Application of Multi-cohort (formerly Uneven-age) Management
Terminology, Concepts & Methodology

What is Uneven-age???

Age Classes
- Uneven-aged Stand
- How many age classes must an uneven-aged stand have?

This is the defining characteristic of an uneven-aged stand.
Uneven-aged Stands

2 Types
- Balanced
- Irregular

Uneven-aged stand = Intimate mixture of age classes

Balanced Uneven-aged Stands

- All-aged Forest
  - Every age class in the rotation is represented
  - Each age class represents approximately the same area
  - Regeneration of new trees would need to occur every year !!!

Balanced Uneven-aged Stands

- The perfect “All-aged” stand is theoretical, it mostly exists only in the imagination
Balanced Uneven-aged Stands

- Even-spaced age class
  - More attainable
  - 3 or more age-classes evenly spaced over rotation (i.e., over a 5-year cutting cycle)

Irregular Uneven-aged Stands

- 3 or more age classes
- Stems are not evenly distributed throughout age classes

Some Terminology

- Silvicultural System
  - Process by which a forest is tended, harvested & regenerated to achieve management objectives
- Selection Method
  - Regeneration method or technique aimed at the creation and maintenance of uneven-aged stands
    - (i.e., Indiv. Tree, Group, Patch)
- Sustained Yield
  - Even-flow, non-declining, i.e., roughly the same cut every year
**Sustained Yield Unit (SYU)**

- Most commonly the SYU is the FOREST
- It is possible for the SYU to be the STAND
  - However, ABSOLUTELY NECESSARY to have a balanced distribution of age classes
  - You are harvesting the tail of the diameter distribution and creating conditions for progression of smaller size classes

**Regulation of the Cut**

- Method by which the annual periodic cut is determined in order to attain a Sustained Yield
  - Two ways to look at this
    - *Area Regulation* (easier)
    - *Volume Regulation* (more difficult)

**Area Regulation**

- A management scheme to produce sustained yield at the forest level
  - NOT at the STAND level
- Does not create Uneven-Aged STANDS
  - Creates Uneven-aged FORESTS
**Conceptualization**

10,000 acre forest 50 Year Rotation – 200 A/yr

- YR 1
- YR 2
- YR 3
- YR 4
- YR 5
- YR 6

2,000 acre working unit (compartment)

200 acre Stands

Work in 1 unit each year

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**Area Regulation**

The ages indicate a 25-year cutting cycle (longer or shorter cycles may be appropriate).

Aerial view

- 0 years
- 25 years
- 50 years
- 75 years
- 100 years

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Volume Regulation

- Removal of Annual or Periodic Growth
- All age classes grow in an INTIMATE MIXTURE
- Mature stems (Rotation age) harvested each year
  - financially mature stems harvested

Financial Maturity

- Tree or stand can be seen as an investment
- When growth falls below an alternative rate of return the stand or tree is said to be financially mature
Uneven-aged Management Entails:
- Maintaining trees of different age classes in the same area
- Calls for more or less equal, periodic harvests
- Under this practice, trees are removed on an individual basis to leave a desired number of trees in each size class
- Variety of goals can be met
- Each harvest stimulates reproduction of new trees and enhances the growth & yield of older trees.

Diameter Distributions

Regulation & Control
- Most straightforward & widely understood types of uneven-aged silviculture is single-tree selection
- Many early attempts failed b/c of inadequate regulation and failure to obtain regeneration at each cutting entry
Regulation & Control

- Cutting was concentrated in large size classes with little thought given to developing and maintaining a balanced diameter distribution.
- High-quality, mature timber was removed first – after repetition this reduced ingrowth into the sawtimber size classes.

Result = Diameter-Limit Cutting or High-grading

- Diameter Limit Cut: Most common practice of harvesting hardwood forests of North America.
  - High grades the forests by taking only the largest and best trees at every harvest.
    - “Taking the BEST, Leaving the REST”
  - Loggers and sawmillers often refer to this as select cutting or selection.
  - It is poor forestry! Unless ----

- "High-grading" selective logging: Poorly planned selective logging results in damaged, poor-quality stands.
- Single tree selection system: Well-planned and well-implemented selection systems can result in high-quality stands with little damage.
High-Grading

Definition
– Occurs when the residual stand has less value and potential value as the stand removed.
– Still widespread in Tennessee (Diameter-limit cutting)

• What's the Harm???
• Most stands in Tennessee are even-aged, NOT uneven-aged
• Favors shade-tolerant species
• Shade-tolerant spp. in the TN tend to be less valuable (economically and sometimes biologically)
• What would happen if Oak spp. were replaced?
**Forest Regulation**

- What we have learned is that regulation requires control over:
  - Diameter distribution
  - Growing stock levels
  - Securing regeneration with each entry

**Stocking Control**

- What stocking levels should be retained after the cut?
- Gross growth varies only slightly over a moderate range of stocking levels
  - 60 or 70% of full stocking enhances individual tree growth & stand growth
  - “Optimal” residual stocking varies with species & sizes of trees, diameter distribution, among others.
Control of Diameter Distribution

- Determining the desired number of trees or basal area to be retained in each diameter class
- “q” quotient --- defined as the number of trees/acre in one diameter (dbh) class divided by the number of trees/acre in the next highest dbh class

“q” quotient

- Expresses number of trees in successive diameter classes as a means of calculating a desired diameter distribution.
- Tends to be fairly constant in many undisturbed, uneven-aged stands.
- Represents the slope of the relationship (slope of the regression) between # of trees/ac and DBH.

“q” quotient (example)

If you had 100 trees in the 6 inch class & a “q” of 1.3 you would have 130 trees in the 5 inch class, 169 trees in the 4 inch class and so on...
To set up a Diameter Distribution based on “q” you must decide upon three parameters (known as BDq):

1. Residual stocking (Basal Area)
2. Maximum tree diameter (considering financial maturity and/or landowner objectives)
3. What “q” to use

• “q” normally varies between 1.3 and 2.0
• Small “q” tend to have higher proportions of the growing space devoted to larger trees (sawtimber)
• Stands managed with higher “q” values dominated by more trees in the smaller size classes (pulpwood, small product objectives)

<table>
<thead>
<tr>
<th></th>
<th>Q = 1.2</th>
<th>Q = 1.5</th>
<th>Q = 1.8</th>
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<tbody>
<tr>
<td>Stems per Acre</td>
<td>low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Size of Stems</td>
<td>More sawtimber = less repro</td>
<td>Less sawtimber = more repro</td>
<td>Least sawtimber = more repro</td>
</tr>
<tr>
<td>Seedling / Mature tree ratio</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Wildlife Hiding Cover</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Landowner Goals</td>
<td>More to timber</td>
<td>Compromise between timber &amp; aesthetics</td>
<td>Least timber</td>
</tr>
</tbody>
</table>
Residual Stand Structure Goals

- Once goals for stocking, max. tree size & “q” have been set, it is simple to calculate stand structure goals.
  - Assign 1 tree to largest DBH – then calculate successive smaller diameter classes with “q”
  - Calculate basal area of each DBH class & total basal area
  - Calculate for both target & actual, then compare

Creation & Maintenance of Balanced Uneven-aged Stands

- Creation from Even-aged stands
  - Can be done, but requires some loss of growth potential
  - Usually takes time (full rotation – removing a portion of the stand each cutting cycle)

Creation from Even-aged stands

- 50-year rotation
- 10-year cutting cycle – enter stand once every 10 years
- Remove 1/5th of the stand each cutting cycle
  - If the decision was made when the stand was 80 yrs old – some 130 year old stems harvested
Creation from Even-aged stands

- If the stand was younger
  - Potentially harvesting immature stems early and overmature stems later in rotation
- In either case – would suffer a financial loss – loss in potential productivity
  - Losses may not be justified

Target vs. Actual
Even-aged vs Uneven-aged Curves

Creation from Irregular Uneven-aged stands

- Can be done much faster
- But potential losses remain a consideration
- Must remove or harvest from all age classes
- Remember “q”
Building an Uneven-aged Forest

Manipulation of Stands

Harvest Cuts – Which trees are removed?

- Older financially mature trees – either as individuals or small groups. Some cutting in all diameter classes is necessary to insure that growing space is created for trees to continue to increase in size.
- Harvested trees represent the annual or periodic growth.
- Replaced by regenerating stems (reproduction) – this is repeated over time to create or maintain an uneven-aged stands.
- Financial maturity – overriding factor.
Other Considerations

- Trees at or above largest diameter – may not want to cut if still vigorous and healthy
- High-risk trees – not likely to make it to the next cycle – disease or insects
- Poor form – may want to remove poor genetic material or damaged stems
- Diameter distribution goals – cut more heavily or lightly in a diameter class to obtain proper diameter distribution

What about the Small Trees?

- Thinnings are required to regulate immature age or size classes
- Can not ignore – represents the future
- Density needs to be controlled to foster ingrowth and continuous regeneration
  - If ignored – small stems will create a bump in the diameter distribution
  - Can cause loss in productivity & prohibit future regeneration
  - Pay attention to “q”

What Trees to Keep (among immature classes)

- Those of the best quality, soundness & vigor
- Offering best probability of survival & growth
- The desired spp.
Modifications of the Selection Method

- Single Tree Selection
- Group Selection
- Strip Selection
- Dauerwald

Single Tree Selection

- Managing Individual stems
- Create openings (removal of mature stems) to regenerate new stems in once occupied space
- Remove sufficient numbers of mature trees to cover area allocated to that age class

Single Tree Selection

- Thin individual immature stems to balance the distribution
  - This redistributes proportional area among fewer stems
  - To optimize growth potential
Single Tree Selection

- Some species adapted --- shade-tolerants:
  - Sugar maple
  - Beech
  - Hemlock
  - Red spruce
  - Grand fir
  - Engelmann spruce

Single Tree Gap

Sunlight able to reach the forest floor
Single Tree Criticisms

- Inability to regenerate shade-intolerant spp.
- Unwillingness to invest in tending of immature stems
- Unwillingness to invest in inventory to determine diameter distribution & needs for tending

Will lead to HIGH-GRADING

Single Tree Criticisms

- Can be difficult with clustering of mature stems
- Difficult to minimize damage to the residual stand
Group Selection System

- Stems cut in small groups rather than as individuals
- Identify family groups of mature and immature trees
  - Harvest mature groups to open the canopy for new regeneration
  - Thin the family groups of immature stems to maintain balance

Group Selection

- Reasons to Use:
  - Species requirements
    - Intolerants do not regenerate in small openings created by single tree selection
    - By modifying the size and arrangements of the group cuts, create a wider range of environments - create conditions most favorable for a particular species

Group Selection

- Reasons to Use:
  - 1. Species requirements
    - Reproduction – develops in small even-aged groups – gives better form
    - Able to track age class development easier (easier to see)
    - Edge effect – may be beneficial in establishment of some spp. – can cause growth reduction later.
    - Not good for phototropic spp. i.e. hardwoods
**Group Selection**

- 2. Economics of harvesting
  - More economical to harvest groups – less damage to residuals

- 3. Wildlife
  - More edge, more environmental conditions that produces a greater diversity of plants for cover, food source, etc...

**Group Selection System**

- Not greater than 1.5 to 2 times the height of average of the dominant canopy

- Not group selection – Patch clearcut
Group Selection Praise

- Can increase chances for regenerating shade-intolerant species
- Semantics – can turn into patch clearcutting if the size of the group is large --- 2 to 3 tree lengths

Group Selection Criticism

- Inventory ignores spatial distribution of family groups
- Unwillingness to tend immature groups
  - Failure to tend immature groups makes it a mere diameter-limit cut

Strip Selection

- Each age class in the stand is concentrated in long narrow strips
- Harvested on a cutting cycle to include one strip each entry
- Seldom used in the U.S.
- Advantage – harvested material concentrated
Strip Selection

- Advantage – less damage to reproduction
- Mostly used for montane watershed management – help increase snowpack
- Difficult to initiate, forces you to cut overmature & immature stems to set up the system

Dauerwald

- German – meaning continuous forest
- Each tree receives TLC
- Managing single trees instead of stands
- Used b/c of lack of land base in Europe
- Highly intensive management
- Promotes shade-tolerant trees (primarily spruce/fir)
Growth & Production

• Debate – uneven-aged stands are more efficient in production of volume and value
  – First, Value – may not be the case – species dependent – in the southeast the most valuable species are generally intolerant

Growth & Production

– Second, Volume – Reproduction occurs under mature harvestable trees
  • Less time for harvestable turnover
  • Space for new cohort is not taken by mature stems
  • Better utilization of the site
– Greater volume has not been conclusively demonstrated through scientific investigation
– Stocking Levels?
– Debate Continues ..........

Economics of Uneven-aged Management

• Uneven-aged management may be appropriate for certain class of ownership
  – Small Private Landowners
    • Some small landowners have a limited land base and wish to obtain periodic returns on investment
    • Especially if stand is already uneven-aged or two-aged – may be too costly to convert to even-age (time lag)
    • More intensive
Small Landowners

- Uneven-aged management may be more acceptable to private landowners
- Why?
  - Trees on site all the time
  - Does not like visuals associated with even-aged methods
  - HOWEVER –
    - many inefficiencies
    - See benefits vs constraints

Small Landowner

Comparisons
- Costs – site prep & planting (Even-aged), improvement cuts and added cost of harvesting (Uneven-aged)
- Returns – value from Even-aged on a periodic basis --- long time between incomes, value from continual harvests (Uneven-aged)

Small Landowners

- Returns are more for plantation management, but large initial investments
- Multiple objectives can be achieved for both even and uneven-age systems --- perhaps move toward two-age
- In the past we have given landowners the alternative of even-aged or nothing --- wide range of options available, each with pros and cons --- give the landowners all the options and let them decide
Other Partial Cuttings

When Conducting a Harvest

Do Not:
- Preclude regeneration
- Upset soils or expose them for long times
- Plug up natural drainages or change landforms

Cuttings Outside this Silvicultural System:
- Give irregular yields of unpredictable amounts
- Take a chance on spp. composition of regeneration
- Accept non-uniform distribution of growing stock
Selective Cutting

not Selection Regeneration

- Creaming, culling or high-grading
- Diameter-limit cutting
- Exploitation that removes certain trees of high value without regards to regeneration
- Known silvical requirements & sustained yield being wholly or largely ignored

Advantages & Disadvantages as compared to even-aged management

- **Advantages**
  - Seed source more assured
  - Better protection of site
  - Less danger of fire
  - Aesthetically more pleasing
  - Sawtimber quality could be better – debate
  - Less susceptible to insects or pathogens

- **Disadvantages**
  - Harvesting is not concentrated – more costly
  - More supervision & expertise required
  - More damage to reproduction & residuals
  - Less chance for selecting for better genotypes
  - Difficult to manage & evaluate
  - Favors tolerant species
  - Fire can damage reproduction
Summary

• Favors tolerant spp. – equates to less valuable timber and wildlife in TN

• Cost of operation is greater – larger area impacted for similar extraction

• Damage to residuals & reproduction

• For method to be effective, must be diligent in cutting in all size/age classes

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Summary

• Markets for all materials are needed, especially smaller age classes

• More expertise & time needed for proper implementation (cost)

• Must create viable regeneration (of desired species) with each entry

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Summary

• Danger of method degenerating to high-grading & diameter-limit cutting unless proper care is taken to promote growth of trees (environmental conditions) in all size/age classes.

• Generally means cutting precommercial stems

• Remember natural disturbance is omnipresent
Article by Guldin & Hodges
Good Summary Article

Even-age vs Uneven-age

- Cutting Cycle vs Rotation
- Number of Age Classes
- Diameter Distribution Curve
- Crown Layers
- Disturbance Levels
- Area vs Volume Regulation
- Stand Treatment Attributes
- Sustained Yield