formulations.

2. Single Tree Treatments - Single stem applications can be used on a small number of large diameter trees or clumps of small diameter trees during crop or pasture land conversion.

A. Tree Injection: Herbicide injection can be used to kill individual medium to large size trees. The herbicide is applied through cuts in the bark of the tree. The cut and injection can be accomplished simultaneously using a basal tree injector or a hypo-hatchet, or a hatchet can be cut a frill around the tree and then a squeeze bottle would be used to immediately squirt the chemical into the frill. Harder to kill tree species (hickory, maple, etc.) should be entirely girdled and treated, for other trees, cuts 2-3 inches apart will be sufficient. Fall treatments will provide a greater level to suppression.

B. Basal Bark Spraying: The method can be used for on young trees with thin bark. Systemic herbicide formulations labeled for this method are tank mixed with a penetrant and sprayed on the basal portion the stem from groundline to a height of 3 feet, ensuring that the entire stem surface is treated. Fall treatments will provide a greater level of suppression.

Mechanical Site Preparation

Mechanical site preparation involves the use of machinery to mediate tree growth restrictions, provide seedbeds and disperse logging residue. Although this practice does not provide residual vegetation suppression, it can be used in conjunction with herbicides to achieve strip suppression along tree planting rows. Tree growth restriction mediation treatments include ripping or mounding and can be applied during afforestation or reforestation. Seedbed preparation includes disking, mulching or mowing and can be applied during afforestation or reforestation. Residue dispersal includes drum chopping and V-blade stripping and is primarily applied during reforestation.

Application Methods

1. Tree Growth Restriction Mediation – This treatment should be used during afforestation (crop and pasture land conversion) and reforestation operations when existing soil conditions limit seedling performance potential. Mediation objectives include: relieve the effects of soil compaction, shatter hardpans below the soil surface, and assist in cultivation of surface soils. Pre-planted herbicide should be applied

following the mediation treatment.

A. Deep Ripping: This is an acceptable treatment when soil compaction test values exceed 145 psi and soil erosion is not a concern (See Appendix 1, Soil Compaction: Detection, Prevention, and Alleviation), and soil erosion is not a concern (See Appendix 2, Ripping Decision Tree for Forest Site Preparation). Ripping can be conducted between August 1 and December 1 when the soil is dry. If ripping occurs between November 1 and December 1, a minimum of 30 days with ample rainfall will be required prior to planting. Ripper running slits shall be centered on the row spacing used for tree planting. If crop land has existing beds, ripper running slit may be placed on the centerline of the bed. Ripping will fracture the soil to a depth of 16 inches or 2 inches below any existing restriction zone. Surface blowouts or the presence of large clods in the ripper running slit will be unacceptable and ripping will cease until soil moisture conditions are suitable or crop residue or grass sod is minimized.

For afforestation operation, the ripping implement will consist of the following:

- 1) the ripper shank will be $\frac{3}{4}$ inch wide producing a running slit no wider than 2 inches;
- 2) a spring loaded rolling 22-inch coulter will be mounted forward of the ripper shank to cut existing sod or crop residue;
- 3) a tiger model 8 inch no till point with wings will be mounted to the ripper shank;
- 4) the wings will set back from the leading edge of the point to direct an upward fracturing force on the soil creating a widespread fracture zone of 2 to 3 inches on each side of the of the no till point extending upward in an inverted triangle to a width of 16 to 18 inches at the soil surface;
- 5) the no till point will be in proper condition before use on the site with the front point width not less than $\frac{1}{2}$ " inch and the wings width not less than 1 inch;
- 6) gauge wheels will be used to maintain proper ripping depth;
- 7) tractor speed during ripping will not exceed 5 miles per hour; and
- 8) a gang chopping wheel with at least four straight blades or two 20-inch 13 wave closing coulters may be mounted to the rear of the ripping shank to assist in closing the running slits, identifying ripped rows and improving tree planter access and efficiency.

Reforestation ripping implement would have similar requirements but the shank, forward mounted coulter and no till point and wings would be larger. The prime mover would be bulldozer with a mounted V-blade.

B. Surface Soil Cultivation: Mounding or flat disking can be used in conjunction with ripping to seal the running slit, to improve surface soil tilth, to enhance tree planter access and efficiency, to allow rapid root penetration, to concentrate nutrients in the rooting zone and to lengthen the period of herbicide weed suppression. Mounds are raised beds that can vary in height and width depending on site, but as a general rule should not exceed 3 feet in width and 1 foot in height. On frequently flooded sites, higher mounds, which can approach 3 feet, can be used to insure early root development of hard mast trees. Flat disking forms a tilled strip approximately 3 feet wide centered on the running slit. Mounds and tilled strip can be prepared simultaneously during the ripping operation by attaching two 20-inch 13 wave closing coulters or a gang chopping wheel to the rear of the ripping shank. Avoid mounding on dry sites because it may channel water away from seedling causing moisture stress. Do

not use mounding in forested wetlands to convert from hardwood forests to pine forests because it will violate the Clean Water Act provisions.

2. Seedbed Preparation –This treatment is acceptable during the conversion of recently cropped land as site preparation for direct seeding of tree species, surface soil tilth improvement or wildlife habitat enhancement. Seedbed preparation can be used in conjunction with tree growth restriction mediation treatments and herbicide applications.

A. Disking: If soil erosion is a concern, disking will be limited to strips centered on the row spacing being used for tree establishment. Disking will be completed prior to tree establishment and will avoid wildlife nesting periods (April 15 - July 1). For crop land conversion, consider a post-plant herbicide application to suppress early growing season weed competition (See Conservation Practice Standard 666).

B. Mowing: Mowing may be used to provide tree planter access when soil growth restrictions and soil surface tilth will not impede tree survival and growth. Mowing will be completed prior to tree establishment, will avoid wildlife nesting periods (April 15 - July 1) and may be limited to strips centered on the row spacing being used for tree establishment. For crop land conversion, consider a post-plant herbicide application to suppress early growing season weed competition (See Conservation Practice Standard 666).

C. Mulching: On reforestation sites, mulching can be used to shred logging residue and residual vegetation within a strip centered along a tree planting row to improve soil tilth and facilitate planter access. Mulching can be used in conjunction with deep ripping. If pre-plant herbicide were not applied, consider a post-plant herbicide application to suppress early growing season weed competition and woody brush release application when the stand is 3-years-old (See Conservation Practice Standard 666).

3. Logging Residue Dispersal – Generally used during reforestation to improve tree planter access, facilitate ground spraying equipment, slow water surface flow and reduce soil erosion. The practice may be applied in broadcast or strip manner.

A. Broadcast dispersal: A drum chopper attached to a crawler tractor is effective on small diameter debris (less than 8 inches) by crushing and cutting debris and brush into small pieces. The chopper weight is adjusted to site needs by filling it with water and usually requires two passes to achieve adequate dispersal. The treatment is preformed in the summer and can be followed by a prescribed burn within 4 to 6 weeks. Terrain will limited the use of this treatment. If pre-plant herbicide were not applied, consider a post-plant herbicide application to suppress early growing season weed competition and woody brush release application when the stand is 3-years-old (See Conservation Practice Standard 666).

B. Strip dispersal: A large V -blade or KG-blade mounted on a crawler tractor is used the move logging residue and residual vegetation to the edge of a strip centered along a tree planting row. This treatment can be used in conjunction with pre-plant herbicide application and deep ripping. If pre-plant herbicide was not applied, consider a

post-plant herbicide application to suppress early growing season weed competition and woody brush release application when the stand is 3-years-old (See Conservation Practice Standard 666).

4. Logging Residue Removal - Generally used during reforestation to improve tree planter access, facilitate ground spraying equipment and the establishment of native ground cover vegetation. Residue removal is an intensive site preparation practice, that normally includes a combination of shearing, root raking and piling. Care should be taken during implementation of this practice to minimize mineral soil disturbance and detachment, reducing soil erosion and stream sedimentation potential. A poorly applied shear, root rake, pile practice can remove nutrients, compact soil, increase erosion and reduce future tree growth. Successful residue removal leaves sufficient slash and duff on the site providing good ground cover that will minimize erosion from the site. If the Soil Erosion Rate (SER) is low, leave at least 40 percent good ground cover; if the SER is medium, leave at least 50 percent good ground cover; if the SER is high, leave at least 60 percent good ground cover. When using mechanical site preparation methods, be sure to leave undisturbed buffer strips along streams, construct windrows on the contour, and never site prepare heavy soils during wet periods. Protect existing conifer regeneration less than 4 inches DBH in formerly mixed deciduous coniferous stands during site preparation. Clumps of conifer are preferable to scattered trees. Consider maintaining the diversity of mast sources on the site, as well as some level of current production of mast sources.

A. Shearing: Undesirable standing trees are severed with a large V-blade or KGblade mounted on the front of a crawler tractor. The shearing blade is used to cut off all vegetation at the soil surface. However, the blade often drops below the soil surface causing a great deal of site disturbance. After a shearing operation, quite a bit of mineral soil is exposed. Conduct shearing along the contour of the land to reduce soil erosion.

B. Root Raking: Woody debris is piled with a large, multi-toothed rake blade that is mounted on a bulldozer or large tractor. Debris is pushed and confined into piles or windrows. Creating a pasture like setting which make machine planting easy. Raking should be conducted along the contour of the land.

C. Piling: Residue maybe gathered in haystack piles or windrows. Haystack pile placed along the soil contour shall be the preferred method of piling. Locate residue piles and windrows to avoid cultural resources, minimize interference with natural drainage patterns and be outside filter strips and riparian zones.

Prescribed Burning

Prescribed burning is used facilitate tree planter access and to reduce wildfire fuel load, and can be applied separately or used in combination with other site preparation practices (See Conservation Practice Standard 338). It was a widely used, low-cost practice better suited for large site preparation operations rather than small operations. Air quality issues such as smoke management, odor emission, regional haze and particulate matter regulations have diminished the effectiveness of burning as site preparation practice for artificial regeneration. If ground fuel loads are adequate, a fall

burn can be used for natural regeneration systems to expose mineral soil required for seed germination. Any prescribed burns will require that a Louisiana Department of Agriculture and Forestry, Certified Prescribed Burn Manager prepare a site specific written burn plan and then supervise the burn implementation to ensure compliance with all federal, state, and local laws and regulations.

APPENDIX 1

AGRONOMY TECHNICAL NOTE – No. 17

Soil Compaction: Detection, Prevention, and Alleviation

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Overview

Soil that is excessively compacted is limited in its ability to function. Soil compaction occurs when moist or wet soil particles are pressed together and the pore spaces between them are reduced. Adequate pore space is essential for the movement of water, air, and soil fauna through the soil. The mechanical strength and poor oxygen supply of compacted soil restrict root penetration. Soil moisture is unavailable if layers of compacted soil restrict root growth. Compaction restricts infiltration, resulting in excessive runoff, erosion (Pierce et al., 1983), nutrient loss, and potential water-quality problems. Soil compaction can restrict nutrient cycling, resulting in reduced yields. Soils in all regions of the country are susceptible to compaction with extreme cases in the upper Midwest, the Pacific Northwest, and the Southeast. Eroded soils are inherently low in content of organic matter and are especially susceptible to compaction. Compaction is caused primarily by wheel traffic, but it also can be caused by animal traffic or natural processes. Soil is especially susceptible to compaction when it is at field capacity or wetter, has a low content of organic matter, or has poor aggregate stability. Saturated soils lack adequate strength to resist the deformation caused by traffic. Moldboard plowing and excessive tillage break down soil aggregates. After the aggregates are broken down and the soil surface is bare, the soil is more likely compacted by the excessive vehicle passes common in conventional tillage systems. Excessive traffic in forests during thinning and harvesting activities can cause compaction that will be detrimental to the next crop of trees. Grazing on wet soils in a confined area can create compacted layers.

Types of Compaction

Surface crusting restricts seedling emergence and water infiltration. It is caused by the impact of raindrops on weak soil aggregates. Soils with cover crops or high-residue cover are less likely to form crusts.

Surface compaction occurs anywhere from the surface down to the normal tillage depth. The compacted layer can be loosened by normal tillage, root growth, and biological activity.

Tillage pan is a compacted layer, a few inches thick, beneath the normal tillage depth. It develops when the depth of tillage is the same year to year.

Deep compaction occurs beneath the level of tillage. Ground contact pressure and the total weight on the tire from the axle load significantly affect the amount of subsoil compaction. Deep compaction is difficult to eliminate and may permanently change soil structure. Prevention is important.

Inherent hardpans can form on some soil types because of variations in soil particle sizes, consolidation of particles by rainfall, and certain organo-chemical factors. These pans are aggravated by tillage and traffic.

Detecting Soil Compaction

Generally, compaction is a problem within the top 24 inches of the soil. Signs of compaction are:

- Discolored or poor plant growth.
- Excessive runoff.
- Difficulty penetrating the soil with a firm wire (survey flag) or welding rod (18" long).
- Lateral root growth with little, if any, penetration of roots into compacted layers.
- Platy, blocky, dense, or massive layers.

Quantitative methods of detecting compaction are (Jones, 1983):

- Measuring soil bulk density.
- Measuring penetration resistance with a commercially available cone penetrometer.

Bulk density measurement

Bulk density is defined as the weight of dry soil per volume. The Soil Quality Kit Guide (NRCS Soil Quality Institute, 2001) includes full directions for using the core method to measure bulk density. Table 1 provides interpretations based on soil texture. Samples can be taken from the surface 3 inches or from 3-inch increments beginning at the top of the compacted layer.

Table 1.

(Pierce et al., 1983; R.B. Grossman, personal communication, 1996).

General relationship

Soil texture	Ideal bulk densities	Bulk densities that may affect root growth	Bulk densities that restrict root growth
----- g/cm ³ -----			
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.40	1.55	>1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

Soil cone penetrometer

A cone penetrometer allows faster and easier readings than bulk density measurements. The soil penetrometer consists of a cone attached to a rod that is pushed through the soil. The force required to push the cone through the soil divided by the area of the base of the cone is the cone index. The cone index is the standard measurement used for soil compaction and is read on the dial indicator of the penetrometer. Cone index is reported in units of pounds/square inch, or psi. Sometimes cone index is reported in bars. A bar is one atmospheric pressure, or about 15 psi. Roots usually cannot penetrate soil compacted to 300 psi or more. This critical value varies with soil type and moisture content of the soil when tested (Schuler et al., 2000). There are potential root restriction problems at 145 psi.

The following instructions for using a penetrometer will ensure good results:

- Soil moisture will impact readings and should be near field capacity. If the user is sure there is compaction and is only trying to determine the depth of the compacted layer, then moisture content is not critical.
- Insert the soil penetrometer smoothly without jerking motions. An uneven force will result in a reading that is not representative.
- The penetrometer should be inserted at a constant rate of 1.2 inches/sec (3 cm/sec). Small variations will not affect the reading. Starting and stopping also will not affect the reading.
- Insert the penetrometer until the cone index reads 145 psi, which is an indication of potential penetration resistance. Stop and record the depth.
- Continue insertion. When the cone index is again less than 145 psi, record the depth. This is the bottom of the hardpan or compacted layer.
- If 145 psi or greater is never reached down to 18 inches, stop, record the maximum reading, and remove the penetrometer.
- Repeat the procedure at all sample locations.
- If soil sticks to the penetrometer, clean off the rod and cone with water after use.

Interpreting compaction indicators

The impact of compaction on crop productivity is determined not only by the amount of compaction, but also by the timing and duration of drought, crop type, planting date, crop variety, and other cropping system factors. Thus, indicators of soil compaction, such as bulk density and cone index readings, are not perfect indicators of the effect of compaction. For example, crops might show the effects of compaction only during years of high or low rainfall. No-tilled soils can have high compaction, as indicated by bulk density and cone index, but plants may grow well if biopores allow for root growth and water infiltration.

Preventing Soil Compaction

Prevention is important because all compaction is expensive to treat and deep compaction may have permanent, untreatable effects on productivity (Voorhees et al., 1989).

Controlled traffic

A controlled traffic system separates traffic zones from cropping zones within a field. Yields normally improve when traffic is restricted to controlled zones between the rows because the

soil directly beneath the rows can retain a loosened structure. A controlled traffic system works well with row crops. If drilled crops are grown, a skip row is required (Reeder and Smith, 2000). One component of controlled traffic systems is ensuring that all equipment covers the same width or multiples of the same width. A second component is minimizing the number of traffic lanes. Table 2 provides examples of traffic patterns. In the first scenario in table 2, the tractor tire width is 60" and the combine tire width is 120". Thus, each set of six rows will have four tire paths and 44 percent of the ground will be trafficked. By increasing the tractor tire width to match the combine tire width (as in the second scenario), the number of paths and area trafficked are cut in half.

Table 2. Examples of traffic patterns for controlled traffic systems (Reeder and Smith, 2000).

Number of rows	Tractor (in)	Combine (in)	Number of paths	% Trafficked
-----30" row spacing-----				
6	60	120	4	44
6	120	120	2	22
8	120	120	2	17
8	60 & 120	120 & 180	6	50
12	60 & 120	120 (6-row)	4	22
16	60 & 120	120 & 180 (8-row)	8	33
24	60 & 120	120 & 180 (12-row)	12	33
-----36" row spacing-----				
6	72	144	4	37
8	72	144	4	28
12	72	144	4	18

Permanent high-residue cropping systems, otherwise known as conservation tillage systems, generally work well with controlled traffic systems because previous crop rows are not tilled and thus traffic rows remain visible. Controlled traffic can be an integral part of ridge-till systems and no-till systems with permanent beds.

Mulch tillage systems (systems with tillage across the entire field) require auto-steer technology (Sandusky, 2003) using guidance from a Global Positioning System (GPS) to locate traffic lanes year after year. Auto-steer technology keeps all field operations in the same traffic lanes. Some systems are even capable of 1-inch accuracy. This technology allows controlled traffic with standard agricultural equipment and full-width tillage. Automatic steering and controlled traffic reduce compaction beneath the row, thereby increasing infiltration and reducing the hazard of erosion and the need for subsoiling. Other advantages of auto-steer technology and controlled traffic include the potential to (Sandusky, 2003):

- Extend work time into night hours.
- Plant in spring over fall subsoiling or fall fertilization strips.
- Protect drip-irrigation lines.
- Get improved yields where harvest machines must be kept on rows.

Other strategies to prevent compaction

Other strategies that minimize compaction are (Schuler et al., 2000; Reeves, 1994):

- Avoid working wet soils. Improve drainage if necessary.
- Decrease tire pressure to increase surface area, thus reducing soil compaction.

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- Use radial tires in lieu of bias-ply tires to create a larger footprint and more surface area.
- Use duals or triples to replace singles. However, this measure increases the area affected by compaction.
- Maximize the number of axles under grain cars or slurry wagons to decrease the axle load per tire.
- Minimize the use of tractor-trailers or other vehicles with high inflation pressure and small footprints in agricultural fields.
- Frequently empty combines and grain carts to minimize field traffic while also minimizing high axle loads that can permanently compact the subsoil.
- Select a tractor with four-wheel drive, front-wheel drive, or a rubber track system, which spreads the load over a larger surface area. However, the extra traction makes it possible to drive on wetter soils, giving the operator the potential to create significant deep compaction.
- Adjust ballast weights for each field operation.
- Reduce the number of trips by using high-residue management systems (conservation tillage).
- Increase the content of organic matter by reducing tillage and using high biomass crop rotations with cover crops. The organic matter improves aggregate stability, which reduces soil compaction.
- Avoid tillage, such as moldboard plowing and disking, which breaks down aggregates and destroys structure.
- Use cover crops and crop residue to conserve moisture. Wetter soils have lower soil strength and thus are less restrictive to root growth.

Alleviating Soil Compaction

Shallow soil compaction caused by natural processes or field operations can usually be alleviated with chisel plowing at shallow depths. However, repeated trafficking by heavy vehicle loads causes deep compaction, which requires more drastic alleviation measures, such as subsoiling. In some regions, combinations of traffic, tillage pans, a low content of organic matter, and natural conditions or processes can lead to deep compacted zones. Subsoiling is recommended if yields are limited by compaction. Subsoiling usually refers to tillage at a depth of at least 35 cm (14 in). Inserting any narrow tool to a depth of less than 35 cm is considered chisel plowing (Raper, 2003).

Although subsoiling or chiseling can alleviate compaction immediately, research shows that a second pass by a single vehicle may nullify the benefits of subsoiling or chiseling (Raper, 2003; Schuler et al., 2000). Before subsoiling is performed, it is important to prevent the recurrence of compaction and prolong the benefits of subsoiling through a controlled traffic system, conservation tillage, crop rotations, cover crops, and in-row tilling (subsoiling or chiseling under the row). Strip tillage is one method of preserving the benefits of subsoiling. It is essentially in-row subsoiling with a no-till planter equipped with row cleaners. The operation consists of pulling a shank directly beneath each row and planting directly behind the in-row subsoiler, thus preventing any traffic compaction. Alternatively, subsoiling and planting can be performed as separate operations.

Subsoiler shank design is an important part of a tillage system. In the 1950s, subsoiler shanks tended to be straight and projected slightly forward. Parabolic shanks soon became popular because they required less draft force. However, when curved shanks are used at deeper or shallower depths than designed, draft forces can increase. Curved subsoiler shanks tend to

disrupt the soil in a symmetric manner, leaving soil on either side of the subsoiler shank as it moves forward and causing surface soil disturbance and burial of crop residue (Raper, 2003). The bentleg subsoiler was developed to disrupt the soil in an asymmetric manner, shattering the pan but leaving the surface almost undisturbed. This shank is bent to one side at 45° with the leading edge turned by 25°. For this reason, many farmers interested in high-residue management use this form of tillage as a method of alleviating compaction while maintaining high amounts of residue on the soil surface (Raper, 2003).

The practice of subsoiling and chiseling costs time and energy. They should be performed only when needed. The benefits of subsoiling and chiseling are generally not long lasting. To avoid wasting an expensive trip across the field, consider the following points (Schuler et al., 2000; Raper, 2003):

- Determine the depth and extent of the compaction problem across the field by taking penetrometer readings correctly. Taking readings in dry soil may give the false impression of a compaction problem.
- Use the appropriate equipment (select a proper subsoiler shank for the desired amount of soil mixing and residue cover) and subsoil when the soil is dry enough for the equipment to properly fracture the pan but moist enough for the equipment to pull the shank. Subsoiling when the soil is too dry will disturb more surface soil, and subsoiling when it is too wet will not fracture the compacted layer, thus wasting the trip. A good compromise is near the permanent wilting point.
- Subsoil or chisel to the depth of the compacted layer. Examine the soil profile to determine the depth of the compacted layer and plan to subsoil or chisel 1 inch below the zone. If several observations are made with a penetrometer or by measurement of bulk density, site-specific tillage can focus on certain portions of the field, e.g., eroded areas or a specific soil type.
- Select the proper spacing, such as in-row versus complete field disruption. Complete field disruption spacing should be 60 to 80 percent greater than the operation depth.
- Timing is important. Subsoiling after fall harvest often works well because more time is available and the compaction caused by harvesting operations can be eliminated. Fall subsoiling also allows better infiltration in winter, when rainfall is more plentiful in many climatic regions. In some regions, such as the Southeast Coastal Plain, however, spring subsoiling is preferable because compacted layers will normally reconsolidate over the winter. Many strip-till planters subsoil and plant in one operation.
- Most importantly, have a controlled traffic plan in place to prevent the recurrence of compaction after subsoiling. Again, in some regions, such as the Southeast Coastal Plain, compaction will naturally recur and may require annual subsoiling.
- In permanent stands, such as grazing lands, orchards, and forests, subsoiling may be needed during planting. As a last resort, pastures can be renovated with bentleg subsoilers. Damage to actively growing roots can be reduced by subsoiling during winter or dormancy. Care should also be taken in forests to subsoil only where needed and to the depth of compaction. Rotational grazing and proper planning of watering facilities and permanent lanes may reduce compaction on grazing lands.

Summary

Soil compaction reduces the ability of the soil to function (to regulate infiltration, provide a deep rooting environment, store available water, etc.) and thus reduces crop yields. To locate the depth and position of the compacted layer in a field, such tools as a penetrometer must be used properly. In particular, penetrability should be measured when soil moisture is at field capacity. Preventing compaction avoids the cost of yield losses and the cost of alleviating compaction.

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Avoid performing field operations when the soil is wet. High-residue management systems, crop rotations, cover crops, and other conservation practices that increase the content of organic matter lessen the effects of compaction. Controlled traffic systems using row spacing or permanent rows lessen compaction in crop-growing areas. Automatic steering helps to reduce traffic, and site-specific tillage helps to economize subsoiling and chiseling. Subsoiling can alleviate soil compaction in some situations. Important issues to be considered before subsoiling include selection of shanks on the basis of the desired amount of soil disruption and surface residue, timing of tillage, depth of tillage, soil moisture, how to keep soil compaction from recurring, and how subsoiling fits within the entire management system.

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**APPENDIX 2
RIPPING DECISION TREE FOR FOREST SITE PREPARATION**

1: Parish Rainfall Index (R-Factor)

If Parish R-Factor ranges between 390 – 480 (Figure 1), **Go to 2. (Page 490 S-15)**

If Parish R-Factor ranges between 510 – 610 (Figure 1), **Go to 3. (Page 490 S-17)**

If Parish R-Factor ranges between 620 – 690 (Figure 1), **Go to 4. (Page 490 S-19)**

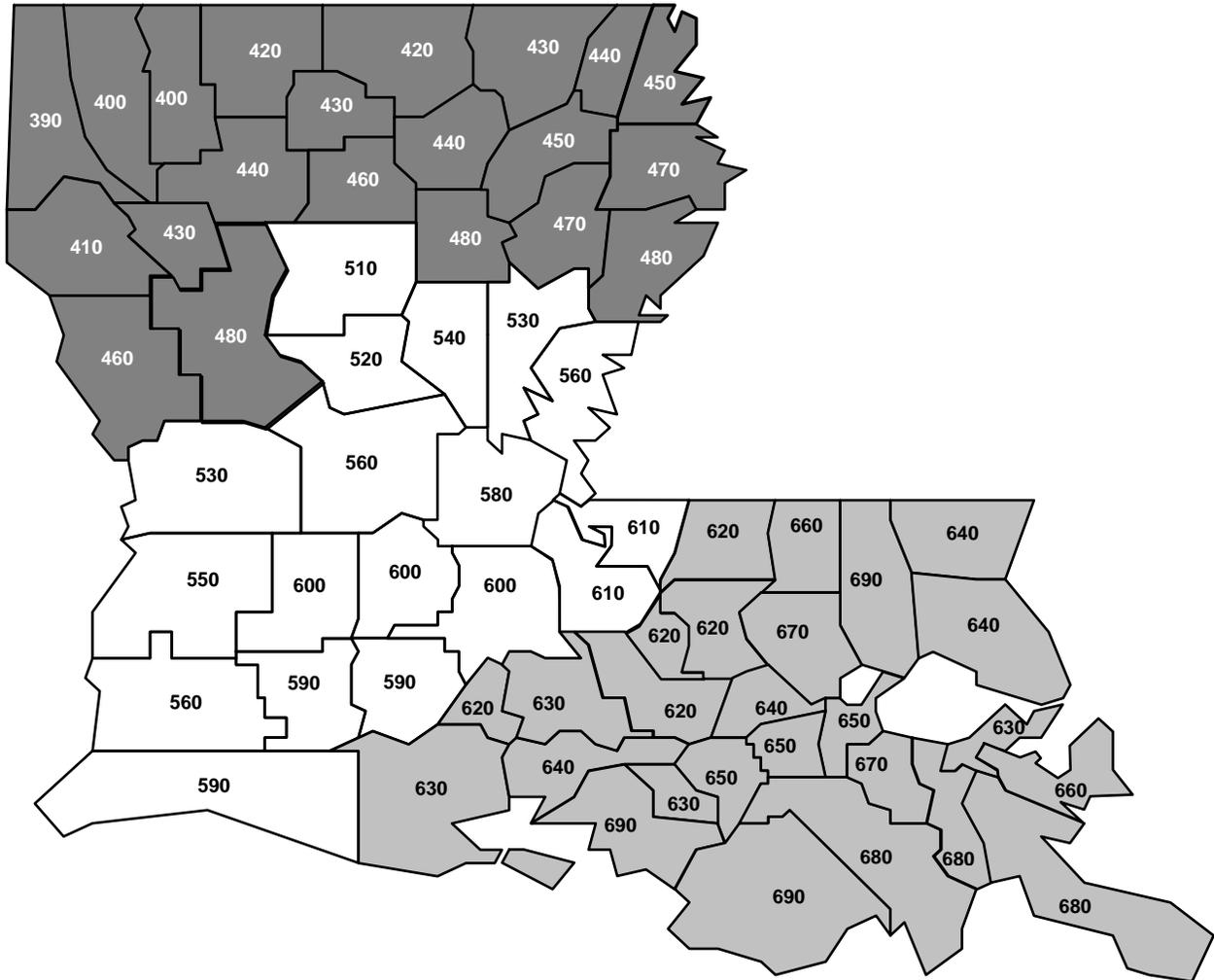


Figure 1. Louisiana average rainfall index (R-Factor) by parish.

2: Parish R-Factor ranges between 390 – 480.

If soil Drainage Class = Very Poorly Drained or Poorly Drained, **Go to 2.A.**

If soil Drainage Class = Somewhat Poorly Drained or Moderately Well Drained, **Go to 2B.**

If soil Drainage Class = Well Drained, Somewhat Excessively Drained or Excessively Drained, **Go to 2C.**

2A: Drainage Class=Very Poorly Drained or Poorly Drained.

If Slope exceeds 5%, **No Soil Disturbance.**

If Slope ranges from 4% - 5%, **Go to 2A1.**

If Slope ranges from 2% - 3%, **Go to 2A2.**

If Slope ranges between 0% – 1%, **Go to 2A3.**

2A1. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey, **No Soil Disturbance.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

2A2. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Clayey with a restrictive layer, **Deep Rip.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

2A3. If Surface Texture is Loamy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

2B: Drainage Class=Somewhat Poorly Drained or Moderately Well Drained.

If Slope exceeds 5%, **No Soil Disturbance.**

If Slope ranges from 4% - 5%, **Go to 2B1.**

If Slope ranges from 2% - 3%, **Go to 2B2.**

If Slope ranges between 0% – 1%, **Go to 2B3.**

2B1. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey, **No Soil Disturbance.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3: Parish R-Factor ranges between 510 – 610

If soil Drainage Class = Very Poorly Drained or Poorly Drained, **Go to 3.A.**

If soil Drainage Class = Somewhat Poorly Drained or Moderately Well Drained, **Go to 3B.**

If soil Drainage Class = Well Drained, Somewhat Excessively Drained or Excessively Drained, **Go to 3C.**

3A: Drainage Class=Very Poorly Drained or Poorly Drained.

If Slope exceeds 5%, **No Soil Disturbance.**

If Slope ranges from 4% - 5%, **Go to 3A1.**

If Slope ranges from 2% - 3%, **Go to 3A2.**

If Slope ranges between 0% – 1%, **Go to 3A3.**

3A1. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey, **No Soil Disturbance.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3A2. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey, **No Soil Disturbance.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3A3. If Surface Texture is Loamy without a restrictive layer, **No Soil Disturbance.**

If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

3B: Drainage Class=Somewhat Poorly Drained or Moderately Well Drained.

If Slope exceeds 5%, **No Soil Disturbance**

If Slope ranges from 4% - 5%, **Go to 3B1.**

If Slope ranges from 2% - 3%, **Go to 3B2.**

If Slope ranges between 0% – 1%, **Go to 3B3.**

3B1. If Surface Texture is Loamy, **No Soil Disturbance.**

If Surface Texture is Clayey, **No Soil Disturbance.**

If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3B2. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3B3. If Surface Texture is Loamy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

3C: Drainage Class=Well Drained, Somewhat Excessively Drained or Excessively Drained.

If Slope exceeds 5%, **No Soil Disturbance.**
If Slope ranges from 4% - 5%, **Go to 3C1.**
If Slope ranges from 2% - 3%, **Go to 3C2.**
If Slope ranges between 0% – 1%, **Go to 3C3.**

3C1. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3C2. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Clayey with a restrictive layer, **Deep Rip.**
If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

3C3. If Surface Texture is Loamy without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
If Surface Texture is Sandy without a restrictive layer, **Deep Rip**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
or Deep Rip with Mounding.

4: Parish R-Factor ranges between 620 – 690.

If soil Drainage Class = Very Poorly Drained or Poorly Drained, **Go to 4.A.**
 If soil Drainage Class = Somewhat Poorly Drained or Moderately Well Drained, **Go to 4B.**
 If soil Drainage Class = Well Drained, Somewhat Excessively Drained or Excessively Drained, **Go to 4C.**

4A: Drainage Class=Very Poorly Drained or Poorly Drained.

If Slope exceeds 5%, **No Soil Disturbance.**
 If Slope ranges from 4% - 5%, **Go to 4A1.**
 If Slope ranges from 2% - 3%, **Go to 4A2.**
 If Slope ranges between 0% – 1%, **Go to 4A3.**

4A1. If Surface Texture is Loamy, **No Soil Disturbance.**
 If Surface Texture is Clayey, **No Soil Disturbance.**
 If Surface Texture is Sandy, **No Soil Disturbance.**

4A2. If Surface Texture is Loamy, **No Soil Disturbance.**
 If Surface Texture is Clayey, **No Soil Disturbance.**
 If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
 If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

4A3. If Surface Texture is Loamy without a restrictive layer, **No Soil Disturbance.**
 If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
 If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
 If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
 If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.
 If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or Deep Rip with Mounding.

4B: Drainage Class=Somewhat Poorly Drained or Moderately Well Drained.

If Slope exceeds 5%, **No Soil Disturbance**
 If Slope ranges from 4% - 5%, **Go to 4B1.**
 If Slope ranges from 2% - 3%, **Go to 4B2.**
 If Slope ranges between 0% – 1%, **Go to 4B3.**

4B1. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy, **No Soil Disturbance.**

4B2. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

4B3. If Surface Texture is Loamy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**

4C: Drainage Class=Well Drained, Somewhat Excessively Drained or Excessively Drained.

If Slope exceeds 5%, **No Soil Disturbance.**
If Slope ranges from 4% - 5%, **Go to 4C1.**
If Slope ranges from 2% - 3%, **Go to 4C2.**
If Slope ranges between 0% – 1%, **Go to 4C3.**

4C1. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy, **No Soil Disturbance.**

4C2. If Surface Texture is Loamy, **No Soil Disturbance.**
If Surface Texture is Clayey, **No Soil Disturbance.**
If Surface Texture is Sandy without a restrictive layer, **No Soil Disturbance.**
If Surface Texture is Sandy with a restrictive layer, **Deep Rip.**

4C3. If Surface Texture is Loamy without a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Loamy with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Clayey without a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Clayey with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**
If Surface Texture is Sandy without a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**

If Surface Texture is Sandy with a restrictive layer, **Deep Rip**
or **Deep Rip with Mounding.**