Learning Objective: Following this lab students will quantify regeneration stocking and potential in stands prior to and following a harvest operation to assess the establishment of a cohort.

Introduction

Regeneration refers to seedlings or saplings that are present in a stand (Adams et al. 1994). Advanced regeneration describes seedlings or saplings that are present prior to applying a silvicultural treatment to create a new cohort. Consideration of other sources of advanced regeneration may be necessary in some stands, as many species have the ability to sprout from either the stump or from roots when they are harvested or damaged in a harvest operation. Stump sprouting is often an important source of advanced regeneration in many hardwood cover types throughout the United States (Hook and DeBell 1970, Dey and Jensen 2002, Randall et al. 2005, Lockhart and Chambers 2007, Atwood et al. 2008).

Quantifying regeneration is a common task necessary to 1) assess the potential response of a stand to a planned harvest operation, 2) determine the efficacy of a harvest operation in successfully establishing a new cohort, 3) verify compliance with certification systems or other policies, 4) identify any potential remedial treatments that may be necessary, and 5) project future yields via modeling (Avery and Burkhart 2002). Commonly regeneration is surveyed 1) prior to a harvest, 2) following a harvest, or 3) following a planting operation. It is important to clearly differentiate stocking (e.g. trees per acre) from survival (i.e. % of planted seedlings living) when discussing how regeneration is quantified. Table 1 gives stocking levels commonly considered sufficient for successful regeneration of a stand.

When quantifying regeneration it is important to ensure that tallied seedlings or saplings are 1) free to grow, 2) of an acceptable size, and 3) of a desired species. Free to grow seedlings are those that have the potential to eventually grow into a dominant or codominant canopy position. The minimum acceptable size varies by species. For planted pines, there may be no minimum as long as the seedling is surviving. For hardwoods, different values may be assigned to differently sized seedlings depending upon the specific survey methodology employed. The desired species depends on the management objective. For pine stands it is typically the single pine species that is being managed, while for hardwoods a list of species must be developed specific to the management objective (Table 2).

Table 1. Acceptable stocking densities for common types of newly regenerated stands in the South.

Species	Regen Source	Initial Spacing (ft)	Acceptable Stocking (TPA)	Age (year)	Source
Loblolly, Slash, Shortleaf Pine	Natural		1,000 – 2,500	1	(NRCS 2008)
			500 – 800	2	(NRCS 2008)
Loblolly Pine	Artificial	6 x 6	600 (~50%)	1	(USDA-FS 1981)
		7 x 8	400 (~50%)	1	(USDA-FS 1981)
		6 x 10	350 (~50%)	1	(USDA-FS 1981)
		8 x 10	225 (~50%)†	1	(USDA-FS 1981)
Longleaf Pine	Natural		3,000 – 6,000	1	(Franklin 2008)
			1,000 – 1,500	3-10*	(Franklin 2008)
	Artificial	N/A	200 – 500†	1	(Franklin 2008)
Bottomland Hardwoods	Natural		75 – 100	2-5	(Belli et al. 1999)

*Free to grow longleaf pine seedlings w/ height growth. †Better stocking may be needed for timber management.

Table 2. Common bottomland hardwood species classified by timber suitability and shade tolerance.

	Very Intolerant	Intolerant	Intermediate	Tolerant	Very Tolerant
Preferred	Cottonwood *Populus deltoides*	White ash *Fraxinus americana* Black walnut *Juglans nigra* Cherrybark oak *Quercus pagoda* Shumard oak *Quercus shumardii* Nuttall oak *Quercus texana*	Pecan *Carya illinoinensis* Green ash *Fraxinus pennsylvanica* Pumpkin ash *Fraxinus profunda* White oak *Quercus alba* Swamp chestnut oak *Quercus michauxii* Bottomland post oak *Quercus similis*		
Desirable	Yellow-poplar *Liriodendron tulipifera* Black willow *Salix nigra*	Silver maple *Acer saccharinum* Sweetgum *Liquidambar styraciflua* Water tupelo *Nyssa aquatica* Swamp tupelo *Nyssa biflora* American sycamore *Platanus occidentalis* Water oak *Quercus nigra* Willow oak *Quercus phellos*	Southern red oak *Quercus falcata* Bur oak *Quercus macrocarpa* Pondcypress *Taxodium ascendens* Baldcypress *Taxodium distichum*		Sugarberry *Celtis laevigata* Hackberry *Celtis occidentalis* Persimmon *Diospyros virginiana*
Acceptable		Waterlocust *Gleditsia aquatica* Honeylocust *Gleditsia triacanthos* Sweetbay *Magnolia virginiana* Swamp cottonwood *Populus heterophylla* Pin oak *Quercus palustris*	Mockernut hickory *Carya alba* Water hickory *Carya aquatica* Bitternut hickory *Carya cordiformis* Blackgum *Nyssa sylvatica* Laurel oak *Quercus laurifolia* Overcup oak *Quercus lyrata* American elm *Ulmus americana* Cedar elm *Ulmus crassifolia*	Red maple *Acer rubrum* Shagbark hickory *Carya ovata* Southern magnolia *Magnolia grandiflora* Winged elm *Ulmus alata* Slippery elm *Ulmus rubra*	American beech *Fagus grandifolia*
Undesirable		River birch *Betula nigra* Carolina ash *Fraxinus caroliniana* Sassafras *Sassafras albidum*	Boxelder *Acer negundo* Buttonbush *Cephalanthus occidentalis* Hawthorn *Crataegus spp.*	Swamp-privet *Forestiera acuminata* Possumhaw *Ilex decidua*	Hornbeam *Carpinus caroliniana* Hophornbeam *Ostrya virginiana* Roughleaf dogwood *Cornus drummondii* Planertree *Planera aquatica* American holly *Ilex opaca* Red mulberry *Morus rubra*

(Adapted from: USDA-FS 1986, Burns and Honkala 1990, Meadows and Stanturf 1997)

Procedure

Equipment for Each Group

1. Loggers Tape (1)
2. Compass (1)

Methods

You will utilize two methods to survey regeneration in two bottomland hardwood stands on the Naconiche Mitigation Area in Angelina County (see map). The first method you will use is a stocked quadrat regeneration survey. The stocked-quadrat method is commonly applied in pine plantations in east Texas to determine whether regeneration following planting is sufficient, or if a stand is understocked. This method is also used to make determinations on whether thinning is required or not. Assessing stocked-quadrats is very simple in application, but requires stocking in terms of stand density to be defined prior to data collection. For example, if desired stocking level is 300 trees per acre, then we would use a 1/300th acre circular plot. Plots need not be circular, but this shape is often most convenient. Within each plot the only data required is the presence or absence of a tree that meets some minimum guideline (e.g. loblolly pine above 3 feet in height or less than 2 inches dbh). If such a tree is present, the plot is stocked, and if no such tree is present, the plot is unstocked. Upon completing an appropriate number of plots, the percent stocking is simply determined as the number of stocked plots divided by the number of total plots, expressed as a percentage.

For this hardwood stand, use the following assumptions and the attached data sheet to survey regen.

1. At least 125 free-to-grow saplings of preferred or desirable species for timber management at a minimum total height of 4.5 feet and a maximum dbh of 4 inches are desired.
2. At least 85% stocking is considered acceptable to meet these regeneration objectives.

The second method was developed specifically for bottomland hardwoods by Belli et al. (1999). This method assigns points for differently sized seedlings based on data that shows that larger seedlings have a greater probability of remaining free-to-grow over longer time periods. Smaller seedlings are shaded out by competing vegetation and often do not survive. The plot size for this method was determined based on the recommendation that 100 free-to-grow oak or ash seedlings per acre will result in a fully stocked stand at maturity. To implement this method:

1. Establish a circular 1/100 acre plot.
2. Tally all red oak and ash seedlings by height and dbh classes as indicated on the attached data sheet.
3. Multiply your tally by the points per tree for each seedling class.
4. Total the points for red oaks, ash, and all seedlings.
5. Determine based on total points the probability of successfully regenerating each plot at an acceptable stocking level.

Literature Cited

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FIELD TALLY SHEET FOR BOTTOMLAND HARDWOOD REGEN ASSESSMENT (1/100th acre plots)

Plot # ____________ **Crew :** ____

Date ________________________

Location ____

Size Class	RED OAKS		
Height	Count	Pts. per Count	Total Points
< 1 ft		1.0	
1 to 3 ft		3.5	
> 3 ft to 1 in. dbh		5.5	
Dbh (1-in. classes)			
1 to 5 in.		4.0	
Total RED OAK points for this plot:			

Size Class	ASH		
Height	Count	Pts. per Count	Total Points
< 1 ft		1.0	
1 to 3 ft		12.5	
> 3 ft to 1 in. dbh		12.0	
Dbh (1-in. classes)			
1 to 5 in.		14.0	
Total ASH points for this plot:			

Total red oak and ash points for this plot:	

Probability of red oak stocking	
Probability of ash stocking	
Probability of either red oak or ash stocking	

Total Points	Probability
35	95%
34	95%
33	94%
32	94%
31	93%
30	93%
29	92%
28	91%
27	91%
26	90%
25	89%
24	88%
23	87%
22	85%
21	84%
20	83%
19	81%
18	79%
17	77%
16	75%
15	73%
14	71%
13	68%
12	65%
11	62%
10	58%
9	55%
8	50%
7	46%
6	41%
5	36%
4	30%
3	23%
2	16%
1	8%

Source: Belli, K., L., C. P. Hart, J. D. Hodges, and J. Stanturf. 1999. Assessment of the regeneration potential of red oaks and ash on minor bottoms of Mississippi. Southern Journal of Applied Forestry **23**:133-138. http://www.ingentaconnect.com/content/saf/sjaf/1999/00000023/00000003/art00003

Crew : ____

Date ________________________

Location ____

Min Stocking *(TPA)*	**Plot Size** *(acres)*	**Plot Radius** *(feet)*	**Min Height** *(ft)*	**Max DBH** *(in)*	**Acceptable Species** *(notes)*

Stand ID:____

Plot Tally (*mark 'Y' if stocked, 'N' if not, leave blank if no data is collected*)

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

Stocked:_________ / # Total:_________ = _____________% Stocking which is ______________ (acceptable?)

Calculating A Circular Plot Radius in Feet from Plot Size in Acres

1) $\frac{1}{x}\frac{acre}{plot} \times \frac{43{,}560\ sq.ft.}{1\ acre} = \frac{A\ sq.ft.}{plot} = A$ $\quad where\ \frac{1}{x} = plot\ size\ \left(e.g.\ \frac{1}{200}\ acres\right)$

2) $A = \pi r^2$ $\quad then\ divide\ both\ sides\ by\ \pi$ to get:

3) $A/_{\pi} = r^2$ $\quad then\ take\ the\ square\ root\ of\ both\ sides$ to get:

4) $\sqrt{A/_{\pi}} = r$ $\quad then\ plug\ in\ actual\ numbers$ to get:

5) $\frac{1}{200}\frac{acre}{plot} \times \frac{43{,}560\ sq.ft.}{1\ acre} = \frac{217.8\ sq.ft.}{plot} = 217.8$

6) $\sqrt{217.8/_{3.14159}} = 8.32\ feet$ $\quad divide\ first, square\ root\ second, or\ you'll\ be\ wrong$

Your Name: Stand Name: Date:

Stand Description

Timeline for silvicultural prescription with narrative notes

Year	Age	Action	Narrative Notes

Silvicultural Prescriptions Grading Key

Annotation	Explanation
1	**Terminology** is incorrect or imprecise. Be sure to use correct silvicultural terminology in all prescriptions.
2	Prescribed action is too **vague**. You need more detail (e.g. marking instructions, removal percentage).
3	Prescribed action does not meet **landowner** **objectives**, or some of the constraints we discussed for this stand.
4	Prescribed action is **incorrectly** **timed**. Is your rotation is too short or long based on growth rates of your species or landowner objectives? Are you applying herbicide too late compared to planting (herbaceous control spring after planting, hardwood control fall before planting)?
5	Prescribed action is not **ecologically** feasible. Does your regeneration method match with the shade tolerance of your crop species? Did you prescribe a burn that will likely kill all your crop trees?
6	Prescribed action is not **operationally** feasible. Is the stand too small? Are you removing too little volume per acre for a logger to take the contract? Are you operating when the site is too wet?
7	Prescribed action is **unnecessary**. Are you fixing something that is not actually a problem (e.g. mechanical site preparation on a site with no soil limitations, herbicide on a site with no competition problems, fertilizer on a droughty site, thinning a stand that's at an appropriate density)?
8	An additional prescribed **action** **needed**. Did you forget to apply herbicides when planting? Was slash management not prescribed on a high-slash site? Was bedding not prescribed on a wet site?
9	Prescribed action will not achieve the **density** you state. Did your planting spacing and density match? Did your row thinning intensity and post-thinning density match?
10	More than one treatments are **combined** on a single line. Be particularly careful with this for establishment of stands, when multiple treatments may be used in within one or two years. Each should go on its own line.