

INTRODUCTION

This technical note provides information on tree and shrub establishment using tree seedlings, container stock, or direct seeding methods.

I. PLANTING DESIGN

A. Planting Rates

A good tree planting design to establish trees will usually include multiple species and objectives. Species may be mixed together within rows, separated by rows, or grouped into clusters. When different species are mixed together it is important that they have similar growth rates to prevent overtopping and slow growth on some species.

Table 1. Recommended planting rates by objectives

Planting Objective	Recommended Spacing	Stems/Acre
Mixed Hardwoods ¹	8 ft x 10 ft to 6 ft x 8 ft	544 - 908
Shrubs	12 ft x 12 ft to 6 ft x 6 ft	302 - 210

¹ Up to 50% conifers may be included as nurse trees. Adjust planting rates within listed ranges for desired objectives, site conditions, maintenance requirements such as thinning, and species needs.

B. Planting Stock

Planting stock should have healthy living root mass that is in balance with the above ground shoots giving the plant the capacity to grow and prosper after planting. Planting stock that is moldy, damaged, or dried out should be discarded. Planting stock should meet the criteria as shown in Table 2. For best results plant trees from locally adapted sources and from no more than 200 miles north or south of the planting site.

Table 2. Planting Stock Specifications

Tree Seedlings (Bare root stock)			
Type	Height	Caliper ¹	
Conifer	9-18"	1/8-3/8"	
Hardwood	18-36"	1/4-3/4"	
Container Stock			
Conifer or Hardwood	Container Size	Height	Caliper ¹
	1 gallon	2 – 4'	3/8 – 5/8"
	3 gallon	2 – 6'	3/8 – 5/8"

¹ Caliper is the stem diameter at ground level measured at the root collar.

C. Species Selection

Indiana has over 100 native tree species with adaptations to different soil and site conditions found across our landscape. Site conditions can vary based upon soil fertility, rooting depth, available water capacity, soil wetness (usually described as soil drainage class) and flooding conditions. Each tree species is adapted to survive and thrive under certain site conditions. Site conditions may be similar enough over a large area so as to be considered one site or different enough to be considered different sites. It is critical that species selected are adapted to the variable conditions of the planting site.

Adapted species can be found at the NRCS Soil Data Mart or Web Soil Survey by generating the Forestland Productivity or Windbreak and Environmental Plantings reports. Species information is also available in Tables 6 & 7. When possible an on-site soils investigation should be completed to evaluate local soil properties to match the most adapted species to the site.

II. SITE PREPARATION AND WEED CONTROL

Eliminate competing vegetation prior to planting (see Table 4). Before direct seeding or installing weed barrier material, heavy grass and/or weed cover should be eliminated to prevent damage to plants from mice and voles.

To ensure successful establishment of trees it is important to have a weed free planting site. Before implementing specific weed control measures, consult a professional forester to develop a site specific weed control plan. Site preparation may be needed to eliminate and control weeds using tillage, herbicides or cover crops.

Contact a professional forester such as Indiana Department of Natural Resources (IDNR) District Forester, Purdue University Extension Service, NRCS Technical Service Provider, or a licensed pesticide applicator for specific herbicide and weed control recommendations. All herbicides shall be applied according to labeled directions. Research has shown that at least three years (growing seasons) free from excessive competitors are necessary to establish tree seedlings.

When herbicides are used they should be applied using a 3 foot circle around each tree or a 2 foot band along each side of each row. Some herbicides can kill or damage seedlings and a directed spray and/or spray shield is recommended to avoid herbicide contact on seedlings.

For best results plant trees in fields that have been previously row cropped using agricultural herbicides to control weeds. This usually permits tree planting in crop stubble without established competing weeds. Prior to planting into crop stubble be sure to investigate prior herbicide use to ensure residual herbicide activity will not damage planted seedlings or prevent germination of hardwood seed (direct seeding).

III. PLANTING SPECIFICATIONS

A. When to Plant

The best time to plant is in late winter or early spring (usually between March and May) when planting stock is dormant and the soil is moist.

Table 3. Planting Dates

Type	Planting Dates
Bare root	After spring thaw until June 1 ¹
	After seedlings enter fall dormancy, until winter freeze. ²
Container	September 15 - June 1
Direct Seeding	September 15- December 1
	After spring thaw until May 15

¹Sites that are flooded or ponded in the spring may be planted using bare root stock until July 1 if the site was flooded or ponded and/or too wet for access for planting equipment during the approved planting time making tree planting unfeasible.

²On sites not susceptible to frost-heave.

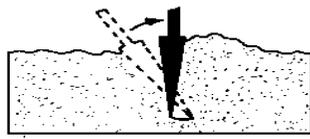
B. Care and Handling of Planting Stock

1. Plant material will be protected from desiccation during temporary storage and delivery to the planting site. Stock will be kept in a cool environment out of direct sunlight and wind.
2. If seedling planting is delayed more than 5 days then planting stock will be stored in a controlled environment according to Hardwood Tree Improvement and Regeneration Center North Central Research Station, USDA Forest Service and Department of Forestry and Natural Resources, Purdue University guidelines <http://www.ces.purdue.edu/extmedia/FNR/FNR-210.pdf>
3. Roots of bareroot stock shall be kept moist during planting operations by placing in water-soil (mud) slurry, peat moss, sphagnum moss, super-absorbent (e.g. polyacrylamide) slurry or other equivalent material. (Note: Do not soak trees in water for more than 2 hours.)
4. Rooting medium of container shall be kept moist at all times by periodic watering.

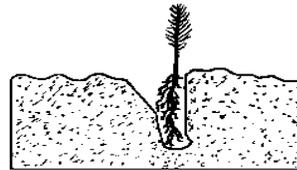
C. Planting Requirements

1. Stock shall not be planted when the soil is frozen or dry. All stock will be planted in a vertical position. Bare root and container stock shall be planted with the root collars approximately at or slightly below the existing ground line.
2. Seedlings: The planting trench or hole shall be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. If the roots are too long for the planting equipment, modestly prune them to the correct length before planting. Never prune back beyond the main root system or more than 25% of the root length. After planting, pack soil around each plant firmly to eliminate air pockets.
3. Container trees: Dig a hole slightly larger than the container diameter. Remove plants from containers before placing in the ground and firmly pack soil around roots to eliminate air pockets. Before planting, loosen any spiraling roots and prune if needed.

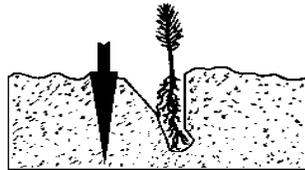
D. HOW TO HAND PLANT SEEDLINGS



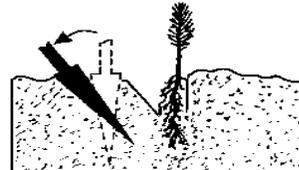
1. Insert dibble at angle shown and push forward to vertical.



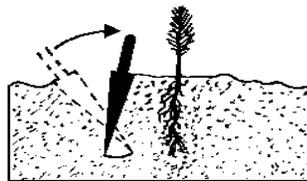
2. Remove dibble and place seedling at correct depth.



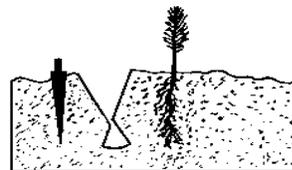
3. Insert dibble vertically, 3-4" back from tree.



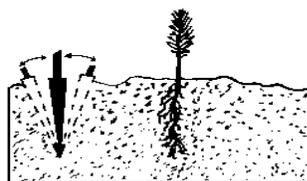
4. Pull dibble back to close bottom of tree planting hole.



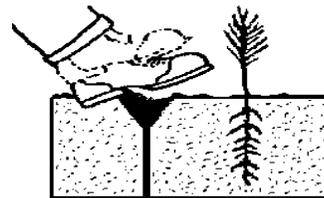
5. Push dibble forward to close top of tree planting hole.



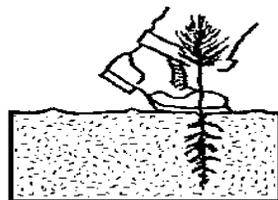
6. Insert dibble vertically 3-4" back of previous hole.



7. Wiggle dibble back and forth to close previous hole.



8. Press hole closed with heel of shoe.



9. Press soil firmly around tree with toe of shoe while moving to next position.

Figure 1: Hand Planting

Table 4 - SITE PREPARATION TREATMENT ALTERNATIVES

SITE/SOIL TEXTURE	SMALL GRAIN OR ROW CROP SITES	TURF OR PERENNIAL FORAGE SITES	HEAVY BRUSH & TREE GROWTH	HEAVY WEED GROWTH	BADLY COMPACTED
SITES WITH LOAMY/ CLAYEY SOILS	#1 or #2	#3a or #3b	#4a, #4b, or #4c depending on equipment available	Develop a site specific plan	#5
SITES WITH SANDY SOILS					Normally not applicable
STEEP SITES (>18%)	#1	#3b, run strips on contour if practical			
ROCKY SOIL SITES	#1	#3a or #3b			

All options for site preparation should also include an approved herbicide application in conjunction with tree planting unless other effective weed control measures are planned and implemented.

- #1 - If needed for wildlife habitat, or to control erosion or weeds, establish a cover/companion crop.¹
- #2 - No site preparation needed.
- #3a - Fall burn-down with approved herbicide over entire site. Best window of opportunity is September 1 to October 15 as long as it is applied at least one week before the first killing frost. Also use a pre-emergent herbicide before or during planting to control emerging seedlings.
- #3b - Fall burn-down in strips 3 to 4 feet wide with approved herbicide. Also use a pre-emergent herbicide before or during planting to control emerging seedlings.
- #4a - Deaden the undesirable trees and shrubs and let them stand. Treat stumps with an approved herbicide.
- #4b - Hand clear by cutting and removing undesirable trees and shrubs. Treat stumps with an approved herbicide.
- #4c - Use heavy equipment to clear and remove undesirable trees and shrubs. Where needed, follow-up with establishment of a cover/companion crop¹ prior to planting. Treat stumps with an approved herbicide. Multiple treatments may be necessary.
- #5 - Subsoil or rip compacted areas. If soil surface is rough use appropriate tillage tool to smooth. Where needed, establish a cover/companion crop¹ prior to planting. On slopes over 6% subsoil or rip on contour.

¹Cover/companion crop seeding rates for tree plantings (seed only one grass species):
 Seed cover/companion crops using methods and dates according to the Indiana Seeding tool:
http://efotg.sc.egov.usda.gov/references/public/IN/Indiana_Seeding_Guidelines.pdf
 Very Poorly Drained to Well Drained Soils = Virginia Wildrye @ 4 lbs PLS/Acre
 Somewhat Poorly Drained to Excessively Drained Soils = Canada Wildrye @ 3 lbs PLS/Acre
 Ladino clover (seed alone or add to one of the above grass species if desired) @ 0.5 lbs PLS/Acre
 For other options use the Indiana NRCS Seed Calculator

III. DIRECT SEEDING

Direct seeding is an alternative method to establish woody vegetation that should be planned by a professional forester.

Seed Inspection: Inspect seed by species by randomly selecting at least 10 seeds/bushel. Crack or cut seeds open to be sure all seed is filled, moist, normal colored and not damaged by insects. If seed appears to be non-viable, increase the seeding rate by the percentage of non-viable seed from the tested sample.

Seed Care and Storage: Field collected seed shall be placed in porous bags e.g. onion bags, burlap bags, or standard feed sacks and placed in storage no more than 50° F and preferably 35-40° F to prevent heat buildup.

All species except oaks should be kept dry. Oak acorns should be re-hydrated by soaking in cold water for 4 - 24 hours as soon as possible after collection or delivery. Maintain moisture content at greater than 25%.

If planting is delayed for more than 2 weeks or planted after February, store seed at 35-40° F in sealed containers as described by species in the *Illinois Direct Seeding Handbook*, <http://www.il.nrcs.usda.gov/technical/forestry/dshndbk.html>

Some species require stratification (a pre-germination treatment to break seed dormancy) and the methods vary by species. Species that need stratification to germinate shall be stratified as described in the *Illinois Direct Seeding Handbook*.

Table 5. Seeds Per Acre

Row planting	Broadcast seeding
3000	4800

Note: all direct seedings will contain 75% heavy seeded tree species (see Table 6) To improve seed germination and to prevent rodent depredation, the site (planting rows or entire area) shall be kept bare and free of grass and weed cover before and 2 years after direct seeding is completed.

Seed will be sown at a depth of 2 times the seed diameter.

To overcome seed predation, double the seeding rate for the first 300 feet on sites adjacent to woodlands.

Table 6. Direct Seeding Rates Table (Note: walnut and all hickory species are husked)

Common Name	Scientific Name	Ave. Seeds/lb	Lbs/Ac. for 1000 Seeds/Ac	Lbs/Ac. for 3000 Seeds/Ac	Lbs/Ac. for 4500 Seeds/Ac
Bald Cypress	<i>Taxodium distichum</i>	1125	0.9	2.7	4
Black Cherry	<i>Prunus serotina</i>	4000	0.25	0.75	1.1
Hackberry	<i>Celtis occidentalis</i>	4000	0.25	0.75	1.1
Yellow Poplar	<i>Liriodendron tulipifera</i>	550	1.8	5.5	8.2
Heavy Seeded Species					
Black Walnut	<i>Juglans nigra</i>	40	25	75	112.5
Kentucky Coffeetree	<i>Gymnocladus dioica</i>	150	6.7	20	30
Hickory, Bitternut	<i>Carya cordiformis</i>	156	6.4	19.2	28.9
Hickory, Mockernut	<i>Carya tomentosa</i>	90	11.1	33.3	50
Hickory, Pignut	<i>Carya glabra</i>	200	5	15	22.5
Hickory, Shagbark	<i>Carya ovata</i>	90	11.1	33.3	50
Hickory, Shellbark	<i>Carya laciniosa</i>	30	33.3	100	150
Oak, Black	<i>Quercus velutina</i>	125	8	24	36
Oak, Bur	<i>Quercus macrocarpa</i>	55	18.2	54.5	81.8
Oak, Cherrybark	<i>Quercus pagoda</i>	265	3.8	11.3	17
Oak, Chinkapin	<i>Quercus muhlenbergii</i>	130	7.7	23.1	34.6
Oak, Overcup	<i>Quercus lyrata</i>	75	13.3	40	60
Oak, Pin	<i>Quercus palustris</i>	215	4.7	14	20.9
Oak, Red	<i>Quercus rubra</i>	65	15.4	46.2	69.2
Oak, Shingle	<i>Quercus imbricaria</i>	230	4.3	13	19.6
Oak, Shumard	<i>Quercus shumardii</i>	70	14.3	42.9	64.3
Oak, Swamp Chestnut	<i>Quercus michauxii</i>	45	22.2	66.7	100
Oak, Swamp White	<i>Quercus bicolor</i>	75	13.3	40	60
Oak, White	<i>Quercus alba</i>	90	11.1	33.3	50
Pecan	<i>Carya illinoensis</i>	125	8	24	36
Persimmon	<i>Diospyros virginiana</i>	785	1.3	3.8	5.7

Seed data were obtained from the Indiana Department of Natural Resources, Division of Forestry, Nursery Section and Seeds of Woody Plants in the United States.

Table 7. Species Information

Common Name	Scientific Name	CTSG Area (map page 8)	Soil Drainage ¹	² Flooding Tolerance	Soil pH Range
Tree Species					
Bald Cypress	<i>Taxodium distichum</i>	Central, South	VPD-WD	Tolerant	4.5-7
Black Cherry	<i>Prunus serotina</i>	All	MWD-WD	Intolerant	4.5-7.5
Black Walnut	<i>Juglans nigra</i>	All	MWD-WD	Intolerant	6.6-7.8
Cedar, Northern White	<i>Thuja occidentalis</i>	North	PD-WD	Somewhat	5.5-7.5
Hickory, Shagbark	<i>Carya ovata</i>	All	MWD-WD	Intolerant	4.5-7.5
Hickory, Shellbark	<i>Carya laciniosa</i>	All	VPD-WD	Somewhat	6.1-7.4
Kentucky Coffeetree	<i>Gymnocladus dioicus</i>	All	SPD-WD	Somewhat	5.5-6.5
Maple, Red	<i>Acer rubrum</i>	All	VPD-WD	Somewhat	4.5-6.5
Maple, Silver	<i>Acer saccharinum</i>	All	VPD-WD	Tolerant	4.5-7.0
Norway Spruce	<i>Picea abies</i>	All	VPD-WD	Somewhat	5.0-7.5
Oak, Black	<i>Quercus velutina</i>	All	MWD-ED	Intolerant	4.5-6.5
Oak, Bur	<i>Quercus macrocarpa</i>	All	PD-ED	Somewhat	4.5-7.5
Oak, Chinkapin	<i>Quercus muhlenbergii</i>	All	MWD-ED	Intolerant	5.0-8.0
Oak, Cherrybark	<i>Quercus pagoda</i>	South	SPD-WD	Intolerant	4.5-6.5
Oak, Overcup	<i>Quercus lyrata</i>	South	VPD-WD	Tolerant	4.5-7.0
Oak, Pin	<i>Quercus palustris</i>	All	VPD-WD	Somewhat	4.5-6.1
Oak, Scarlet	<i>Quercus coccinea</i>	All	MWD-ED	Intolerant	4.5-6.5
Oak, Shingle	<i>Quercus imbricaria</i>	All	SPD-WD	Intolerant	4.5-6.5
Oak, Shumard	<i>Quercus shumardii</i>	All	SPD-WD	Somewhat	6.1-7.4
Oak, Swamp Chestnut	<i>Quercus michauxii</i>	South	SPD-WD	Somewhat	4.5-6.5
Oak, Swamp White	<i>Quercus bicolor</i>	All	VPD-WD	Somewhat	4.5-6.1
Oak, White	<i>Quercus alba</i>	All	MWD-WD	Intolerant	4.5-6.5
Pecan	<i>Carya illinoensis</i>	Central, South	SPD-WD	Tolerant	6.1-7.8
Pine, White	<i>Pinus strobus</i>	All	MWD-WD	Intolerant	6.1-7.5
Persimmon	<i>Diospyros virginiana</i>	All	MWD-WD	Somewhat	4.5-6.5
River Birch	<i>Betula nigra</i>	All	VPD-WD	Somewhat	4.5-6.5
Sweetgum	<i>Liquidambar styraciflua</i>		PD-WD	Tolerant	5.5-6.5
Tuliptree	<i>Liriodendron tulipifera</i>	All	MWD-WD	Intolerant	5.0-7.0
Shrub Species					
American Elder	<i>Sambucus nigra ssp. canadensis</i>	All	VPD-WD	Tolerant	4.5-7.4
America Plum	<i>Prunus americana</i>	All	MWD-ED	Somewhat	4.5-6.5
Black Chokeberry	<i>Photinia melanocarpa</i>	All	PD-WD	Somewhat	4.5-6.5
Buttonbush	<i>Cephalanthus occidentalis</i>	All	VPD-WD	Tolerant	6.1-7.8
Chokecherry	<i>Prunus virginiana</i>	All	SPD-WD	Intolerant	5.5-8.0
Dogwood, Gray	<i>Cornus racemosa</i>	All	VPD-WD	Tolerant	4.5-7
Dogwood, Silky	<i>Cornus amomum</i>	All	VPD-WD	Tolerant	4.5-7.4
Hazelnut	<i>Corylus americana</i>	All	MWD-WD	Intolerant	4.5-7.4
Ninebark	<i>Physocarpus opulifolius</i>	All	VPD-WD	Somewhat	4.5-7.4
Pawpaw	<i>Asimina triloba</i>	All	SPD-WD	Intolerant	5.5-7.4
Small Trees					
America Plum	<i>Prunus americana</i>	All	MWD-ED	Intolerant	4.5-6.5
Dogwood, Flowering	<i>Cornus florida</i>	All	MWD-WD	Intolerant	5.5-7.4
Redbud	<i>Cercis canadensis</i>	All	MWD-WD	Intolerant	6.0-7.4
Washington Hawthorn	<i>Crataegus phaenopyrum</i>	All	SPD-ED	Intolerant	4.5-7.4

¹ VPD=very poorly drained; PD=poorly drained; SPD=somewhat poorly drained; MWD=moderately well drained; WD=well drained; ED=excessively drained

² Flooding tolerance during the growing season for established trees: Tolerant (T)-can withstand inundation for more than 30 days; Somewhat Tolerant (ST)-can survive saturated soils and inundation for up to 30 days; Intolerant (I)-able to survive only 1 to 5 days of inundation

Conservation Tree and Shrub Groups Division Boundaries

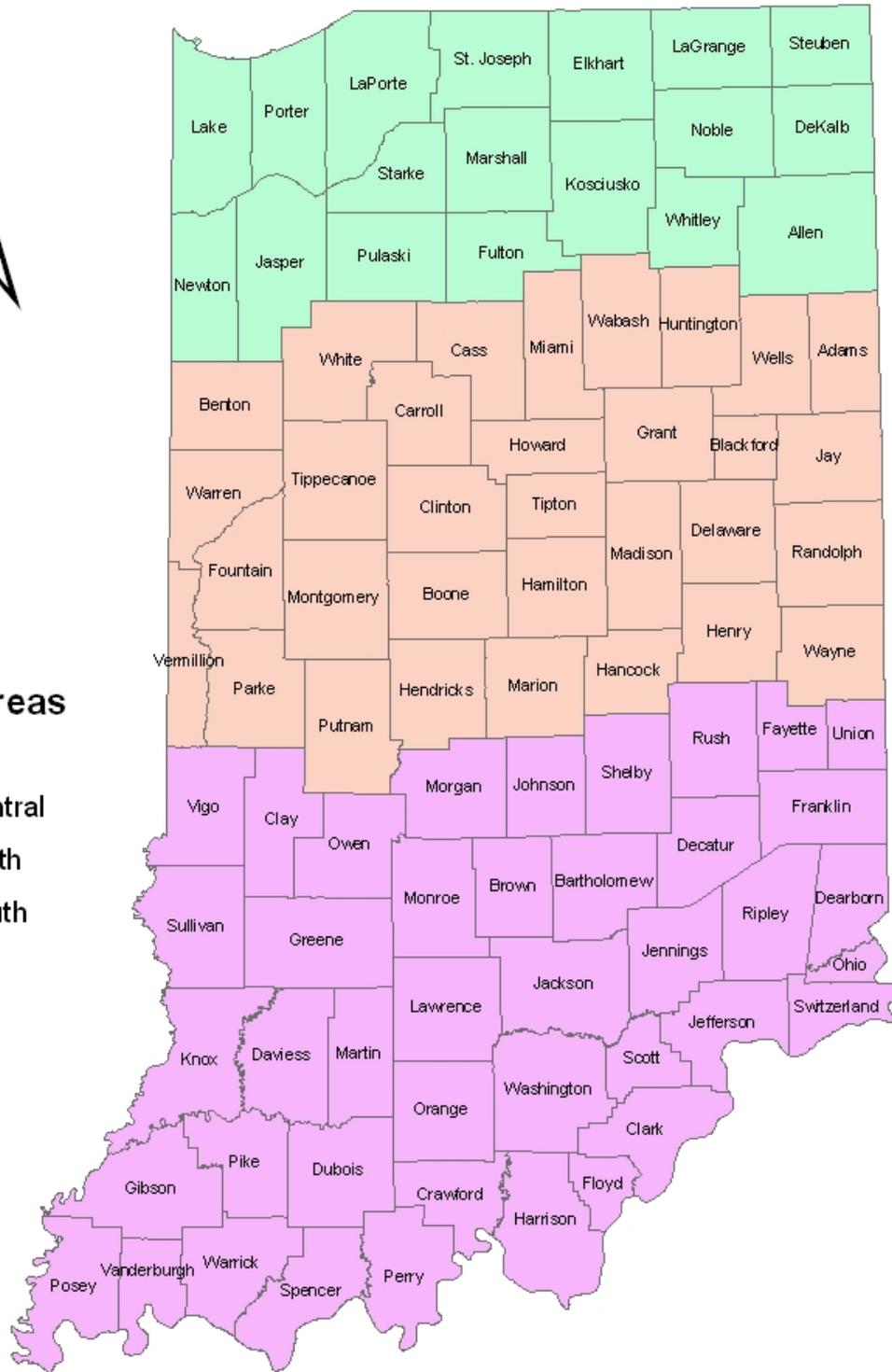


Legend

CTSG areas

CTSG

- Central
- North
- South



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