



USDI BLM  
&  
Oregon Dept. of Forestry



Density Management Training  
*Stand Establishment Phase*

February 27, 2008  
Silver Falls State Park, Oregon

# What is the scope of this module?

- While its title is “thinning during stand establishment” – actually it’s about vegetation manipulation during the stand establishment phase with an emphasis on practices that affect:
  - Species density/spatial arrangement
  - Species composition & competition

Everything has a beginning, & for forests it's the ***stand establishment*** phase



# What is the Stand Establishment Stage?

- **Textbook**

- After a **disturbance** new individuals and species continue to appear for several years **until growing space is reoccupied** and new stems quit initiating.

- Oliver & Larson 1996 *Forest Stand Dynamics*



# What is the Stand Establishment Stage?

- **BLM**

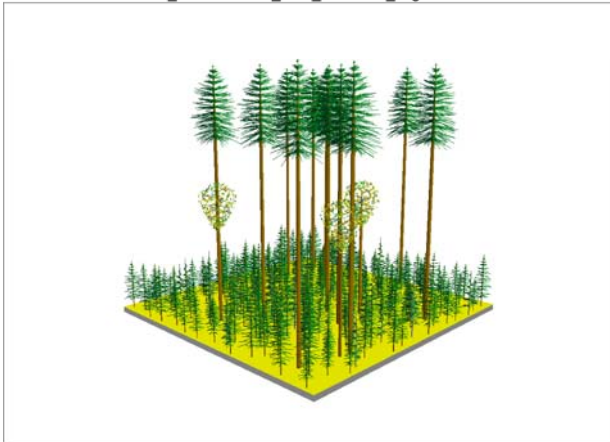
- Average tree height is < 50 feet tall

- BLM WOPR 2007

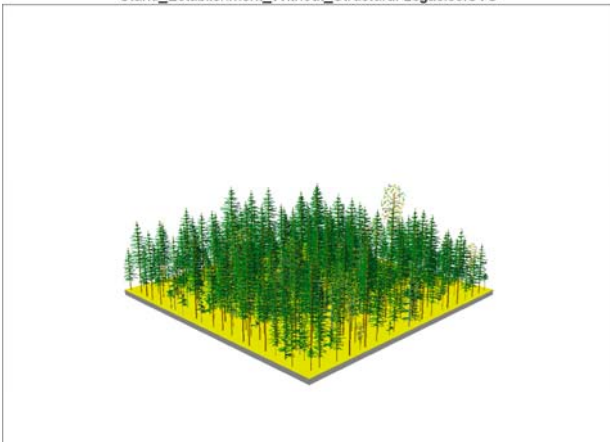


# What is the Stand Establishment Stage?

Stand\_Establishment\_With\_Structural\_Legacies.SVS



Stand\_Establishment\_Without\_Structural\_Legacies.SVS



- **ODF**
  - A new generation of trees are established.
  - In a managed stand this stage may last until approximately 10 years-old (until crown closure)

• Oregon Dept. of Forestry - 2004 *Elliott State Forest Mgt. Plan*

# What is the Stand Establishment Stage?

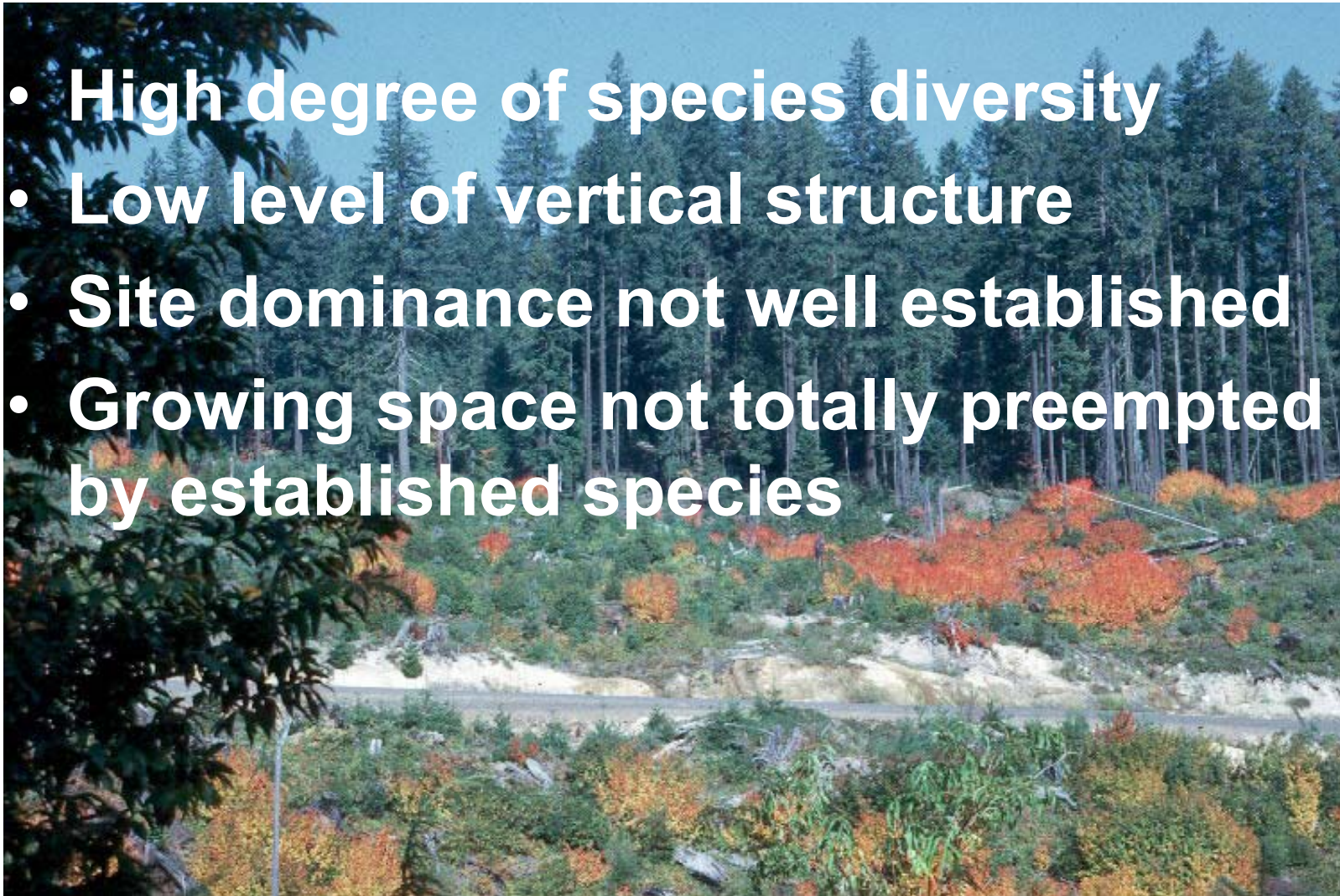
- **FOR THIS CLASS**

- From time of initial disturbance –
- To the age/size when the efficacy of non-commercial thinning (e.g. PCT) becomes questionable (after stands exceed  $\approx 30'$  tall)



# Characteristics of the Stand Establishment Stage

- High degree of species diversity
- Low level of vertical structure
- Site dominance not well established
- Growing space not totally preempted by established species





# Density Management in the Stand Establishment Stage

- in this stage of stand development the potential is high for managing:
  - tree density
  - species composition
  - species dominance



# What you do in the Stand Establishment Stage

- has long-term effects on stand developmental trajectories



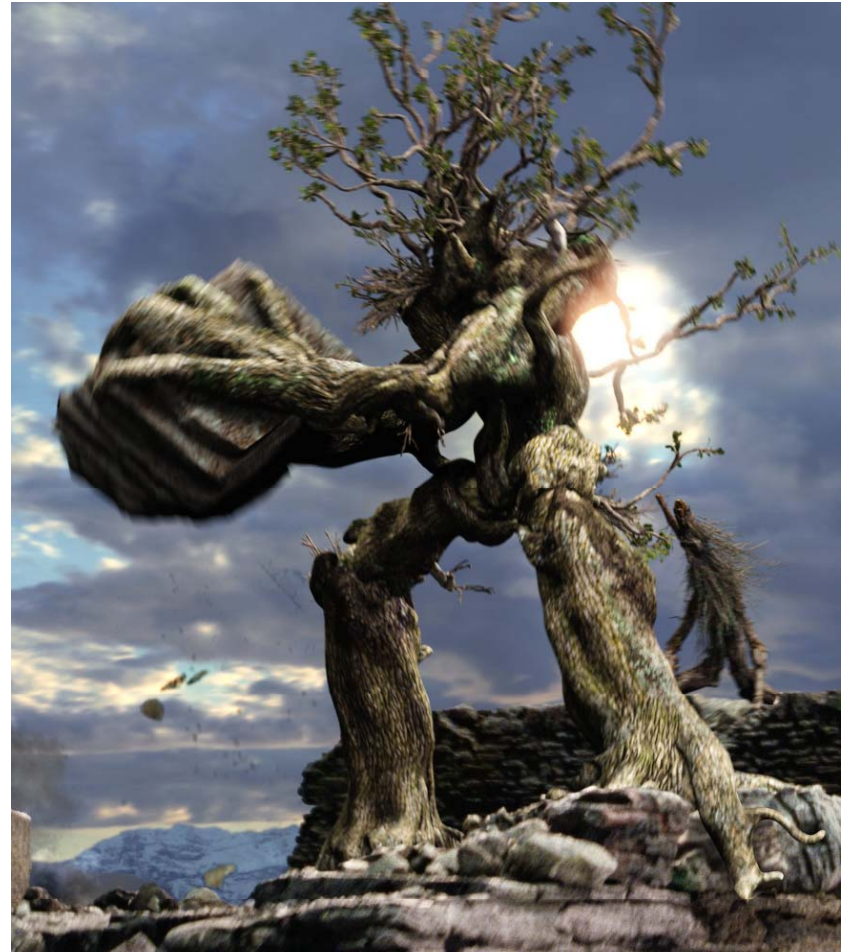
# What you do in the Stand Establishment Stage

- Is critical in determining whether or not your management objectives are met.

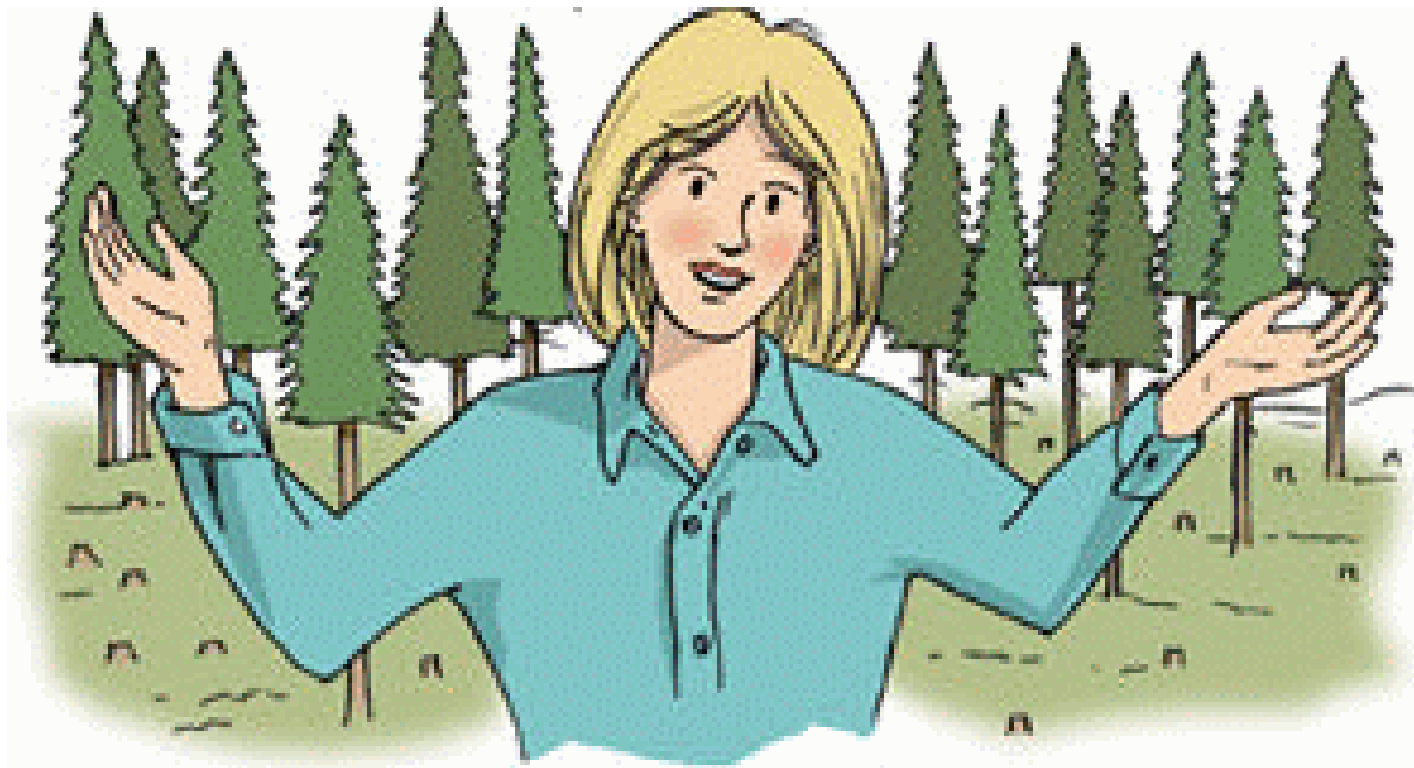


# During Stand Establishment

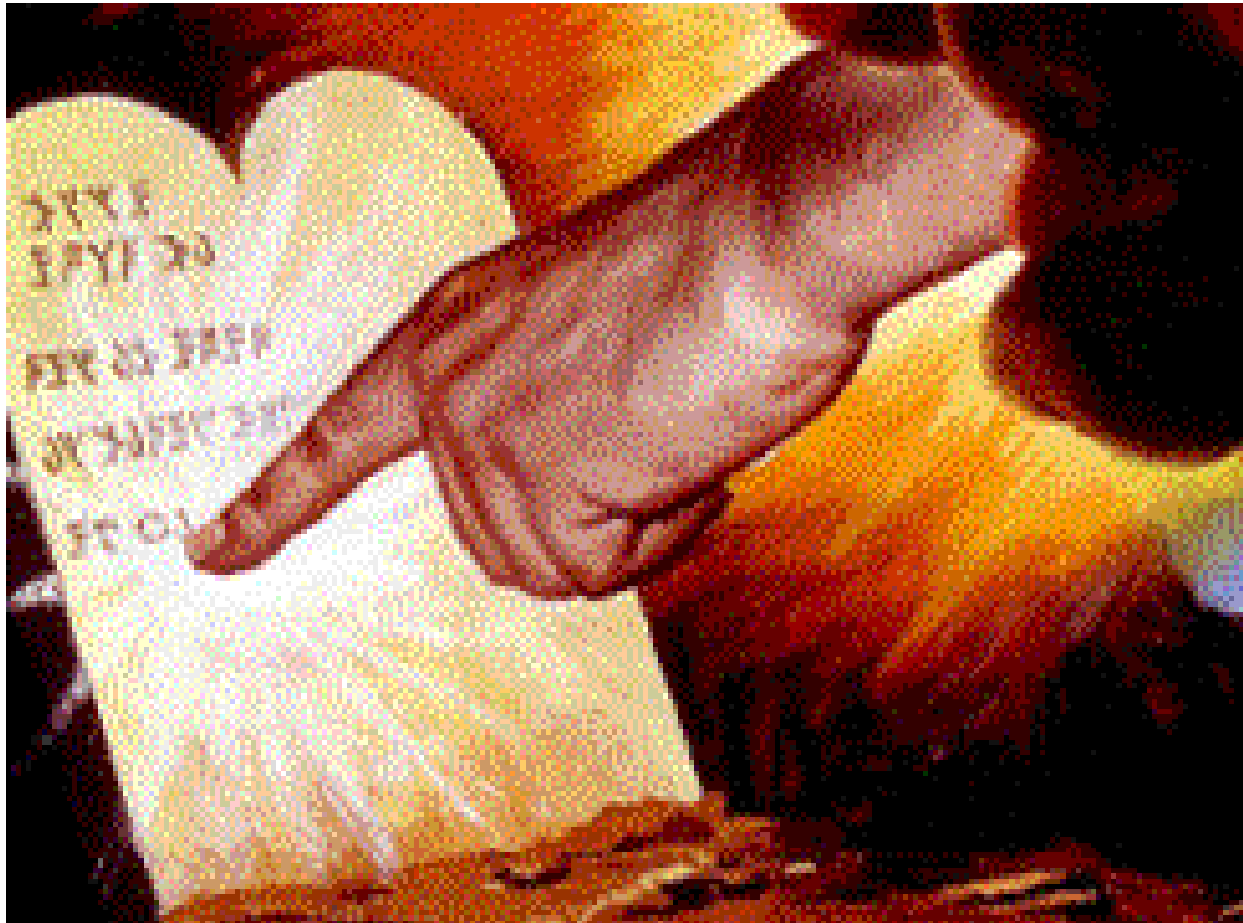
- Your focus is promoting the dominance of those species (usually trees) which are your management priority and suppressing the others as needed to meet your goals



What are your management options?



Land Management Plan  
objectives/direction & agency  
policies provide basic guidance



# Objectives & direction need to be applied to individual sites

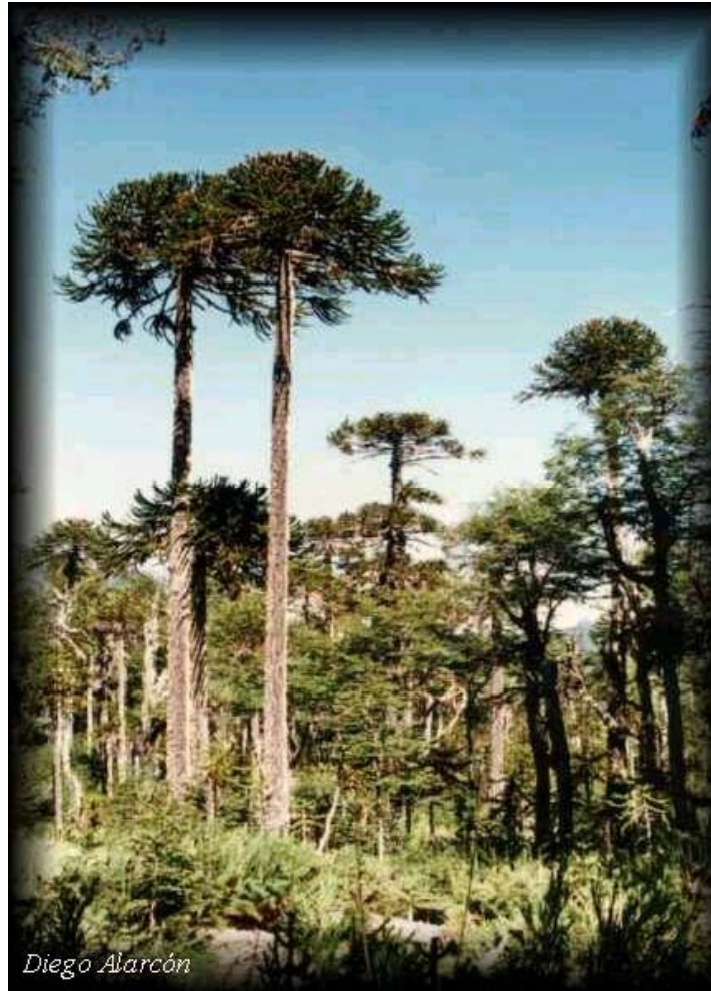


using local knowledge, experience  
and site specific factors





So as to produce the desired **end product** –  
a stand that meets the objectives for the  
land use allocation



*Diego Alarcón*



# From a silvicultural stand point

- The *stand establishment* phase can be divided into *subphases* with different management challenges and management options

<<<<<<<<<<< **Stand Establishment** >>>>>>>>>>

**Harvest** >>>> **Site Preparation** >>>> **Reforestation** >>>> **Maintenance** >>>> **Juvenile Spacing**



# What are subphases of Stand Establishment?

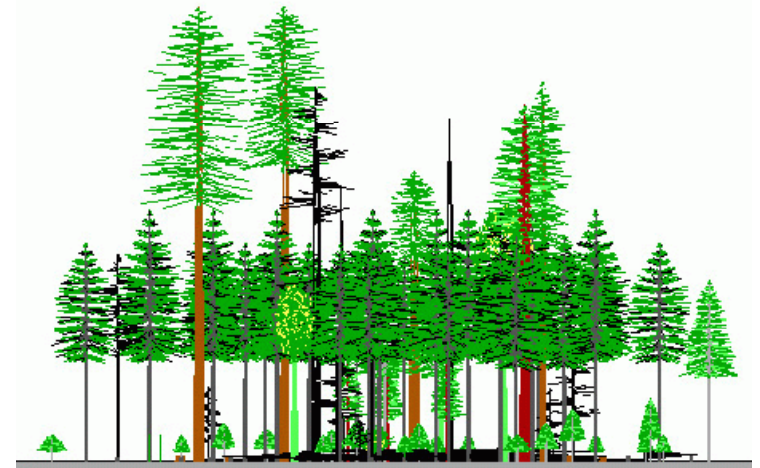
- Harvest
- Site preparation
- Reforestation
- Stand Maintenance (animal & vegetation management)
  - (reduce the numbers/damage or dominance of undesirable species)
- Juvenile spacing aka precommercial thinning (PCT)

# Harvest



- Affects vegetative composition
- Influences need for site preparation
- Long-term effects on stand development trajectory and structure

# Harvest Type is the Dominant Influence on Future Stand Structure



1 year post regeneration harvest

80 years post regeneration harvest

# Site Preparation

- Prepares the site for reforestation
  - Affects the quality of seed bed when relying on natural regeneration
  - Affects quantity and quality of planting locations
  - Affects the development of competing vegetation
    - Species density, composition and vigor

# Site Preparation

- Actions taken prior to reforestation
- 4 basic types
  - Broadcast burning
  - Mechanical w/wo burning
  - Manual
  - Chemical (not available to BLM)



# Site Preparation- Broadcast Burning

- Kills smaller residual conifer trees
- Can have major effect on GTR survival
- Top kills sprouting hardwoods/shrubs
- High degree of site accessibility for planting



# Site Preparation - Mechanical



- crushes smaller residual conifer trees
- High potential for GTR survivability
- Crushes or uproots sprouting hardwoods & shrubs
- Moderate-high degree of site accessibility for planting

# Site Preparation - Manual

- No effect on residual conifer trees (unless targeted)
- Temporarily retards growth of sprouting hardwoods & shrubs
- Low degree of site accessibility for planting



# Site Preparation - Chemical



3700SYS



UGA2307267

- Low-high degree of vegetation control depending on:
  - Application method
  - Chemical
- By itself minimal effect on planting accessibility

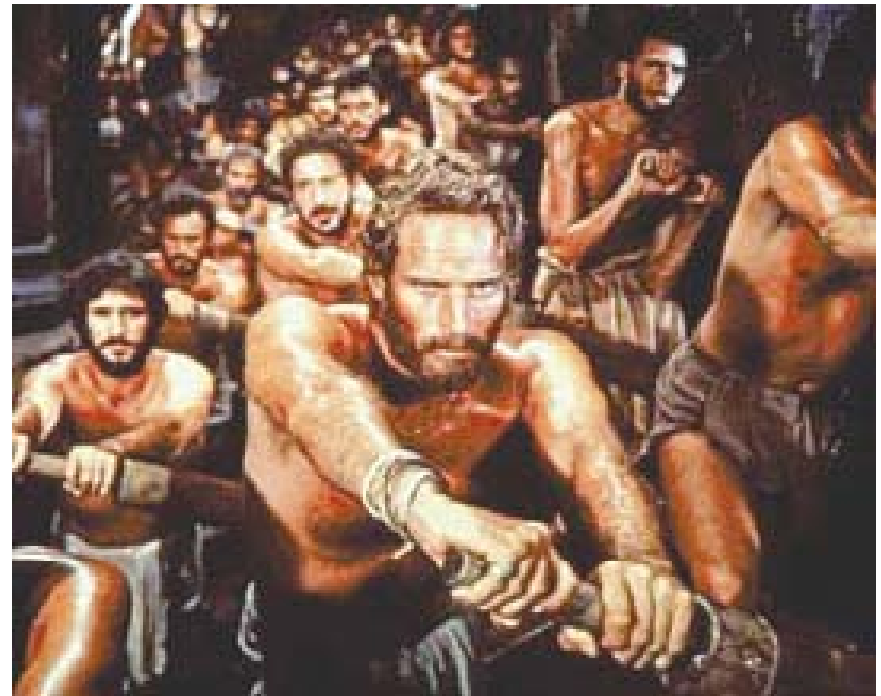
# Reforestation – 2 types

- Natural (seed & sprouting)
- Artificial (seeding & planting)



# Reforestation - Natural

- You are the slave of nature & past mgt.
- species composition, density dependent on seed sources & crops
  - Adjacent seed blocks?
  - Green trees retained for seed, shelter, habitat?



# Reforestation - Artificial



- You are the Master
- planting or spot seeding -
  - You control species composition & density
- broadcast seeding –
  - You control species composition, but not density

# Reforestation - *Reality*

- You are not in complete control
  - *"Let all men know how empty and worthless is the power of kings. For there is none worthy of the name but God, whom heaven, earth and sea obey".*
    - King Canute *the Great*
- “A man’s got to know his limitations”
  - *Dirty Harry Callahan*





# Reforestation - *Reality*

- Plantations are not perfect
  - Some spots can't be planted
  - Seedlings die
  - Hardwoods & shrubs resprout or invade
  - Natural regeneration from seed can occur
- Often these conditions occur in a clumpy pattern



# Reforestation - *Reality*

- Notwithstanding the natural forces against you:
  - Your ability to influence composition, density & spatial arrangement is high with plantation reforestation





# Reforestation - Planting

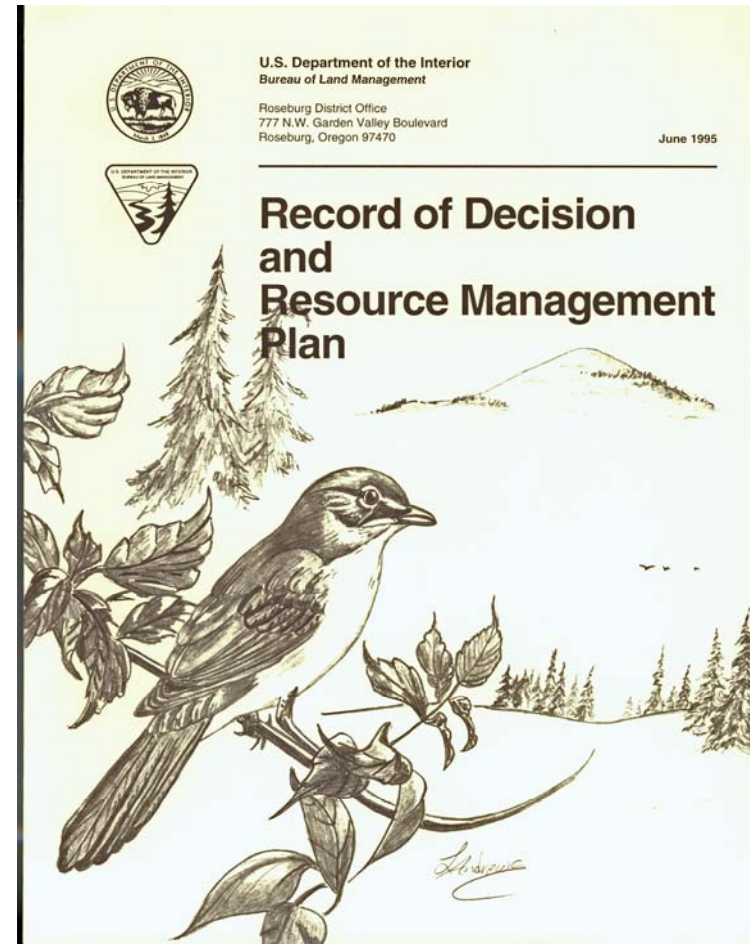
- What density should I plant?
  - planting density should be based on:
    - Desired target tree sizes at the time of 1<sup>st</sup> planned timber harvest, or future tree sizes for future mgt.
    - Tree size criteria can be translated into a specific number of trees/acre or a spacing
    - Density targets should be adjusted to allow for anticipated juvenile mortality
- Briggs 2007; BLM data 2007

# Reforestation - Planting

- What density should I plant?
  - Average planting density Westside  $\approx$  480 trees/acre for Douglas-fir & western hemlock plantations (Briggs 2007; BLM data 2007)
  - These are about 20-90% higher than the #/acre desired at about stand age 10 years-old (Briggs 2007; BLM data 2007)

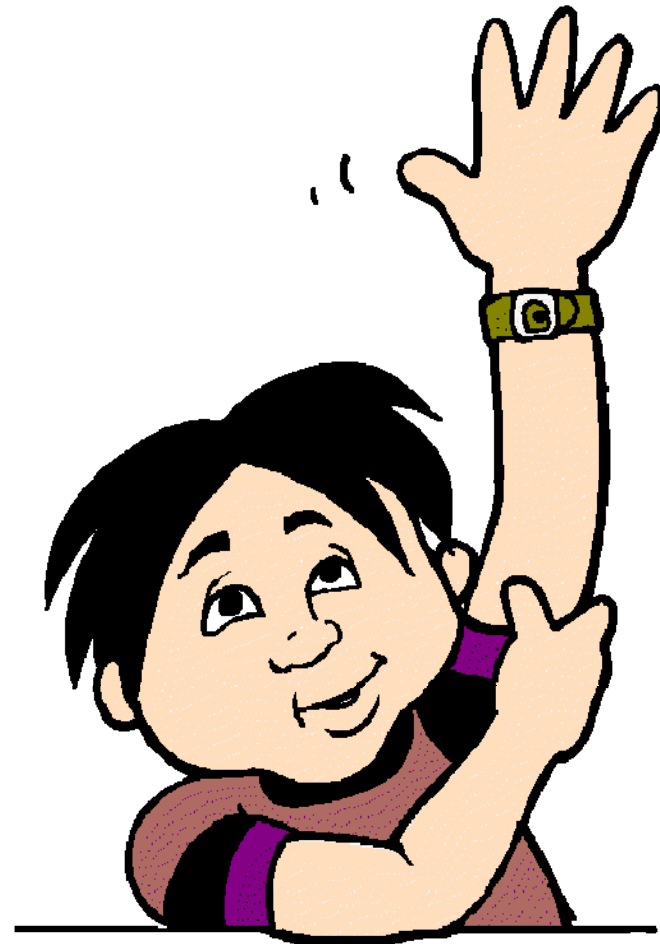
# Reforestation - Planting

- consult your land use plan for explicit direction e.g.
  - The selection of tree species, planting density, and stock types would depend on site characteristics, the composition of the original stand, and projected future management of each stand. [Matrix LUAs]. Salem BLM Record of Decision and Resource Management Plan 1995

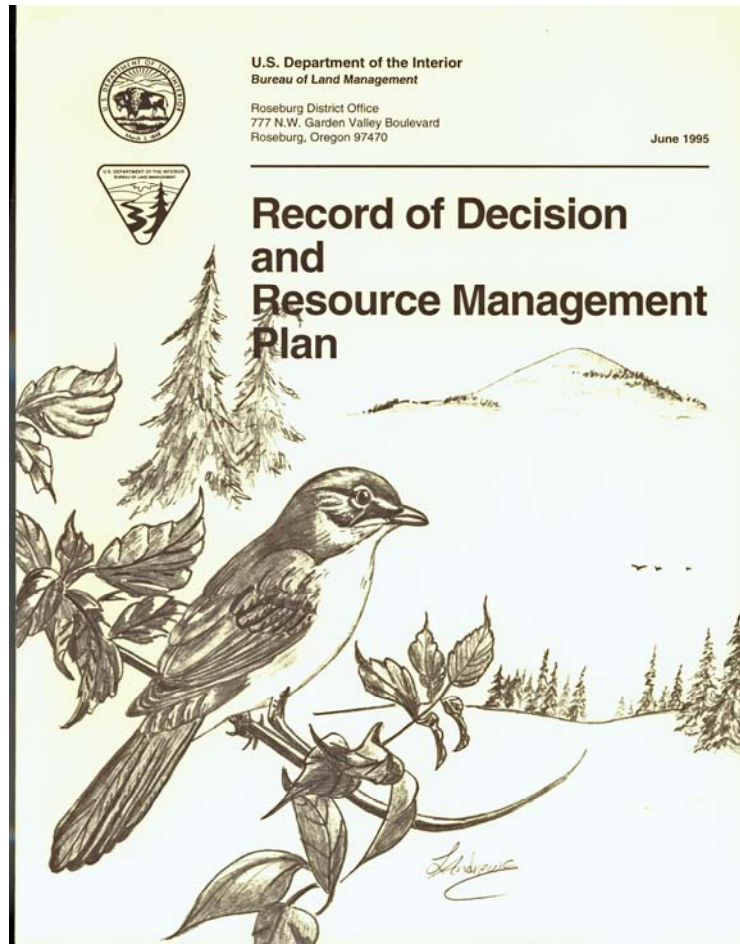


# Excuse Me!

- That's not very explicit? Isn't there more?
- NO, not under reforestation direction
- Try looking under precommercial thinning – post-PCT targets should inform you as to minimum planting targets



# Reforestation - Planting

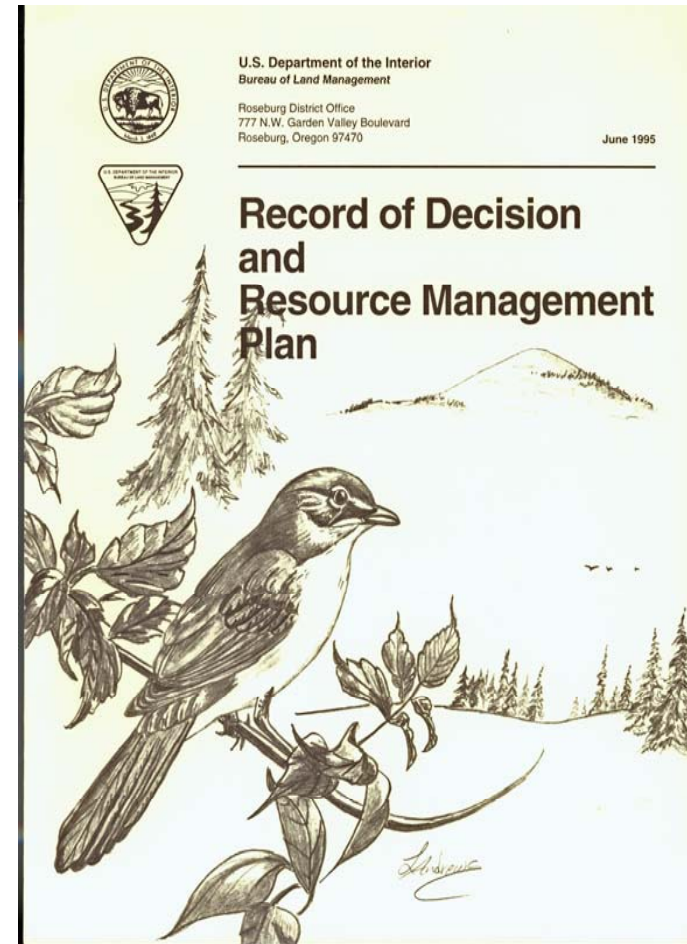


- Here's the management direction for PCT.
  - Consider precommercial thinning of stands between 10 and 15 years old that average over 450 trees per acre. Thin to an average spacing of 12 to 16 feet. The **number of trees left may vary from 170 to 300 per acre** [Matrix LUAs]. Salem BLM Record of Decision and Resource Management Plan 1995

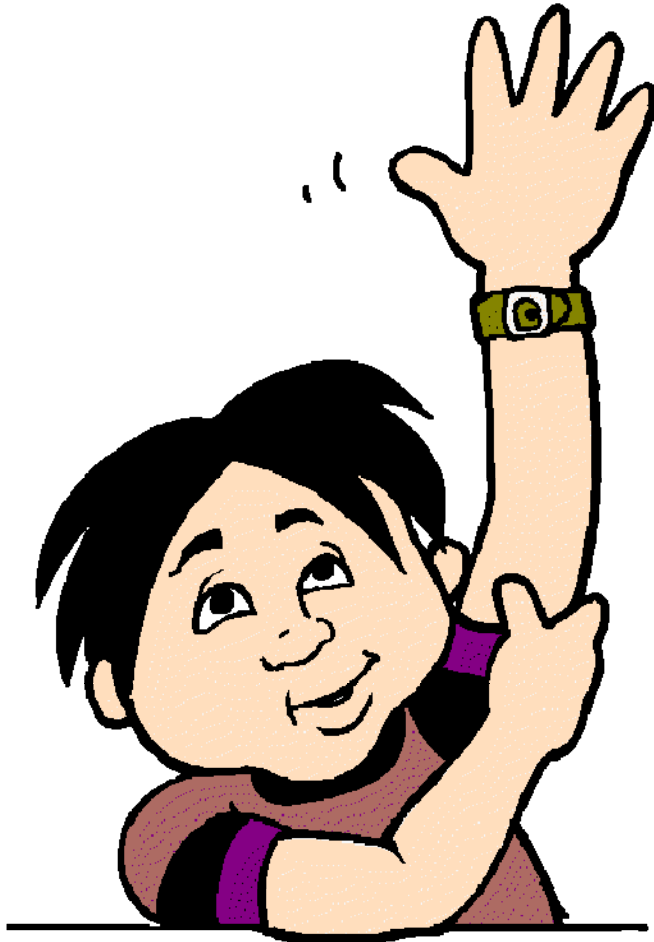


# Reforestation - Planting

- So the answer in this case is a minimum of
  - 170 to 300/acre
    - while not explicit, targets apply to the Connectivity & GFMA respectively\*
    - Planting #s should be increased per local experience for anticipated mortality prior to 1<sup>st</sup> timber harvest
- \* based on modeling assumptions underlying the RMP ROD



# Excuse Me!

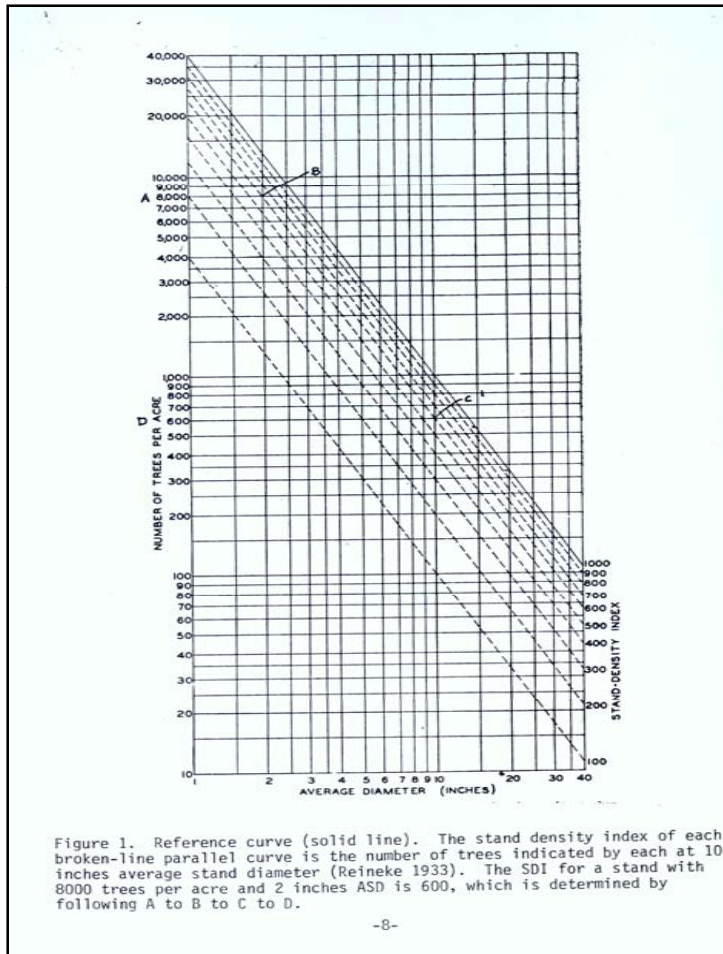


- Where did these density guidelines come from originally?
- How were they determined?
- Good question.

A long time ago a forester named  
Reineke observed an interesting  
relationship



# Reineke's SDI



- Reineke observed that even-aged stands of a variety of species followed the same size density relationship or self-thinning pattern.
- From this relationship he derived *Stand Density Indices*

- Reineke 1933

# Reineke's SDI

- Stand Density Index (SDI) varies by species or species mixture

*Table 1. Suggested Maximum SDI by species and source.  
English units are number of  
10-inch trees per acre..*

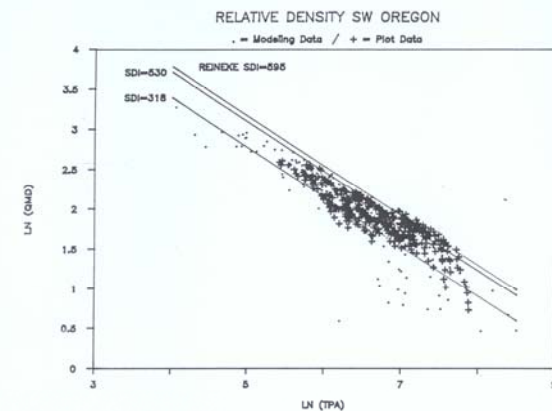
<b>Species</b>	<b>Maximum SDI (English)</b>	<b>Source</b>
White fir	830	Reineke, 1933
Red fir	1000	Reineke, 1933
Mixed conifer for CA	750	Reineke, 1933
Douglas-fir for WA-OR	595	Reineke, 1933
Douglas-fir for CA	600	Reineke, 1933
Ponderosa Pine	830	Long, 1985
Douglas-fir	587	Long, 1985
Western Hemlock	790	Long, 1985
Ponderosa Pine	450	Long and Shaw, 2005

# 30 years after Reineke

Yoda and others (1963)  
established that a similar principle  
was applicable to plants in general

# Yoda's Law

- For any given density there is a maximum tree diameter attainable.
- Beyond that limit, further increase in diameter must be accompanied by a decrease in density.



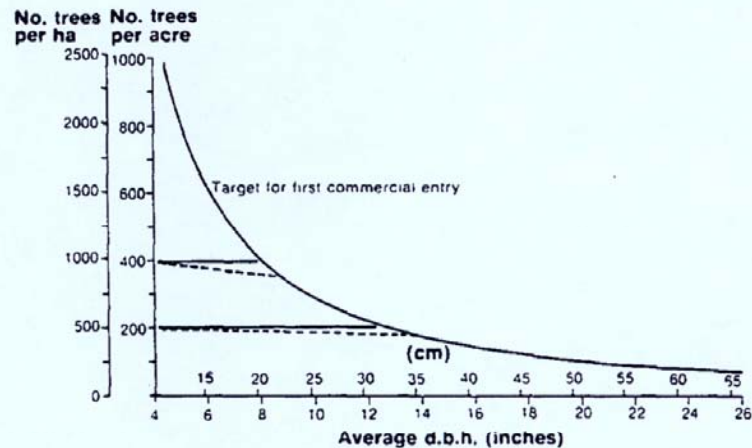
- Yoda et al. 1963

# Application of Reineke's SDI

- In the 1970s & 1980s guidelines for density management were developed based on Reineke's & Yoda's principles, & growth-growing stock studies taking the form of *Density Management Diagrams*
- The goal of SDI-based management is to manage stands to meet objectives within defined density ranges using thresholds to trigger management actions.



# Application of SDI Concept



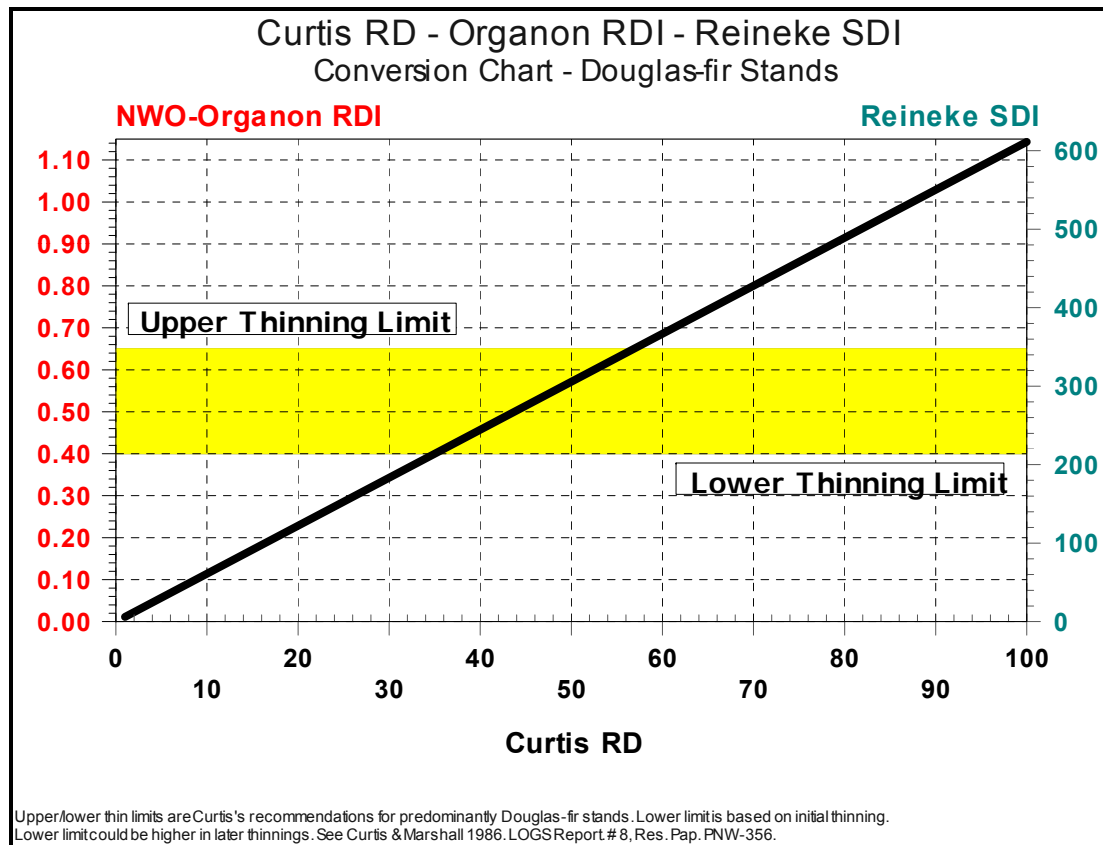
**Figure 3.** Target for first commercial entry expressed in terms of number of trees per acre (ha) and stand average diameter (Dg) (adapted from Reukema 1975). Horizontal lines show development of stands, without mortality, to two possible target densities: 400 trees per acre at a Dg of 8.0 inches (988/ha at 20.4 cm) and 200 trees per acre at a Dg of 12.7 inches (494/ha at 32.3 cm). Dashed lines show comparable development if 10% of the trees die.

- *Density Management Diagrams* can be relatively simple

•Smith & Reukema 1986



# Application of SDI Concept



- DMDs & rules are all based on the same underlying principles

- Curtis 1982
- Reineke 1933
- <http://www.cof.orst.edu/cof/fr/research/organon/orgfaq.htm#FAQ8> (1999)

# Um, excuse me, but...



- is there another way besides using density management diagrams to decide on a planting or post-PCT density?
- Like an electro-techno tool?

# EXCUSE ME! I'm am also wondering ...

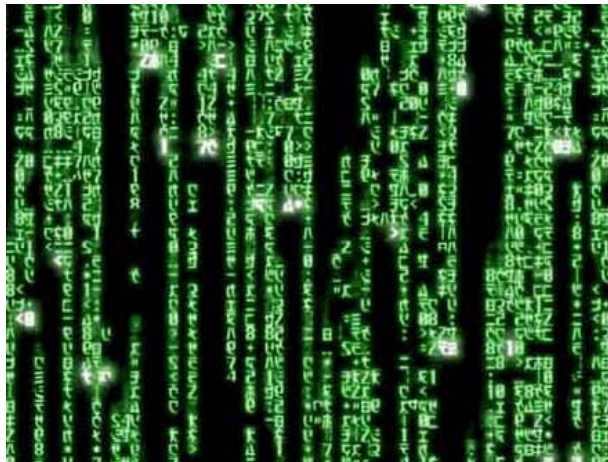
- What if there is no DMD for the species or type of management you are interested in?
- What if your stand has a mixture of species?
- What if it is uneven-aged?



AP / Aman Sharma

# There is another way!

- Computerized growth and yield programs are
  - available for specific geographic areas & species
  - contain equations incorporating density relationships
  - versatile – can simulate many different possibilities



# Computer Models

- were being developed at about the same time as DMDs by forester geeks who saw the limitations of DMDs and other prediction tools for stand management and wanted more time to play video games.



And as they say “the rest is history”

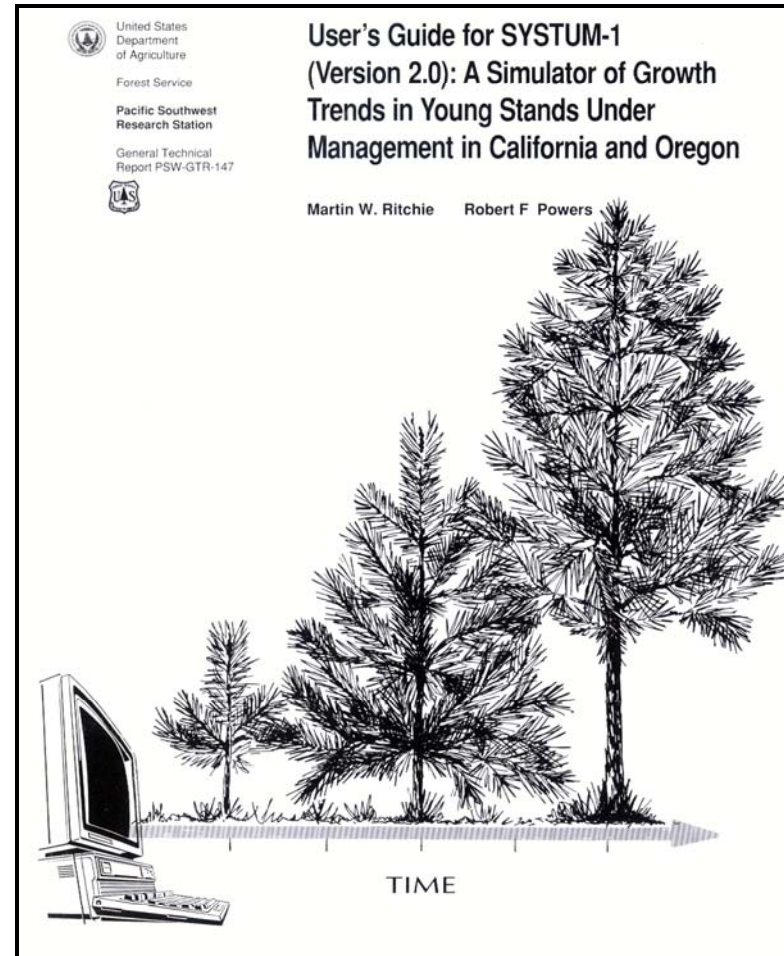


- Computer models are now the main tool used for density management prescriptions



# Computer Models

- “Young-stand” models
  - 3-20 years-old range
  - e.g. SYSTUM-1, CONIFERS
  - Can simulate different planting/PCT densities & shrub/hardwood competition
  - Used in conjunction with older stand growth models, e.g. ORGANON, FVS



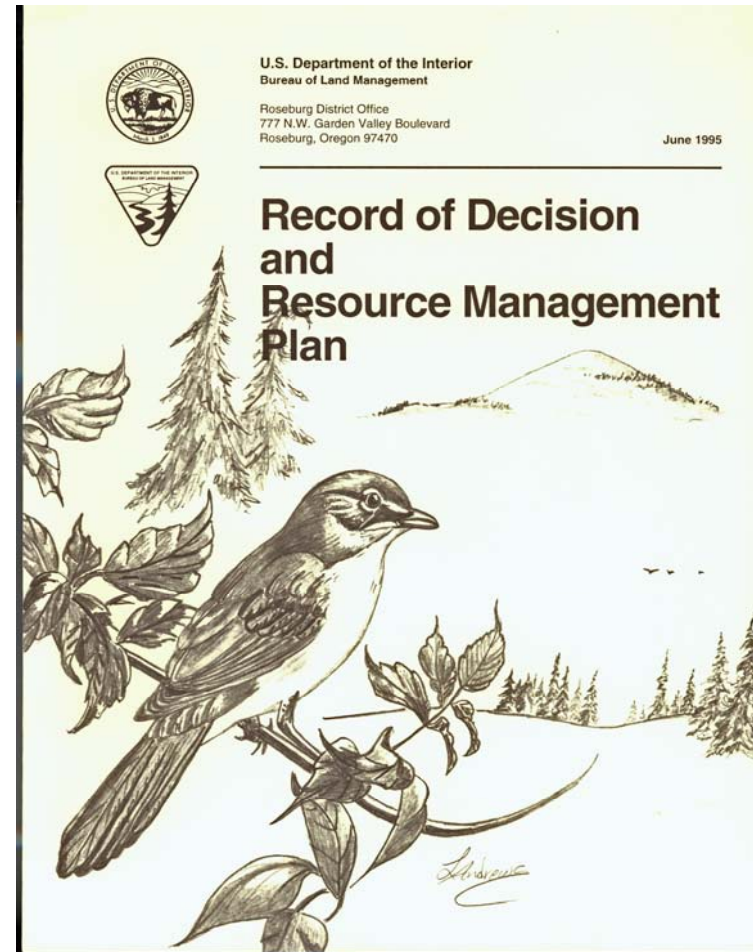
# Computer Models



- “older-stand” models
  - $\geq 20$ -? years-old range
  - e.g. ORGANON, FVS
  - simulate different density management treatments & other silvicultural treatments
  - Reports can be output for economic analyses

# Computer Models

- Your agency's density targets for planting & precommercial thinning were likely derived from iterative computer simulations of various scenarios



# Reforestation – Species to plant?

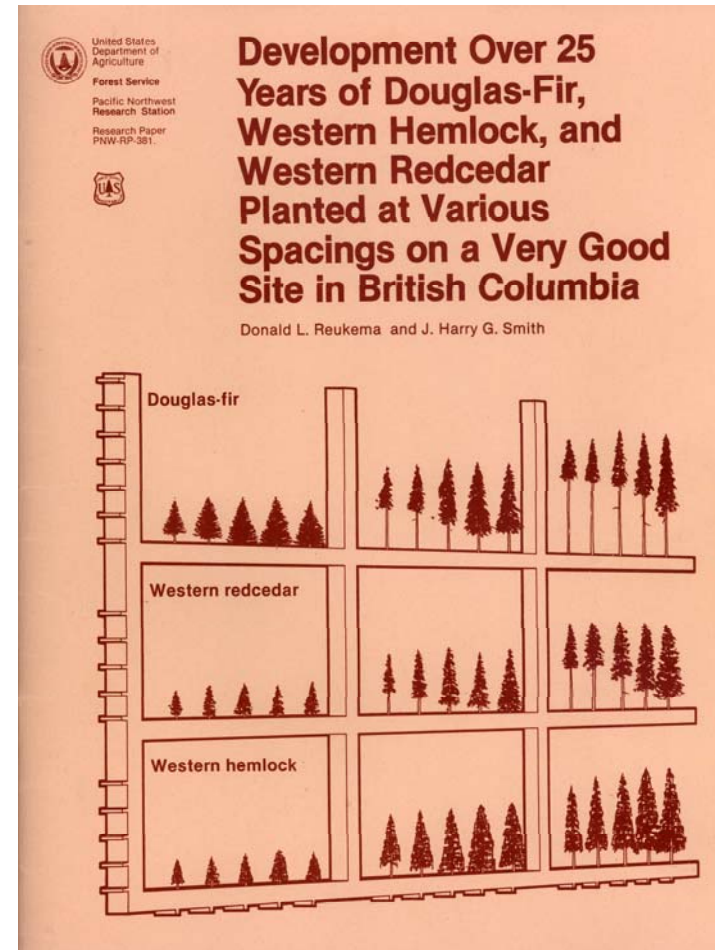
- Ecologically adapted to site
- What is the your management direction?, e.g.
  - Manage so that tree species trend over time toward average species compositions consists of approximately 89 % Douglas-fir, 5%, pines, 4% grand fir, & 2% other conifers. [General Forest Management Area]
  - Genetically selected stock will ... be ... used to the extent available in accordance with BLM's Western Oregon Tree Improvement Plan. [General Forest Management Area]
- Roseburg BLM Record of Decision and Resource Management Plan 1995

# Reforestation – Species to plant?

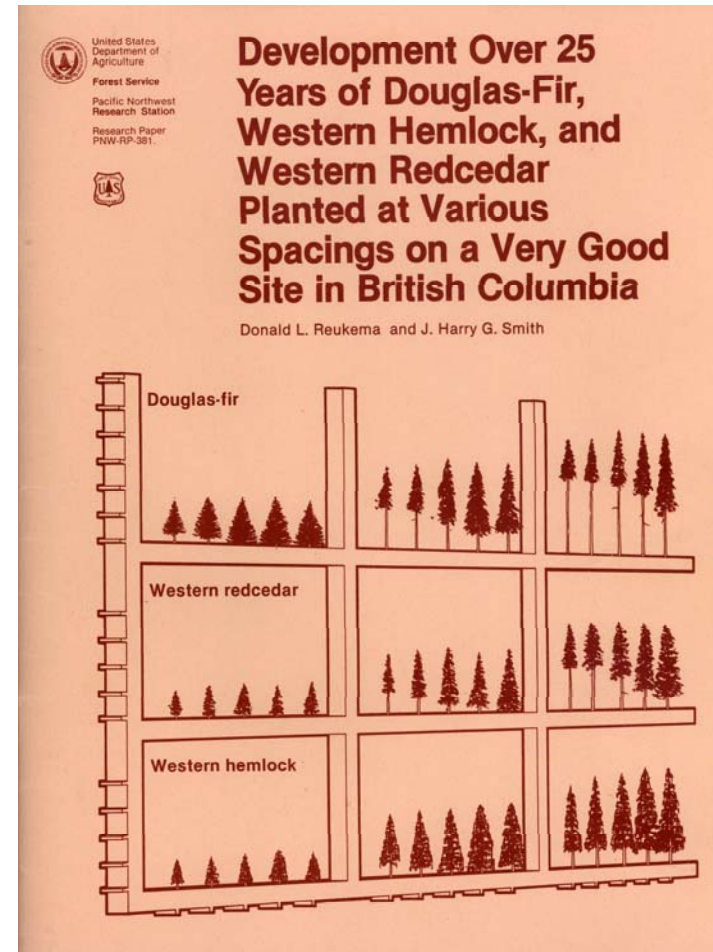
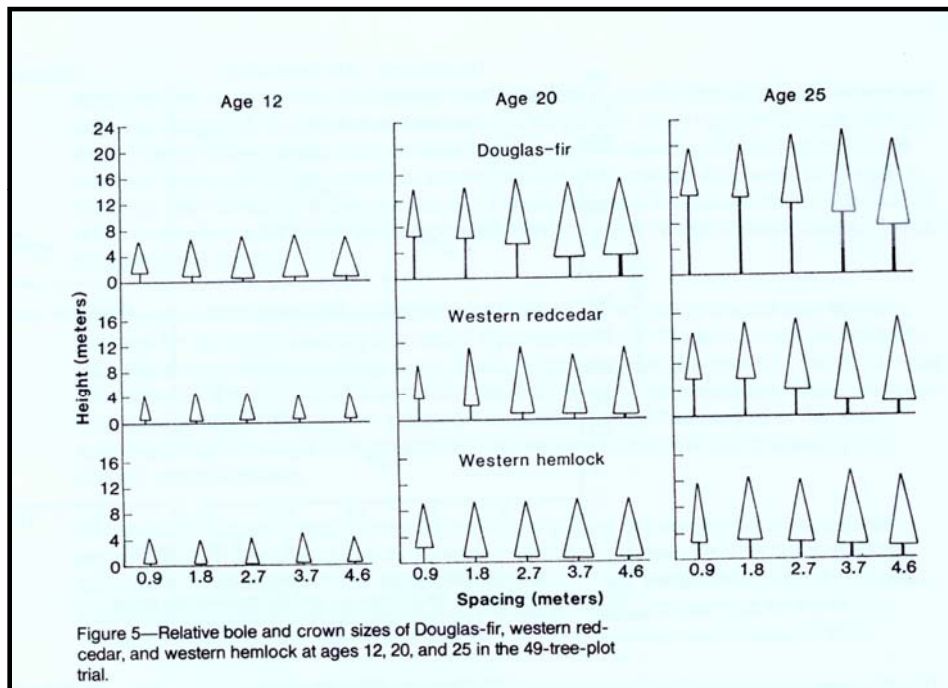
- Other things to consider
  - Effect of species or mix of species on:
    - Yield
    - Disease prevention or amelioration
    - Future stand structure
      - Stratification of species may result:
        - » Better form or wood quality
        - » Wildlife benefits
        - » Reduce the need for future density mgt.

# Reforestation – Species to plant?

- A good basic primer on juvenile growth rates & characteristics of 3 major conifer species
- New information on mixed-species management is being made available



# Reforestation – Species to plant?







# Stand Maintenance is done to

- Maintain the density and promote the dominance (usually defined as height) of the desired species (usually trees) and
- To reduce the density or dominance of the undesirable species (often herbs, shrubs & trees).
- Done prior to juvenile spacing (PCT)

# Stand Maintenance – 3 types

- Examples
  - Chemical
    - herbicides
    - animal repellents
  - Manual (physical barriers)
    - mulches & tubes
  - Manual
    - cutting or scalping

# Stand Maintenance - Chemical

- Effect on different species is dependent on chemical formulation & method & timing of application e.g.
  - Aerial vs. ground application
  - Dormant or growing season application



# Stand Maintenance - Manual

- Physical barriers
  - Mulches
    - Control herbaceous vegetation in the immediate vicinity of the seedling
  - Animal control
    - Devices such as plastic tubes to protect seedlings from animal damage



# Stand Maintenance - Manual

- Cutting reduces cover of shrubs and hardwoods to promote dominance of desirable species





# Precommercial Thinning

- 1) the removal of trees not for immediate financial return but to reduce stocking to concentrate growth on more desirable trees. Helms [SAFI 1998



# Precommercial Thinning

- 2) the practice of reducing the density of trees within a *stand* by manual cutting, girdling, or herbicides to promote growth increases or maintain growth rates of desirable tree species. The trees killed are generally *unmerchantable* and retained on the treated area. USDI

2007

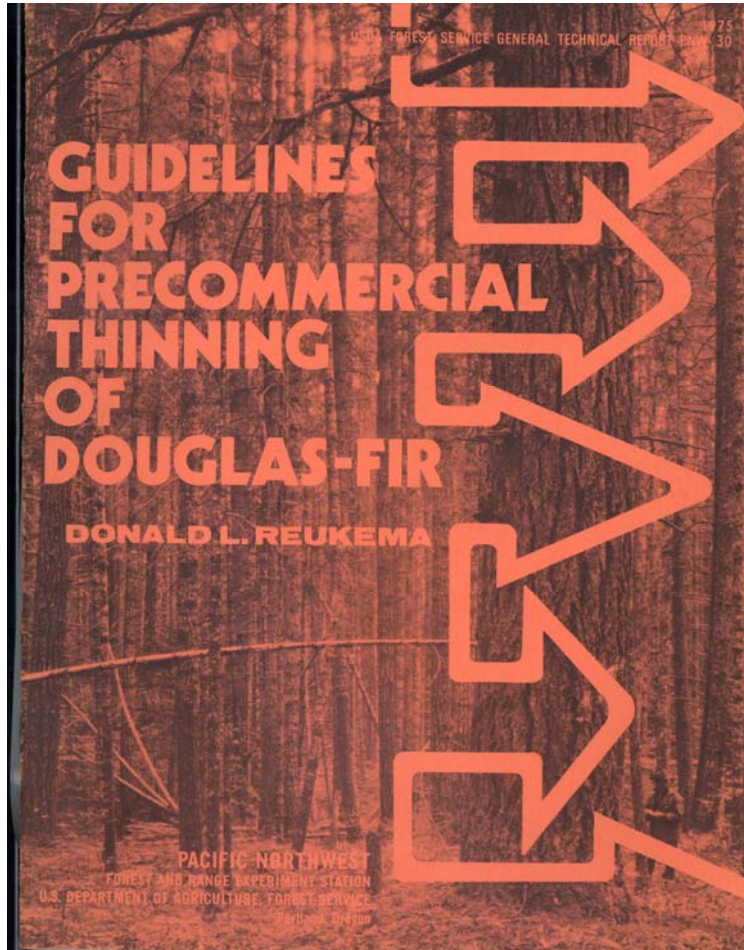




# Precommercial Thinning

- The density at which stands should be precommercially thinned to are based on the same principles of plant competition as are used in deciding what the initial planting density should be

# Precommercial Thinning

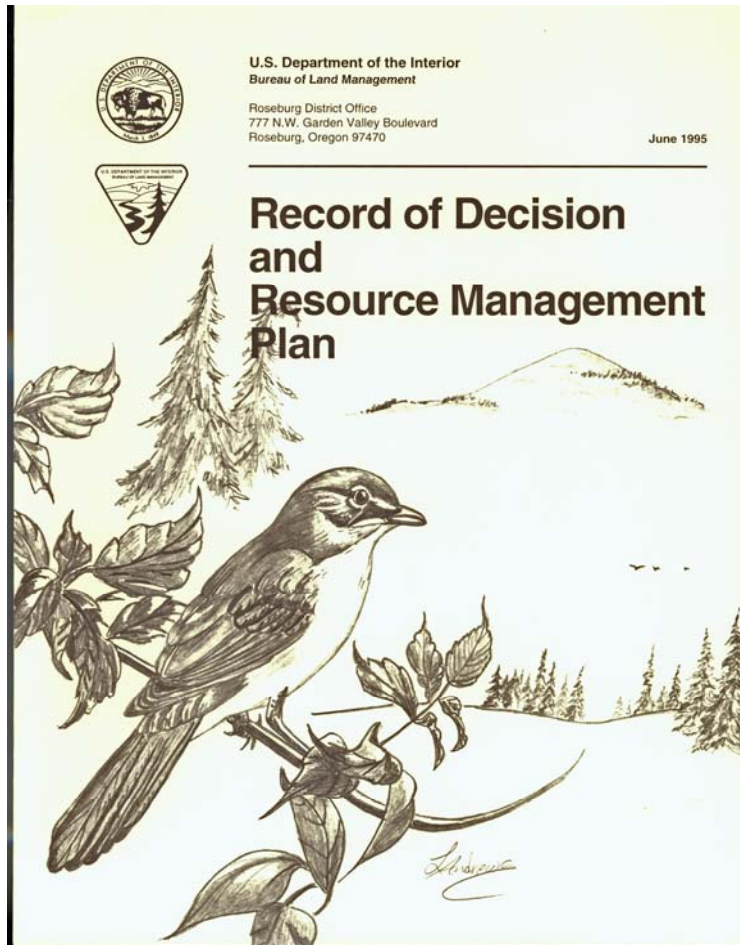


- What density should I thin to?
  - Concepts and guidelines published in 1975
    - Concepts are still valid although the growth projections are dated, since they were derived from DFSIM and early growth model

# Precommercial Thinning

- What density should I thin to?
  - Post-PCT density should be based on:
    - Desired target tree sizes at the time of 1<sup>st</sup> planned timber harvest - whether it's thinning or regeneration harvest
    - Tree size criteria can be translated into a specific number of trees/acre or a spacing

# Precommercial Thinning



- Management Direction:
  - Apply precommercial thinning to ... stands that are overstocked. Thinning will generally be done between ten and 20 years of age. Average number of trees left will vary between **150 to 250 trees per acre** ... [Matrix LUAs].
- Roseburg BLM Record of Decision and Resource Management Plan 1995

# Supplemental Management Direction

Date: December 23, 2005

To: Carson, T. Moser

cc: Todd, Haigh, Thomas, O'Sullivan

From: Craig Kintop, District Silviculturist

Subjects: Precommercial Thinning (PCT)) Potential and Recommendations for FY 2006-2010

RMP Assumptions and Treatment Threshold Recommendations:

**Table 1 shows RMP assumed implementation guidelines based on LUA objectives and desired future condition of the stand. To be consistent with the RMP, prescriptions and contracts should be within the range of assumptions modeled for Land Use Allocations (LUA) contributing to the Allowable Sale Quantity (PSQ), i.e. the matrix lands. Reserve land use allocations do not contribute to the ASQ and were not specifically modeled for the RMP. For those land allocation it is recommended that guidance for the Connectivity LUA generally be followed. The Connectivity prescriptions were designed to accelerate stands toward late-successional characteristics and maintain management flexibility should objectives change in the future.**

# Supplemental Management Direction

Table 1 ORIGINAL (1994) RMP ASSUMPTIONS FOR PRECOMMERCIAL THINNING & Revisions (2005)		
STAND CHARACTERISTIC	Land Use Allocation	
	GENERAL FOREST MANAGEMENT	CONNECTIVITY
Pre-thin Density	> 400-450/acre <sup>3</sup> > 350-400/acre <sup>4</sup>	> 400-450/acre <sup>3</sup> > 250-300/acre <sup>4</sup>
Pre-thin Average Conifer Height	10'-30'	10'-30'
Pre-thin Stand Age <sup>1</sup>	8-20 years	8-20 years
Post-thin Conifer Density	250-300/acre	150-220/acre
Post-thin Hardwood Density <sup>2</sup>	3-10/acre	10-45/acre
Hardwoods (except alder) ≥ 8" dbh	Retain	Retain

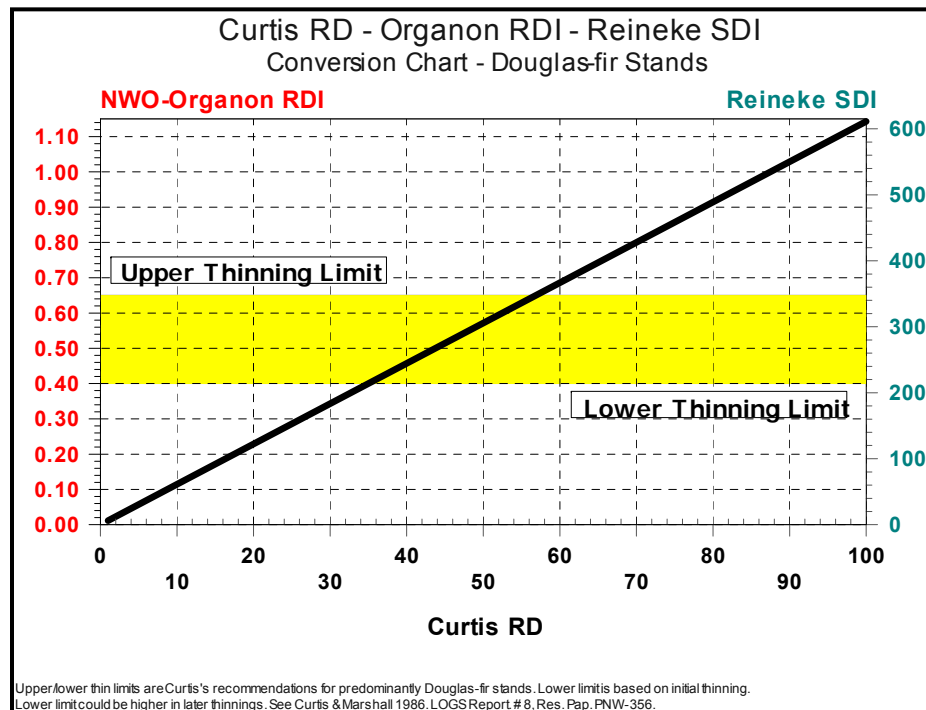
# Supplemental Management Direction

Table 1 ORIGINAL (1994) RMP ASSUMPTIONS FOR PRECOMMERCIAL THINNING & Revisions (2005)		
STAND CHARACTERISTIC	Land Use Allocation	
	GENERAL FOREST MANAGEMENT	CONNECTIVITY
Post-thin Species Composition	Generally favor faster growing condition for conifers	Generally proportional to pre-thin condition for conifers
Spacing Variation	+/- 20 %	+/- 20 %
Unthinned Clumps & Openings	No unthinned clumps, no increase or enlargement of openings currently present	≤ 5% of area retained in un-thinned clumps, no increase or enlargement of present openings
Conifers ≥ 8" dbh (sound & cull)	Retain	Retain
Snags	Retain	Retain
Coarse Woody Debris	Not Applicable	Not Applicable

<sup>1</sup> Shown for reference only. Treatment should be based on average heights of regeneration not age.  
<sup>2</sup> Lower end of the range shown is appropriate when most hardwoods are tree form ≥ 8" dbh.  
<sup>3</sup> original RMP assumed density  
<sup>4</sup> revised density criteria of December 23, 2005 per this memo

# How was the target density determined?

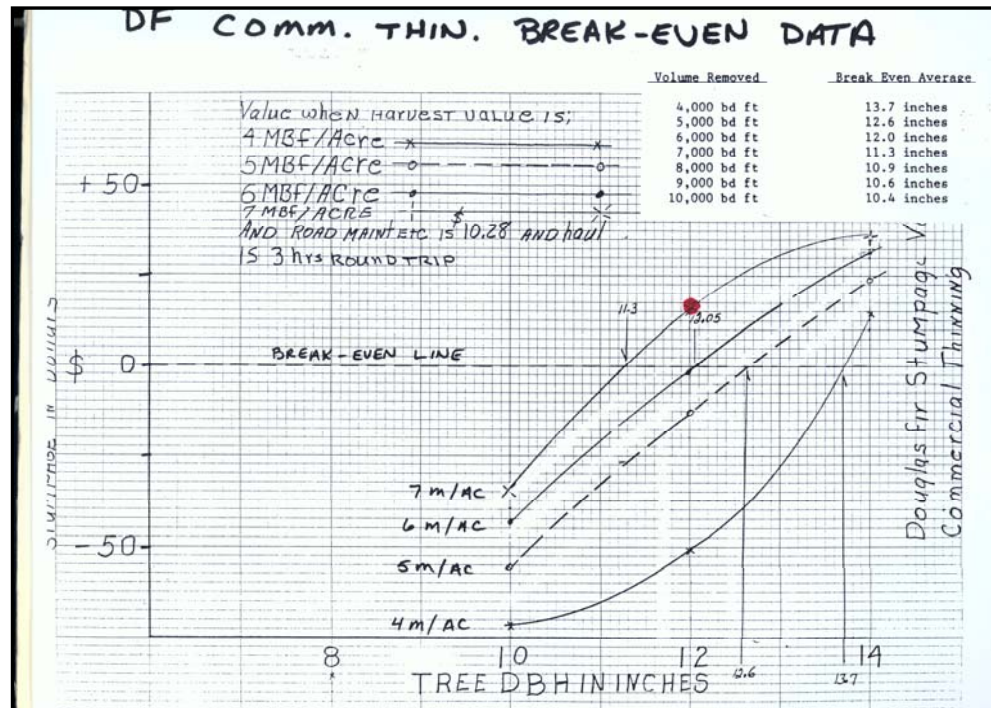
- Example: 250 trees/acre target
  - Iterative computer simulations to find:
    - the **maximum density** that produced a stand **average diameter  $\approx 12''$**  and a **minimum potential CT volume of 7 MBF/acre** before the suppression related **mortality threshold was exceeded** [Curtis RD  $\approx 55$ ]





# How was the target density determined?

- Determine the number of trees that:
  - Maintains highest level of density that
    - Produces minimum diameter &
    - and volume
    - for an economically viable timber harvest



# Timing of PCT

- Average tree height rather than age is a better criteria
  - 10'-15' average stand height is best
    - Depending on site productivity this could occur earlier than stand age 10 years-old

- Reukema 1975
- Wiley & Murray 1974

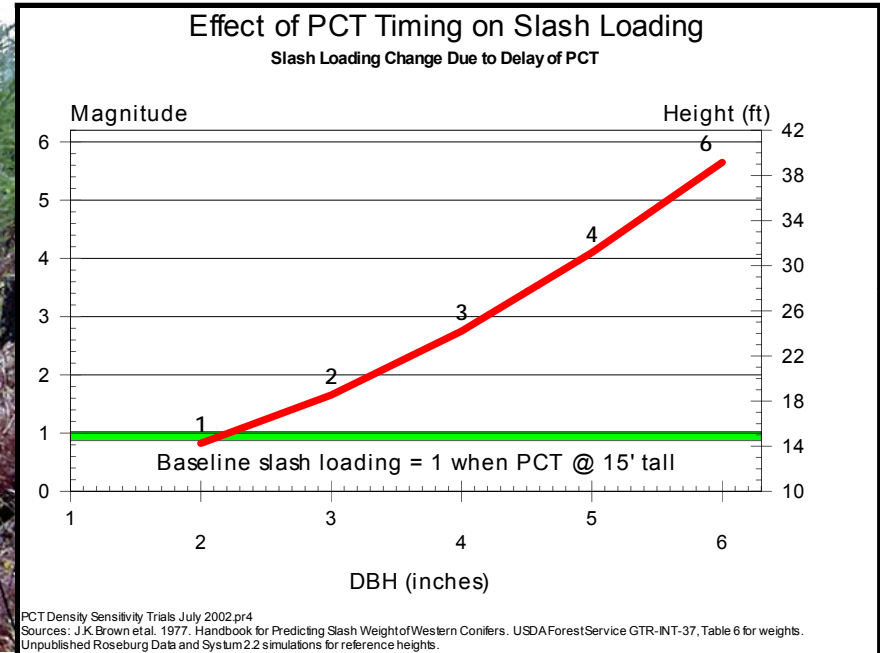


# Timing of PCT



- At 10'-15' average stand height:
  - trees tall enough to escape browsing\*
  - large enough to exhibit growth patterns\*
  - High potential for
    - high DBH growth
    - future volume gain
    - reduced time to harvest
  - Lower fuel loads
  - Smith and Reukema 1986

# Effect of timing on slash load

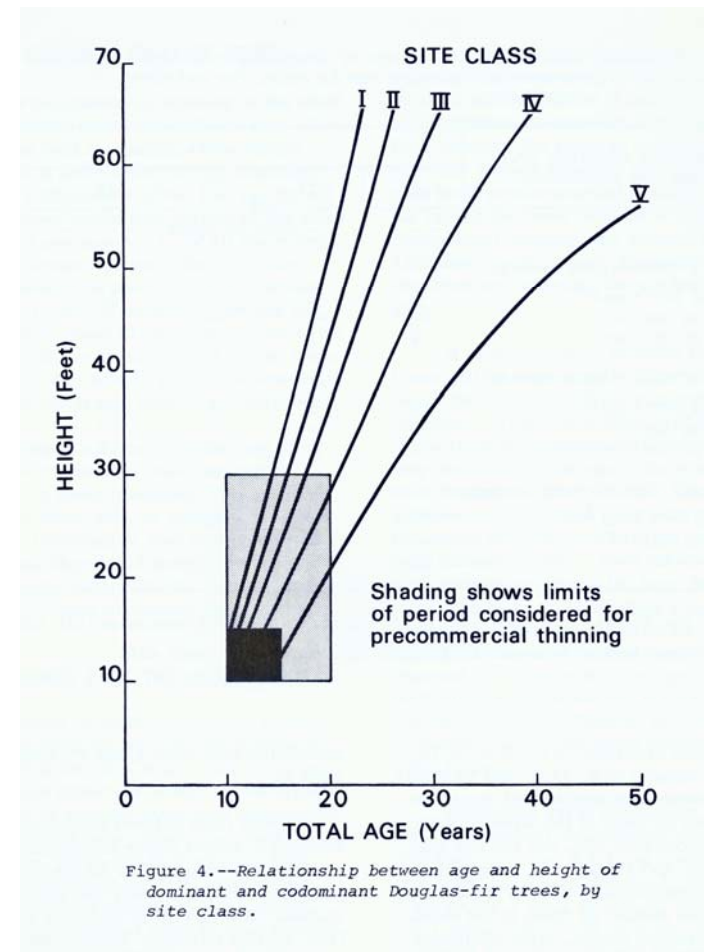


- early PCT = lower biomass = lower fuel loads
- wildlife implications – movement (deer, elk)

# What if I missed that optimum size/age - should I still PCT?

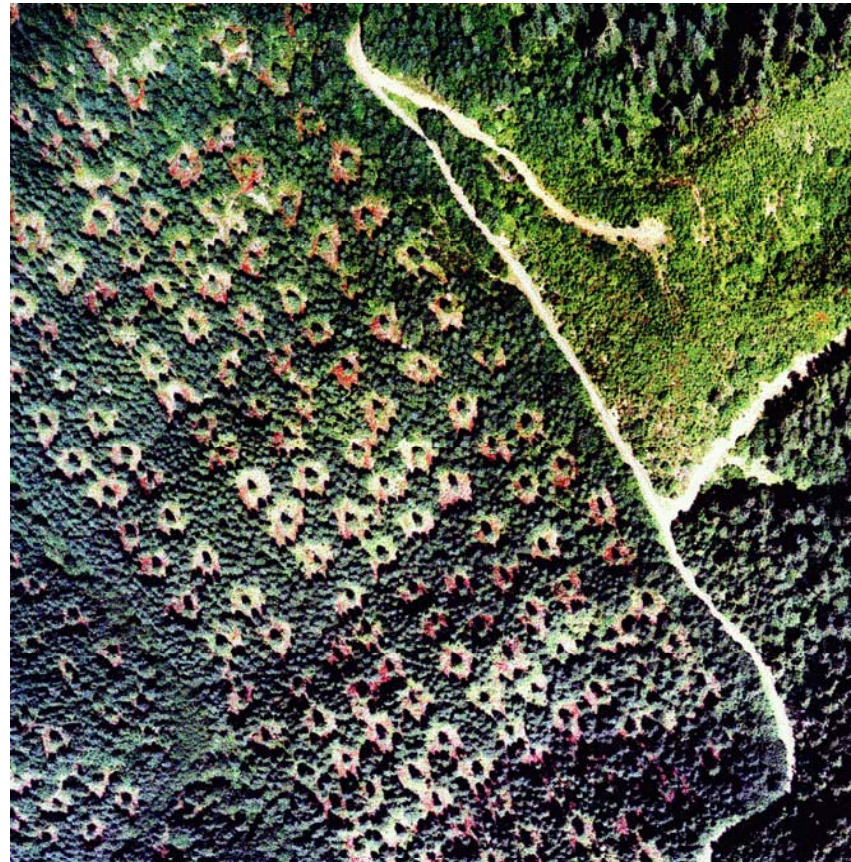
– Early is best, but:

- Volume & DBH gains in stands up  $\approx 30'$  in height are still substantial, but less than optimal age thin\*
- Delay in gain to CT opportunity
- Later PCT may be justified for purposes of enhancing habitat development, stand health purposes
- \*Smith and Reukema 1986



# Are there exceptions to the timing guidelines?

- Habitat development
- Stand stability – long or no rotation, e.g. late-successional reserves



# Um, but what if ...



- my stand is the optimum size/age, but the density is close to the target and I don't have “official” direction?
- How should I decide whether it makes sense to PCT or just let the stand develop at a somewhat higher density

# Density Thresholds

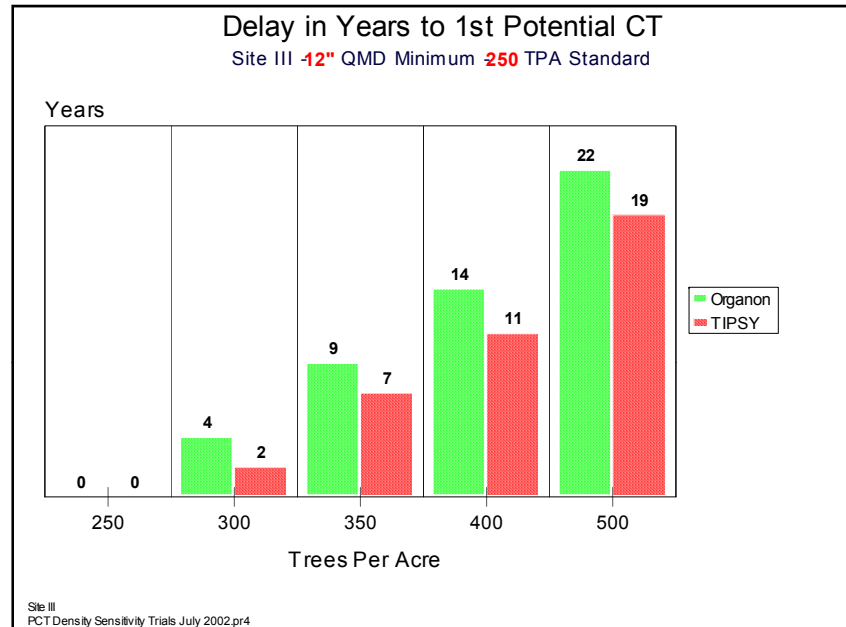
- The level of analysis to determine how many trees above optimum will should trigger a PCT treatment will vary by organization
  - Economic return (private)
  - Growth and harvest assumptions underlying ASQ (government)
  - Combination (government)



# Density Thresholds

- Example of a non-economic analysis:
  - BLM target is 250 trees/acre
  - Harvest scheduling ASQ model is sensitive at the level of 10 year increments
  - Threshold would be based on whether the higher density delayed potential timber harvest by 10 years or more.

# Density Thresholds



- If 250 trees/acre with a 12" DBH is my standard
  - then I should PCT only if the stand density exceeds 350-400 trees per acre

# Species Selection

- PCT is your last chance to significantly influence the species composition of the overstory & midstory
- And in some cases the development of an understory
- This could have a substantial influence on stand structure as well

# Last word on PCT - it's not just for even-aged stands anymore

- Stands past the stand establishment phase managed for structure, i.e. habitat development may need understory density management as well if long-term goals are to be met



# Summary

- The *Stand Establishment* period provides the best opportunity for molding a stand and sending it on a trajectory to your Desired Future Condition --- choices have long lasting results



# Next – Competitive Exclusion





HERE, THERE BE DRAGONS...