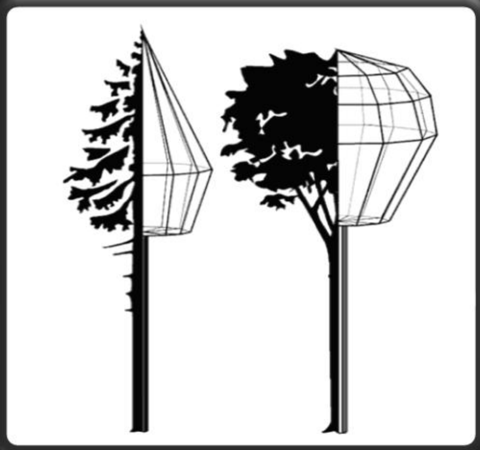
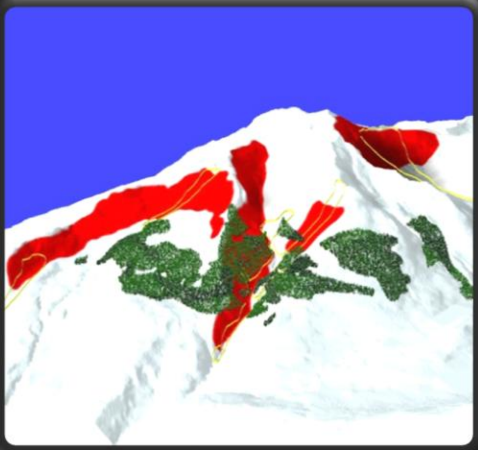
Corso di laurea in SFA e DISMIT
Modulo di ecologia forestale
Anno Accademico 2007-08





Giorgio Vacchiano – Dip.AgroSelviTer
giorgio.vacchiano@unito.it

LA MODELLIZZAZIONE DELLE DINAMICHE FORESTALI

agroselviter
Dipartimento di Agronomia,
Selvicoltura e Gestione del territorio

Contenuti del seminario

- **La modellistica forestale**
  - Modelli e sistemi naturali
  - Oggetto: le dinamiche forestali
  - Tipologie di modelli forestali
  - Strumenti di visualizzazione
- **La gestione della densità**
  - Stand Density Index
  - Density Management Diagrams
- **Esercizi**
  - Calcolo dello SDI dei lariceti piemontesi
  - Gestione selvicolturale su DMD – un caso di studio

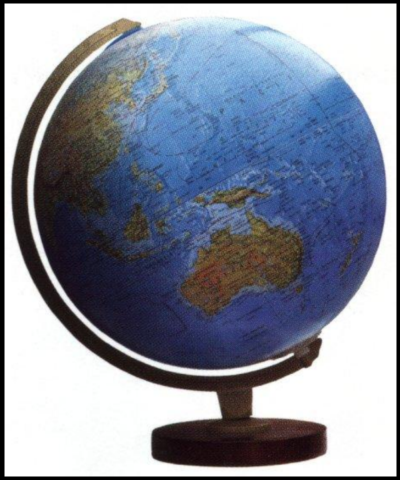
Cos'è un modello?

Una rappresentazione delle caratteristiche fondamentali di un sistema, che produce la conoscenza di quel sistema in una forma utilizzabile.

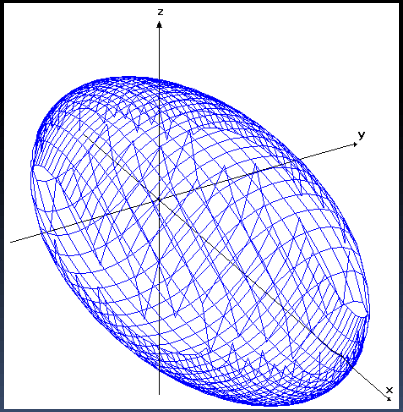
Eykhoff (1974)

Semplificare Codificare	Conoscere Interpretare	Prevedere Decidere

Cos'è un modello?

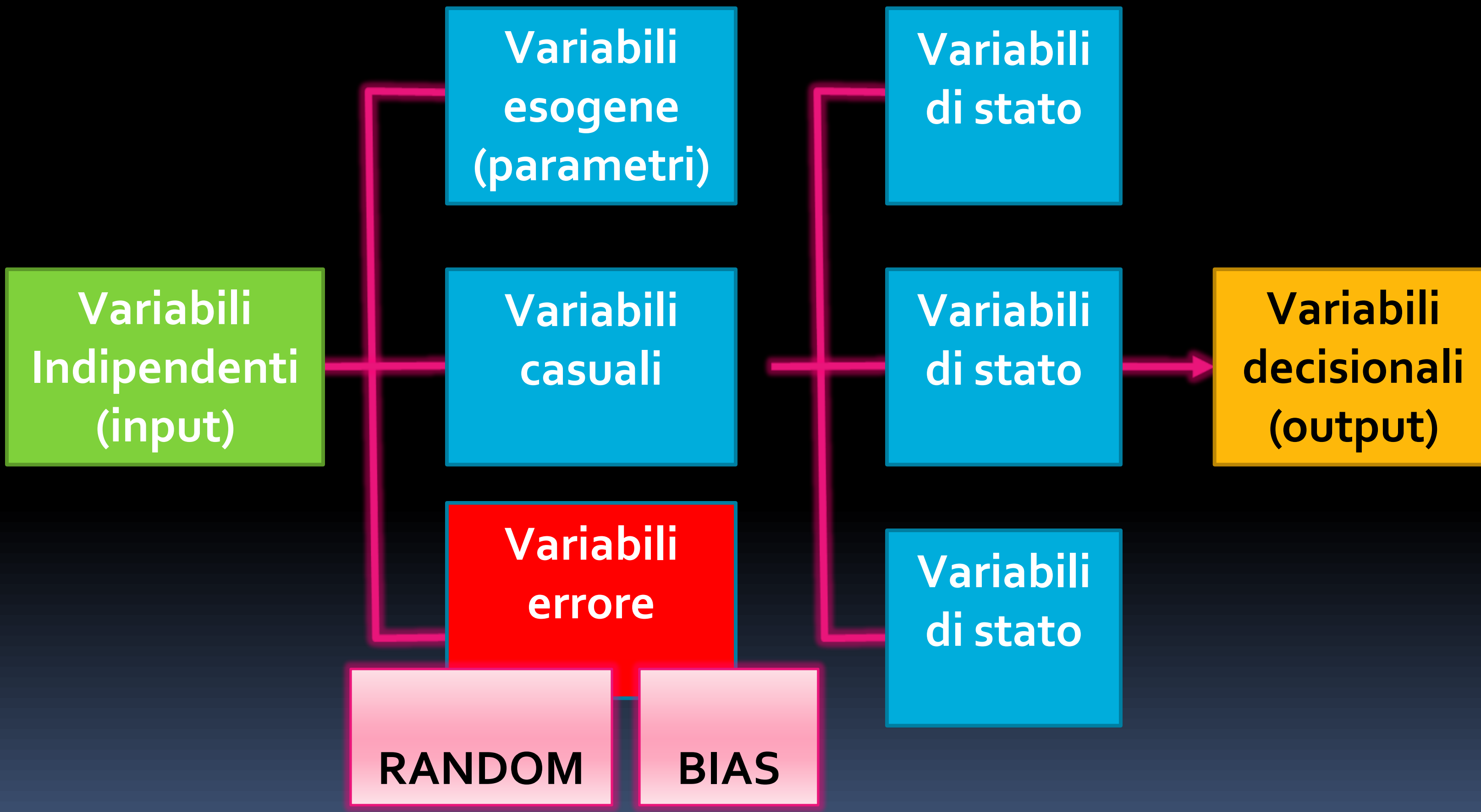


Modello fisico
Relazioni tra oggetti

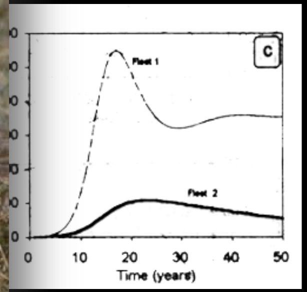


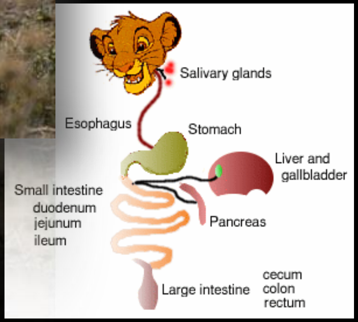
Modello matematico
Relazioni tra variabili

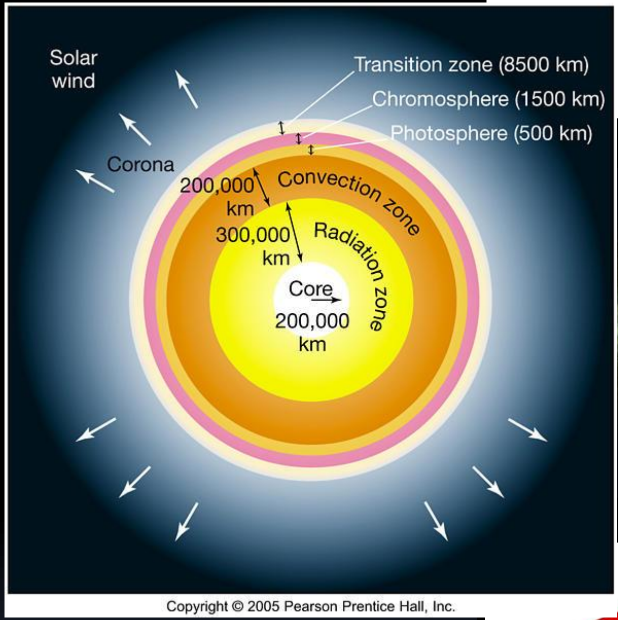
Cos'è un modello?

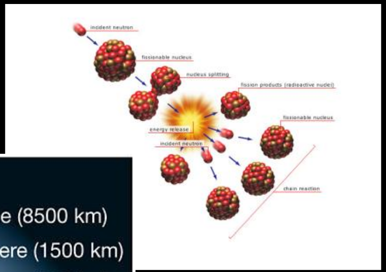


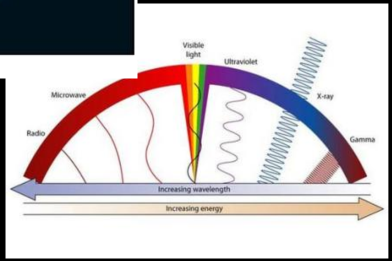
Molti a uno


C
Fleet 1
Fleet 2
0 10 20 30 40 50
Time (years)

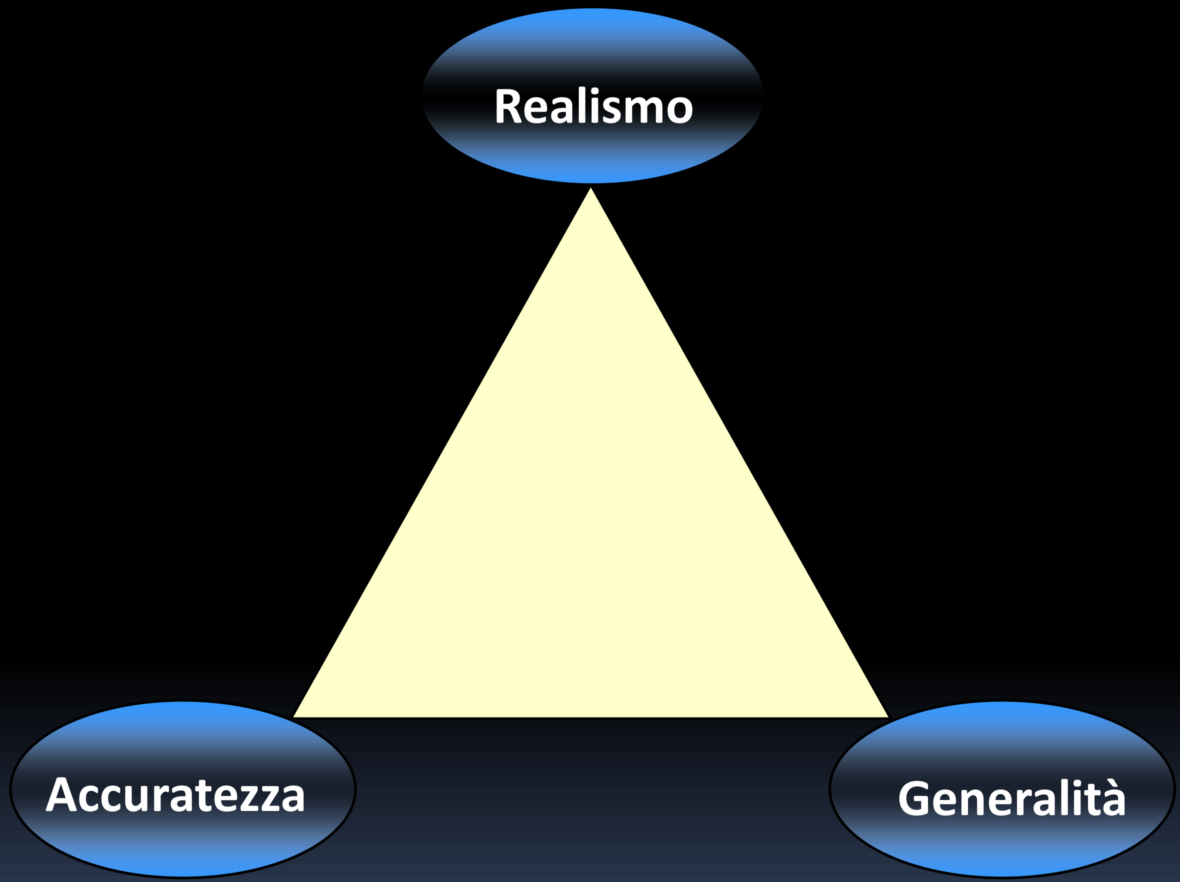

Salivary glands
Esophagus
Stomach
Liver and gallbladder
Small intestine
duodenum
jejunum
ileum
Pancreas
Large intestine
cecum
colon
rectum


Solar wind
Transition zone (8500 km)
Chromosphere (1500 km)
Photosphere (500 km)
Corona
200,000 km
Convection zone
300,000 km
Radiation zone
Core
200,000 km
Copyright © 2005 Pearson Prentice Hall, Inc.

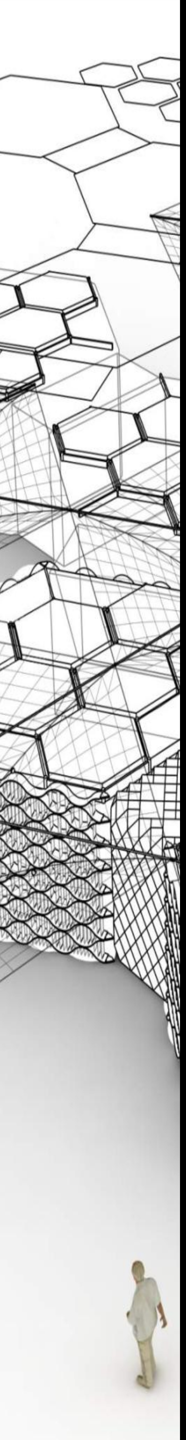



Visible light
Ultraviolet
Microwave
X-ray
Radio
Gamma
Increasing wavelength
Increasing energy

Criteri di scelta



da Levins (1966), Sharpe (1990), Guisan and Zimmermann (2000)



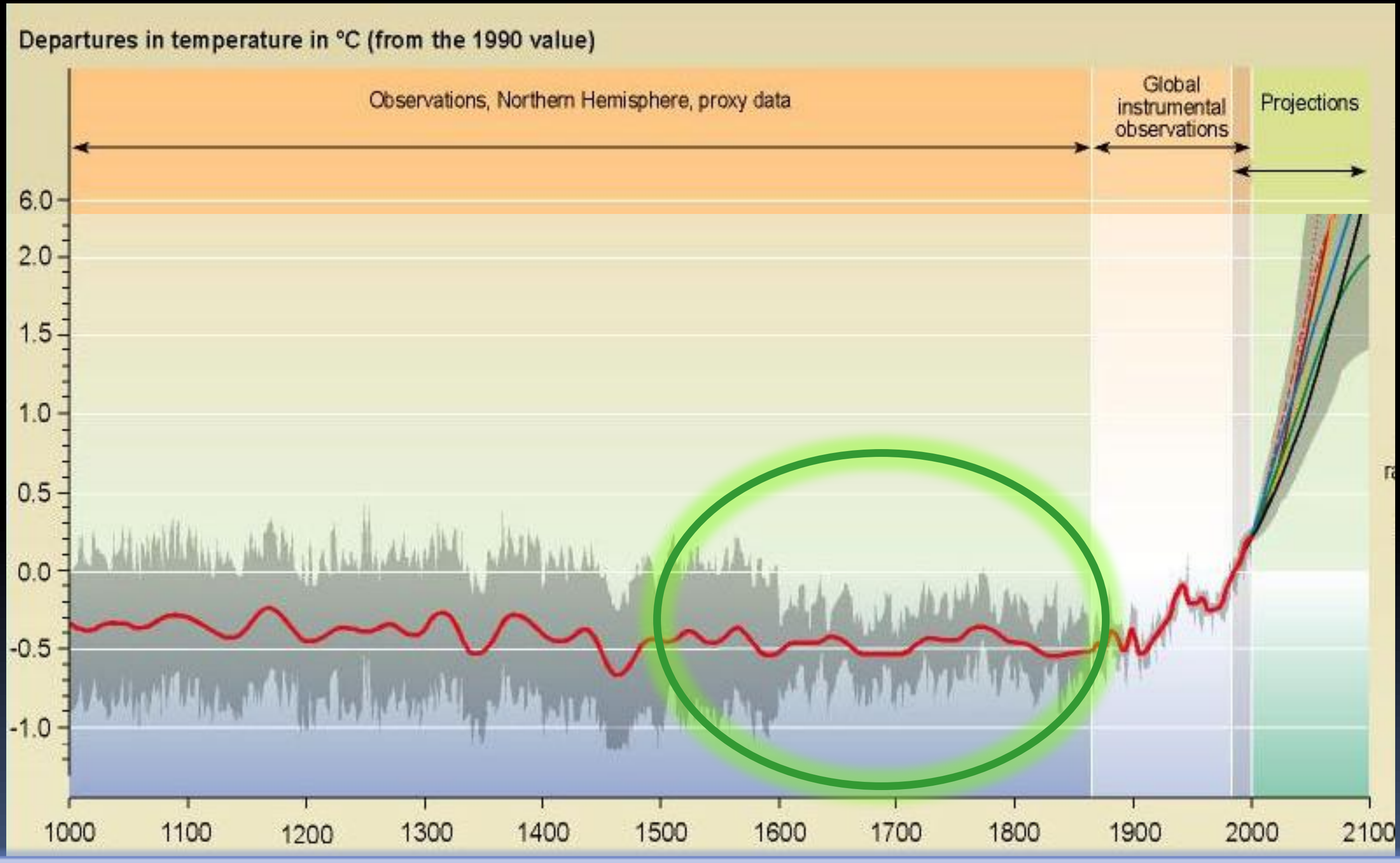
Realismo

Un modello è sempre diverso dalla realtà

- Errore di ADATTAMENTO (scarto)
- Errori LOGICI (causalità)
- Errori SOSTANZIALI (realismo)

Generalità

Campo di applicazione (estrapolazione)



Accuratezza

I fenomeni naturali sono complessi

Riduzionismo
Piccola scala
Molte variabili
Flessibili

MODELLI DETERMINISTICI

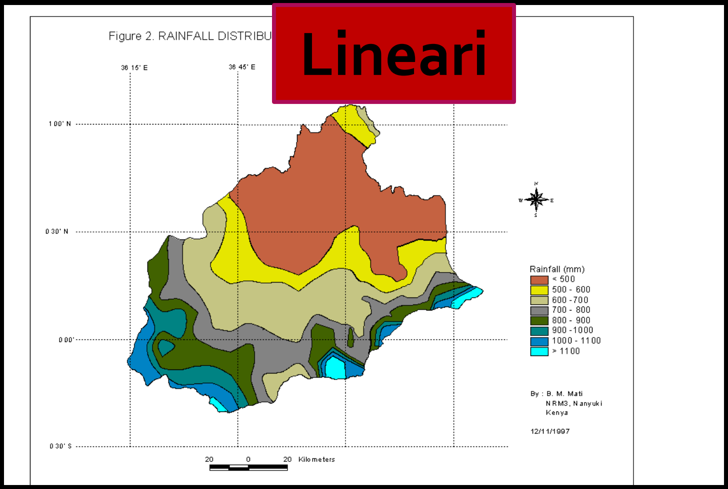
Rasoio di Occam

Parsimonia
Grande scala
Poche variabili
Rigidi

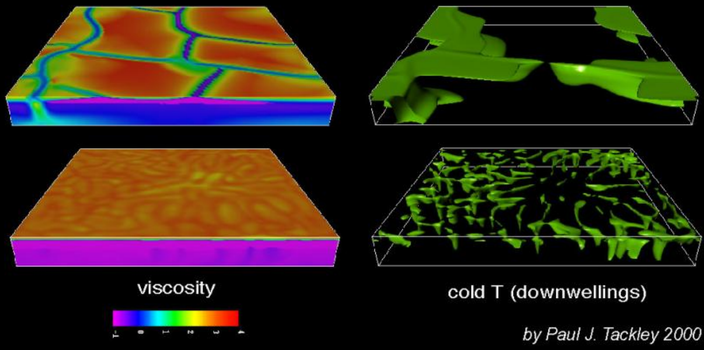
MODELLI PROBABILISTICI

Cos’è un modello?

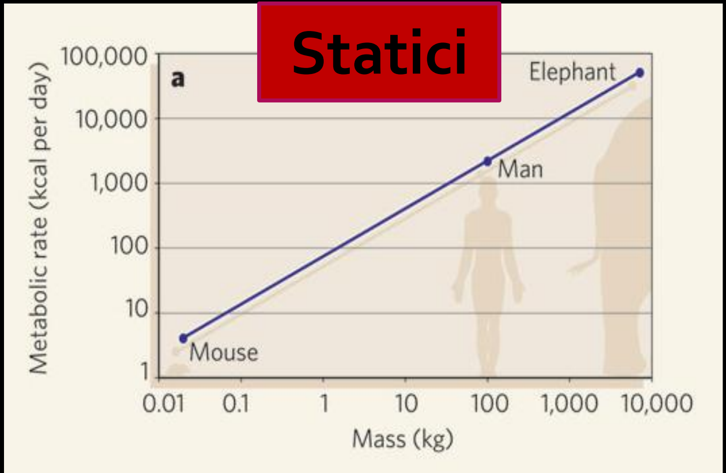
Lineari



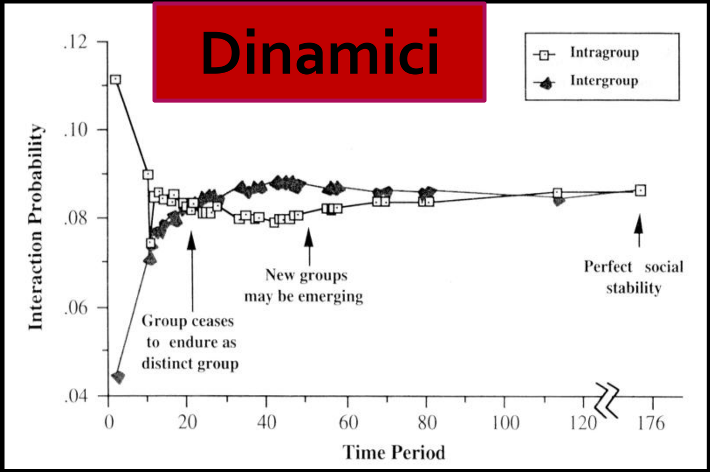
Nonlineari

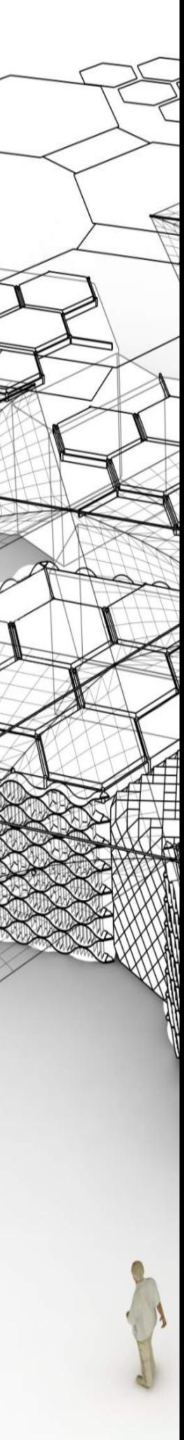


Statici



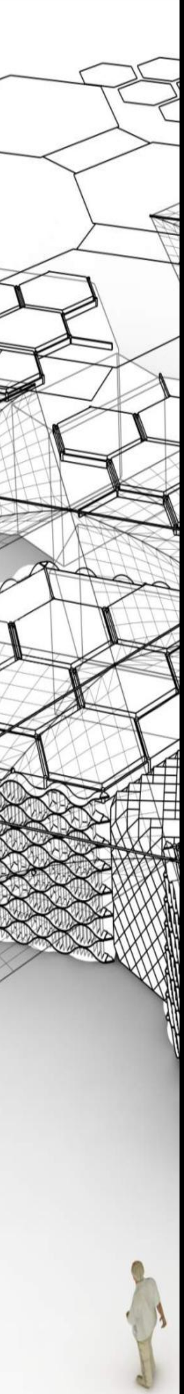
Dinamici

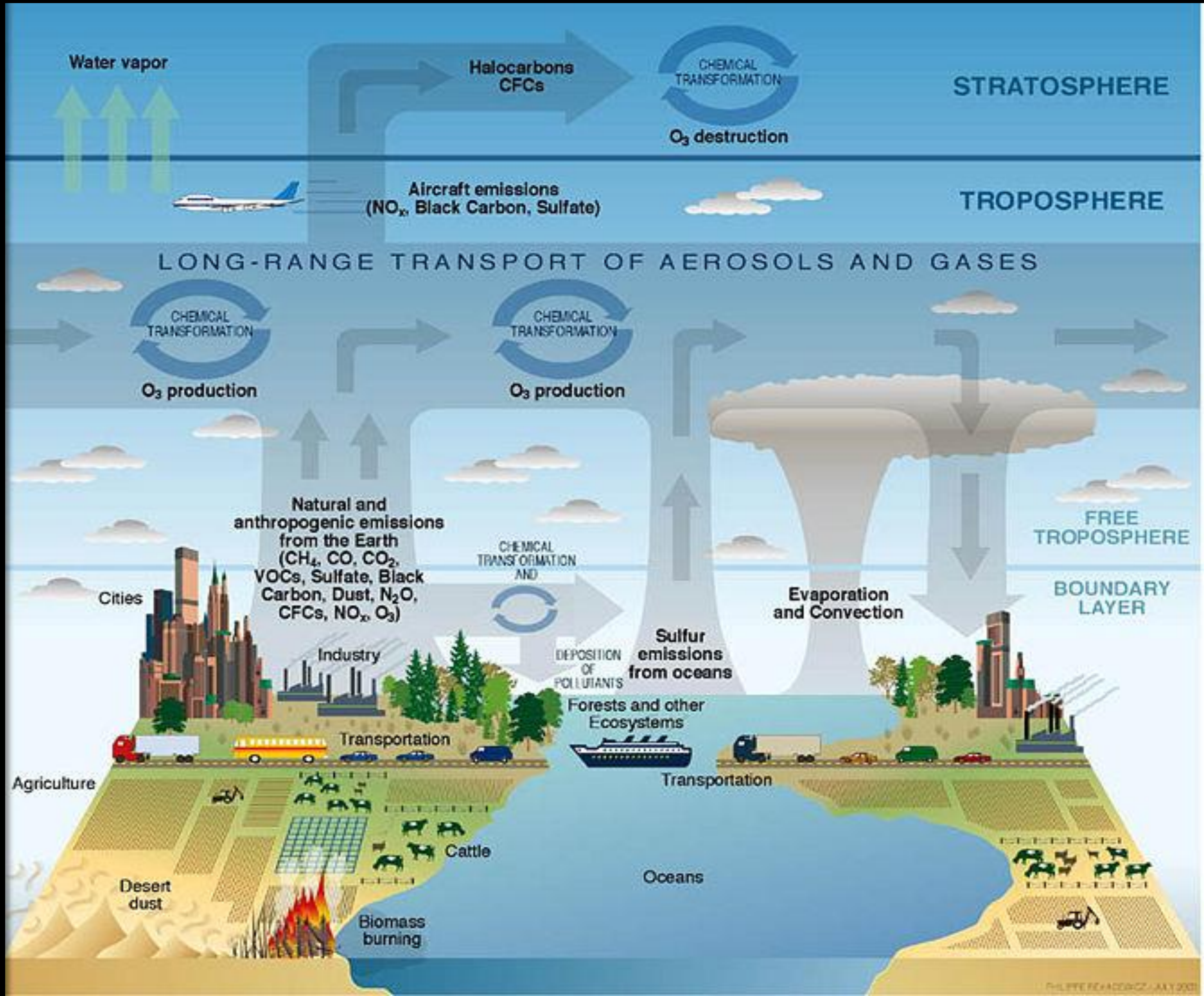




Descrivere

- Esplorare il comportamento di sistemi complessi. “Come reagisce il sistema…”
  - Al passare del tempo, *coeteris paribus*
  - Se l’evento “a” si verifica (es. eruzione vulcanica)
  - Se il fattore “b” cambia (es. temperatura)
  - Se la variabile “c” è rimossa dal sistema (es. circolazione oceanica)

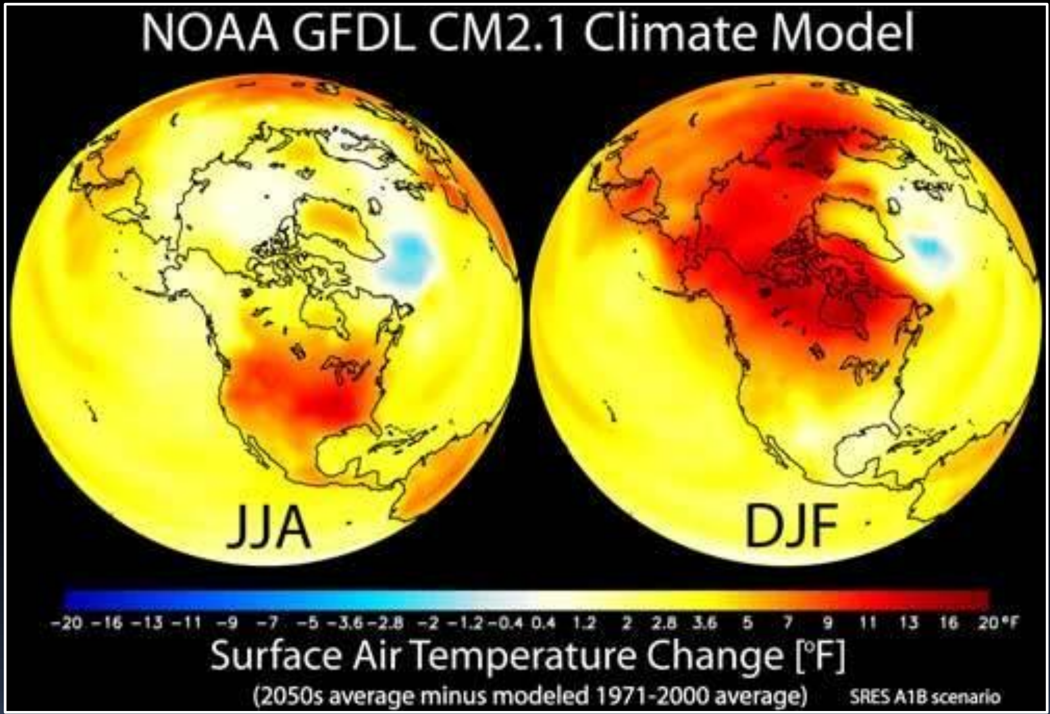


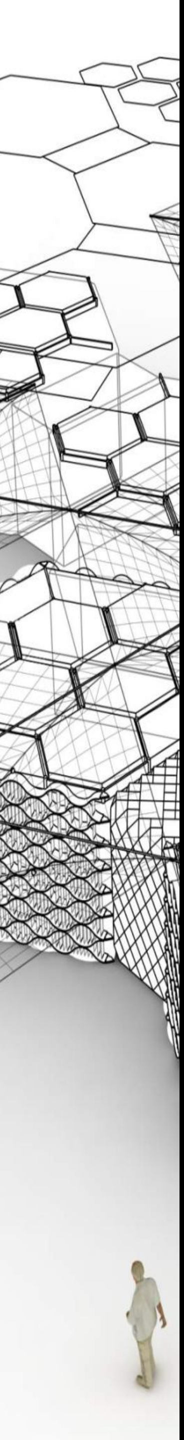


Water vapor
Halocarbons CFCs
CHEMICAL TRANSFORMATION
O_3 destruction
STRATOSPHERE
Aircraft emissions (NO_x, Black Carbon, Sulfate)
TROPOSPHERE
LONG-RANGE TRANSPORT OF AEROSOLS AND GASES
CHEMICAL TRANSFORMATION
O_3 production
CHEMICAL TRANSFORMATION
O_3 production
Natural and anthropogenic emissions from the Earth (CH_4, CO, CO_2, VOCs, Sulfate, Black Carbon, Dust, N_2O, CFCs, NO_x, O_3)
CHEMICAL TRANSFORMATION AND
DEPOSITION OF POLLUTANTS
Sulfur emissions from oceans
Evaporation and Convection
FREE TROPOSPHERE
BOUNDARY LAYER
Cities
Industry
Forests and other Ecosystems
Transportation
Transportation
Agriculture
Cattle
Desert dust
Oceans
Biomass burning

Prevedere

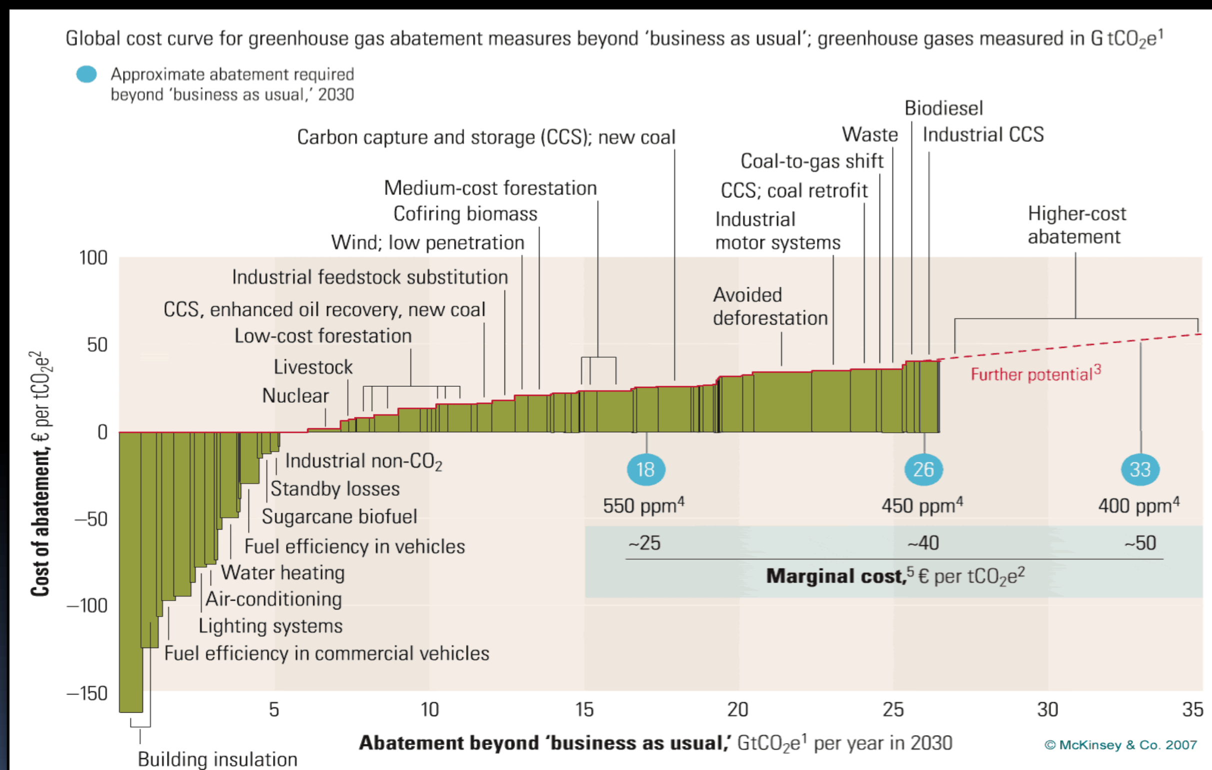
- In base alle leggi indotte dai sistemi osservati, come si comporteranno questi in futuro?

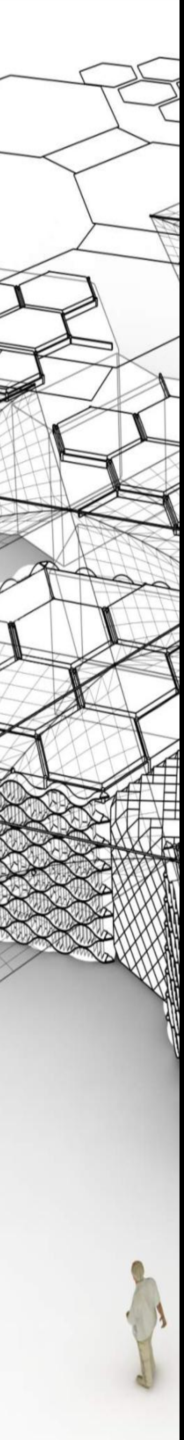




Decidere

- In base allo scarto tra obiettivi e previsioni, come gestire il sistema in questione?





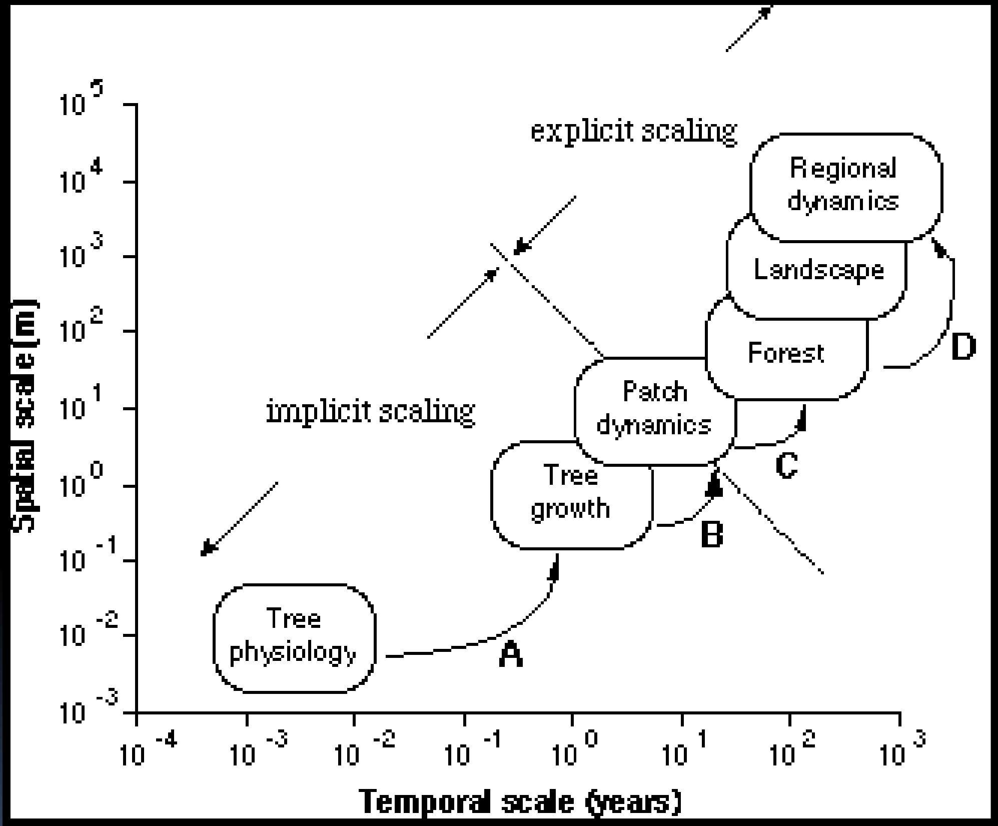
Model building

1. Osservazione
2. Interpretazione (ipotesi)
3. Forma del modello (algoritmo)
4. Codifica (calibrazione)
5. Controllo (validazione)
6. Visualizzazione
7. Utilizzatore finale

Fase induttiva
Dati -> hyp

Fase deduttiva
Hyp -> Dati

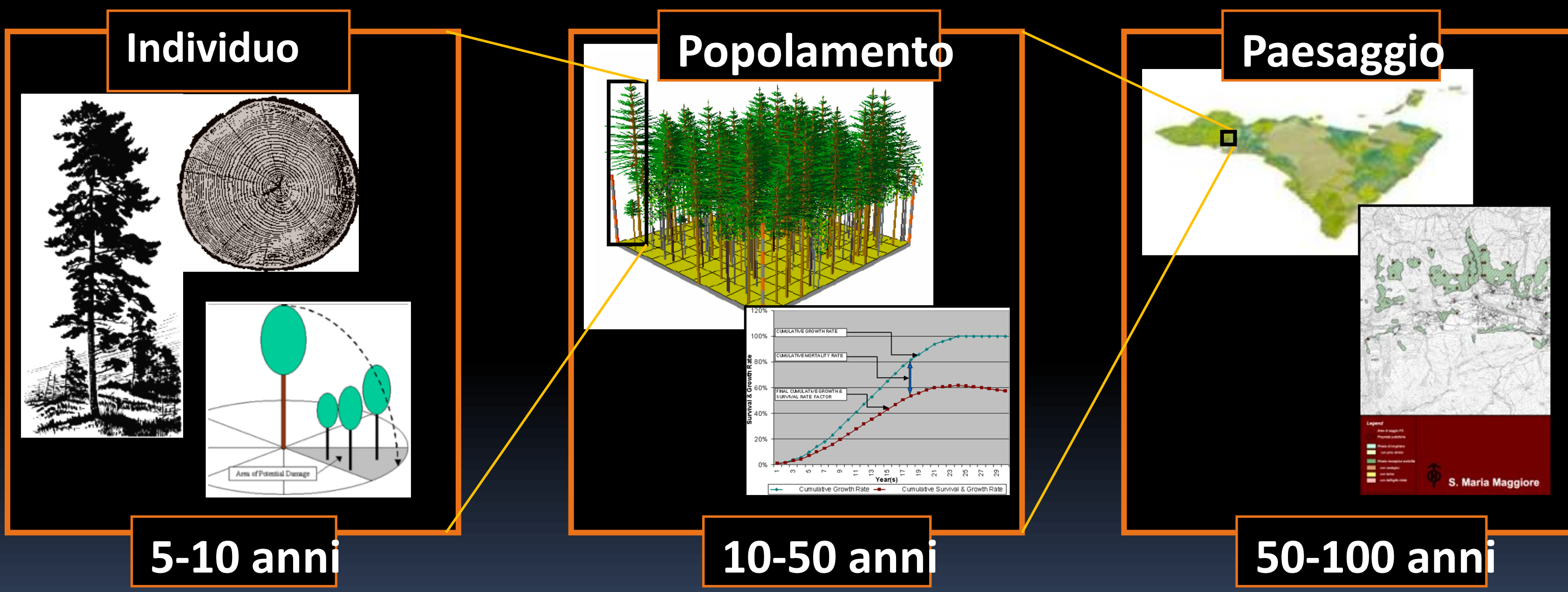
Oggetto della modellizzazione



I processi che caratterizzano qualsiasi <u>livello di organizzazione</u>, o anche più di uno (modelli GERARCHICI)

Oggetto della modellizzazione

Modelli predittivi delle dinamiche forestali



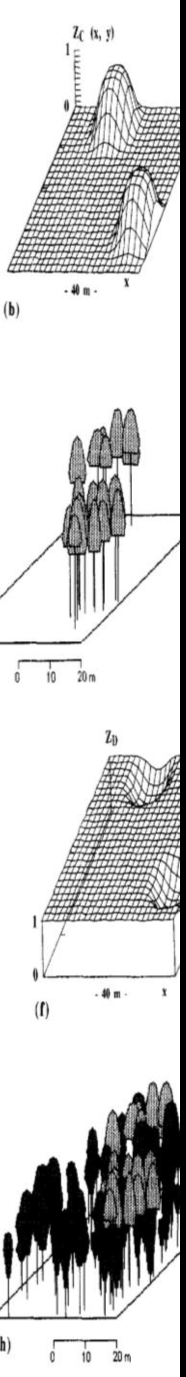
Oggetto della modellizzazione

1896

now

future

????



Empirical growth models

Incorporation of knowledge about the physiological processes

Flexibility and extrapolation ability

Process-based models

Complexity/Scale^{-1}

Detail of *output*

Demand of *input*

Stand models without DBH distribution

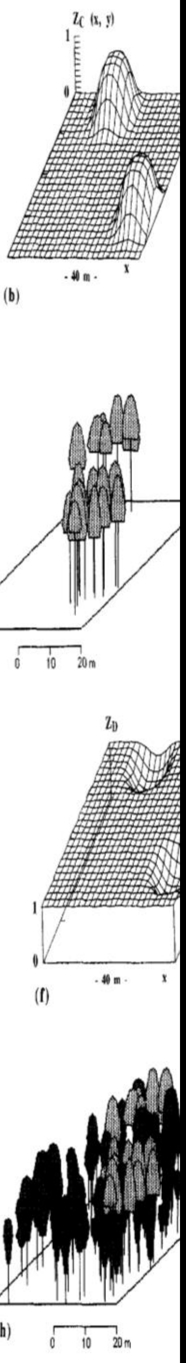
Stand models with DBH distribution

Individual tree models distance independent

Individual tree models distance dependent

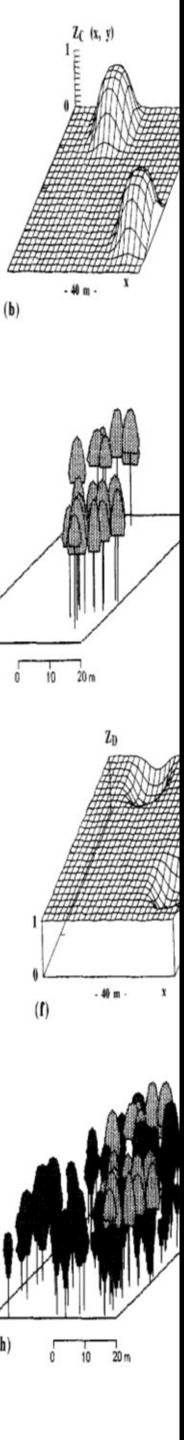
Physiological models Gap models

Detail of *output*

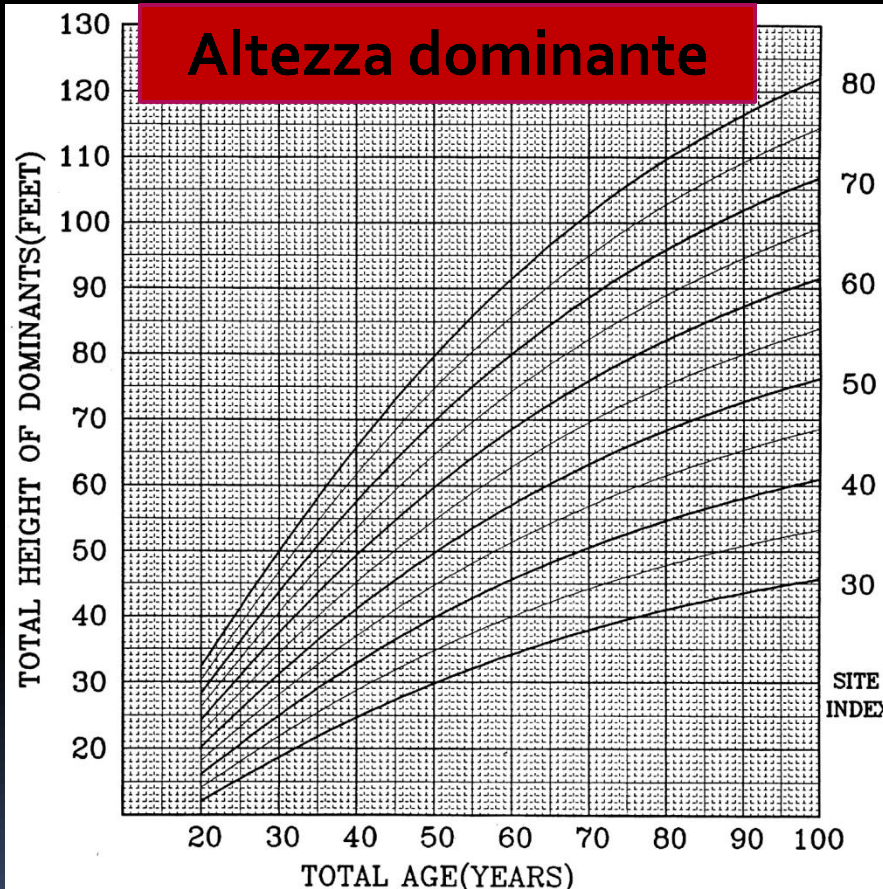


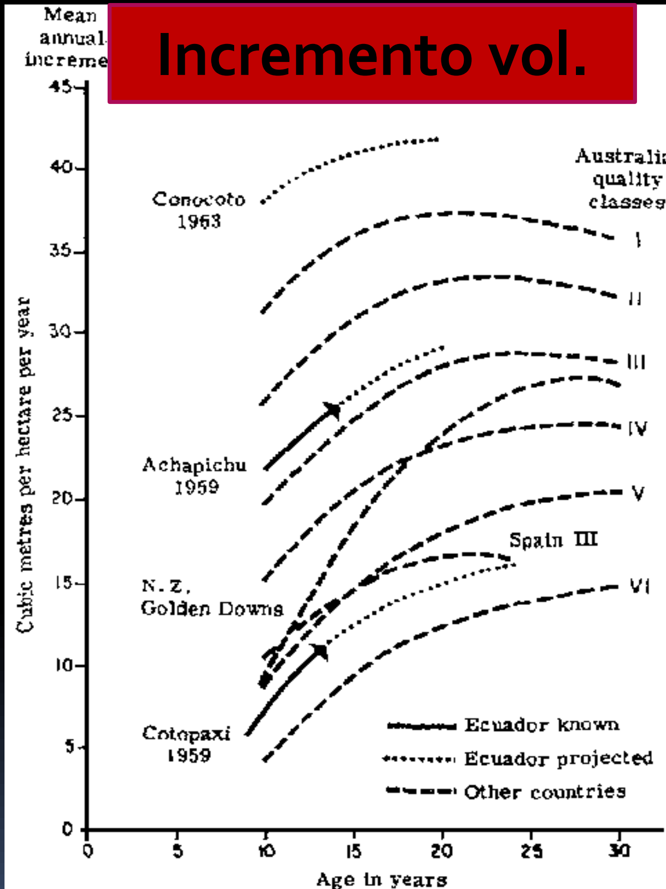
Tavole alsometriche

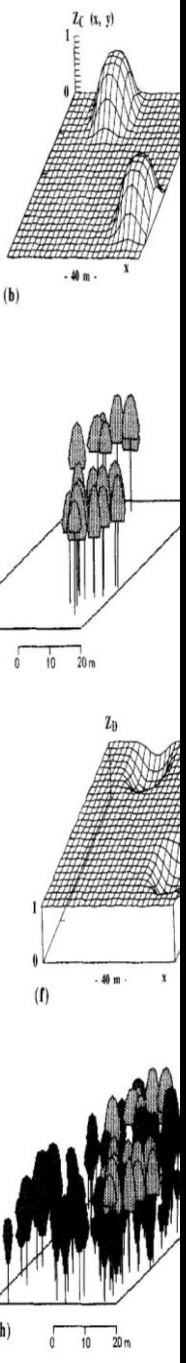
	CLASSE OTTIMA				CLASSE MEDIA					CLASSE SCADENTE		
Età media	altezza media	massa totale	incre-mento medio totale	altezza media	massa totale	legna	incre-mento medio totale	incre-mento medio legna	altezza media	massa totale	incre-mento medio totale
anni	m.	mc.	mc.	mc.	mc.	mc.	mc.	mc.	m.	mc.	mc.
10	2.50	26.1	2.61	1.90	20.9	1.5	2.09	0.15	1.30	15.0	1.50
12	3.10	34.4	2.87	2.30	26.9	8.9	2,24	0.74	1.60	19.4	1.61
14	3.60	42.2	3.01	2.70	33.4	16.0	2.38	1.14	1.90	14.0	1.71
16	4.00	51.5	3.22	3.10	40.2	23.2	2.51	1.45	2.10	29.0	1.81
18	4.30	60.7	3.37	3.30	47.5	30.4	2.64	1.69	2.30	34.2	1.90
20	4.60	70.0	3.50	3.60	54.7	37.2	2.73	1.86	2.50	39.4	1.97
22	4.90	79.2	3.60	3.80	61.8	44.2	2.81	2.01	2.70	44.5	2.02
24	5.10	88.5	3.69	4.00	69.0	50.8	2.87	2.12	2.80	49.7	2.07
26	5.30	97.5	3.75	4.10	75.9	57,2	2.92	2.20	2.90	54.6	2.10
28	5.50	105.0	3.75	4.30	82,2	63.0	2.93	2.25	3.00	59.0	2.11
30	5.60	111.9	3.73	4.40	87.5	68.4	2.92	2.28	3.10	63.0	2.10
32	5.70	118.6	3.70	4.50	92.4	73.2	2.89	2.29	3.10	66.5	2.08
34	5.80	124.2	3.65	4.50	97.0	77.5	2.85	2.27	3.20	69.8	2.05
36	5.90	129.0	3.58	4.60	100.8	81.1	2.80	2.25	3.20	72.6	2.02
38	5.90	133.3	3.50	4.60	104.4	84.8	2.74	2.23	3.30	75.2	1.98
40	6.00	137,0	3.42	4.70	107.3	87 . 8	2,68	2.20	3.30	77.3	1.93



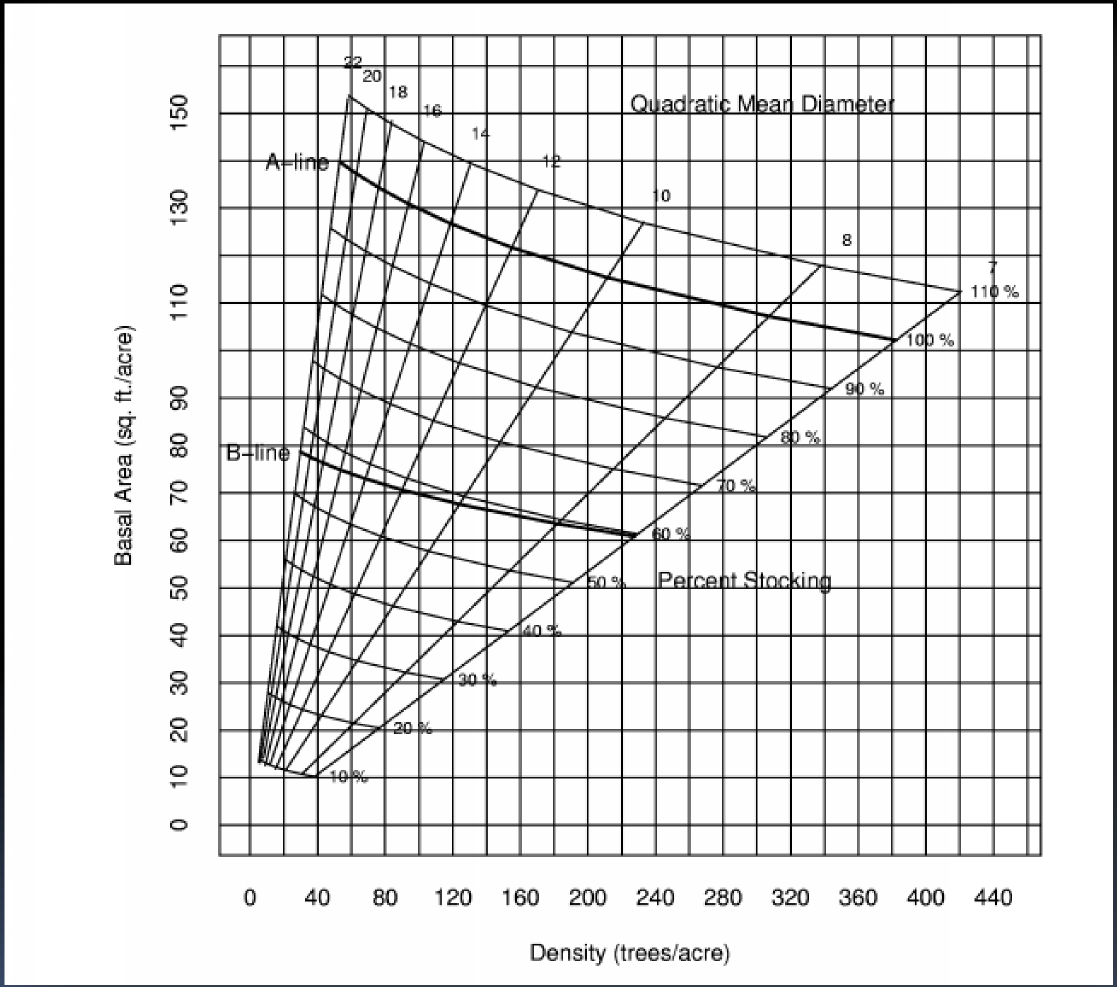
Equazioni differenziali

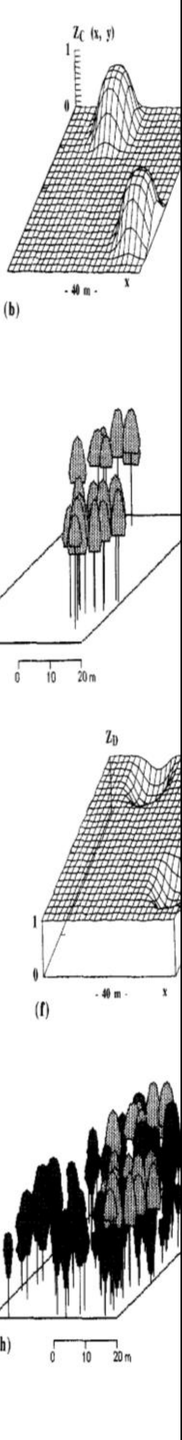




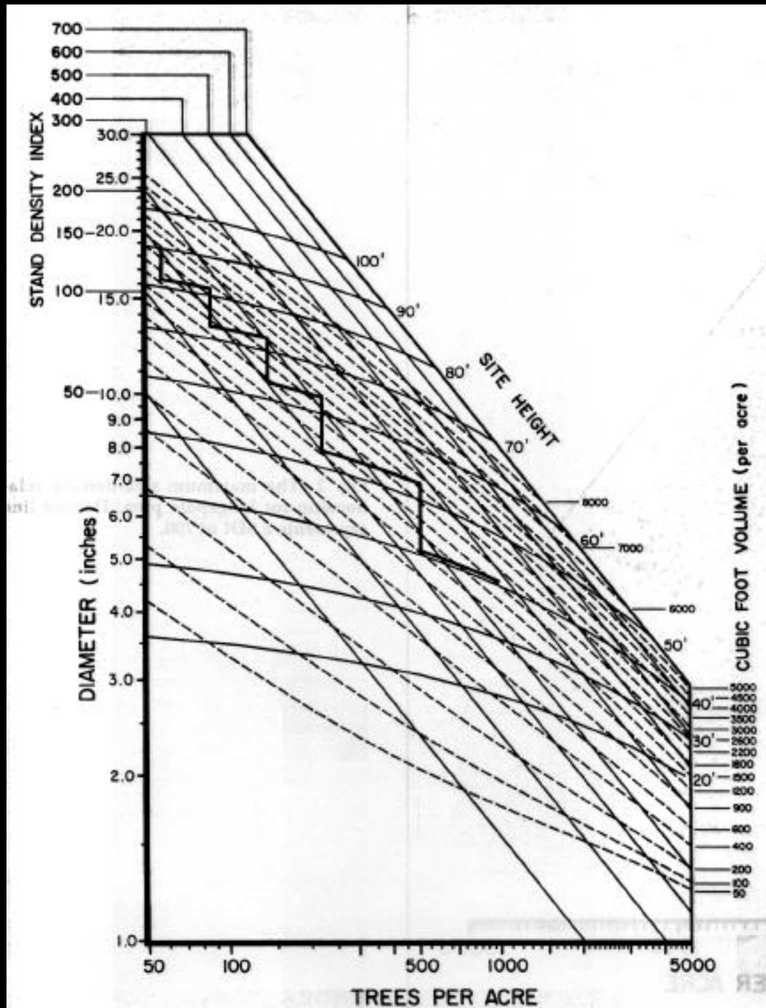


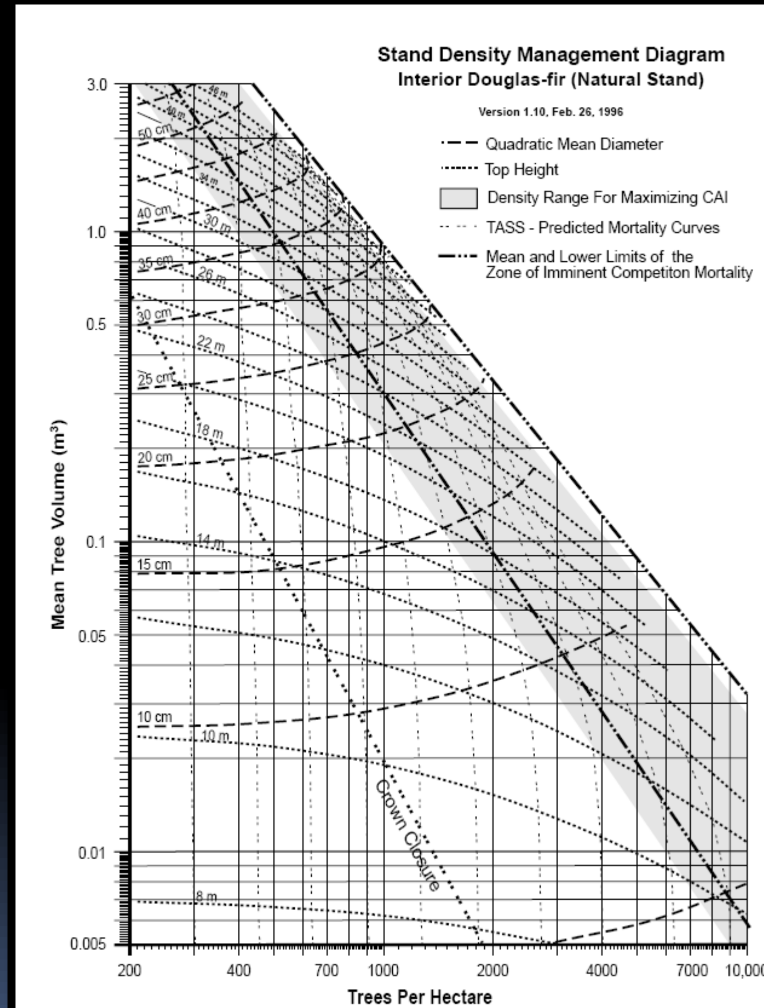
Stocking charts



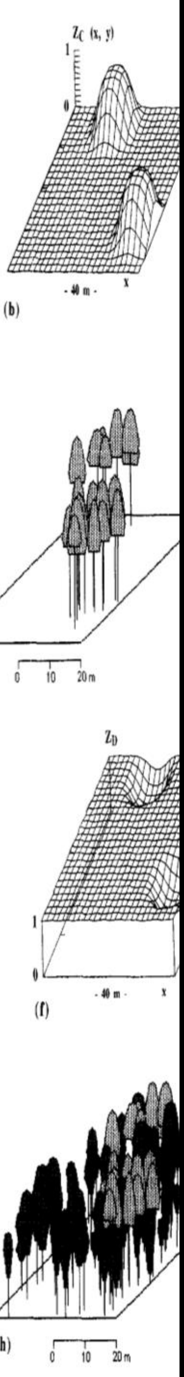


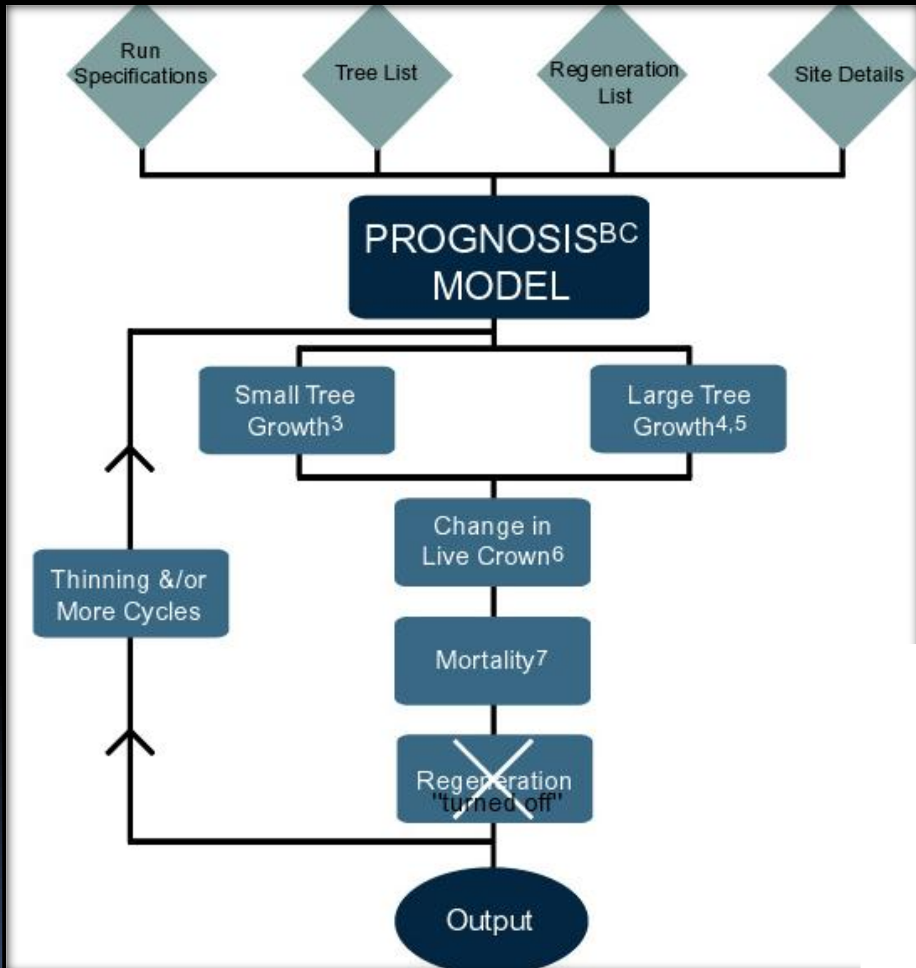
Density Management Diagrams

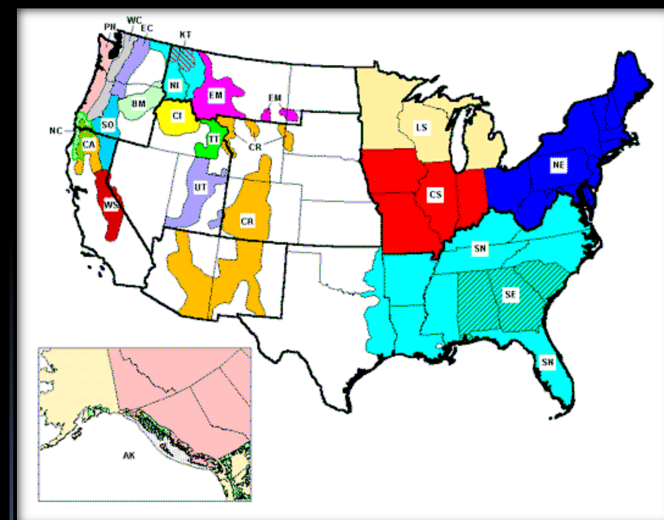


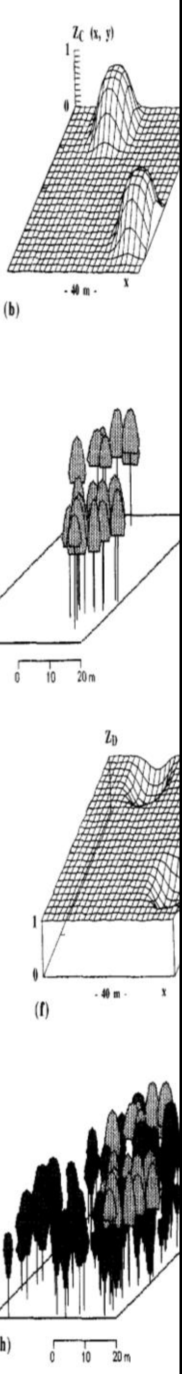


Modelli individuali

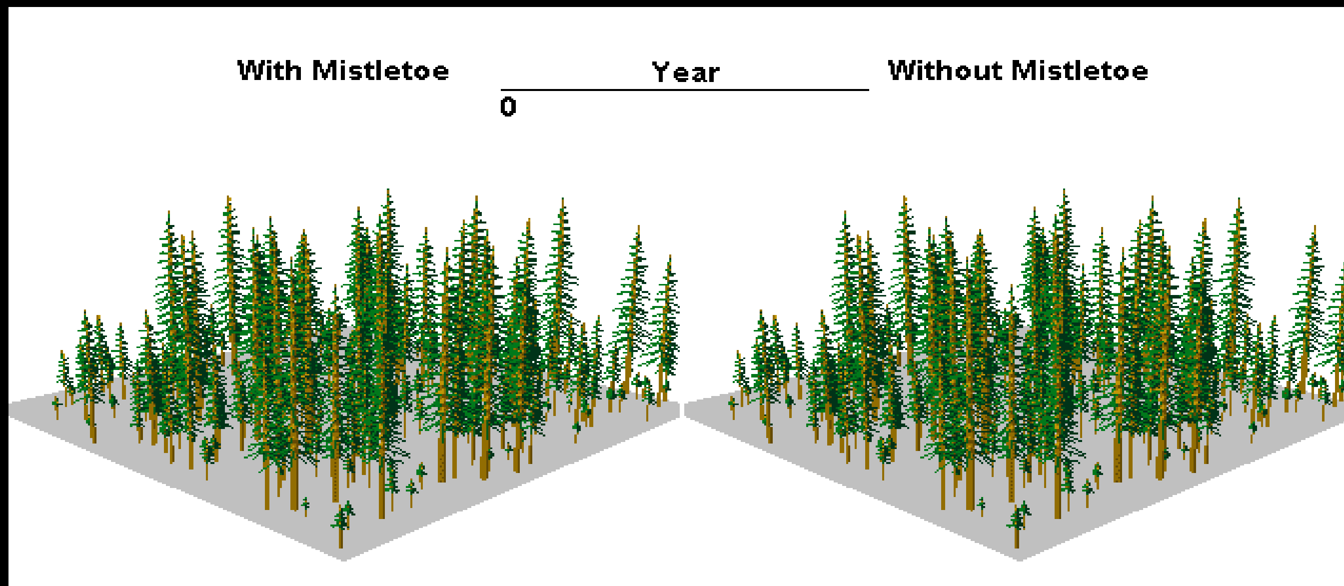


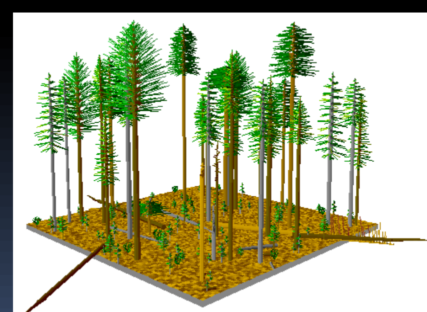




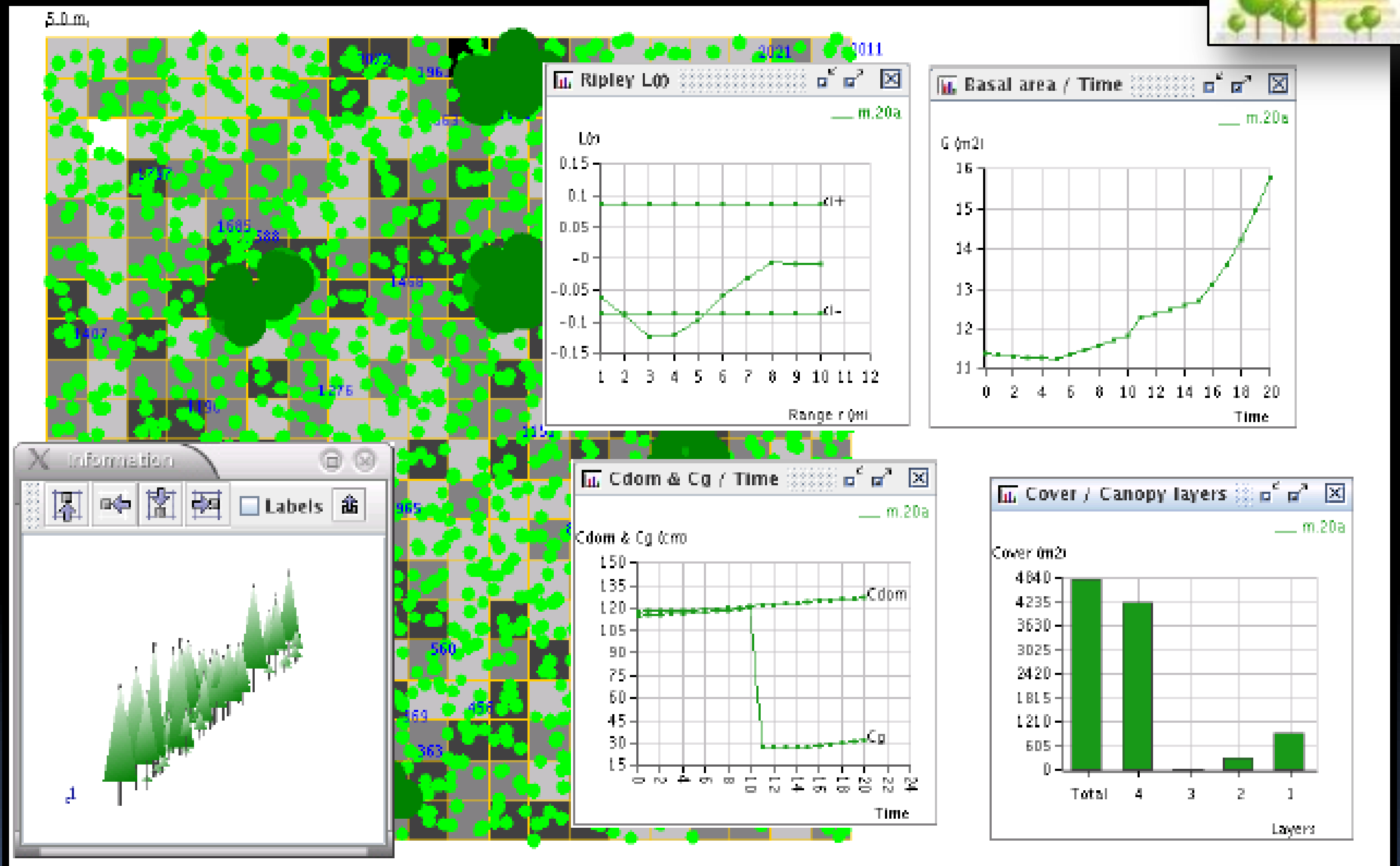


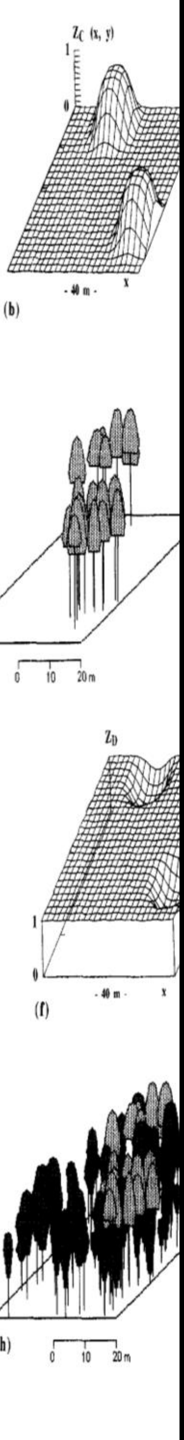
FVS (senza coordinate)

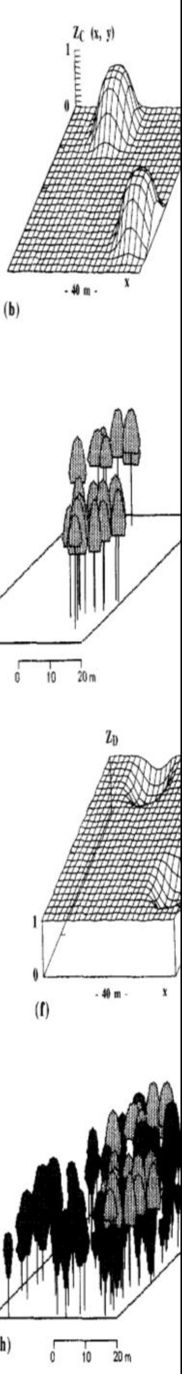




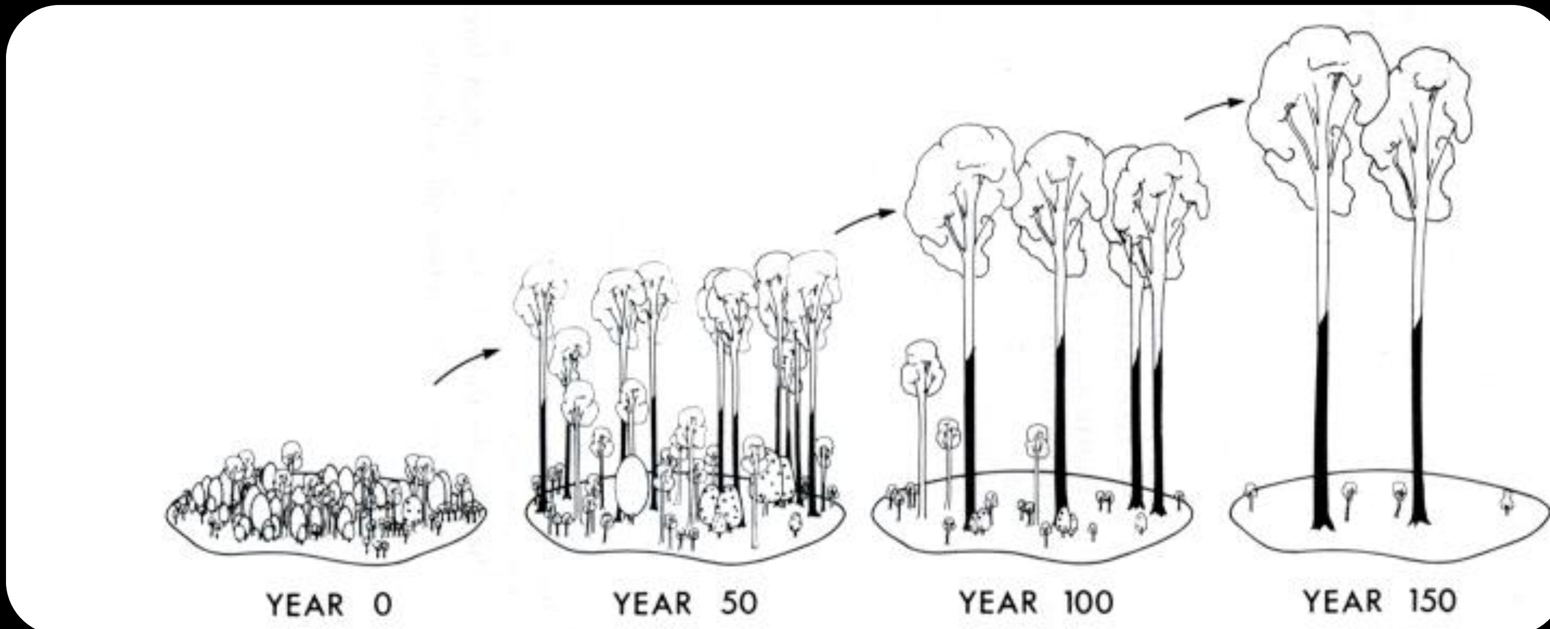
CAPSIS (con coordinate)

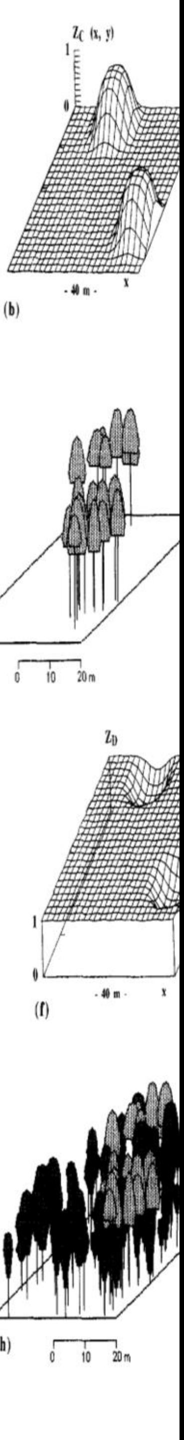




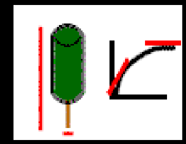
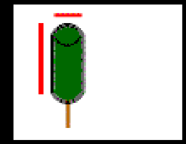
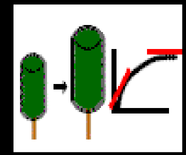
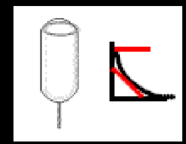
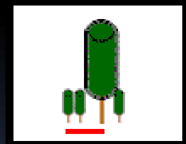
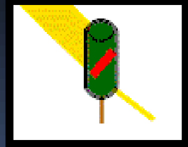


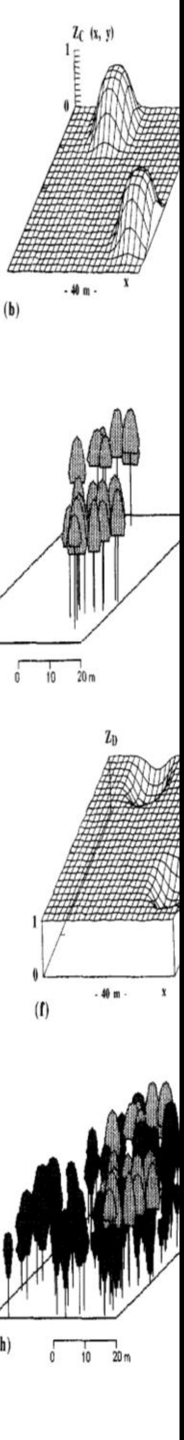
Modelli di patch



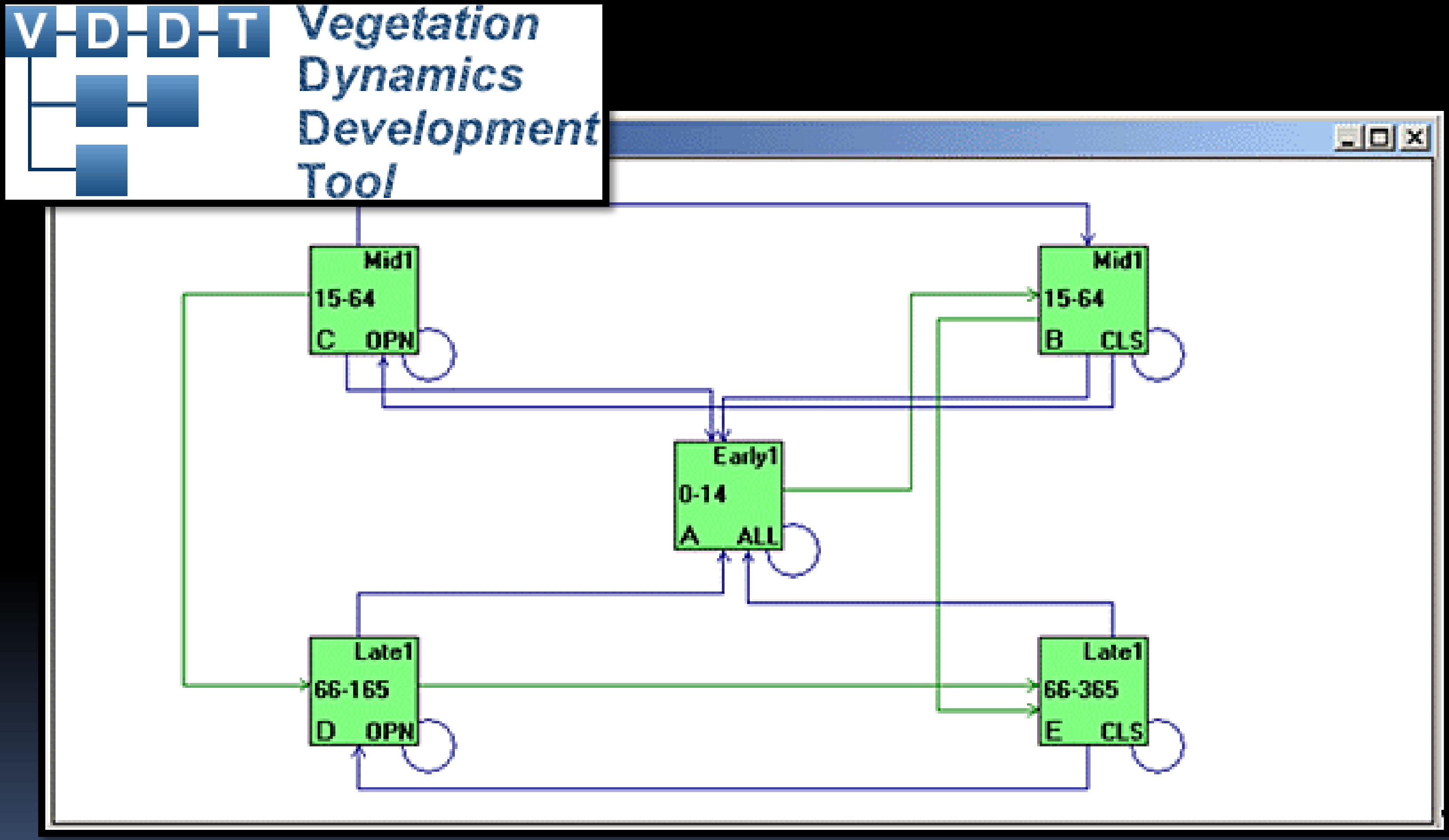


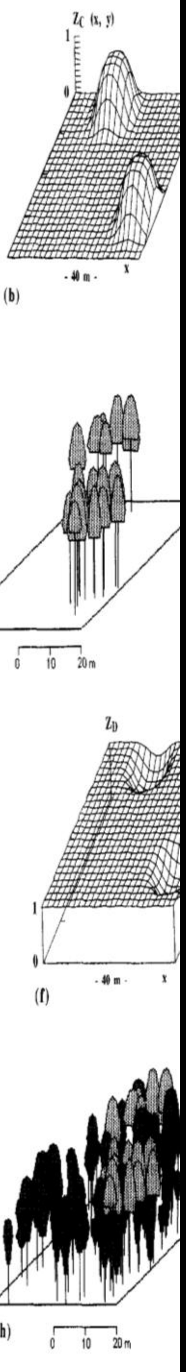
Modelli di patch

Tree Allometry		Relationship between tree height and trunk diameter.
Crown Allometry		Crown width and depth as a function of tree height.
Growth function		Slope and asymptote of growth as a function of light.
Mortality function		Intercept and decay rate of mortality as a function of growth rate.
Dispersal		Distance that seedlings are dispersed.
Shading		The amount of light intercepted by the crown.

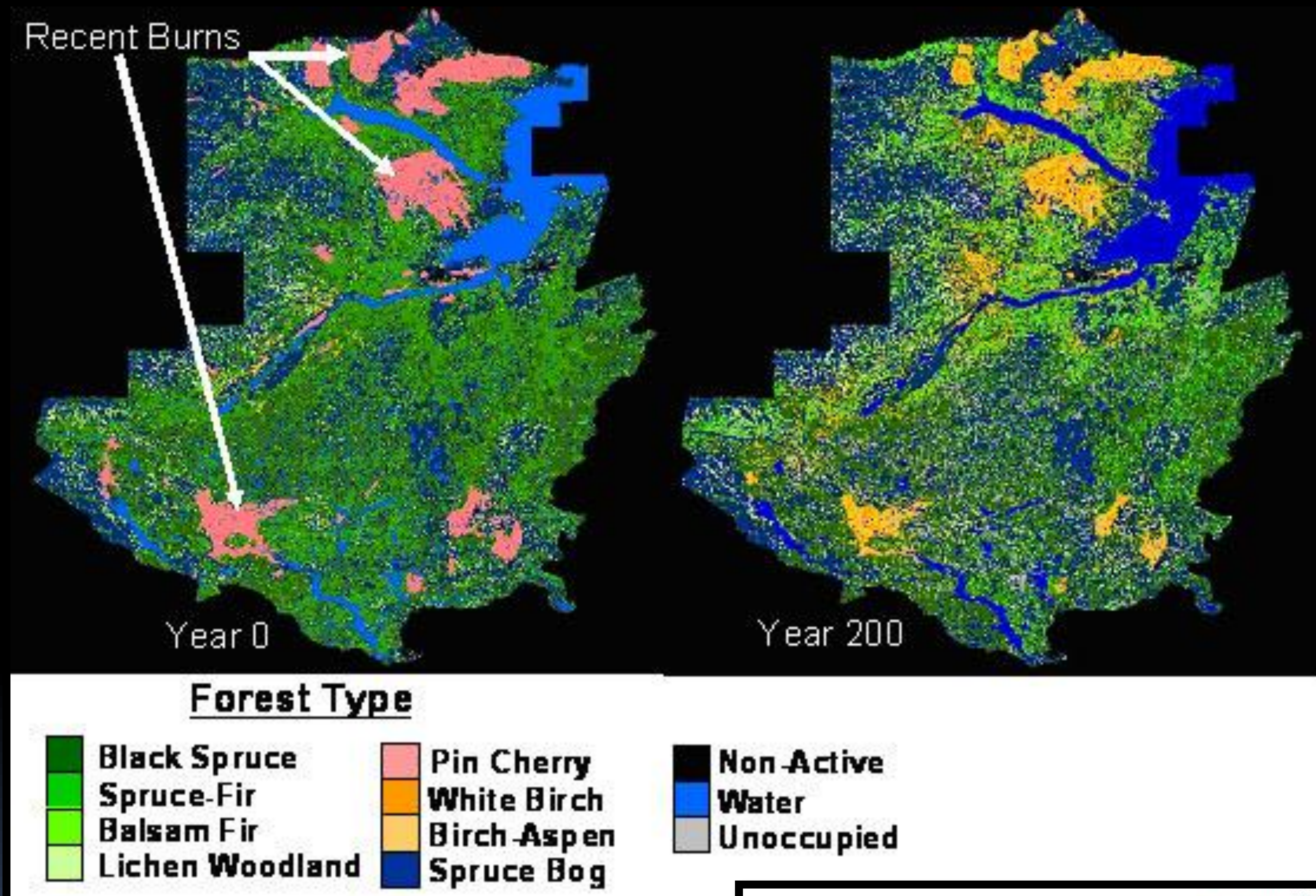


Modelli *state-and-transition*: successioni

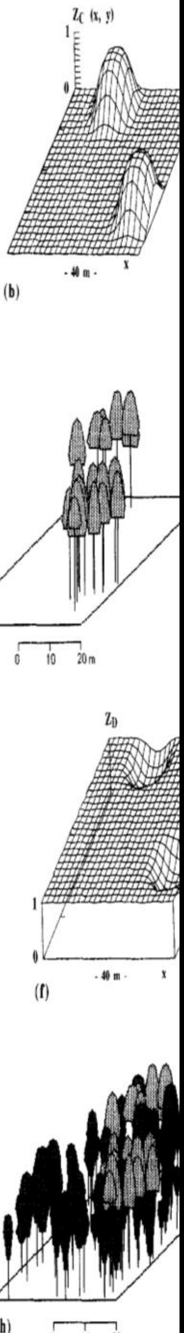




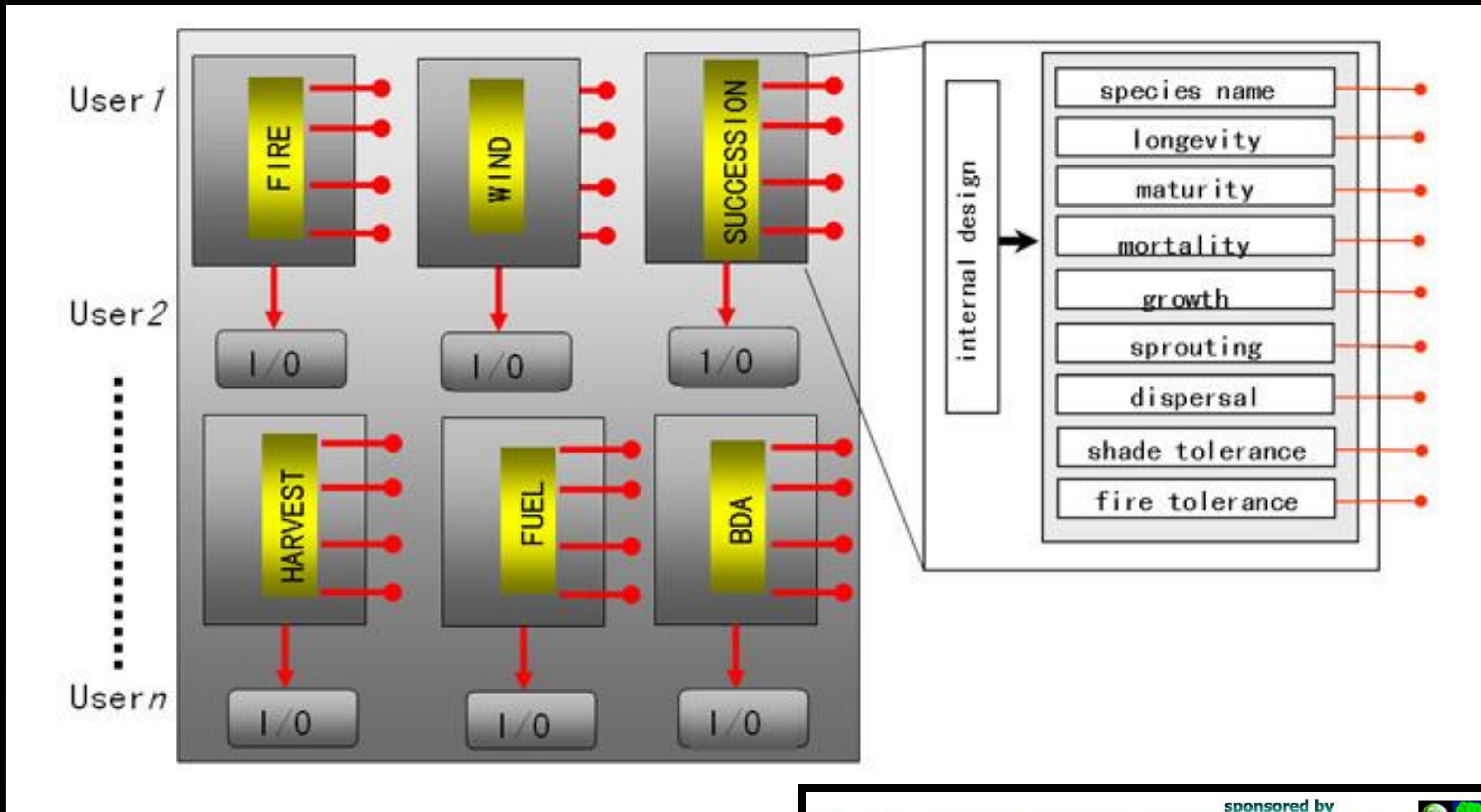
Modelli di paesaggio

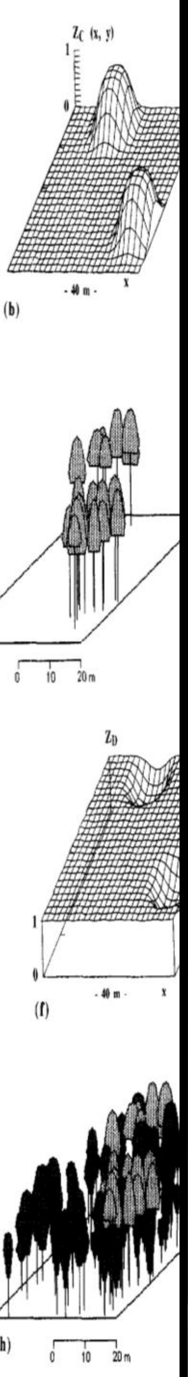


LANDIS-II sponsored by



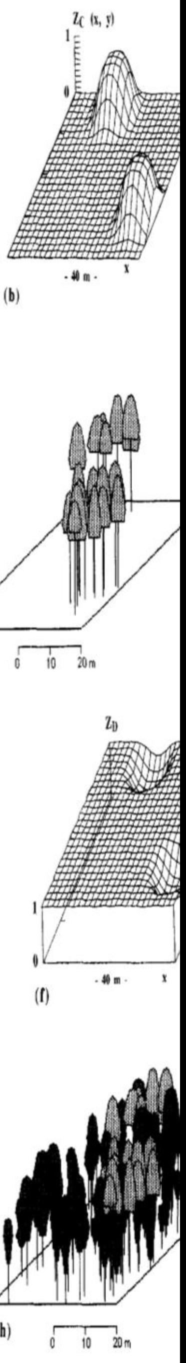
Modelli di paesaggio





Riferimenti utili

- C. Peng (2000) Understanding the role of forest simulation models in sustainable forest management. Environmental Impact Assessment Review 20: 481–501A.
- Porté, H.H. Bartelink (2002) Modelling mixed forest growth: a review of models for forest management. Ecological Modelling 150: 141–188
- J. Landsberg (2003) Modeling forest ecosystems. Can. J. For. Res. 33: 385–397
- A. Stage (2003) How forest models are connected to reality. Can. J. For. Res. 33: 410-421



Riferimenti utili

- www.fs.fed.us/fmsc/fvs/
  Forest Vegetation Simulator
- http://coligny.free.fr/
  CAPSIS
- www.essa.com/vddt/
  Vegetation Dynamics Development Tool
- www.landis-ii.org/
  LANDIS II
- http://eco.wiz.uni-kassel.de/ecobas.html
  www server for Ecological modeling

Density Management Diagrams

Mortalità da competizione che si verifica progressivamente al crescere degli individui.

Data una certa **capacità portante** esiste un numero limite di alberi di una certa dimensione che possono coesistere sulla stessa area.

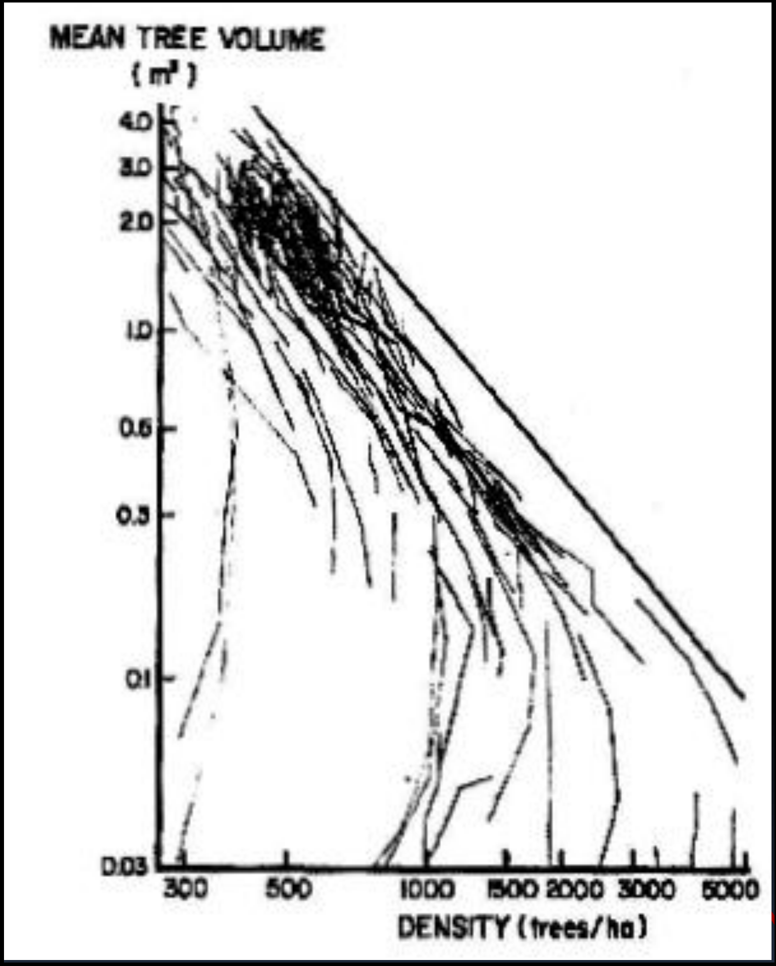
A causa della competizione intraspecifica, **dimensioni massime** degli individui e densità sono inversamente proporzionali.

Density Management Diagrams

Popolamenti puri, coetanei, indisturbati.

Linea di max densità:

$$Vol = aN^{-3/2}$$



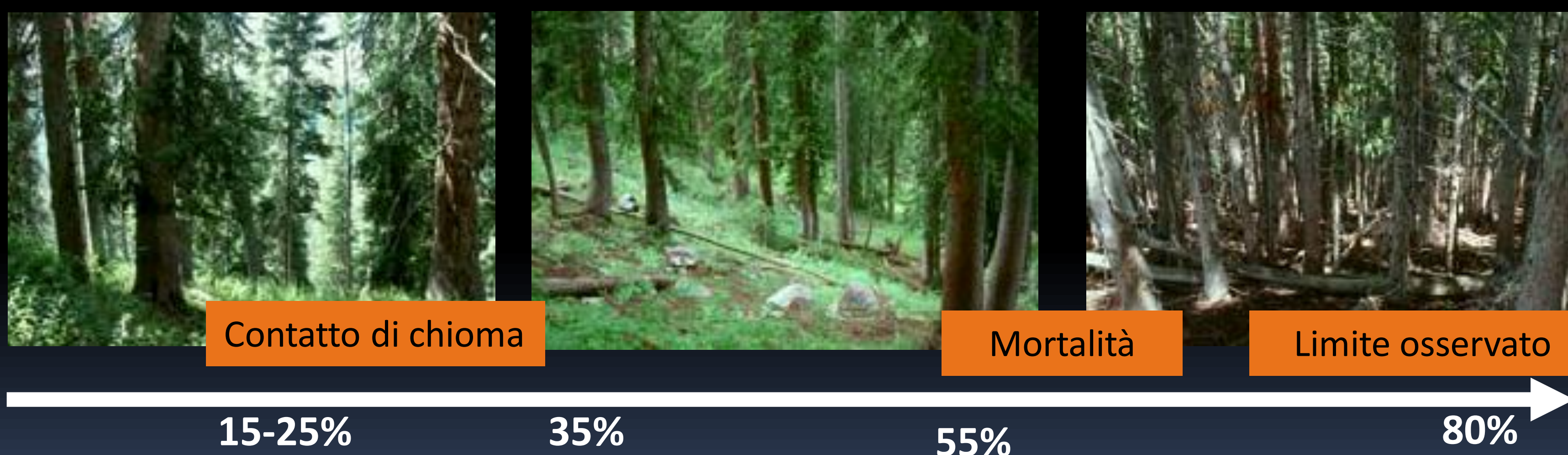
da Drew & Flewelling,(1977, 1979)

Density Management Diagrams

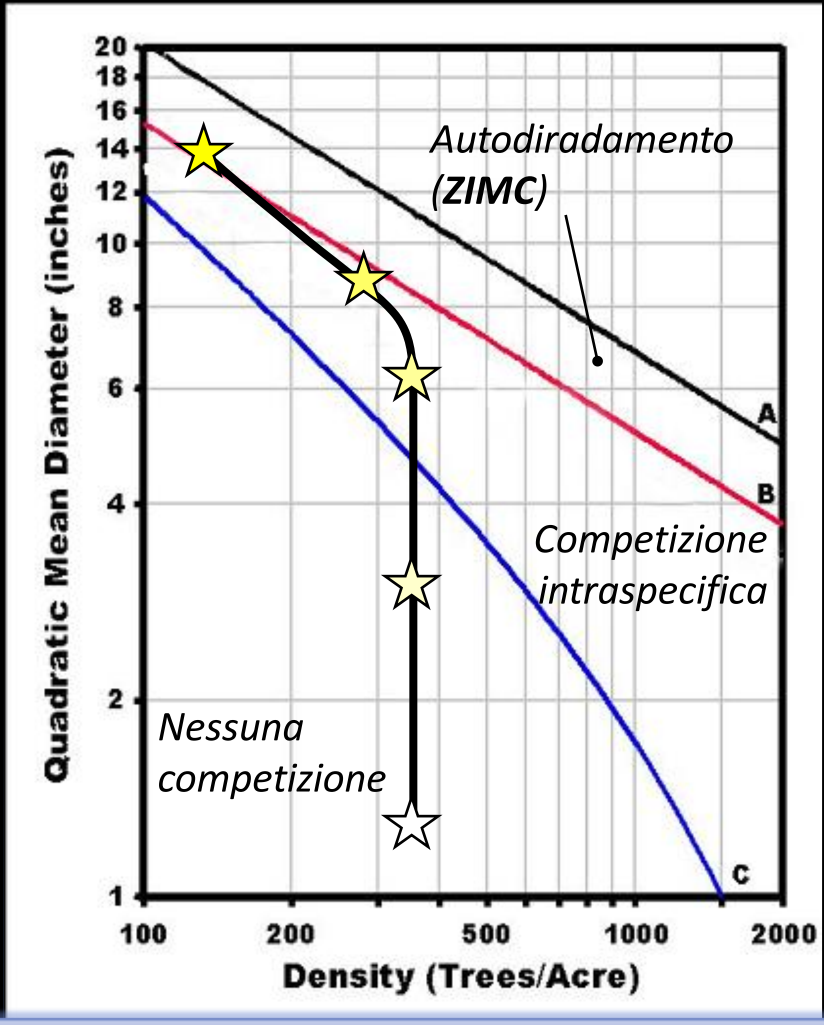
- Limite fisico per lo sviluppo dei popolamenti

  La vicinanza di un popolamento alla linea di massima densità indica l'intensità della competizione.

  Densità / densità massima = DENSITÀ RELATIVA.



Density Management Diagrams



A. Densità massima e limite dimensionale della specie

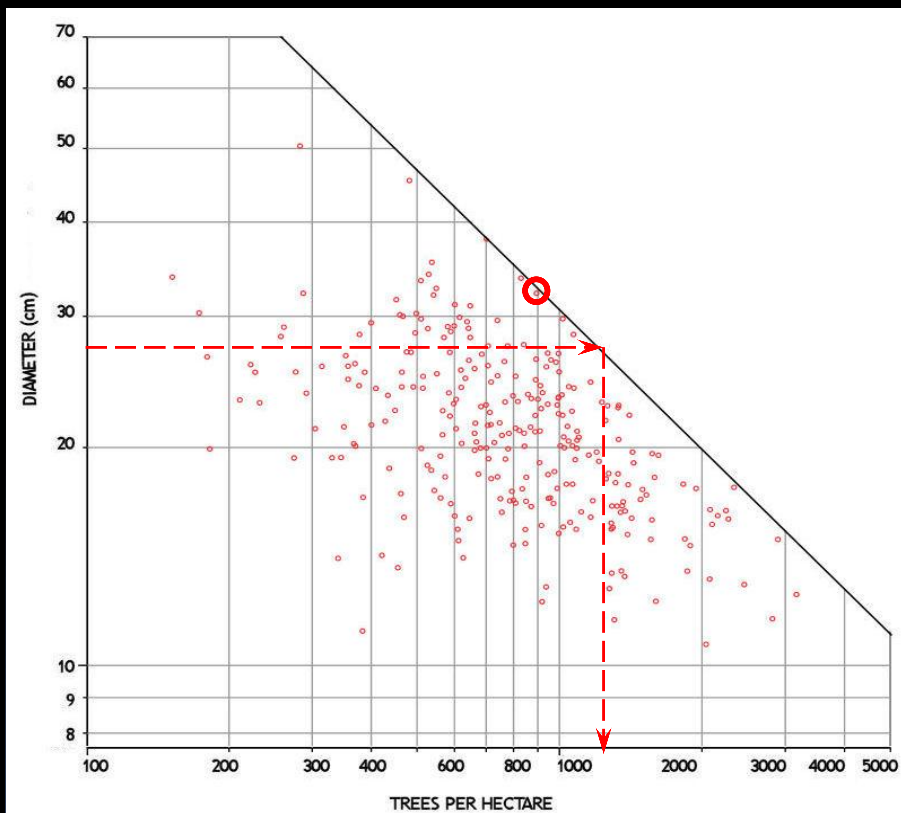
B. Inizio dell'autodiradamento, **<u>zona di imminente mortalità da competizione.</u>**

C. Contatto tra le chiome e inizio della competizione.

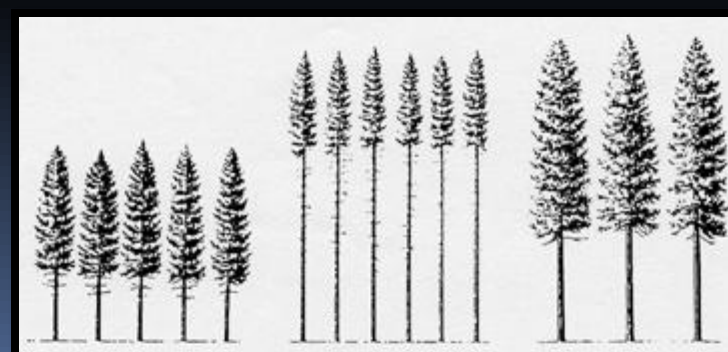
Misurare la competizione

Stand Density Index (SDI)

Densità di fusti da 25 cm che esprime l'affollamento osservato

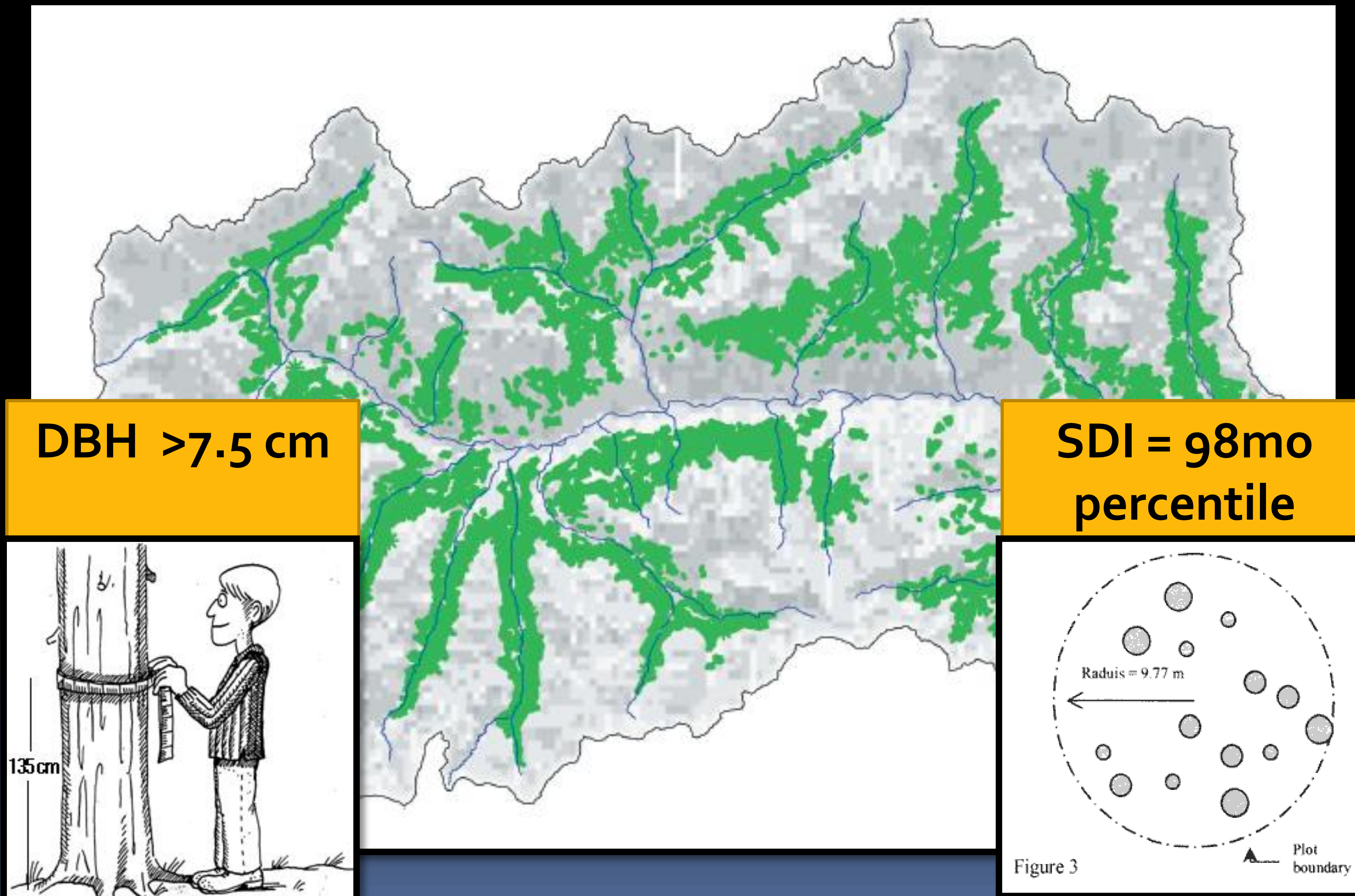


$$SDI_{sum} = \sum \left[\left(\frac{D_i}{25} \right)^{1.6} \right]$$



da Reineke (1933)

Stand Density Index



DBH >7.5 cm

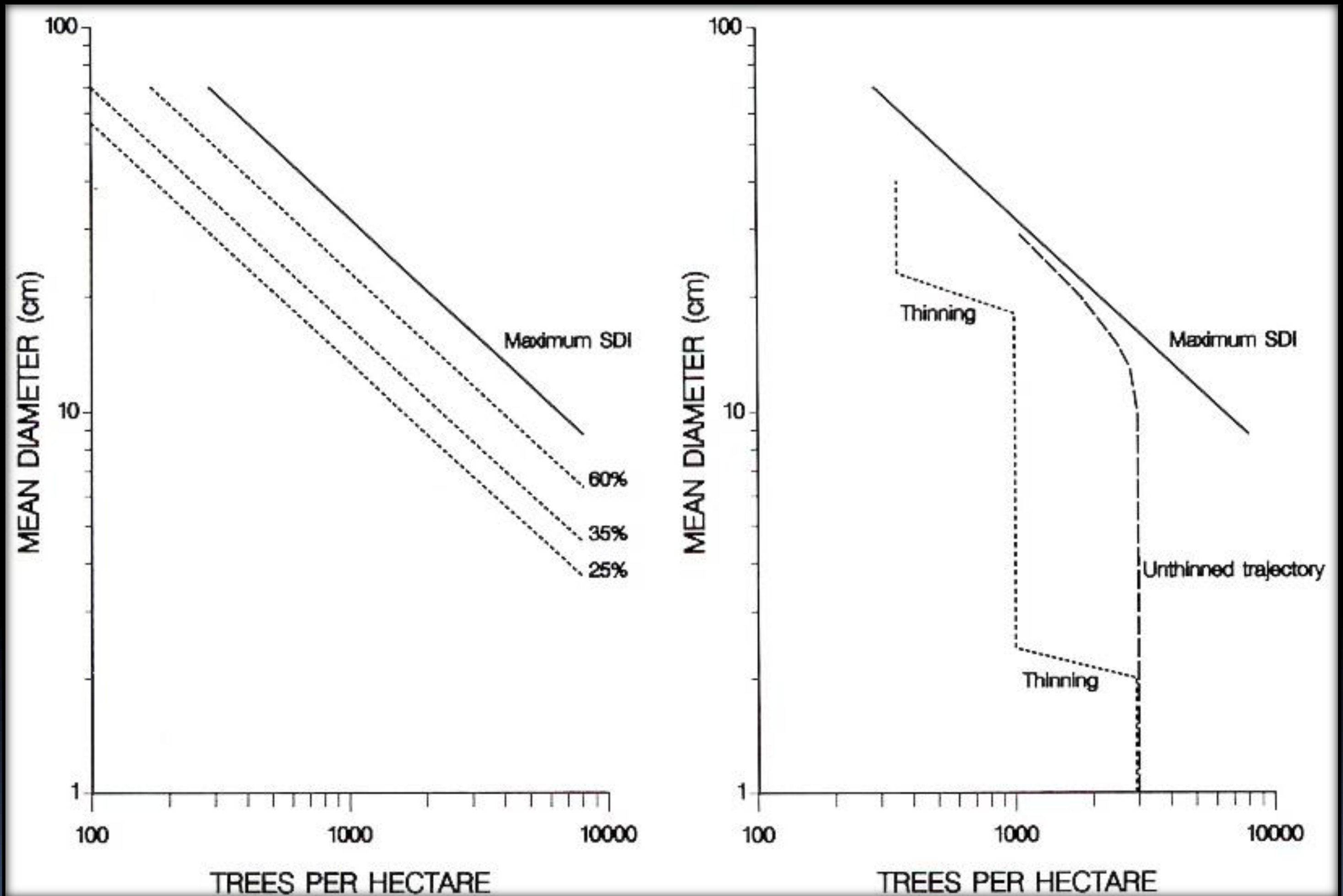
SDI = 98mo percentile

Figure 3

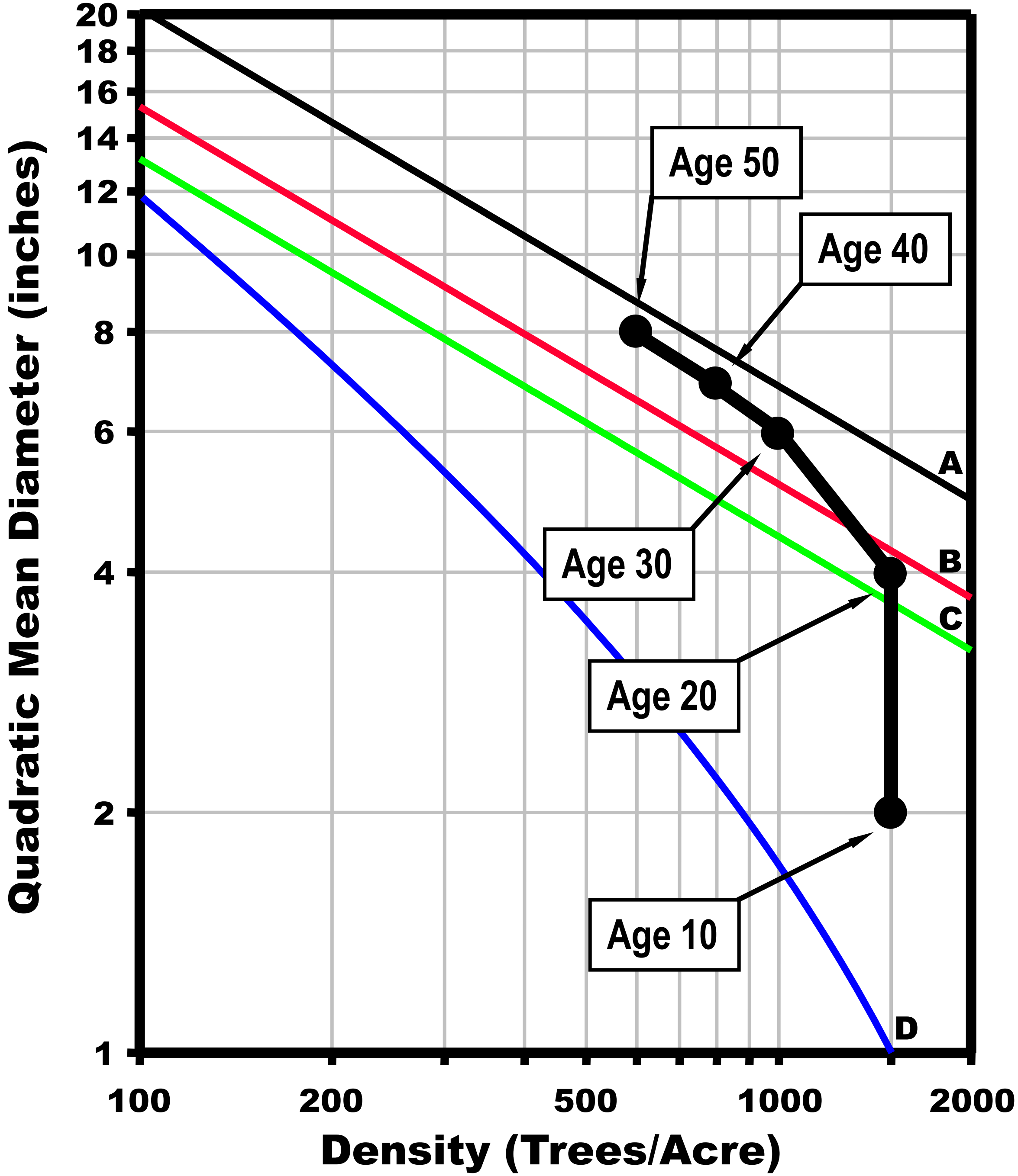
Stand Density Index

Quercus spp.	**568**	**Schnurr (1937)**
Pinus palustris Mill.	988	Reineke (1933)
Larix occidentalis Nutt.	**1013**	**Cochran (1985)**
Abies lasiocarpa (Hook.) Nutt.	1028	Cochran et al. (1994)
Picea engelmannii Parry	1158	Cochran et al. (1994)
Eucalyptus globulus Labill.	1210	Reineke (1933)
Abies alba Mill.	**1360**	**Vacchiano et al. (2005)**
Pinus sylvestris L.	**1440**	**Vacchiano et al. (2008)**
Pseudotsuga menziesii (Mirb.) Franco	1482	Reineke (1933)
Picea abies (l.) Karst.	**1680**	**Castagneri et al. (2008)**
Tsuga heterophylla (Raf.) Sarg.	1951	Long (1985)
Abies concolor (Gordon & Glend.) Lindl.	2050	Reineke (1933)
Sequoia sempervirens (D. Don) Endl.	2470	Reineke (1933)

Density Management Diagrams

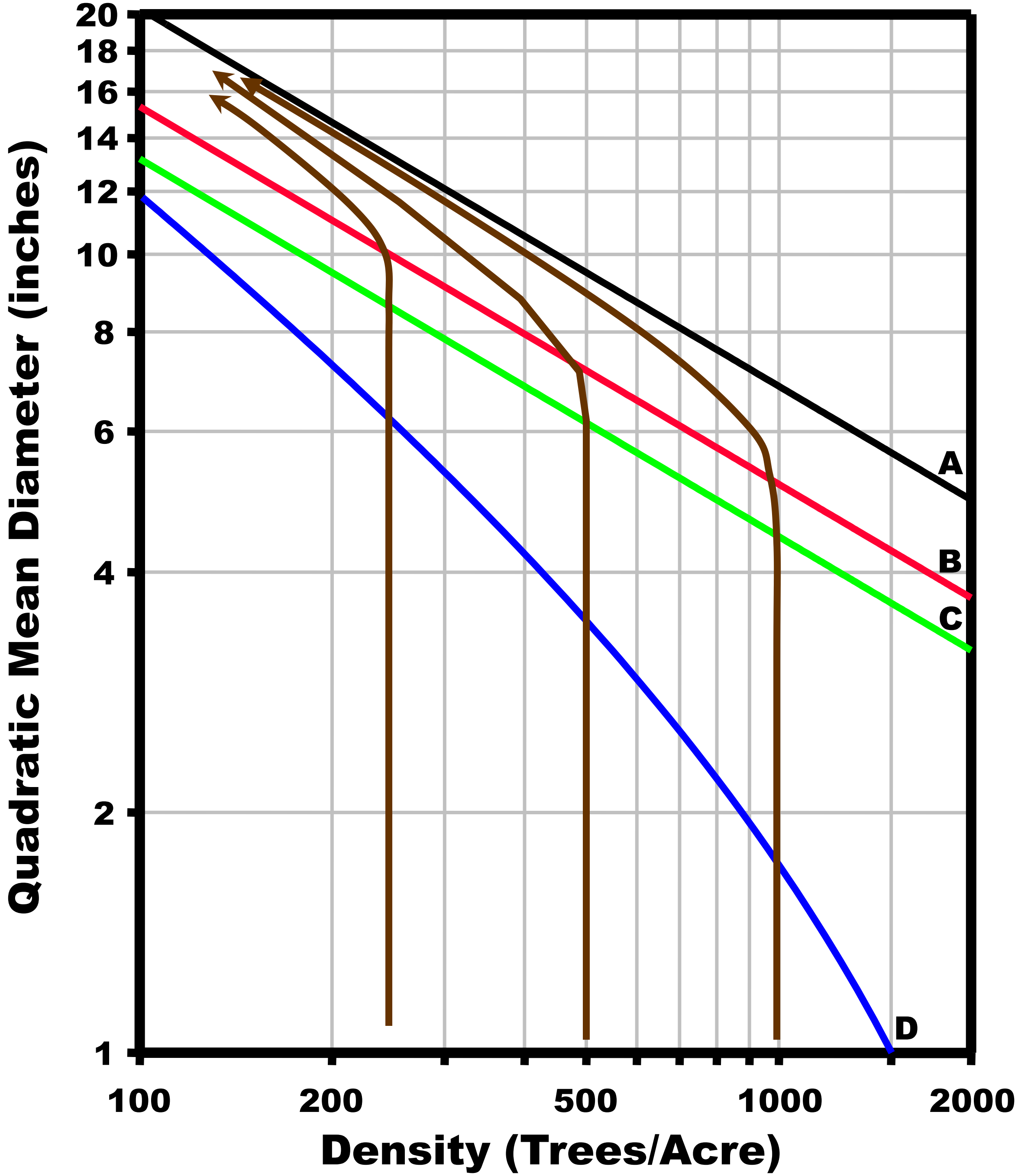


Exercise1: Plotting A Stand Trajectory



Age	DBH_q	TPA
10	2.0	1500
20	4.0	1500
30	6.0	1000
40	7.0	800
50	8.0	600

Example: Unmanaged Stand Trajectories (without Ingrowth)

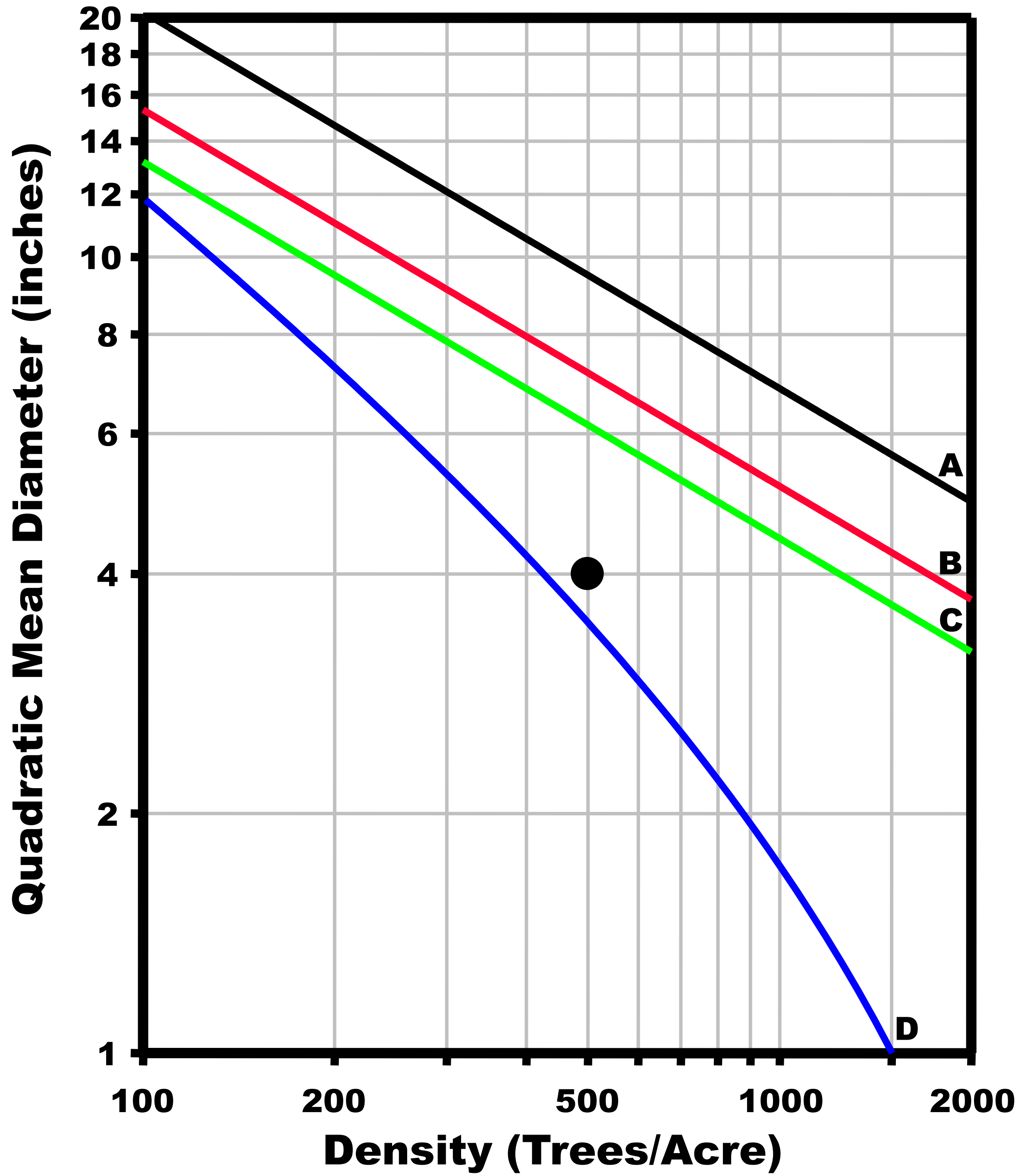


Stand Trajectories: Unmanaged Stands (cont.)

- **Regardless of site quality or age, unmanaged stands of the same initial density will approximately follow the same stand trajectory.**
- **However, the higher quality stand will move along a given density trajectory faster than a lower quality stand of the same initial density.**

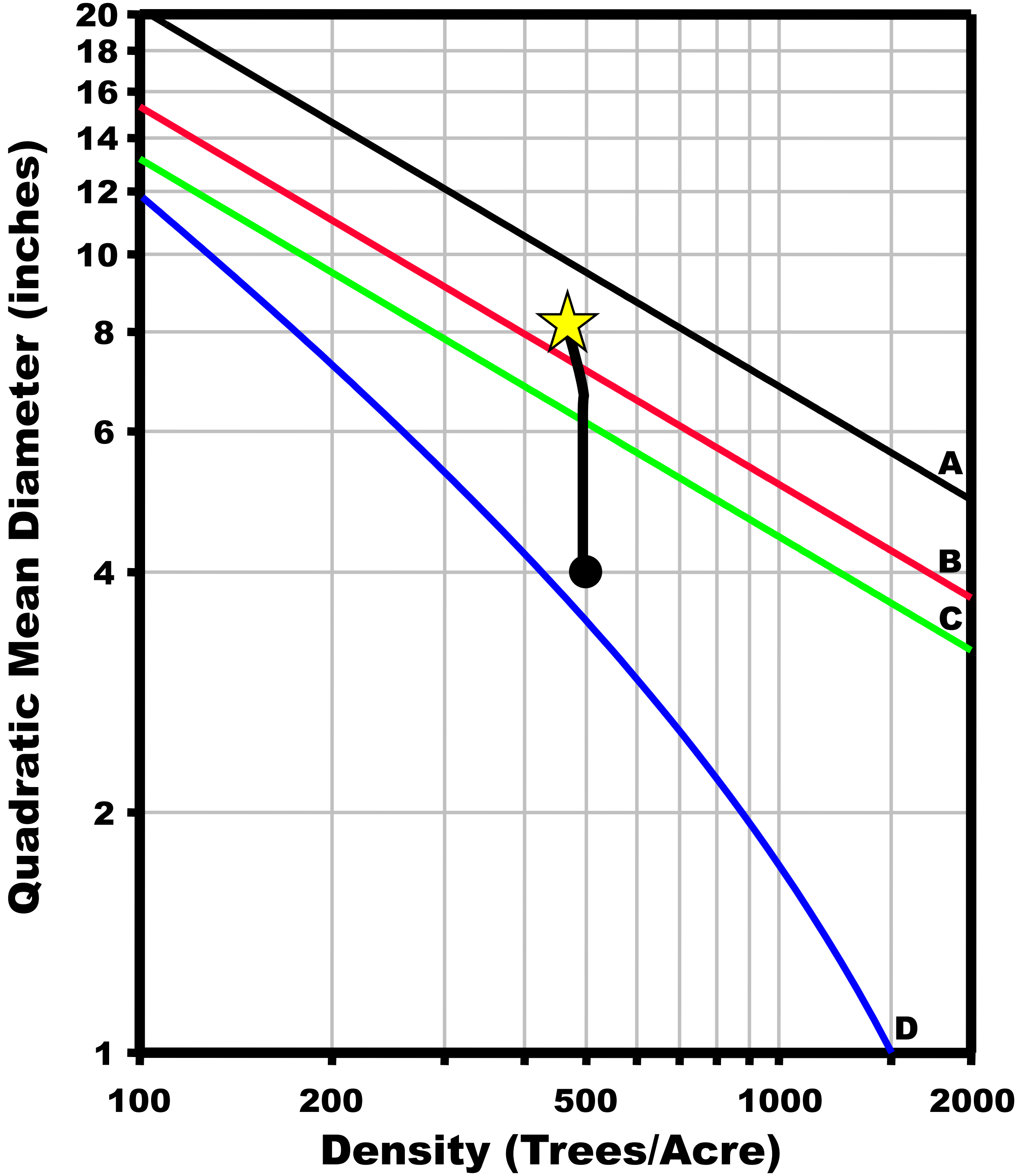
Exercise 2:
To thin or not to thin?

- Current stand has 500 tpa and average diameter of 4 inches
- Management goal: Pulpwood with average diameter of 8 inches at harvest
- Do you thin the stand?



Exercise 2: To Thin or Not to Thin?

We plot the current density and diameter on the DMD.



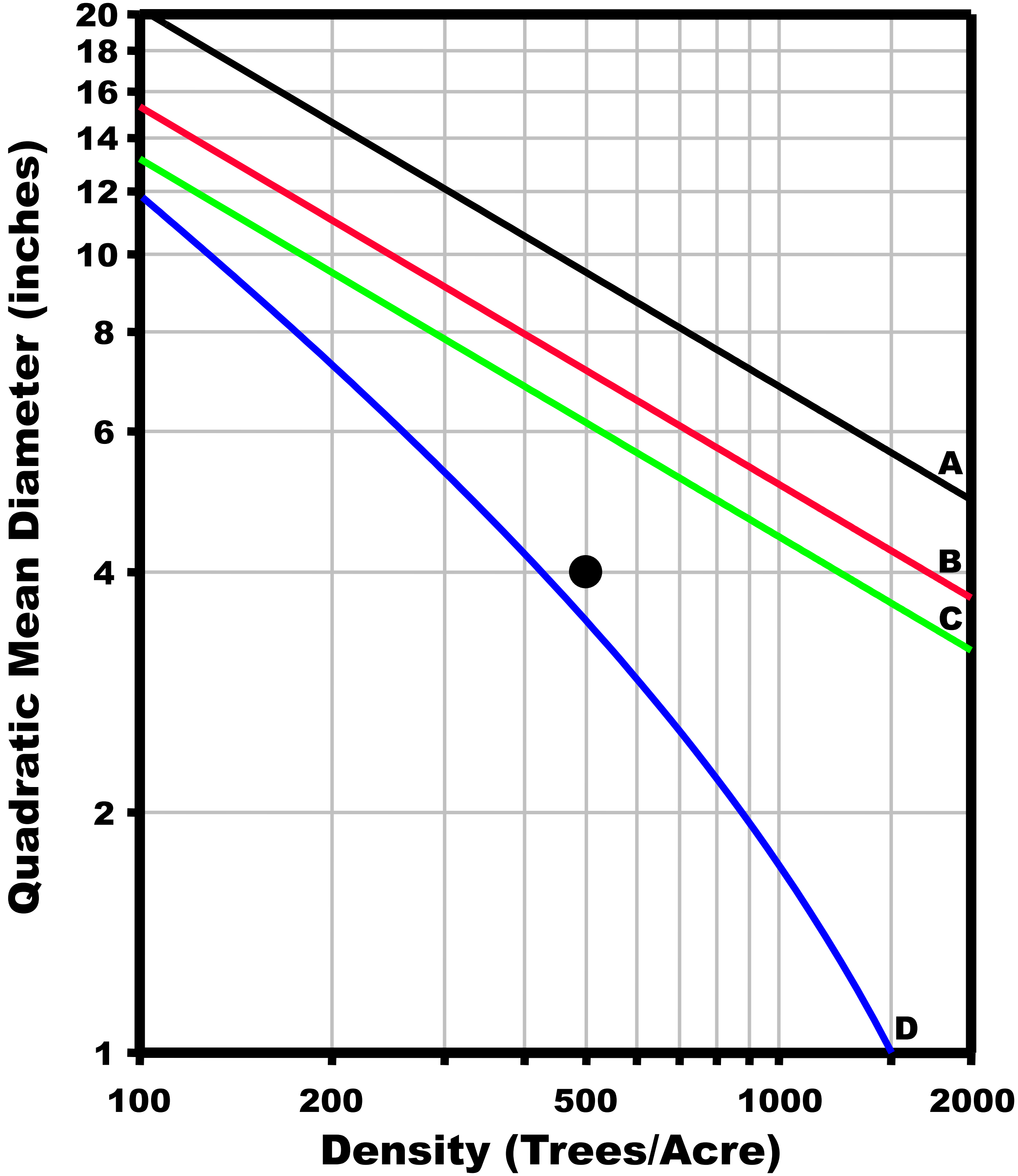
Exercise 2: To Thin or Not to Thin?

No.

This stand will have little mortality before it reaches harvest size.

Exercise 3:
To thin or not to thin?

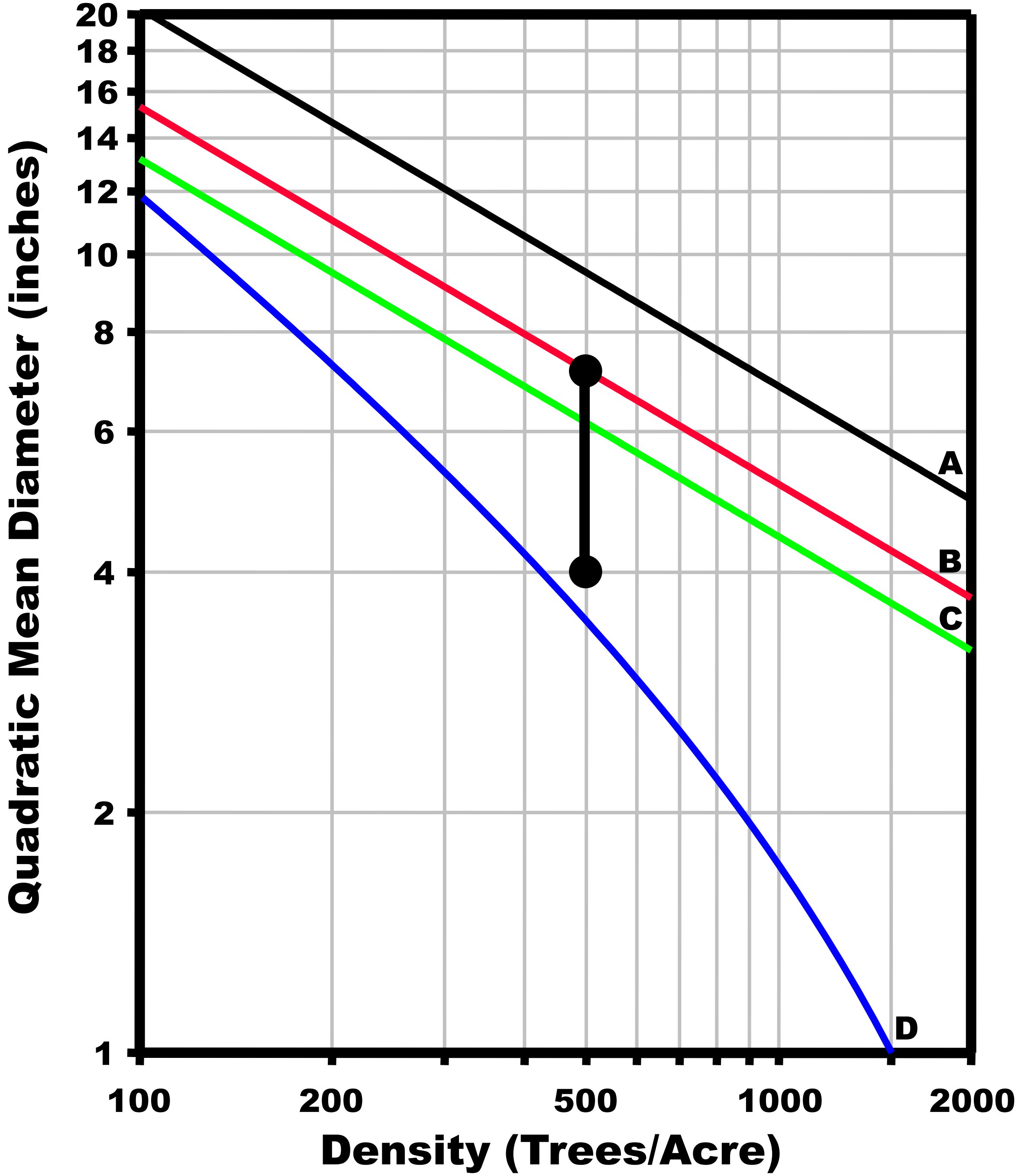
- Same stand: Current stand has 500 tpa and average diameter of 4 inches
- Management goal: Average diameter of 12 inches at harvest
- Do you thin the stand?



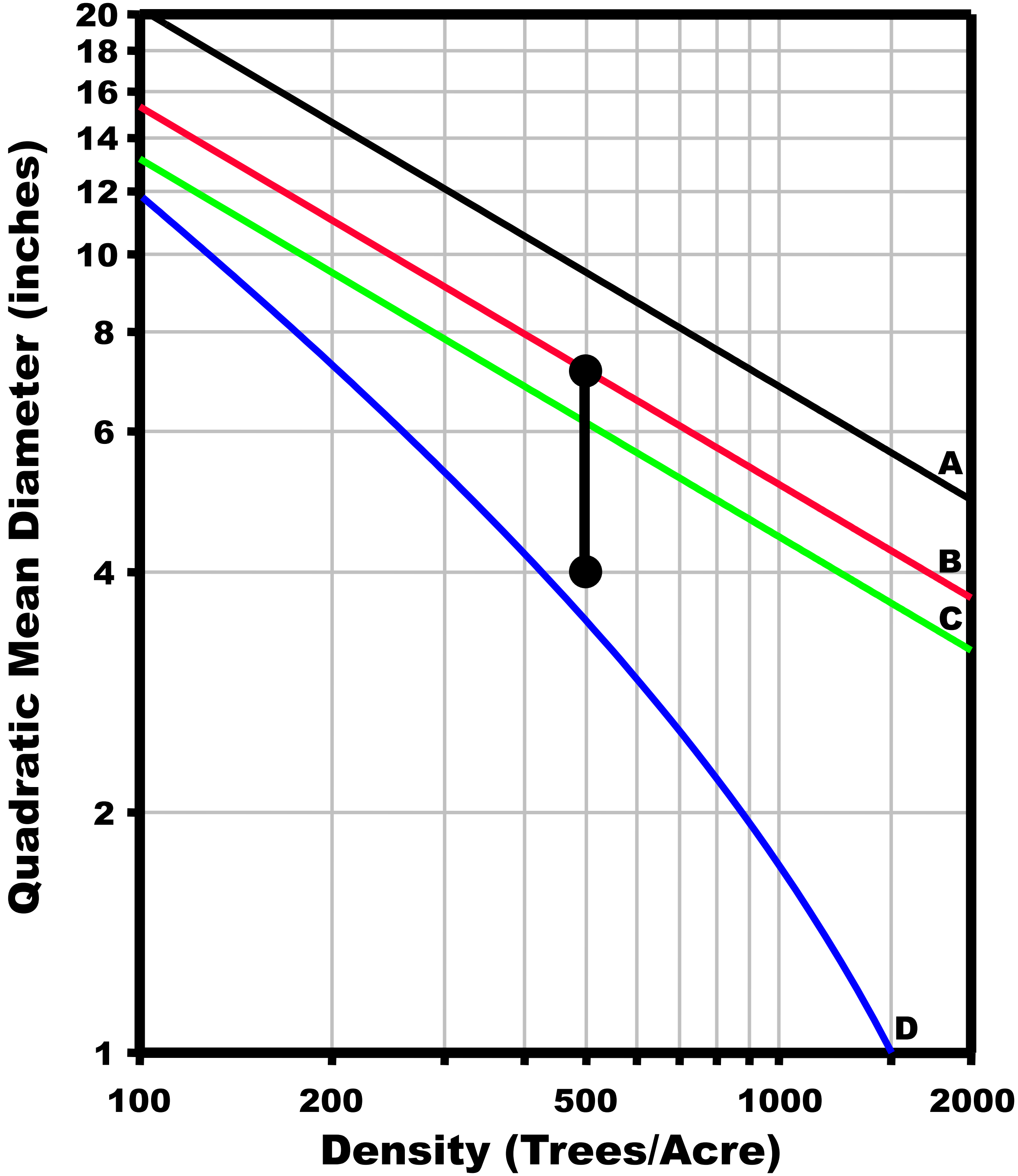
Exercise 3:

To Thin or Not to Thin?

Exercise 3: To Thin or Not to Thin?



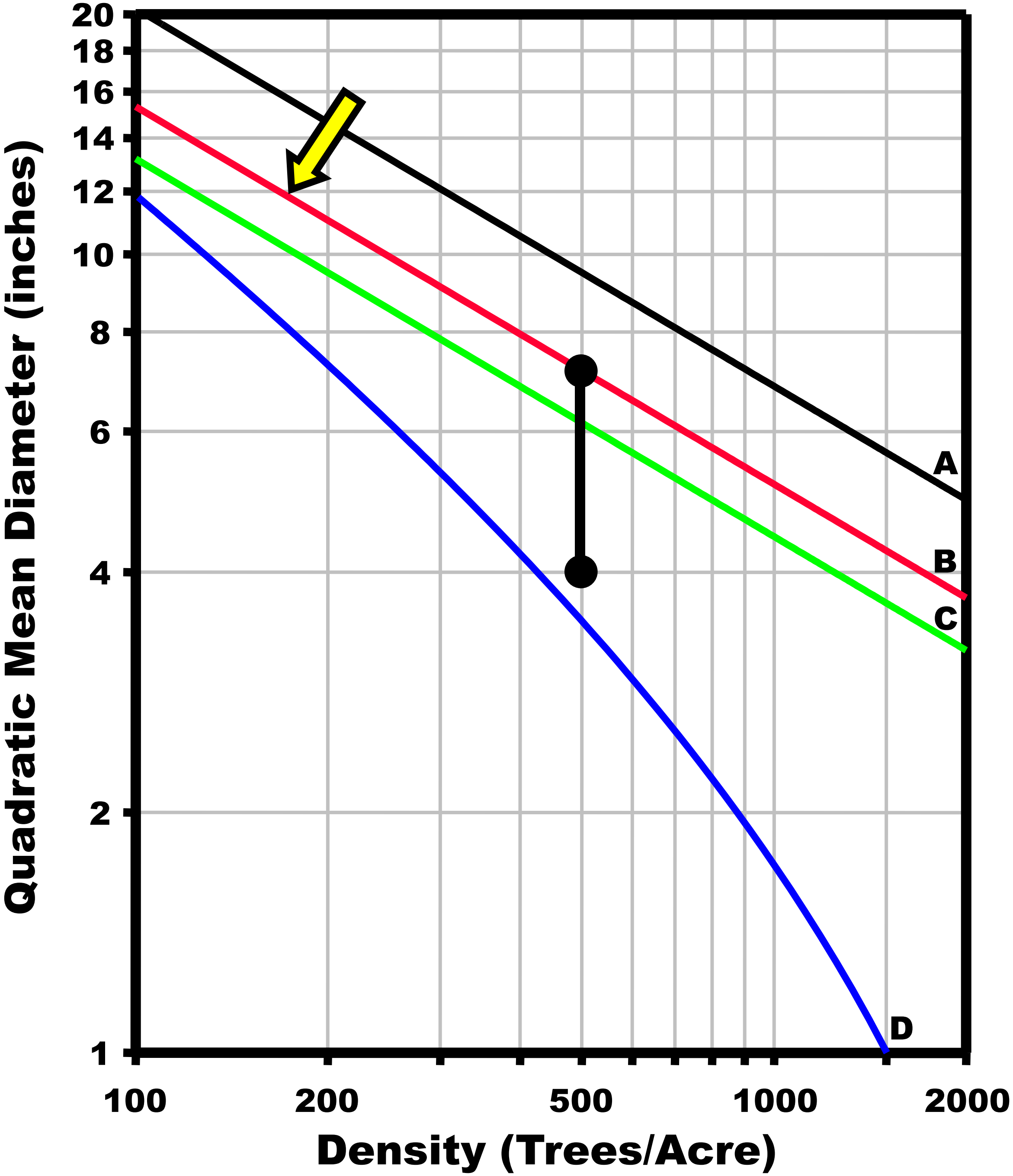
The stand will develop only to about 7" before it crosses the B Line and mortality begins.



Exercise 3: To Thin or Not to Thin?

The is not anywhere close to harvest and is experiencing mortality.

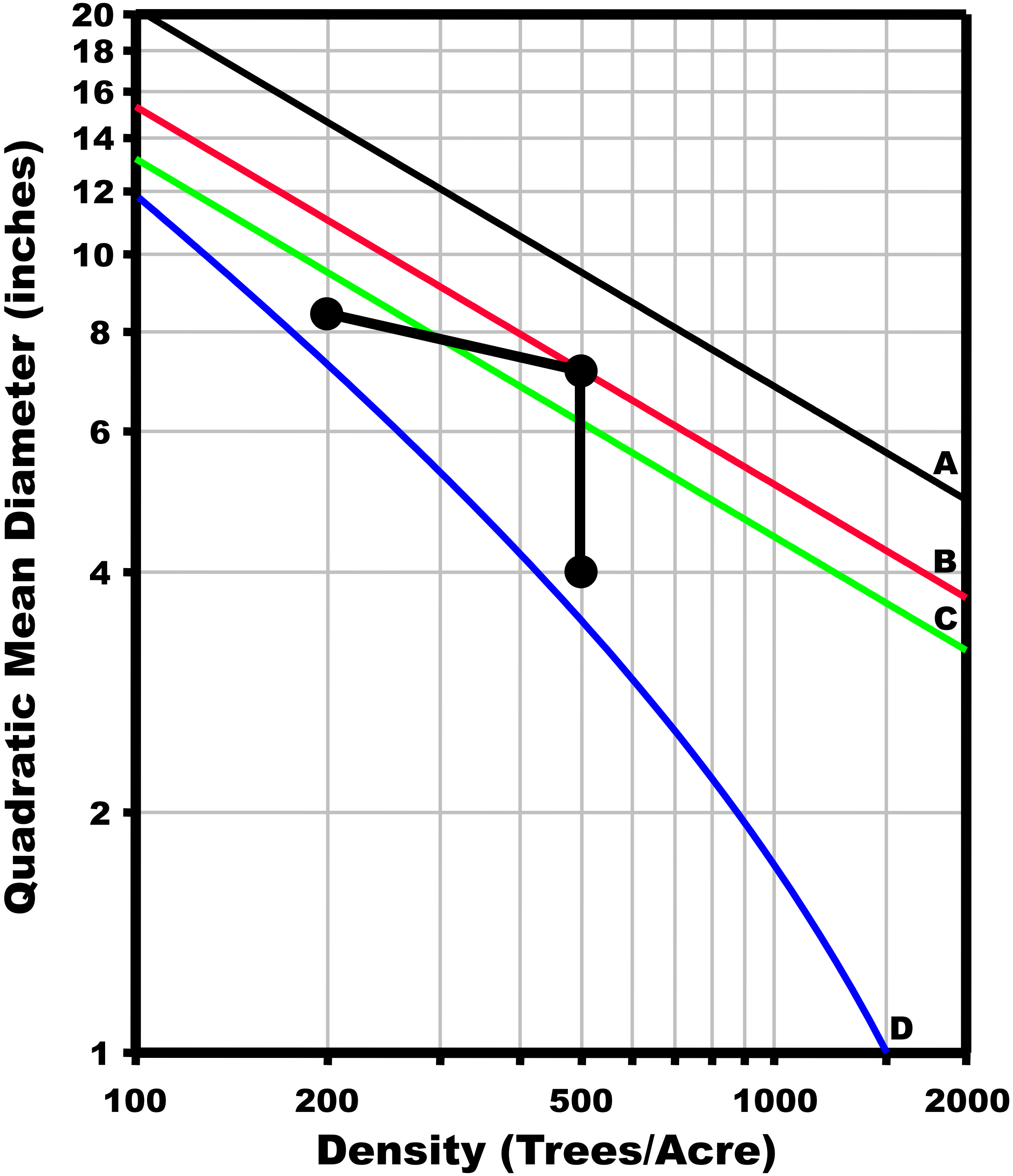
We should schedule a thinning



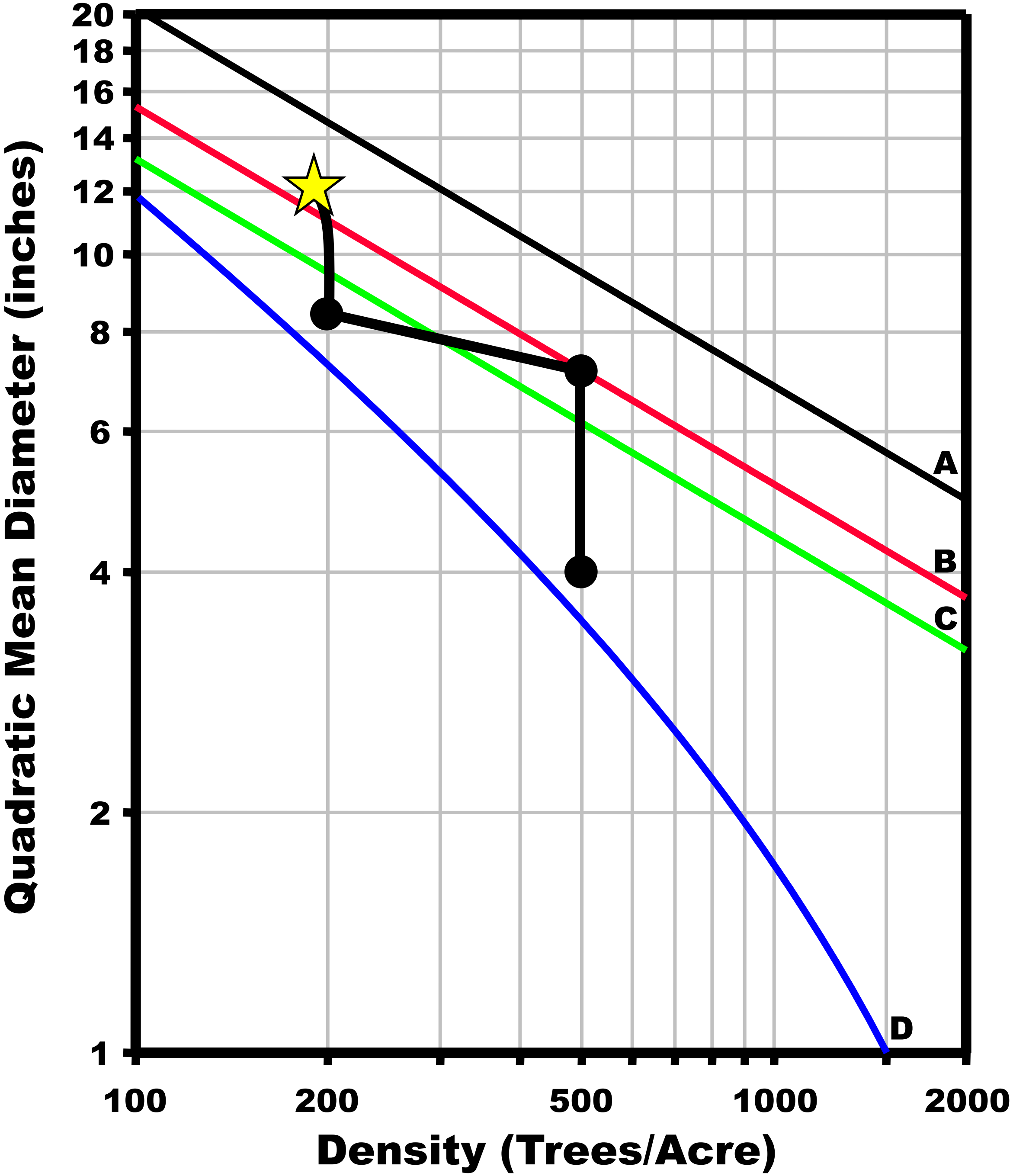
Exercise 4: When and How Much to Thin?

Well, as we look at the graph the B Line crosses 12” at about 175 tpa.

Exercise 4: When and How Much to Thin?



Therefore, we should remove about 300 tpa.



Exercise 4: When and How Much to Thin?

This will allow the stand to develop to 11” before it crosses the B Line.

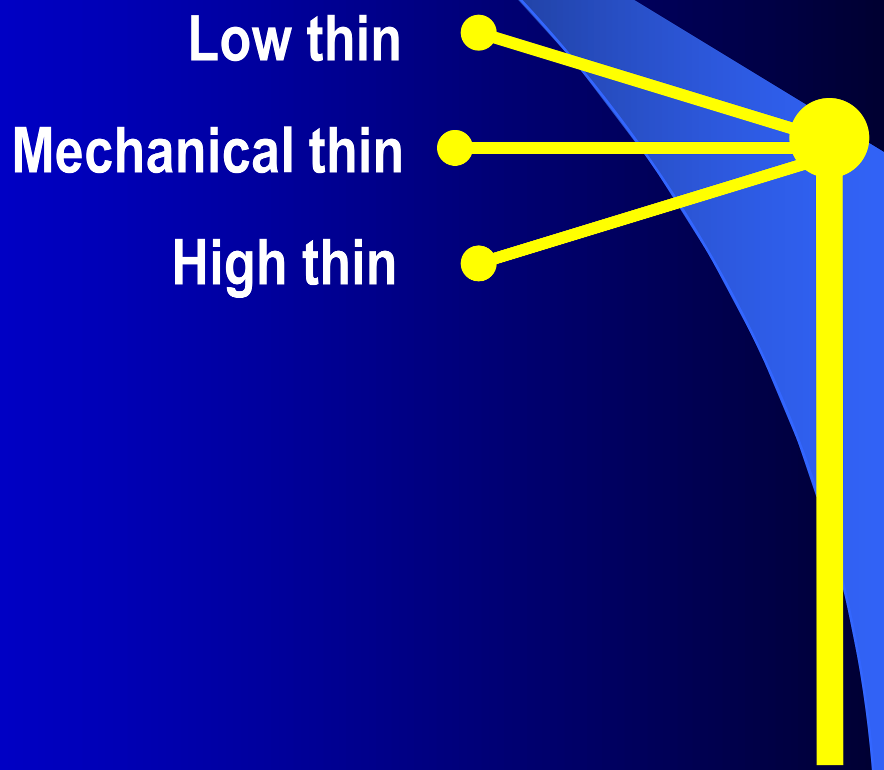
We can accept the small amount of mortality beyond that.

Plotting a Thin

- Low thins remove the smallest trees are from the stand, thereby increasing the DBH_q after the thin.
- By the same token, a high thin will reduce the DBH_q and a mechanical thin will have no effect on DBH_q.

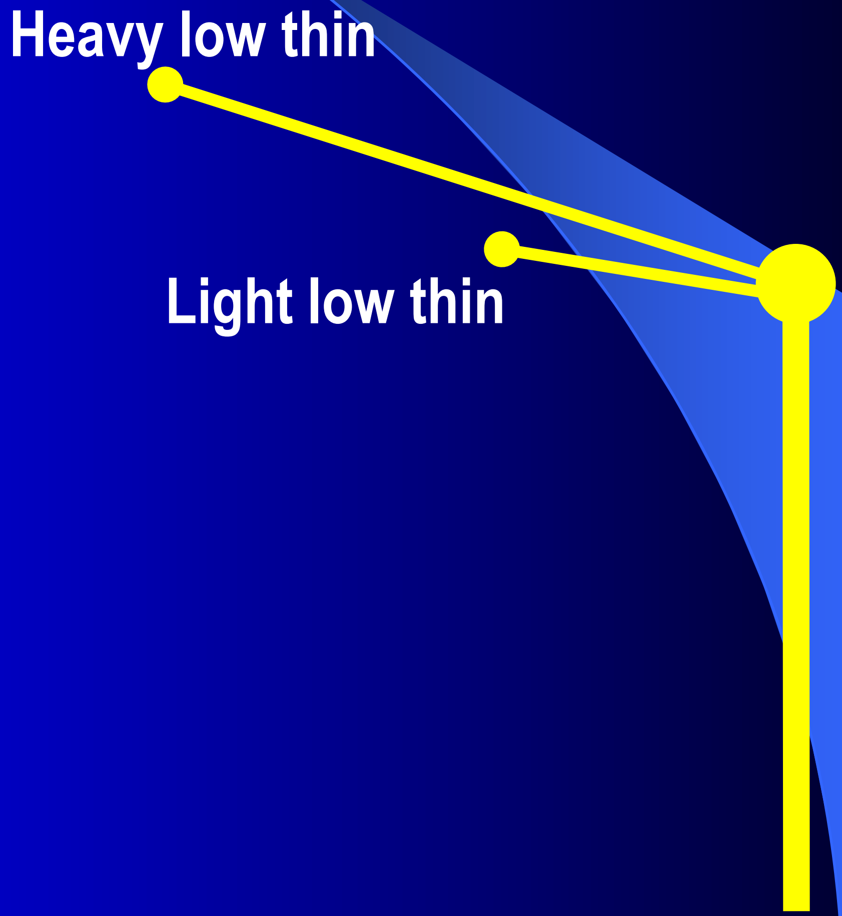
Plotting a Thin (cont.)

- Therefore, the type of thin will determine if the trajectory has positive, negative, or no slope, based on how it affects DBH_q.



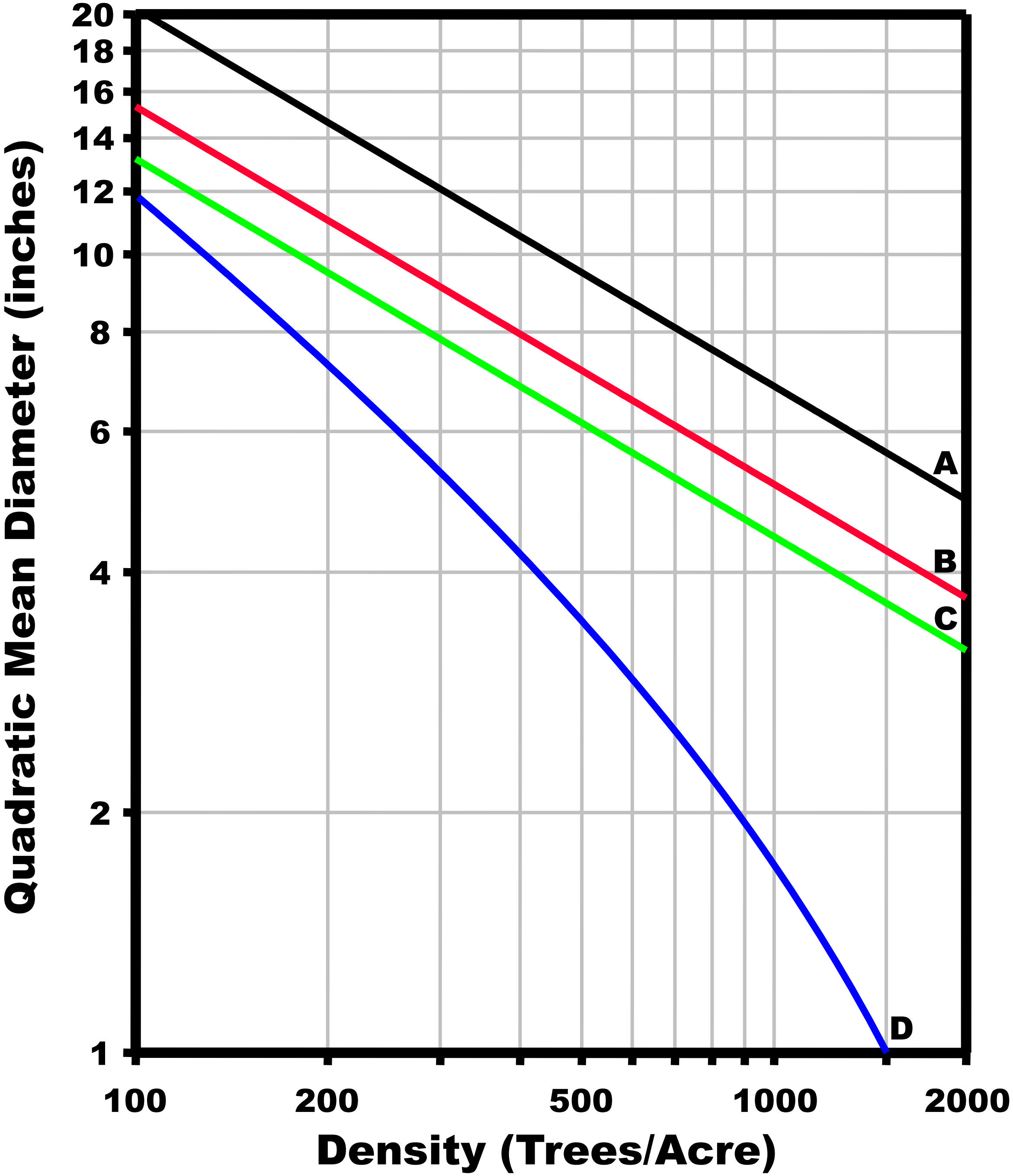
Plotting a Thin (cont.)

- The intensity of the thin then determines the length and the amount of upward or downward slope of the lines.



DMDs as Management Tools III

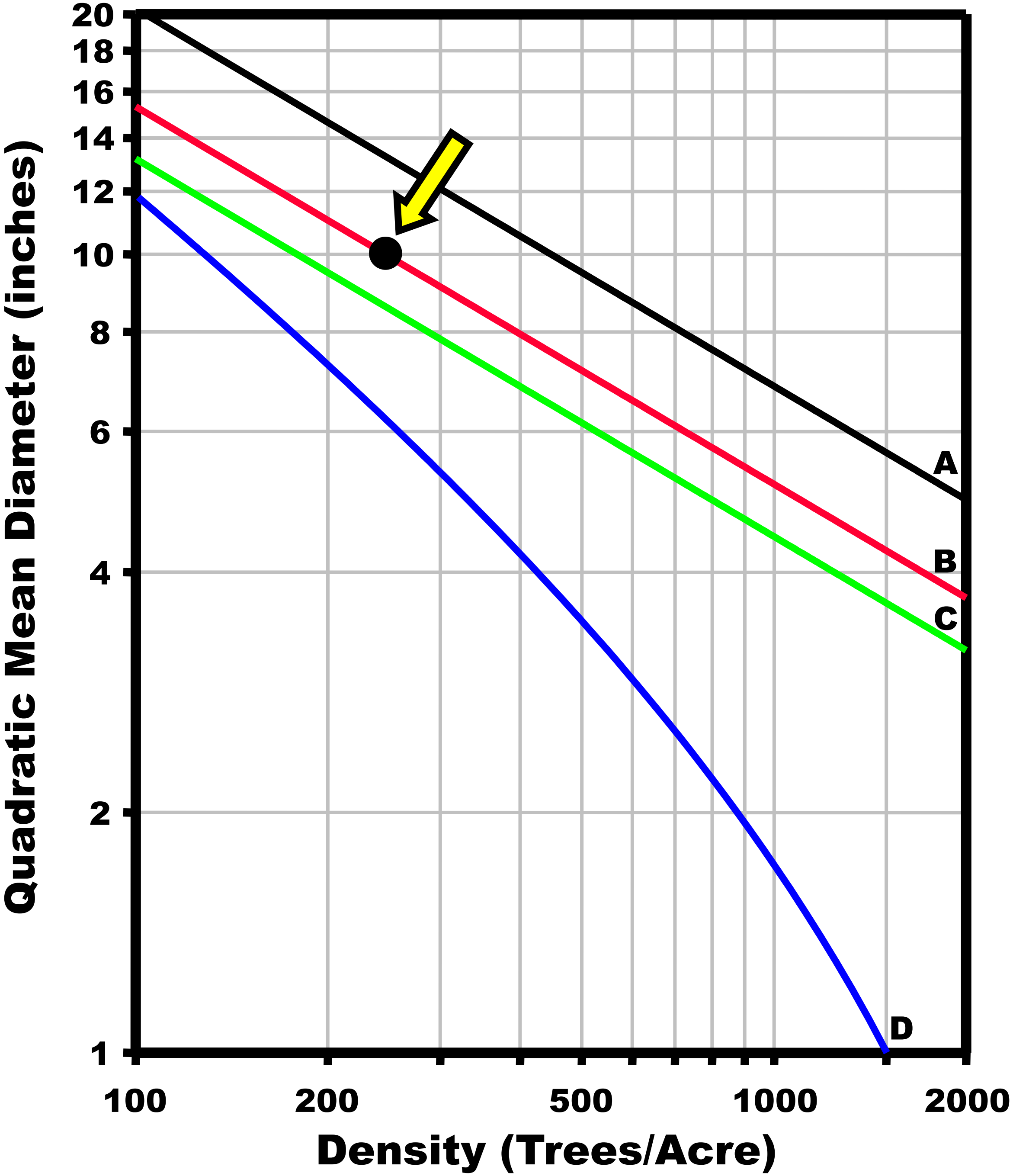
- **DMDs can also be used for determining initial planting density.**



Exercise 5: How many trees to plant?

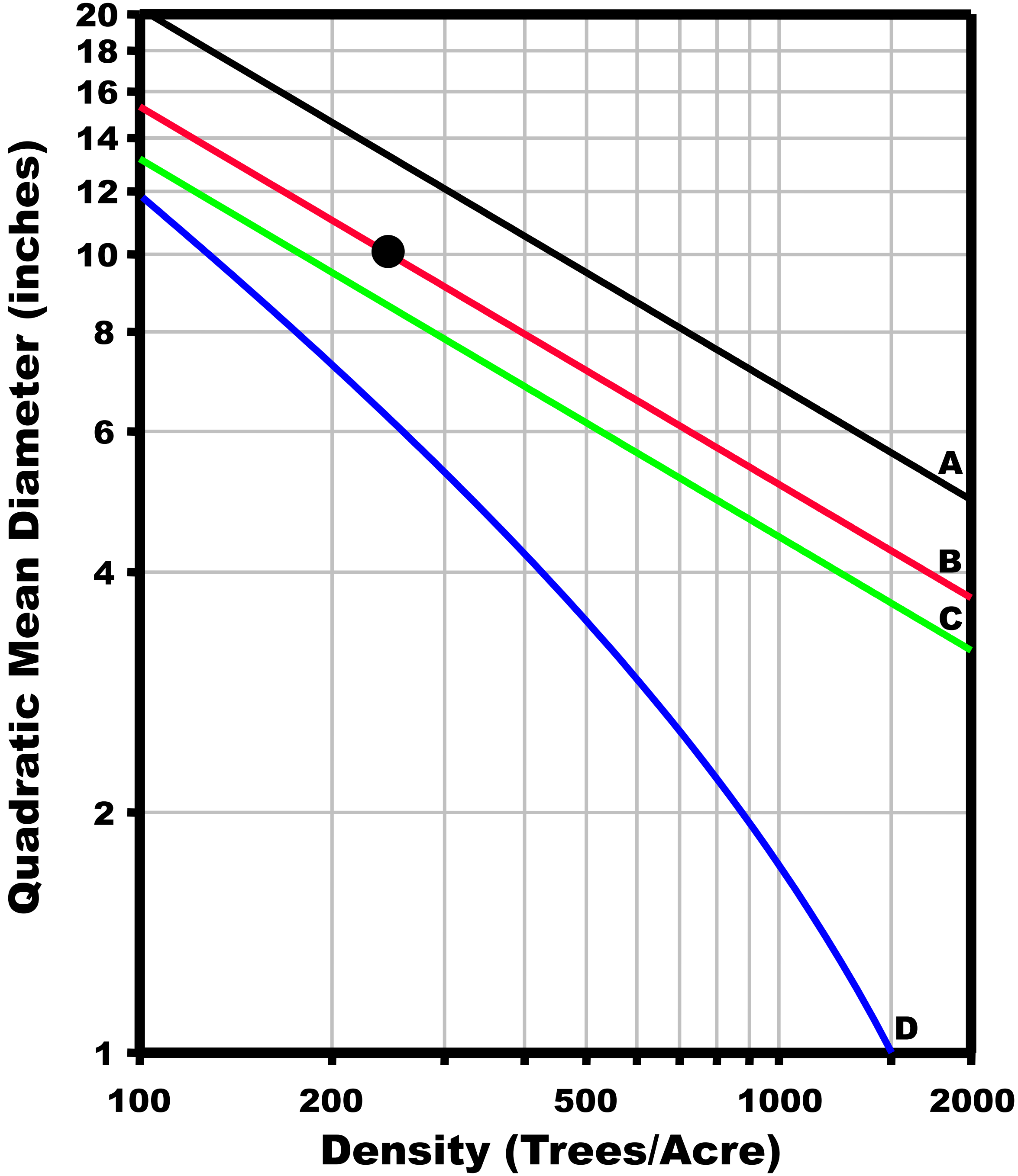
Let's assume that we want a final harvest DBH_q of 10".

We may consider one thinning.



Exercise 5:
How many trees to plant?

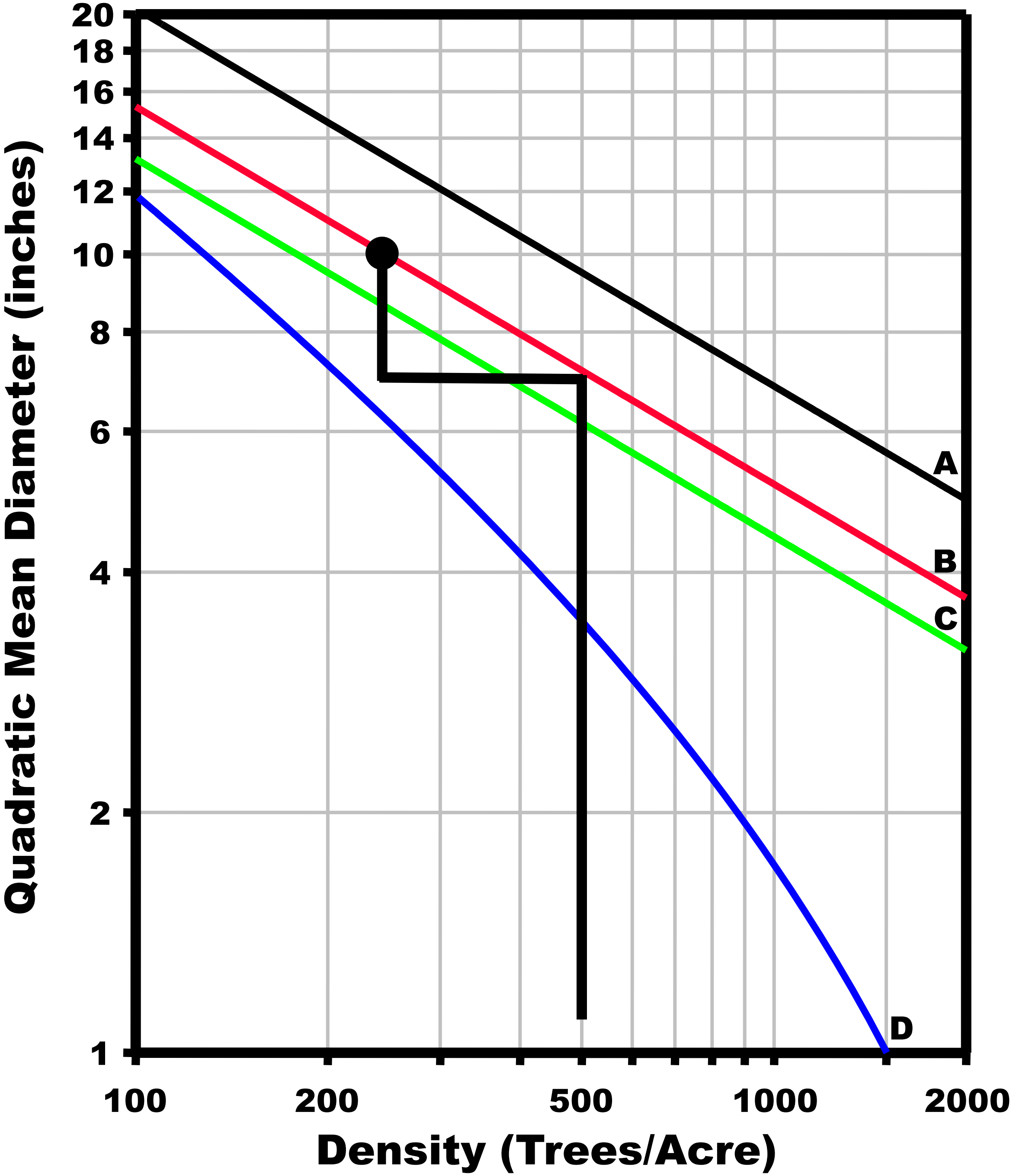
By looking where the B Line crosses 10”, we estimate final density to be about 250 tpa.



Exercise 5:
How many trees to plant?

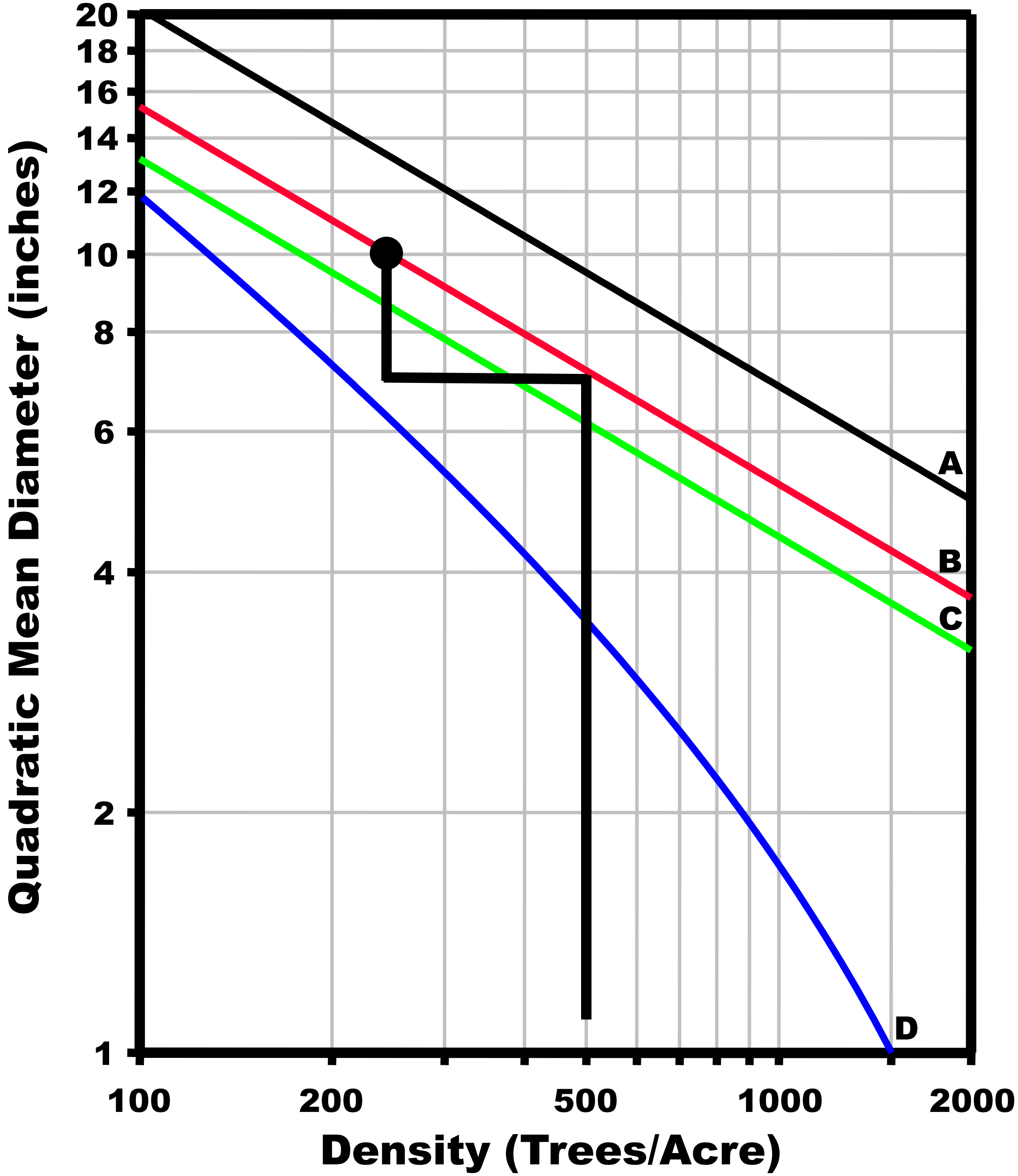
Therefore, assuming that we will do only 1 thin and remove about 50% of the trees…

Example 5: How many trees to plant?



… initial planting density should be around 500 tpa.

Example 5: How many trees to plant?



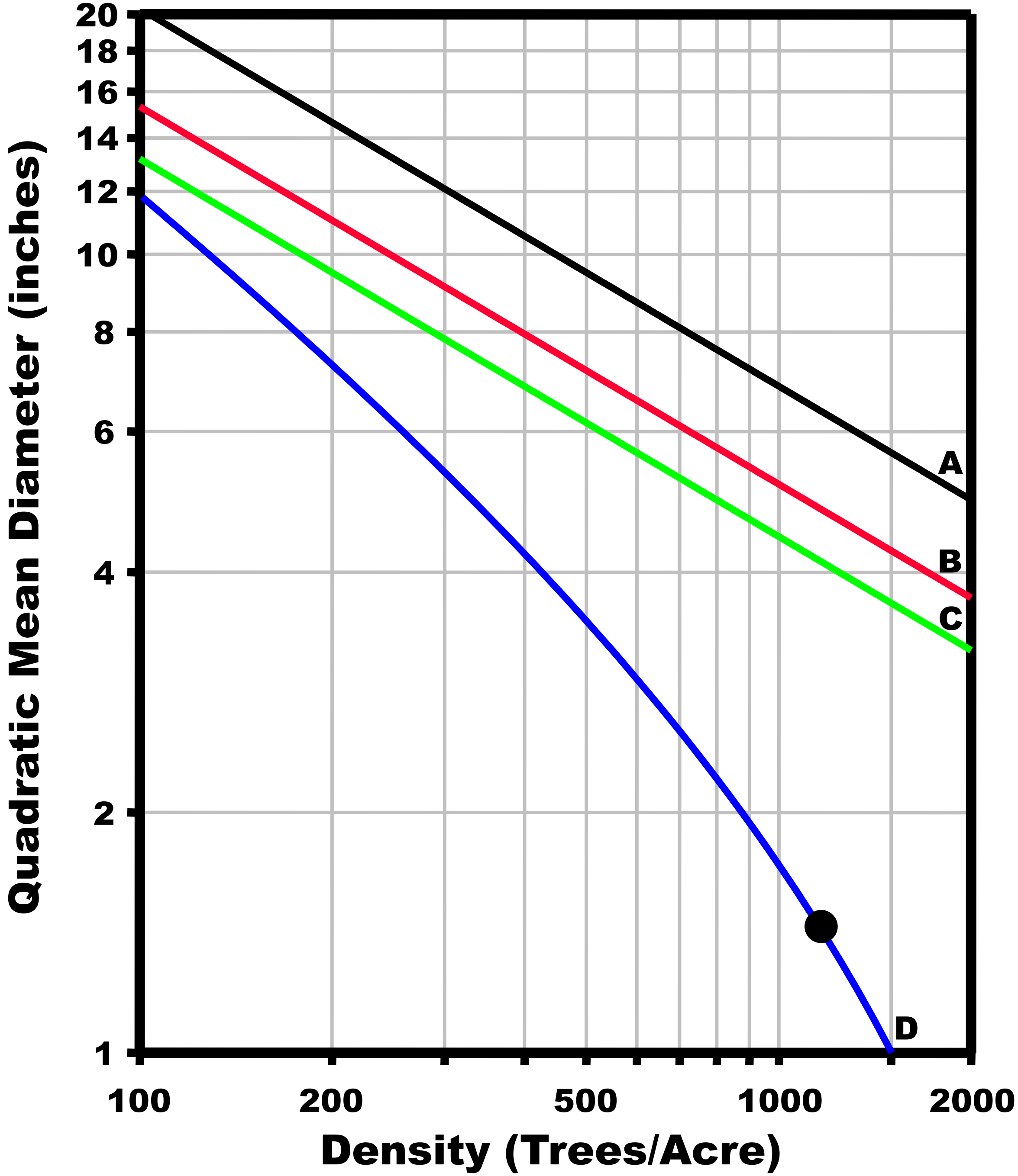
Also, you may wish to plant more if you can estimate seedling mortality (before they would show up on DMD).

Exercise 5: Planning an entire rotation

1. The current density is 1200 tpa (6' X 6') and the current DBH_q is 1.5".
2. Our minimum harvest diameter is 14".
3. We have a budget to allow for two thins, and one may be precommercial.
4. We can accept 10% mortality in the stand before we will thin or harvest.

DMDs as Management Tools IV

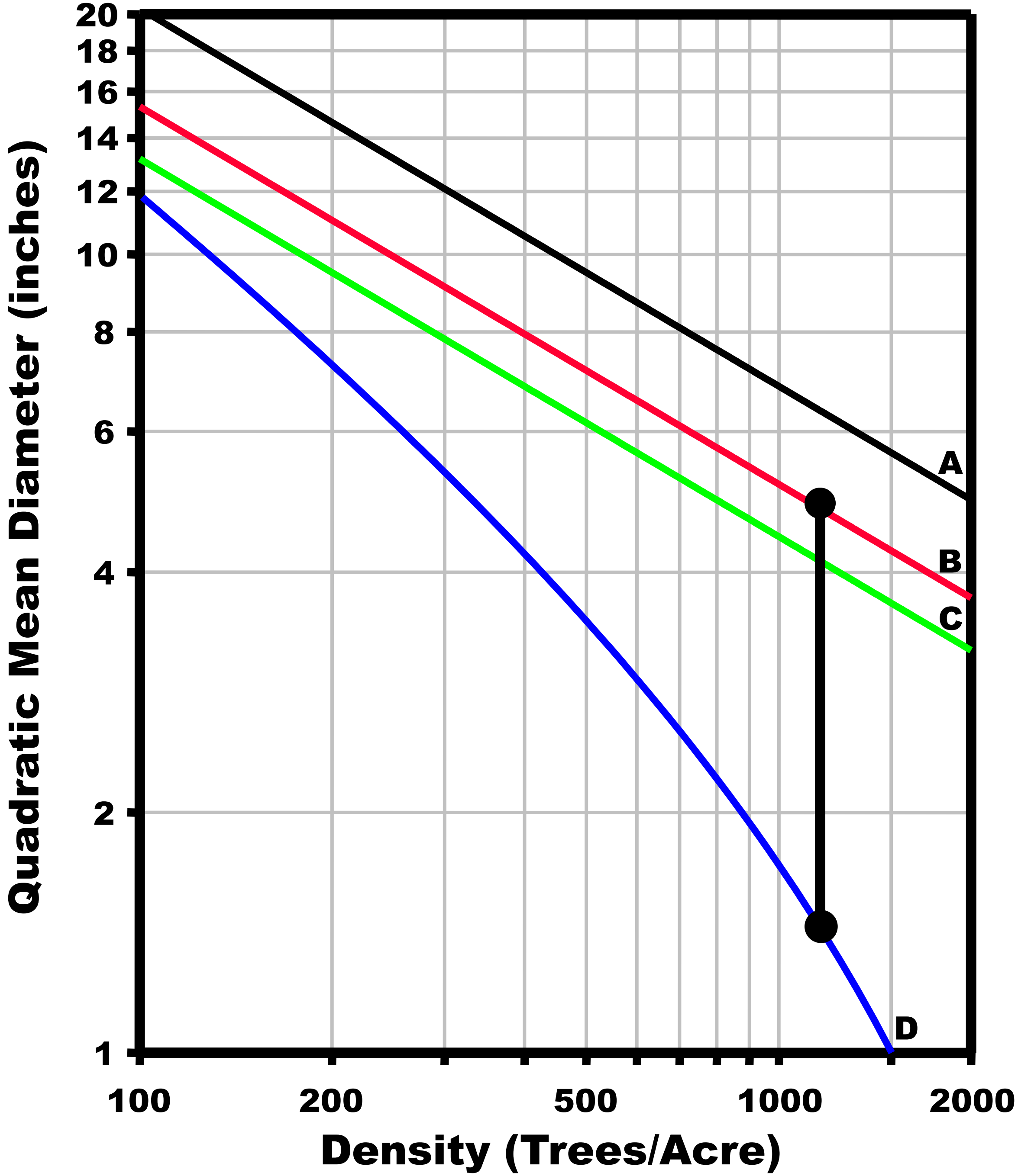
- So, the questions are:
  1. When, in terms of DBH_q, should we schedule thinnings?
  2. What type of thinnings should we use?
  3. Can we make some predictions of the intensity of the thinnings required?
- Going to the chart …



Exercise 5 : Planning an entire rotation

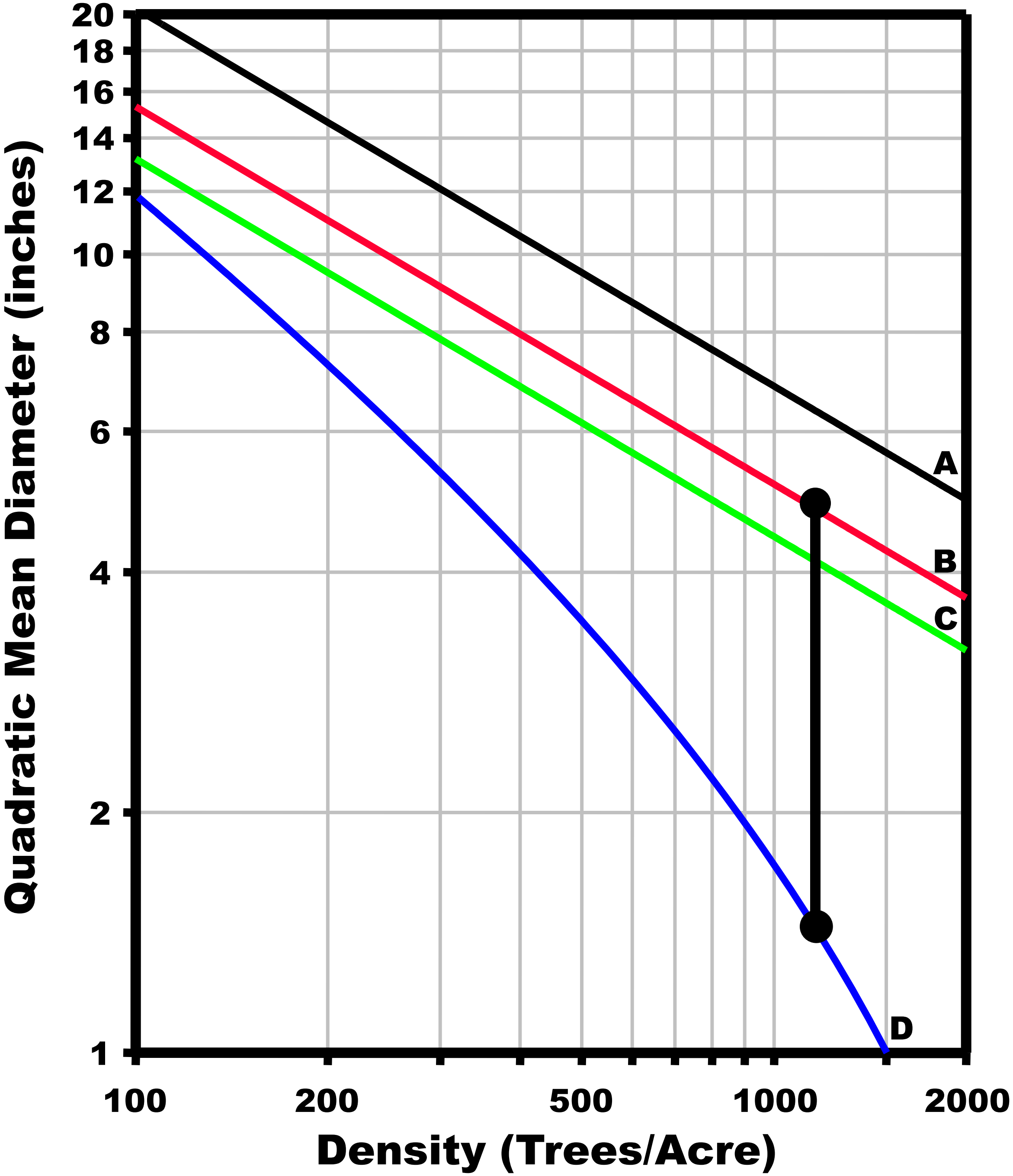
First, let's plot the initial stand conditions.

Exercise 5:
Planning an entire rotation

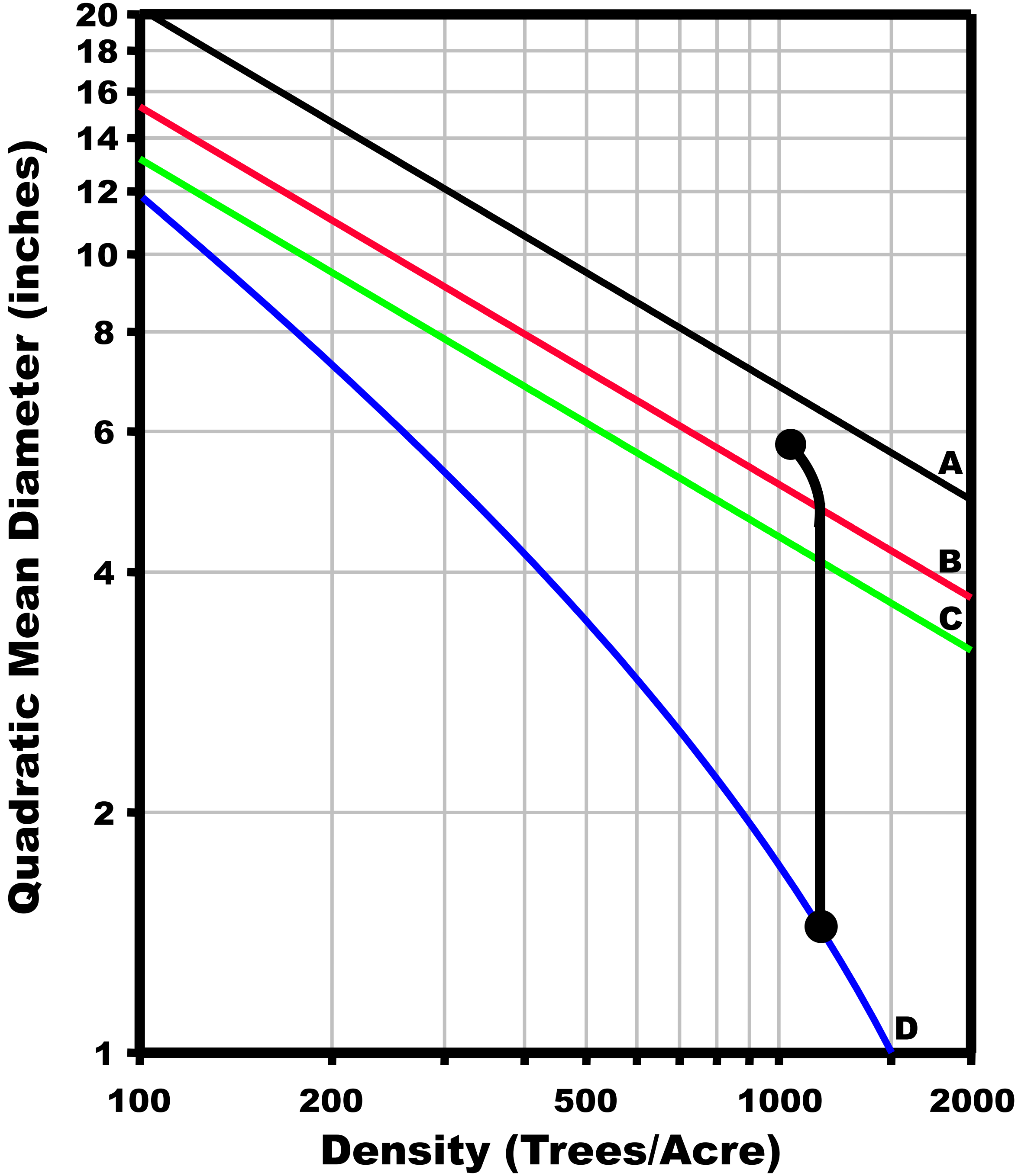


This stand should develop without much mortality until it approaches the B Line.

Exercise 5: Planning an entire rotation



At this point, the stand could be thinned, but the trees are still small.



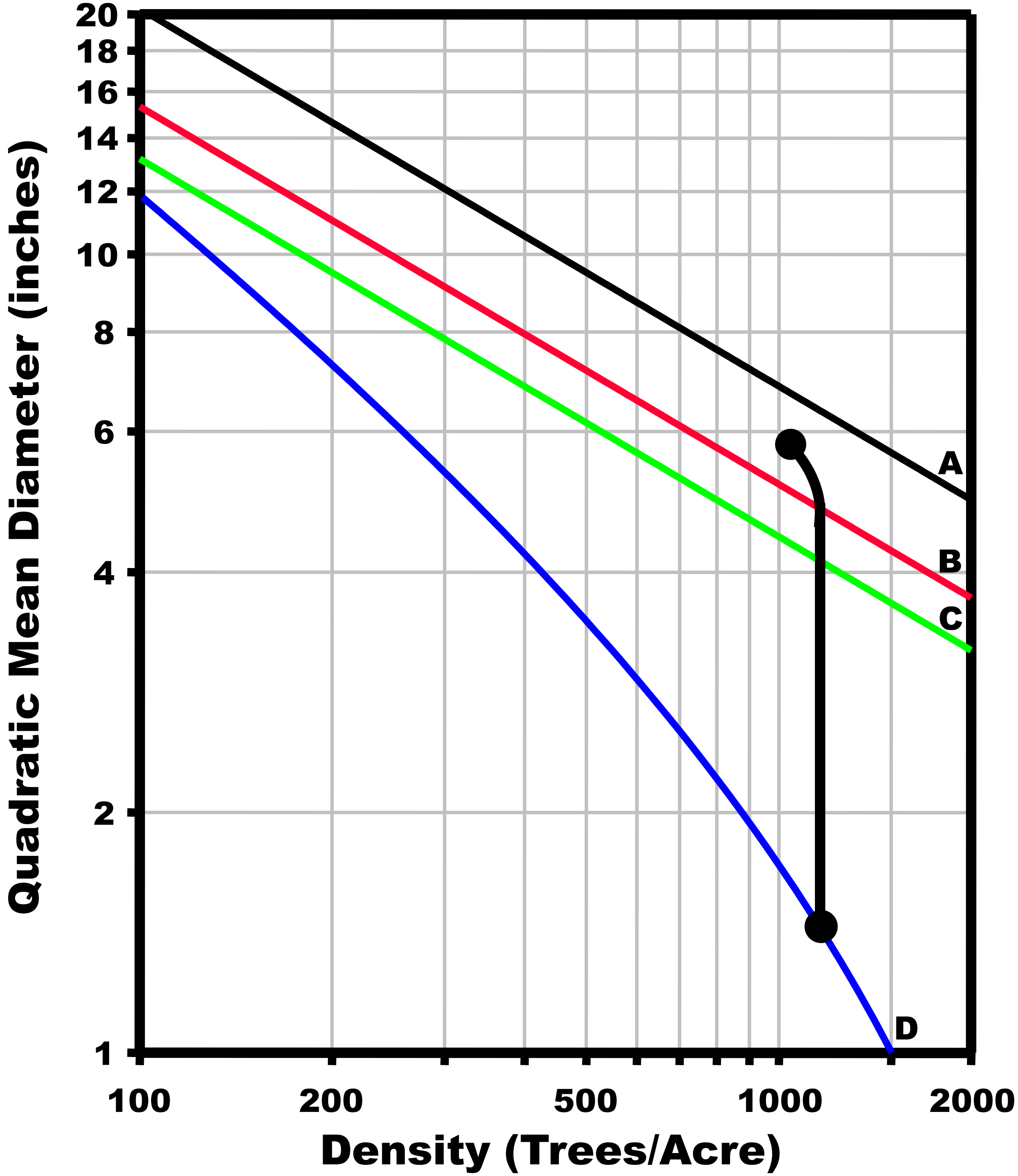
Exercise 5:
Planning an entire rotation

We could either:

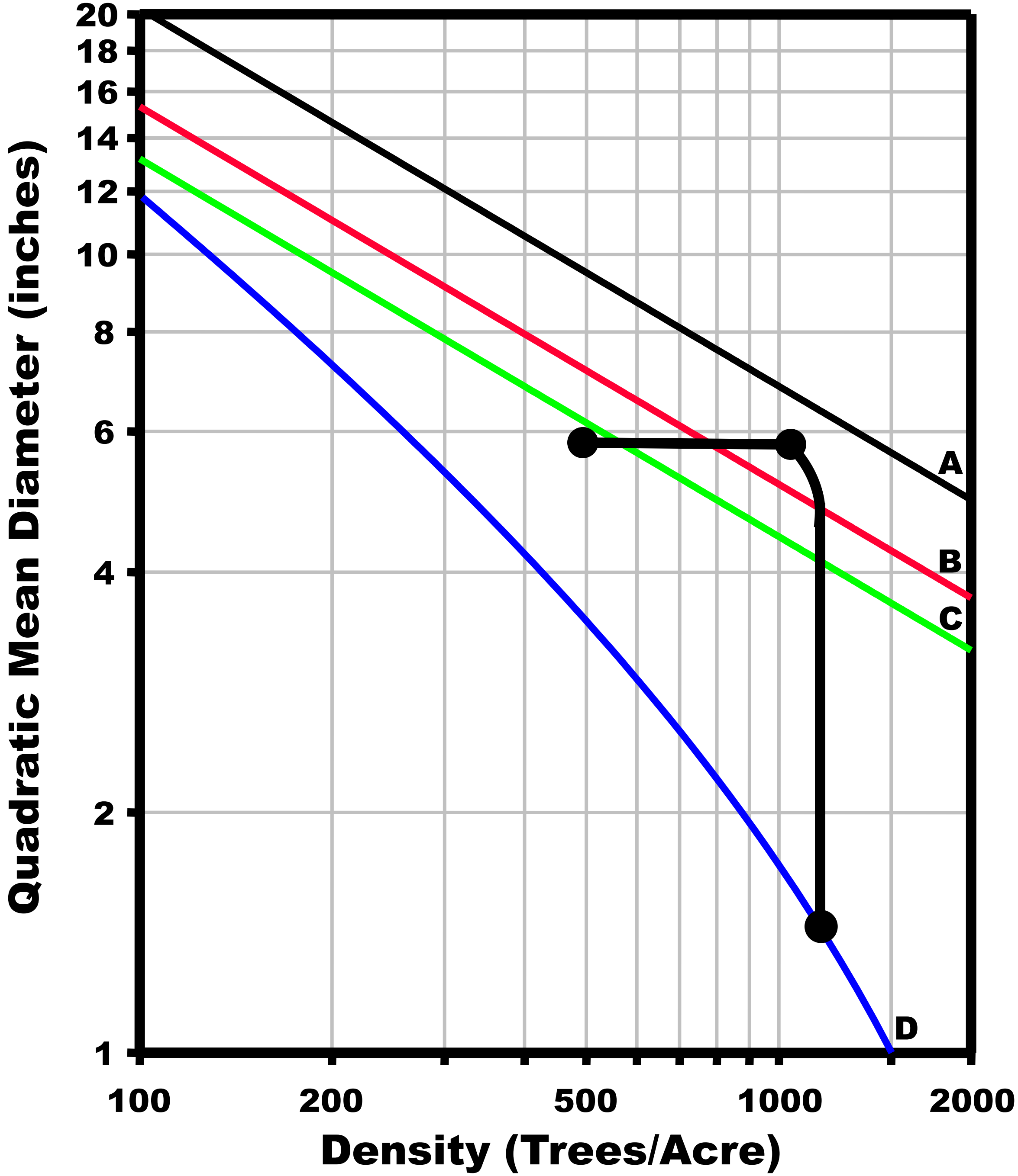
1. Thin the trees now precommercially; or
2. Wait a few years until trees are larger.

I chose #2.

Exercise 5: Planning an entire rotation



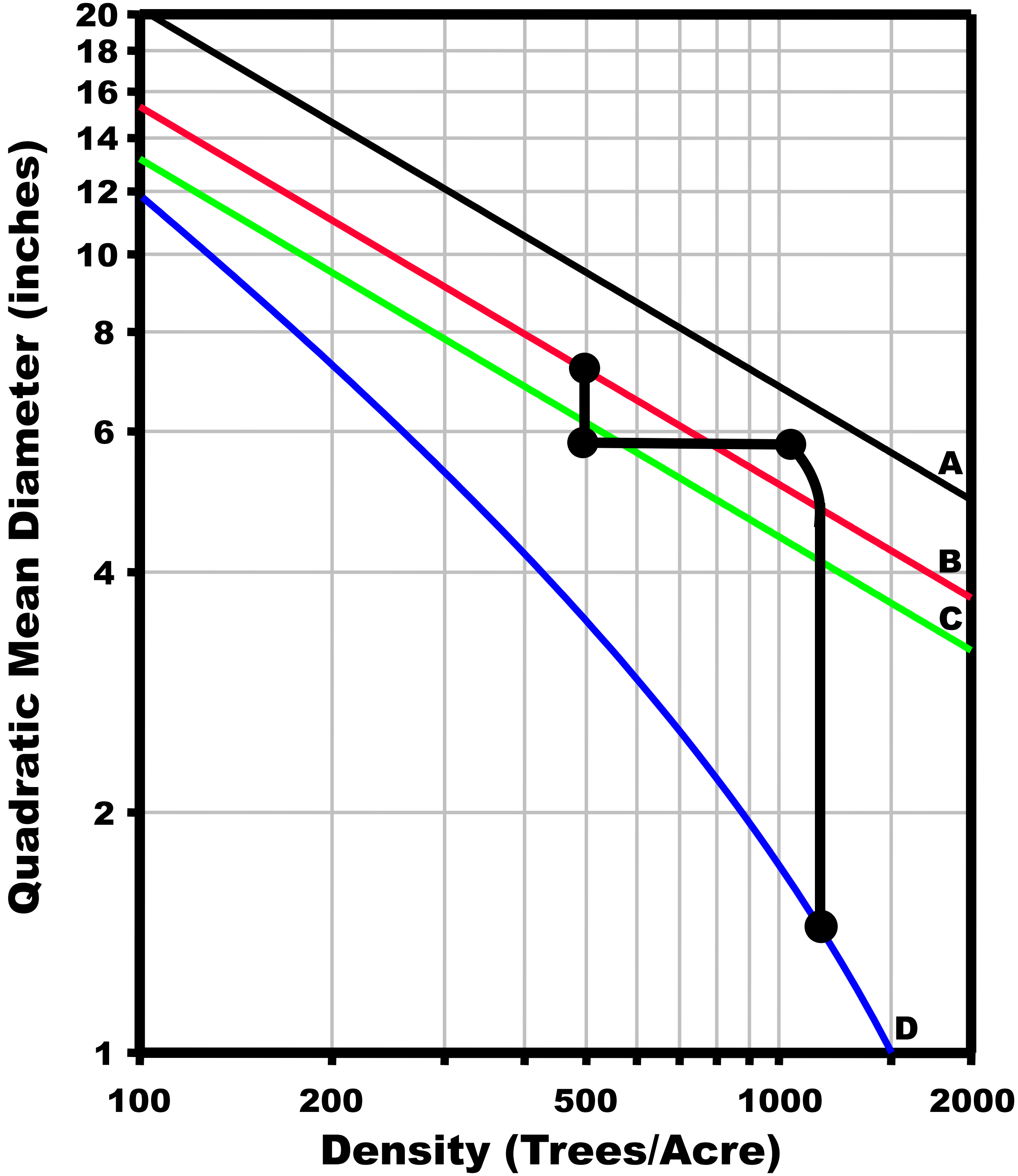
We wait until the stand develops to a DBH_q of 6” and a density of 1000 tpa.



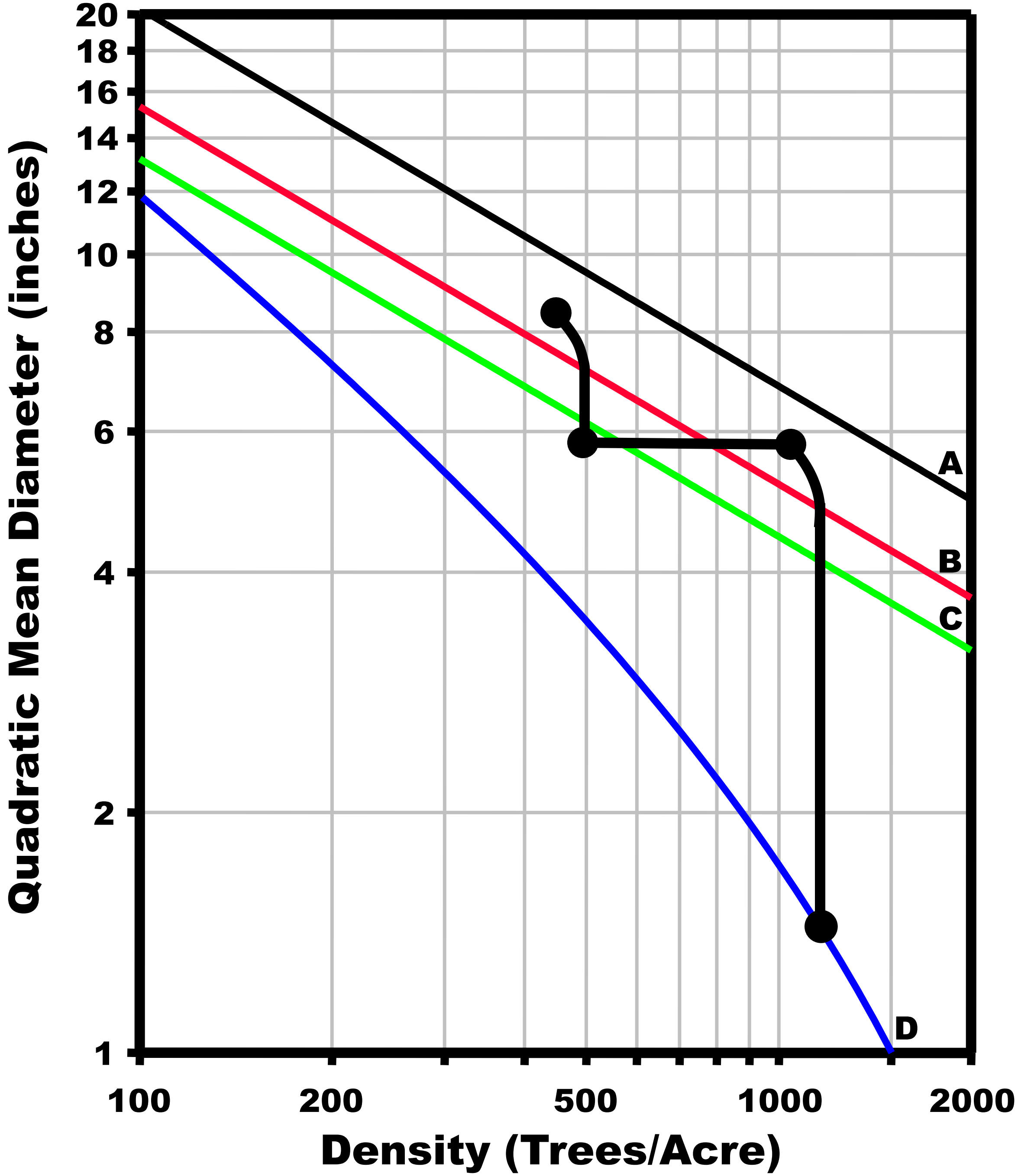
Exercise 5:
Planning an entire rotation

At this size, a mechanical thin removing every other row is most appropriate.

Exercise 5: Planning an entire rotation

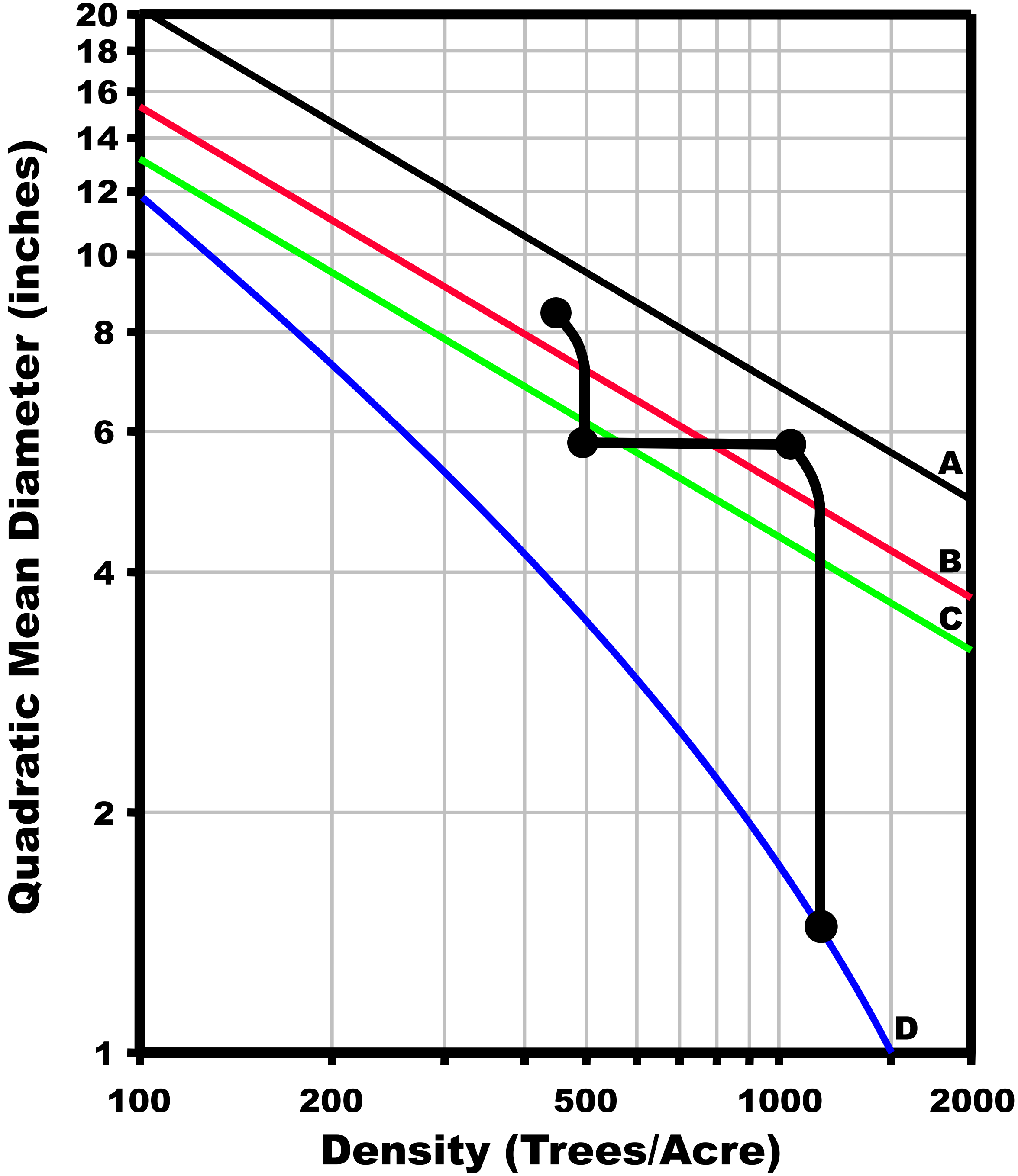


Now, the stand will develop to about 7" DBH_q before crossing the B Line.



Exercise 5:
Planning an entire rotation

Again, I am going to wait for the stand to develop further and accept some mortality.



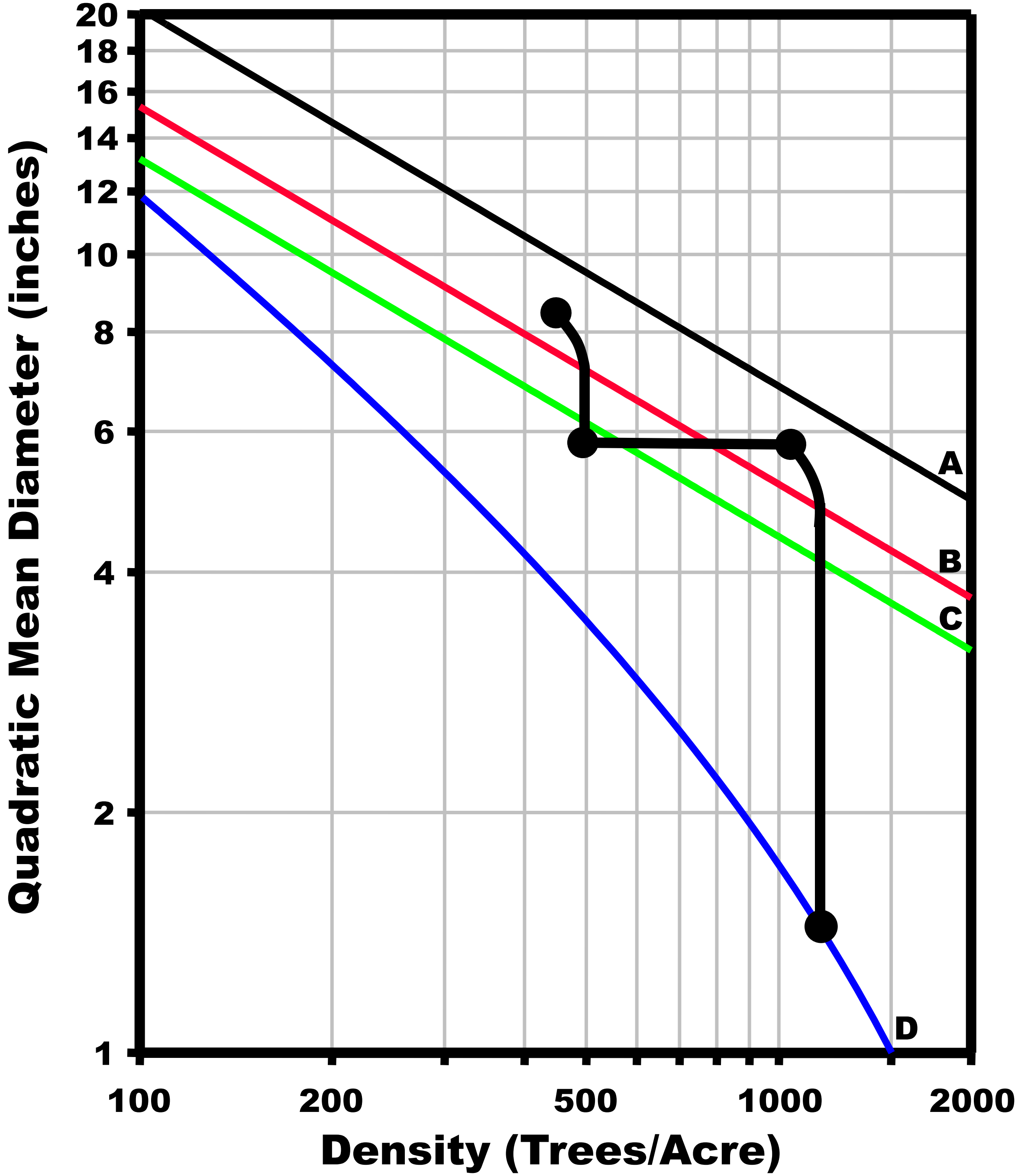
Exercise 5:
Planning an entire rotation

Now, at a DBH_q of 8.5”, we have to thin, but…

What kind?

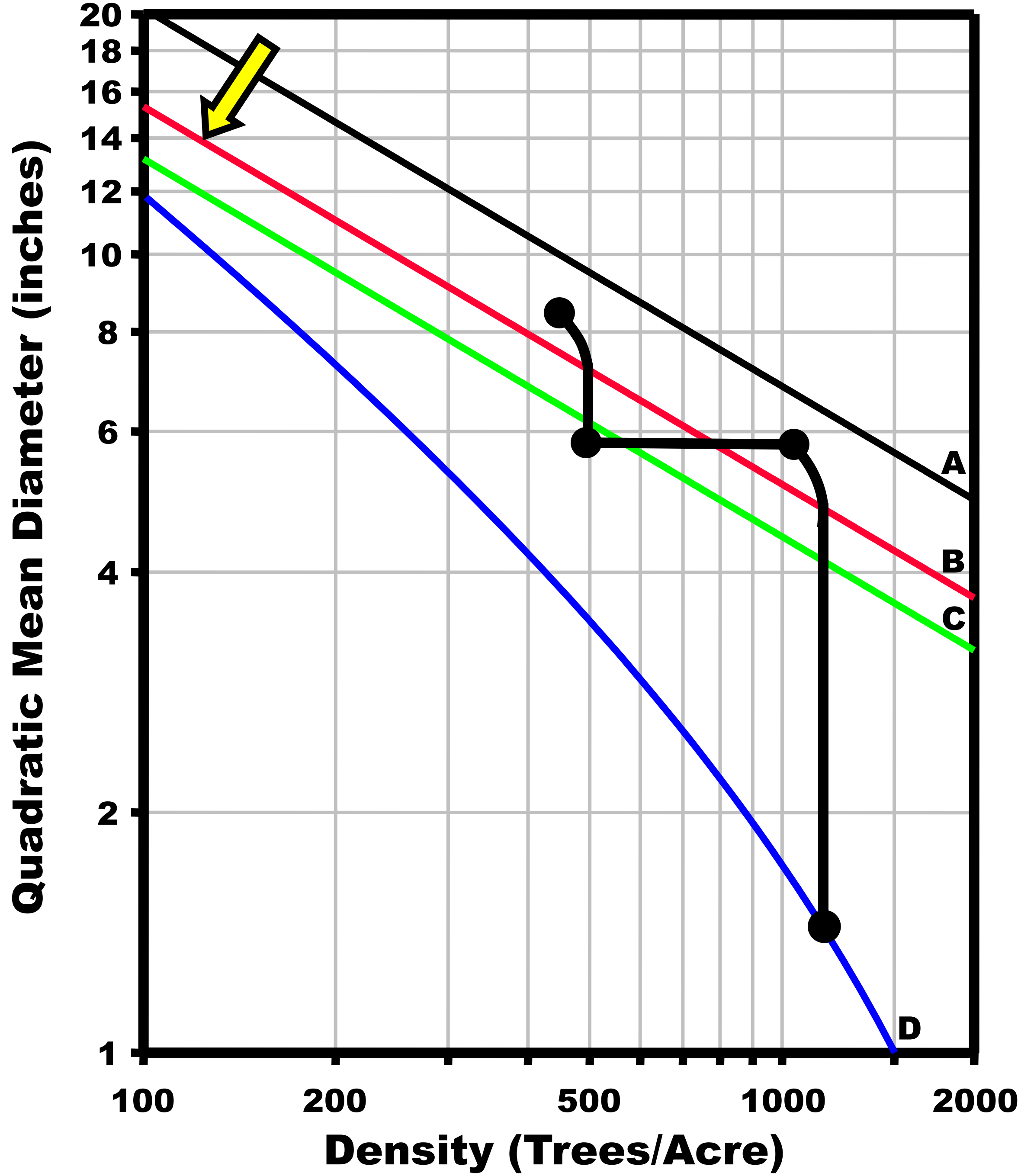
and…

How intense?



Exercise 5:
Planning an entire rotation

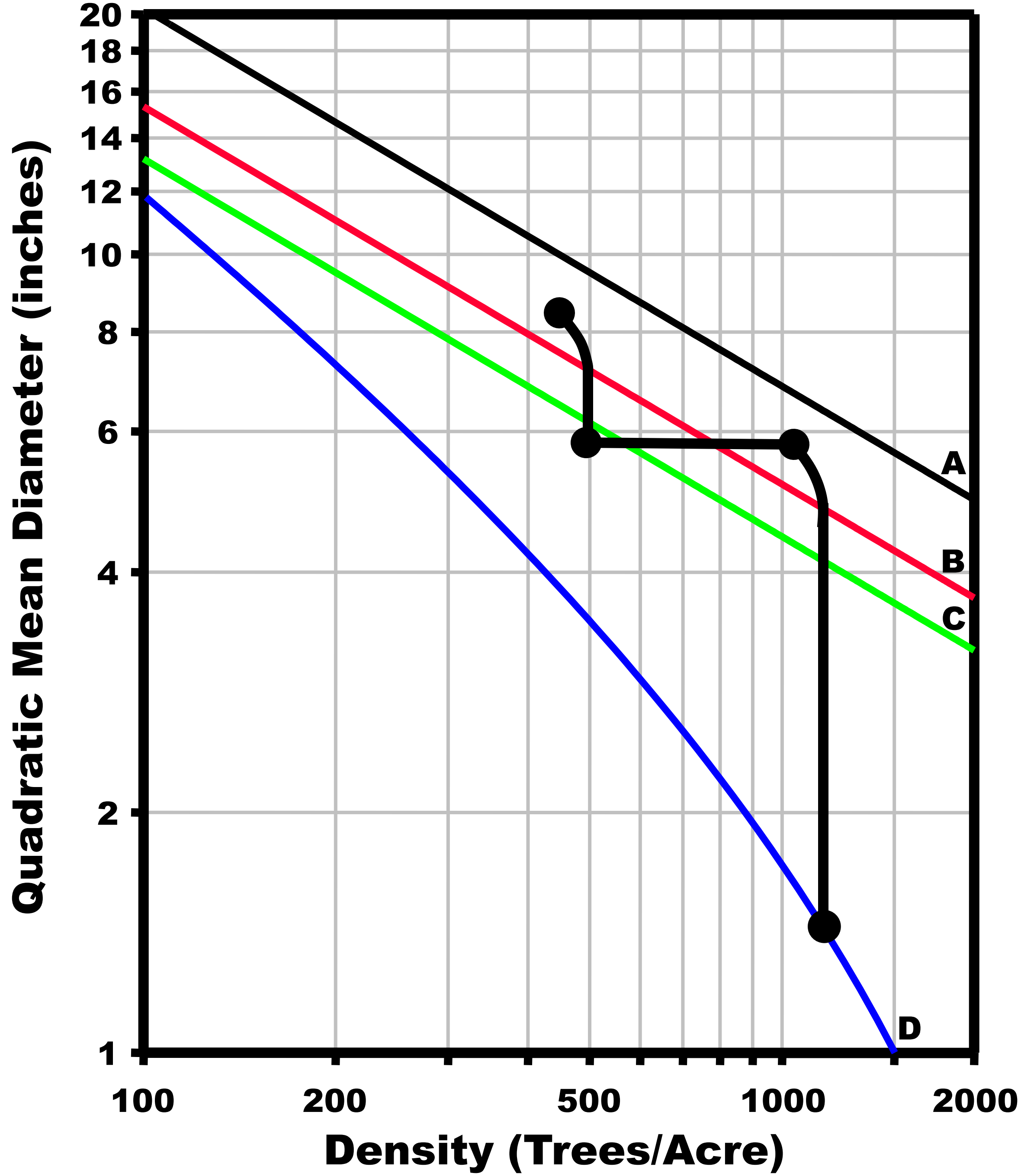
To answer these questions, we need to figure out what the final harvest density will be.



Exercise 5:

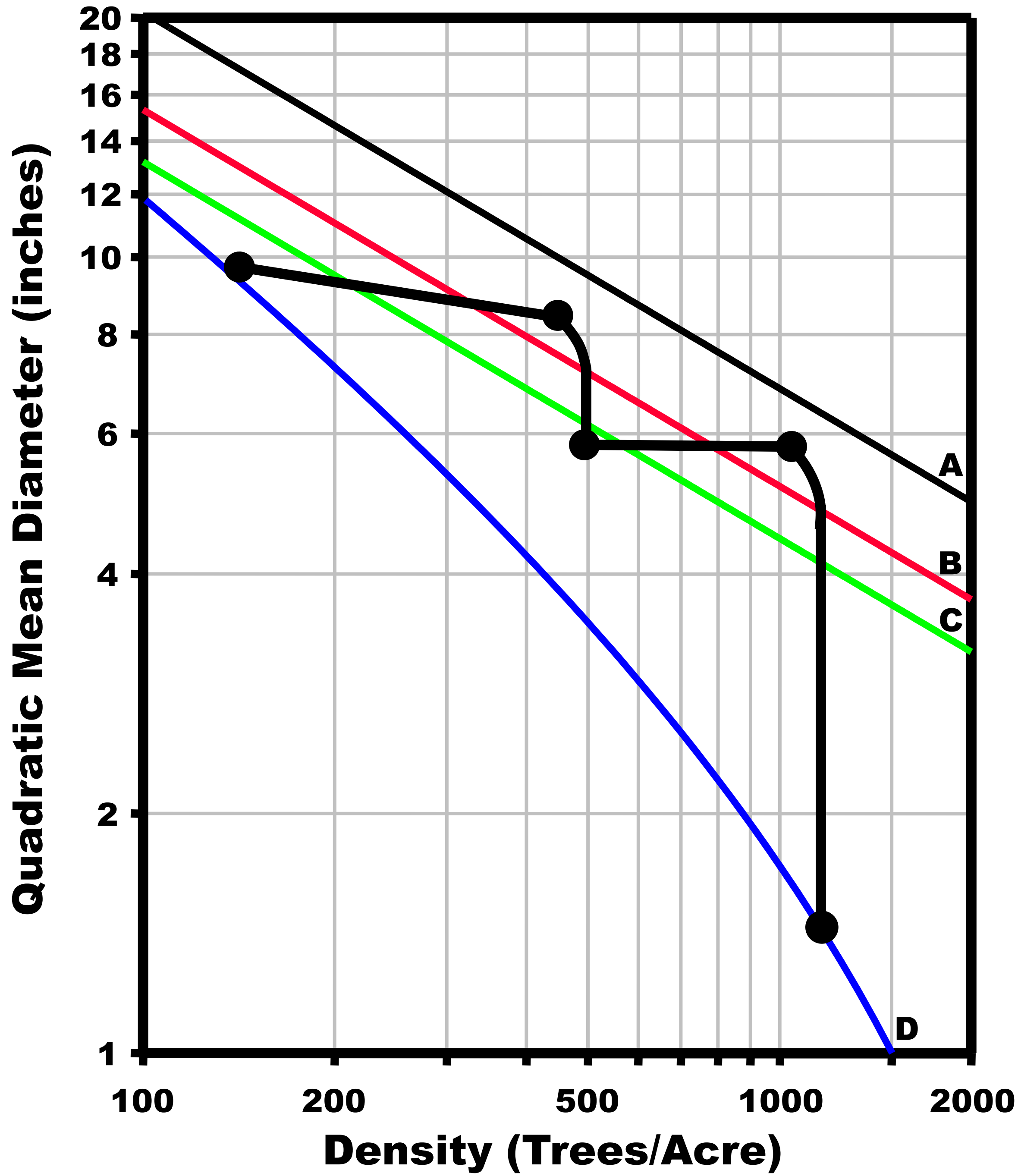
Planning an entire rotation

At a harvest DBH_q of 14”, there will be about 125-150 tpa.



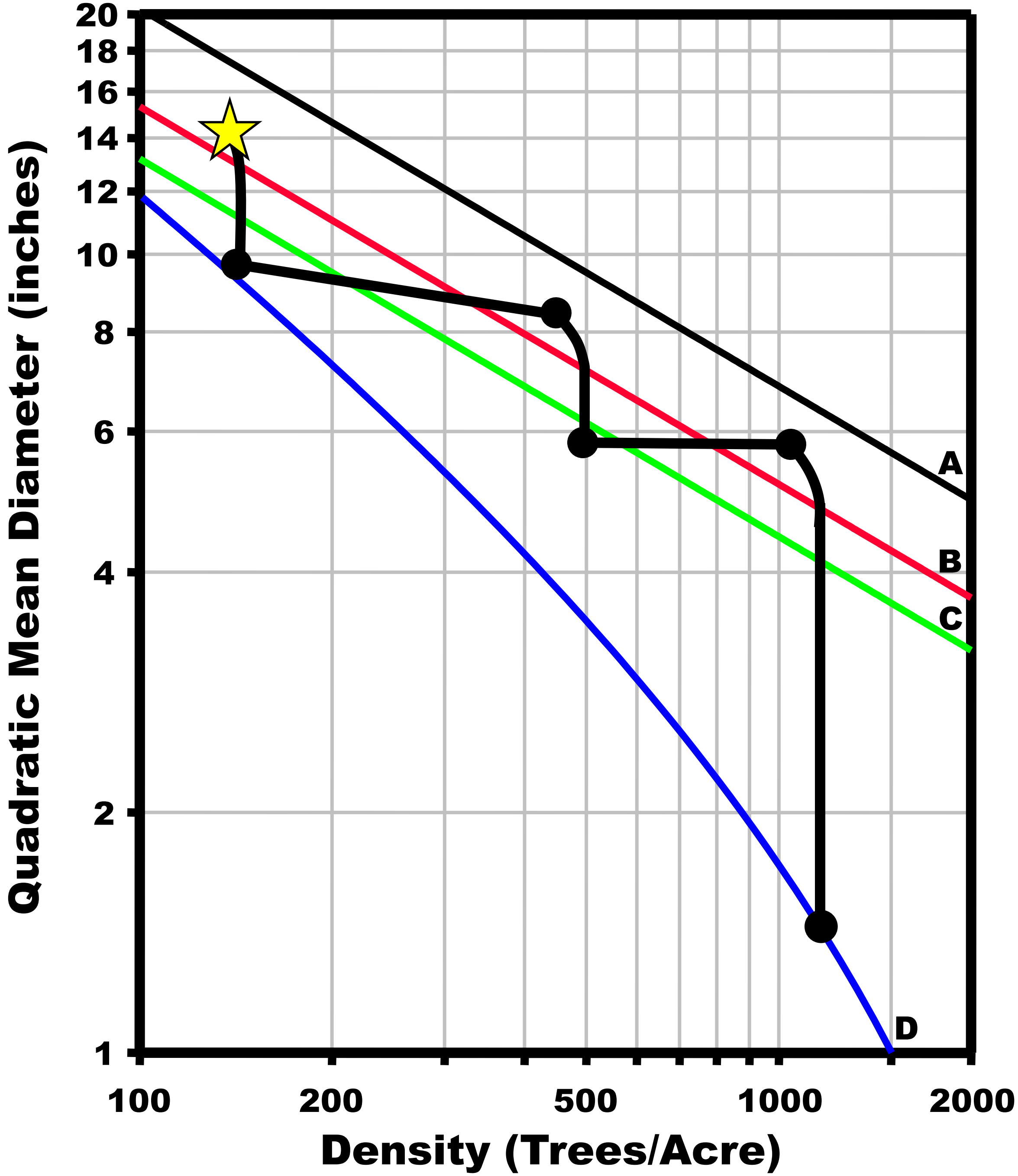
Exercise 5:
Planning an entire rotation

If we thin to about 150 tpa, we would remove about 2/3 of the trees.



Exercise 5:
Planning an entire rotation

This would require a very intense thin, most likely a low thin that would select for the best crop trees.



Exercise 5 : Planning an entire rotation

Now, the stand should develop to a harvest DBH_q of 14” w/o significant mortality.

Cautions

- **Although DMD are very useful, there are some cautions about their application one should be aware of:**
  1. **No temporal component**
  2. **Only density-dependent mortality**
  3. **Only as good as the data that formed them**
  4. **Should be applied cautiously outside there intended purpose**

Altre caratteristiche

Altezza dominante

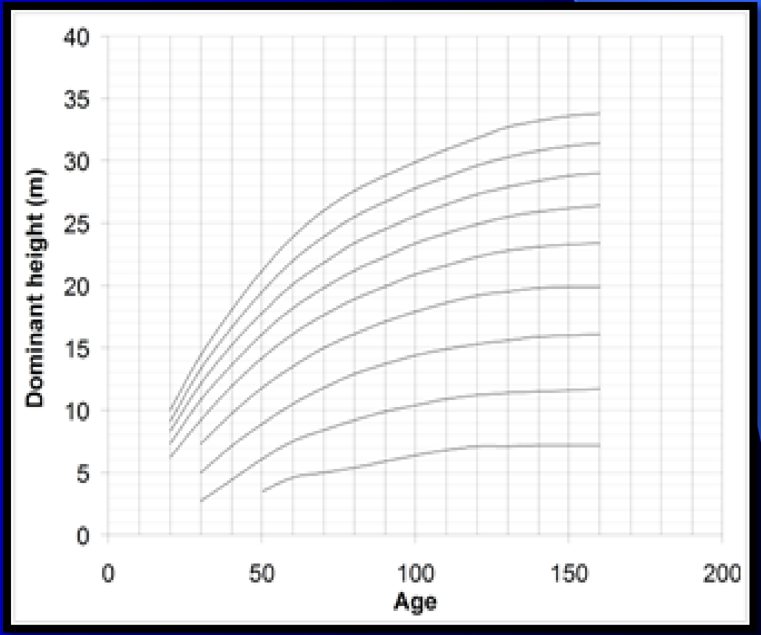
In funzione della densità e del diametro medio

Site Index

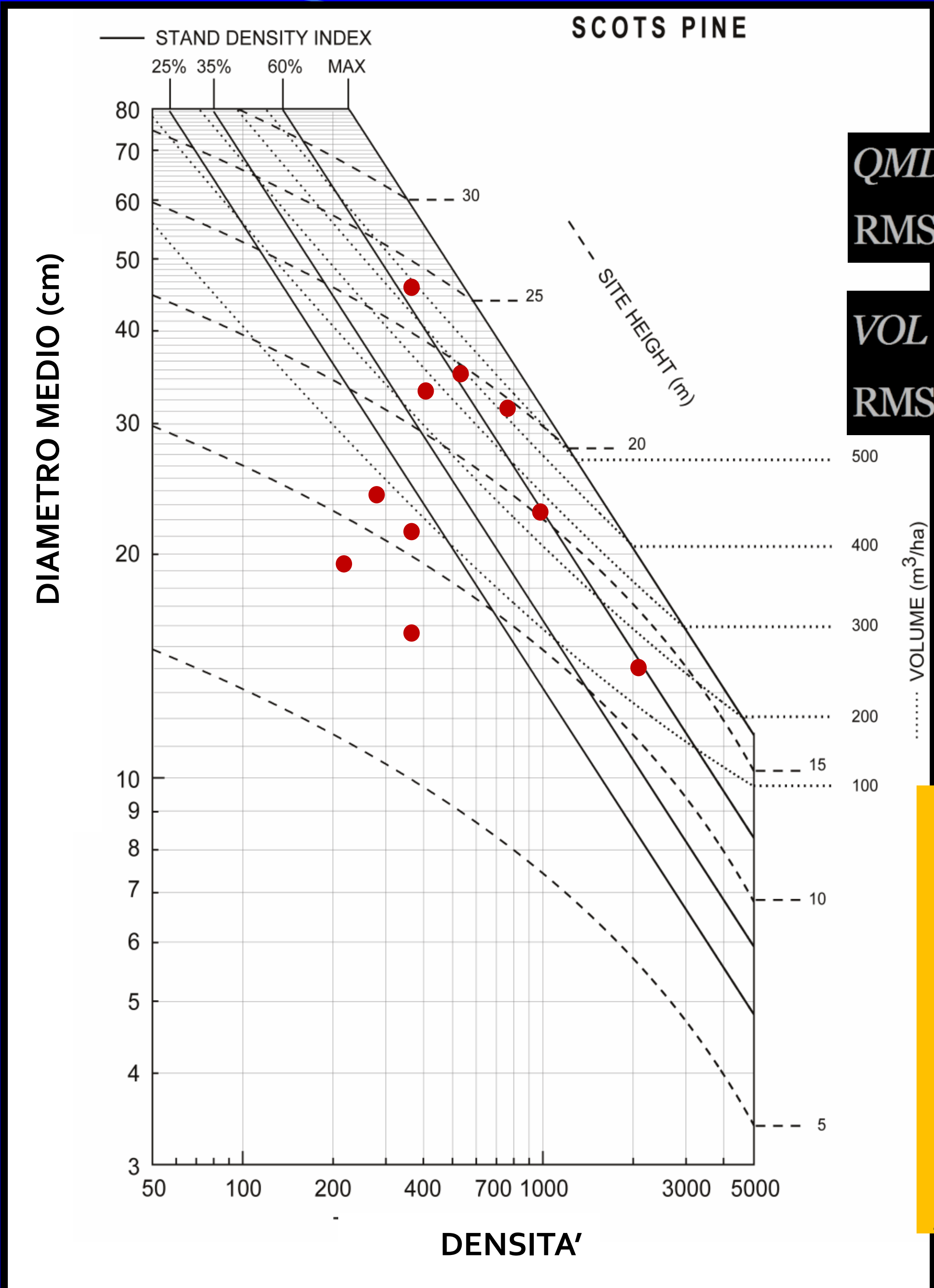
Tempo necessario a conseguire una data struttura

Provvigione

Yield-density effect



fonte: Wiedemann 1949



$$QMD = H_{100}(4.927 - 0.498 \ln N)$$

RMSE=0.75 m

$$VOL = 0.002N(QMD - 5.713)^{1.808}$$

RMSE=263.27 m^3 ha^{-1}

Ogni popolamento è rappresentato da una coppia di variabili

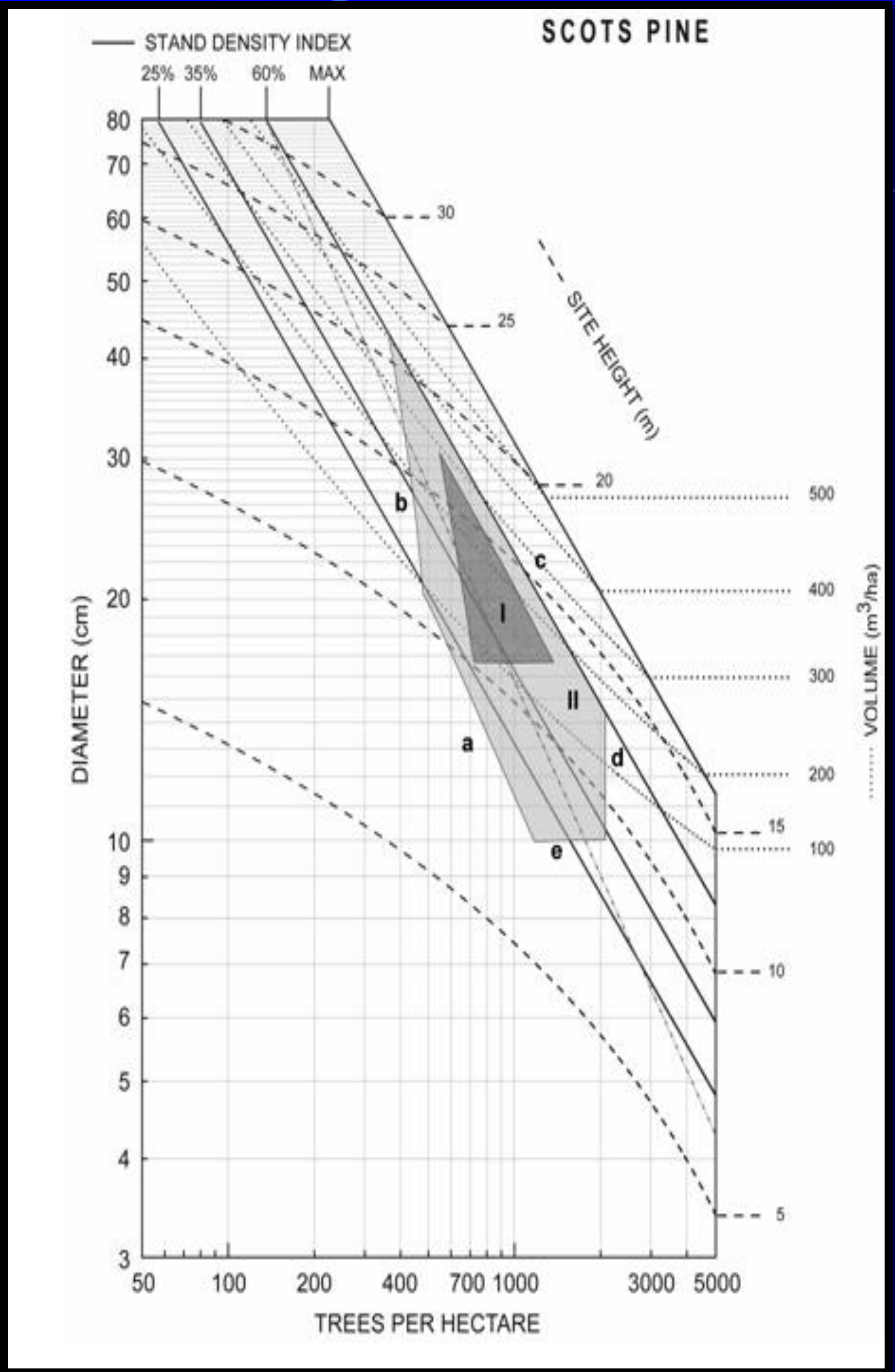
(densità, D_{medio}, densità relativa, altezza dominante, provvigione).

Gestire le foreste di protezione

Obiettivo di gestione:

Conseguire e mantenere una struttura ottimale per ridurre il pericolo di caduta di pietre.

Obiettivo → Struttura → Zona di gestione attiva



Gestire le foreste di protezione

a. Copertura > 60%

Relazione dbh-raggio chioma

b. Distanza media < 30 m

Funzione della densità e del Ø dei massi

c. Lunghezza chioma viva > 30%

Funzione della competizione (SDI)

d. Coeff. snellezza < 80

Relazione dbh-altezza per alb. dominanti

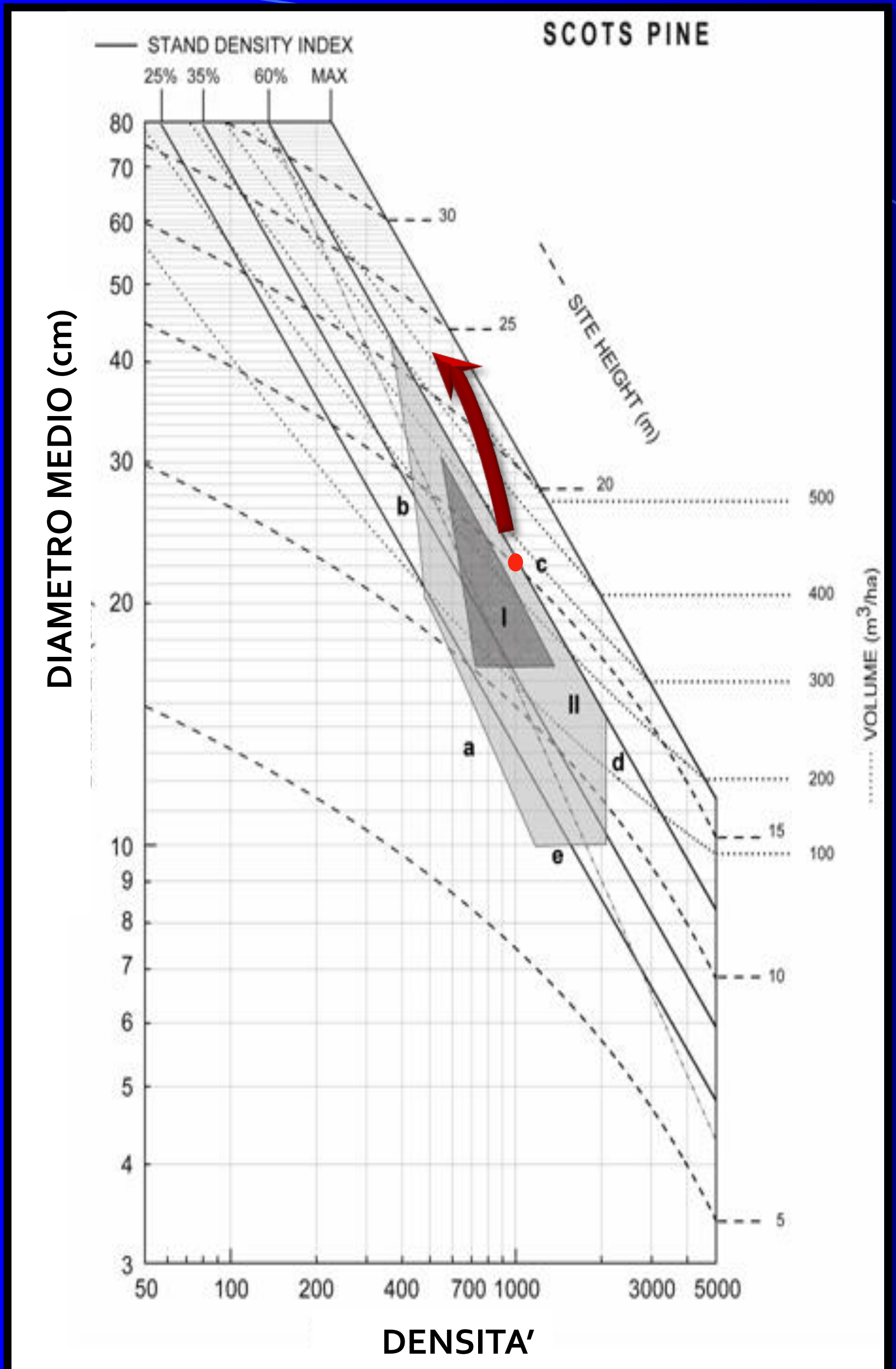
e. D_{medio} > ⅓ x Ø massi (30cm)

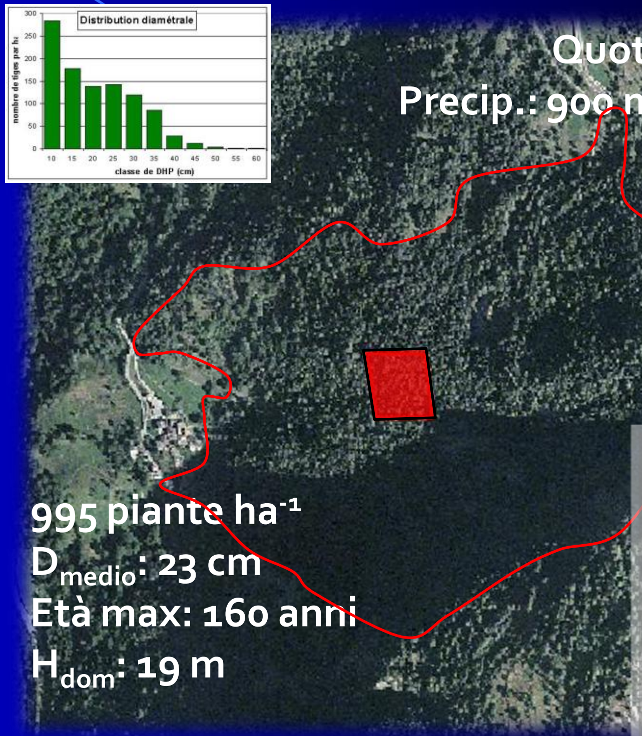
SDI: da 600 a 1000, per garantire adeguata copertura e sufficiente stabilità meccanica e fisiologica (soddisfatto)

I: massima funzionalità protettiva

II: protezione minima accettabile

Gestire le foreste di protezione





Caso di studio:

Bois de Liex (AO)

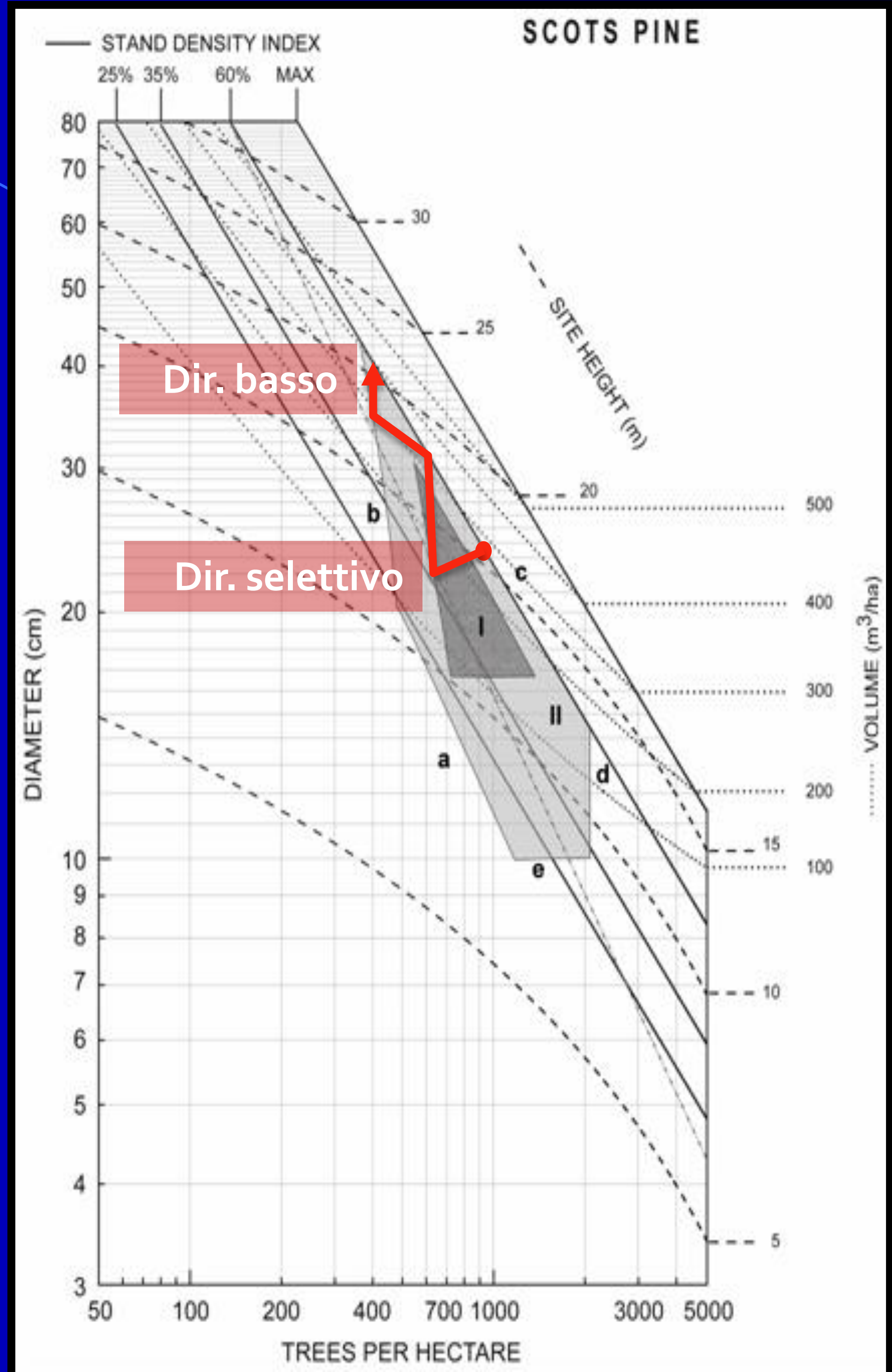
Gestire le foreste di protezione

Il popolamento è al limite esterno della zona di minima protezione, e tende ad evolvere verso un'area di COMPETIZIONE INTENSA

(densità relativa= 0.62).

Selvicoltura attiva			Evoluzione libera
Diradamento dal basso	*Diradamento selettivo*	*Diradamento selettivo + dal basso*	

Gestire le foreste di protezione



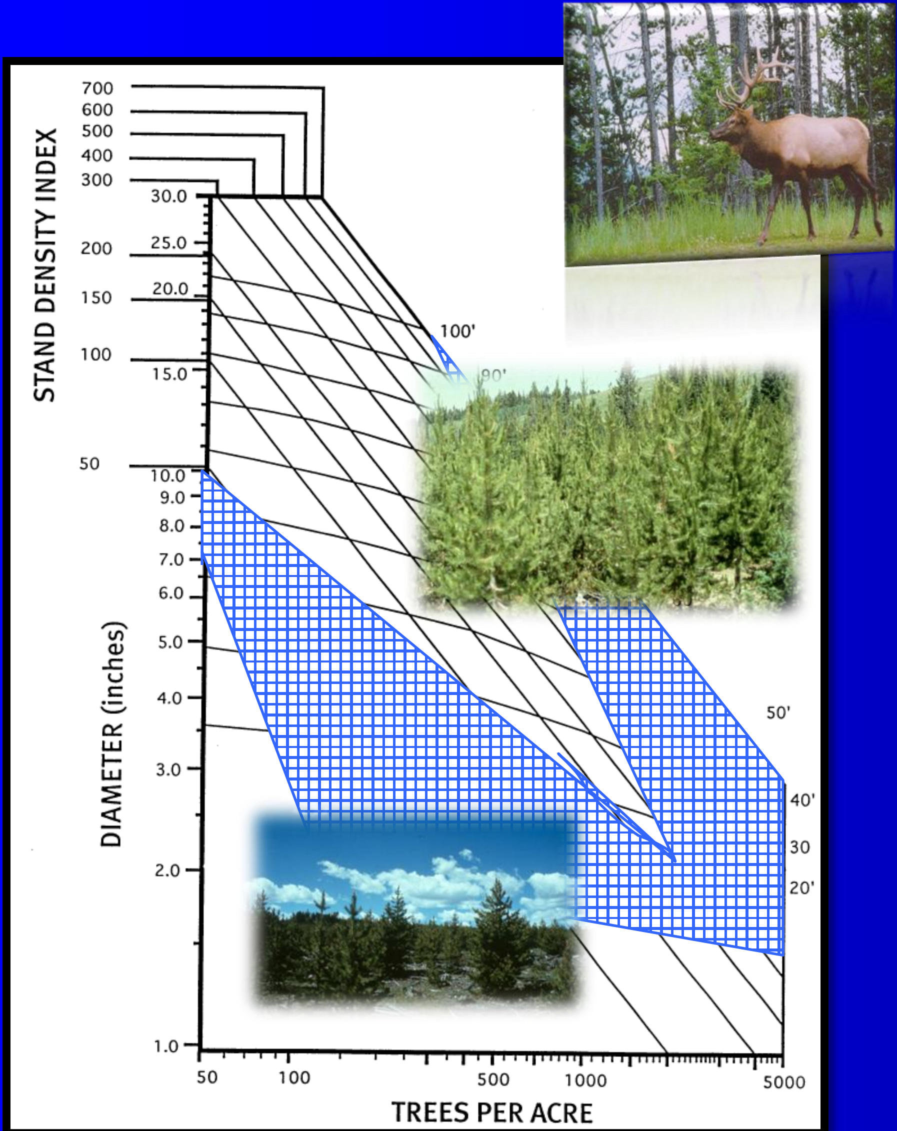
Interventi mirati a massimizzare il tempo trascorso nella zona di massima protezione.

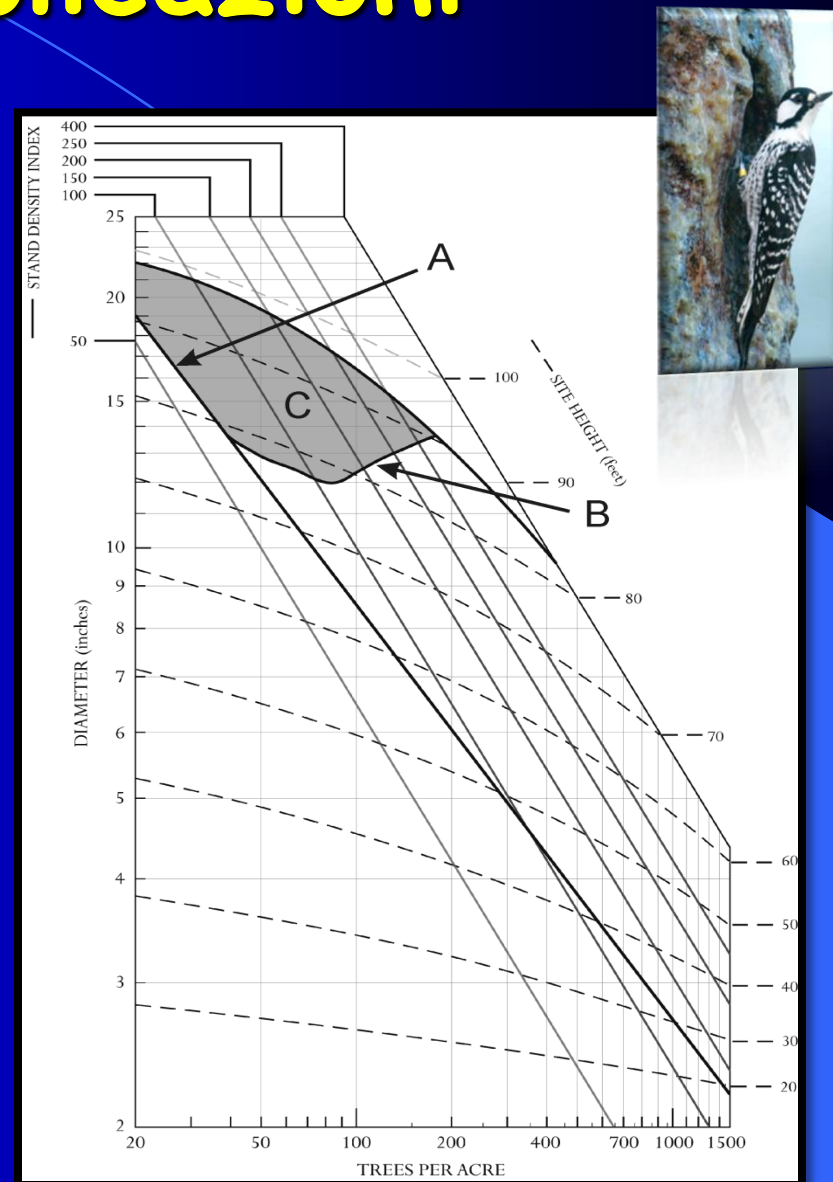
Gestire le foreste di protezione

	Età[a]	H_{dom} (m)	N (TPHa)	D_{medio} (cm)	VOL (m^3 ha^{-1}) [b]
Condizioni iniziali	80	**16**	**995**	**22.7**	**330**
i) Libera evoluzione[c]	150	20	796	32	587
Tempo in zona minima + ottimale	*0+0 anni*				
ii) Dopo diradamento basso	80	16	895	23	310
Tempo in zona minima + ottimale	*0+5 anni*				
iii) Dopo diradamento selettivo	80	13	641	22	199
Tempo in zona minima + ottimale	*13+20 anni*				
iv) Prima 2° diradamento basso	95	17	600[d]	30	384
Dopo 2° diradamento basso	95	17	400	33	316
Tempo in zona minima + ottimale	*10+35 anni*				

[a] Età media stimata (differente dall'età massima misurata in campo). La durata delle fasi evolutive è calcolata usando SI18.
[b] Volume calcolato mediante funzione allometrica (il volume iniziale differisce dal valore reale).
[c] Traiettoria stimata di sviluppo on mortalità densità-dipendente, fino a H_{dom} =20m.
[d] La riduzione didensità rispetto al valore previsto è dovuta all'effetto simulato della caduta di pietre sulla mortalità degli alberi nel popolamento.

Altre applicazioni





Visualizzare i risultati

- Geometric modeling

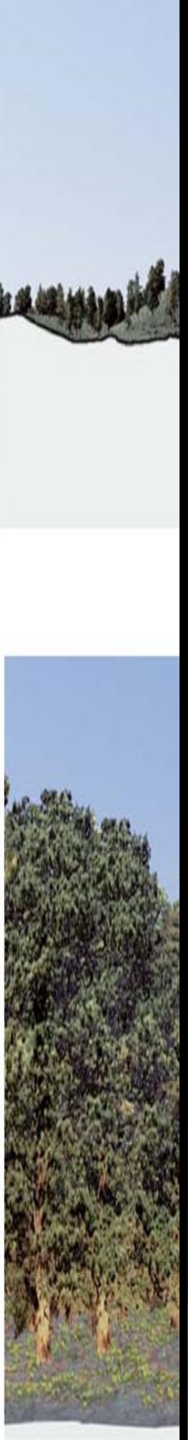
  CAD e software dedicati

- Video imaging

  Photoshop

- Image draping

  GIS - Geographic Information Systems

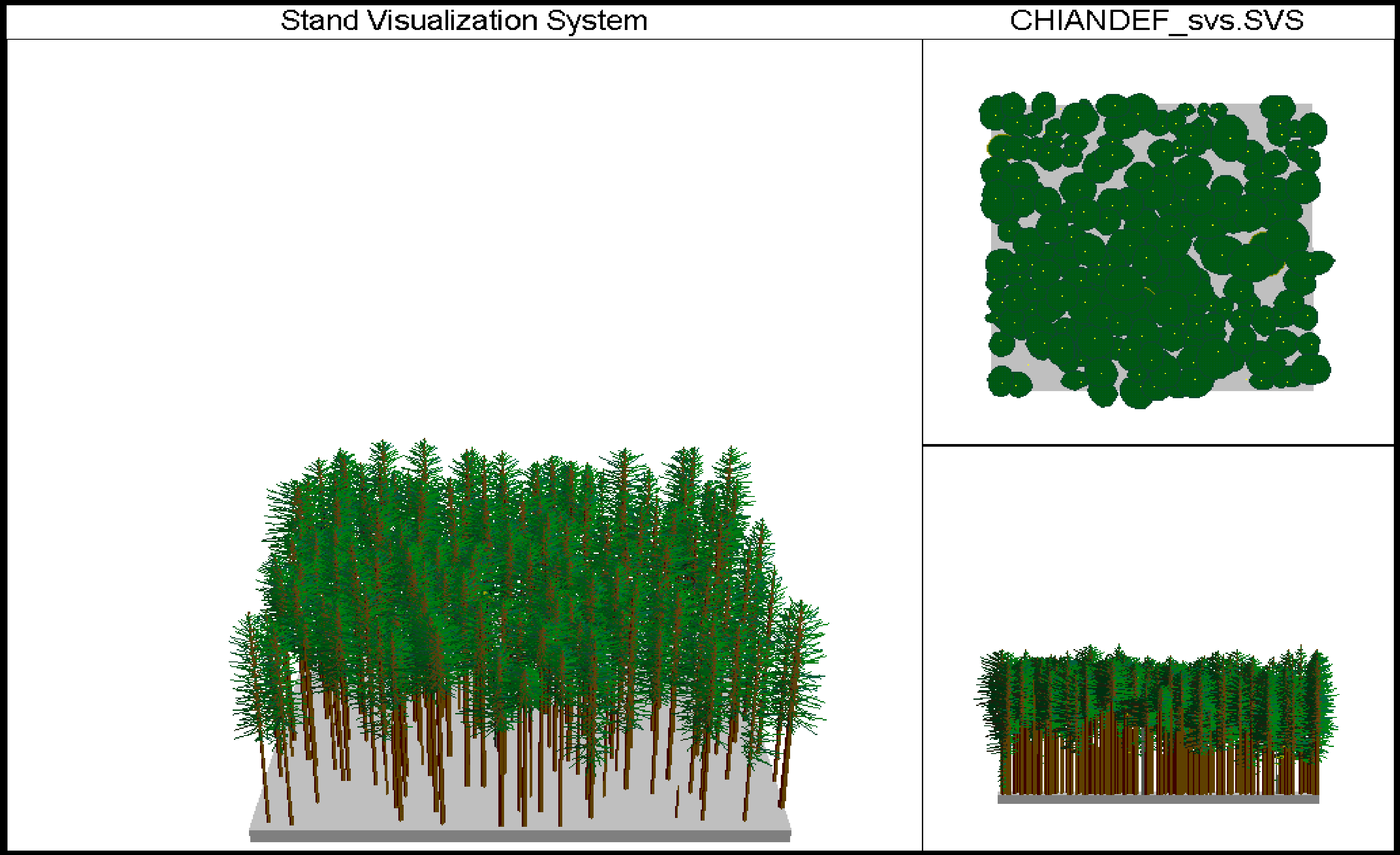


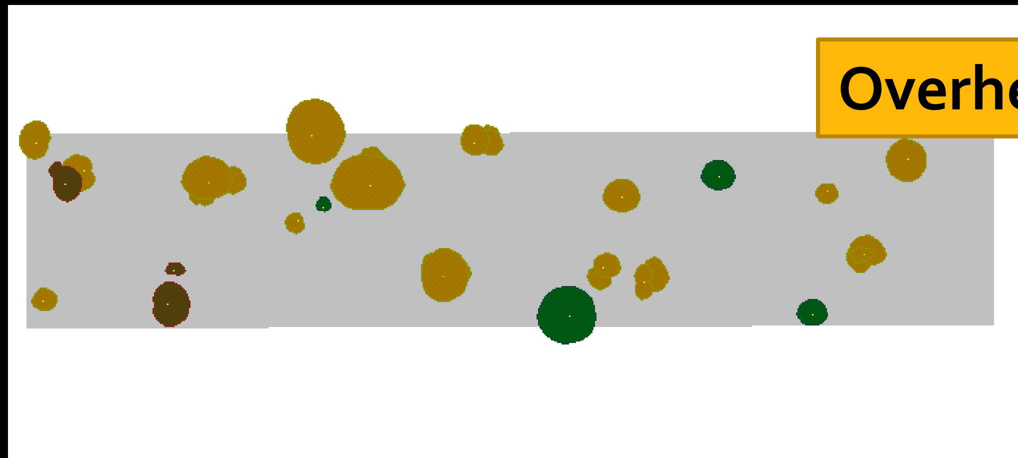
Visualizzare i risultati

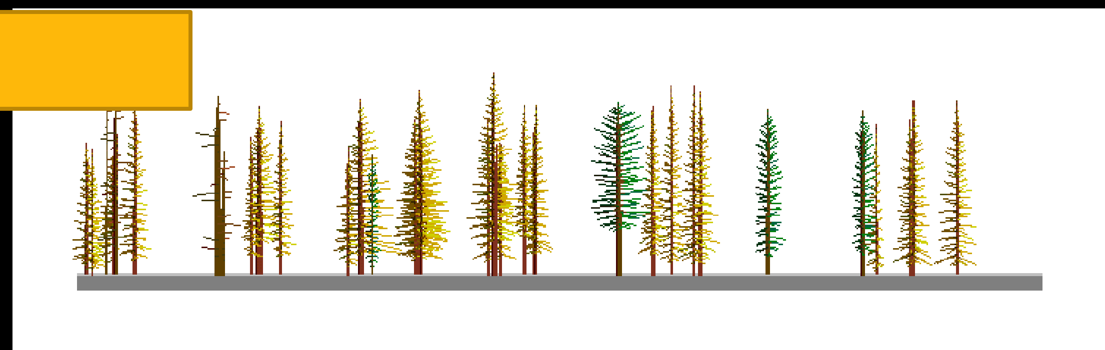
- **Geometric modeling**

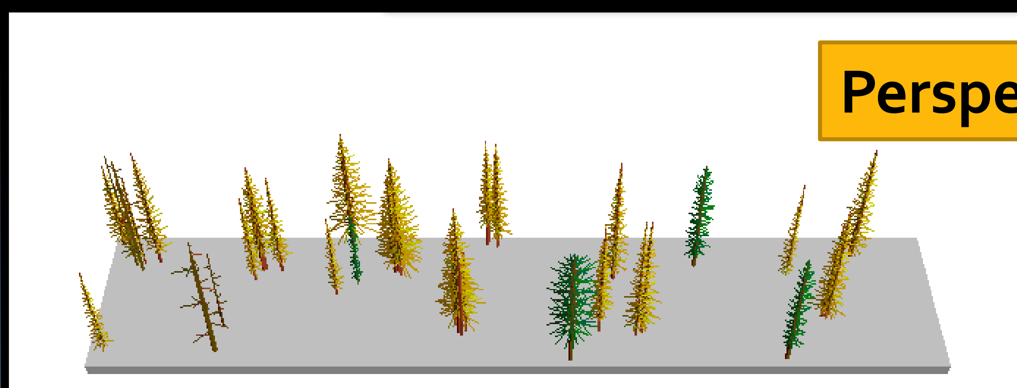
  3-D geometric models of individual features such as trees, ground surface, plants, roads, etc. The individual 3-D objects are assembled to create a forest stand or landscape view. Scenes are then rendered given perspective from a viewpoint.

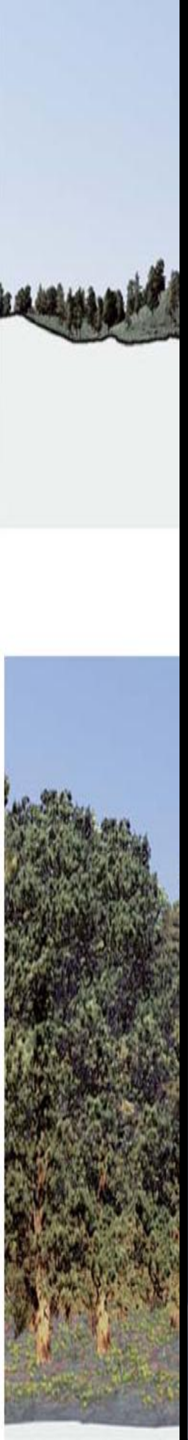
Stand Visualization System




Overhead


Profile


Perspective

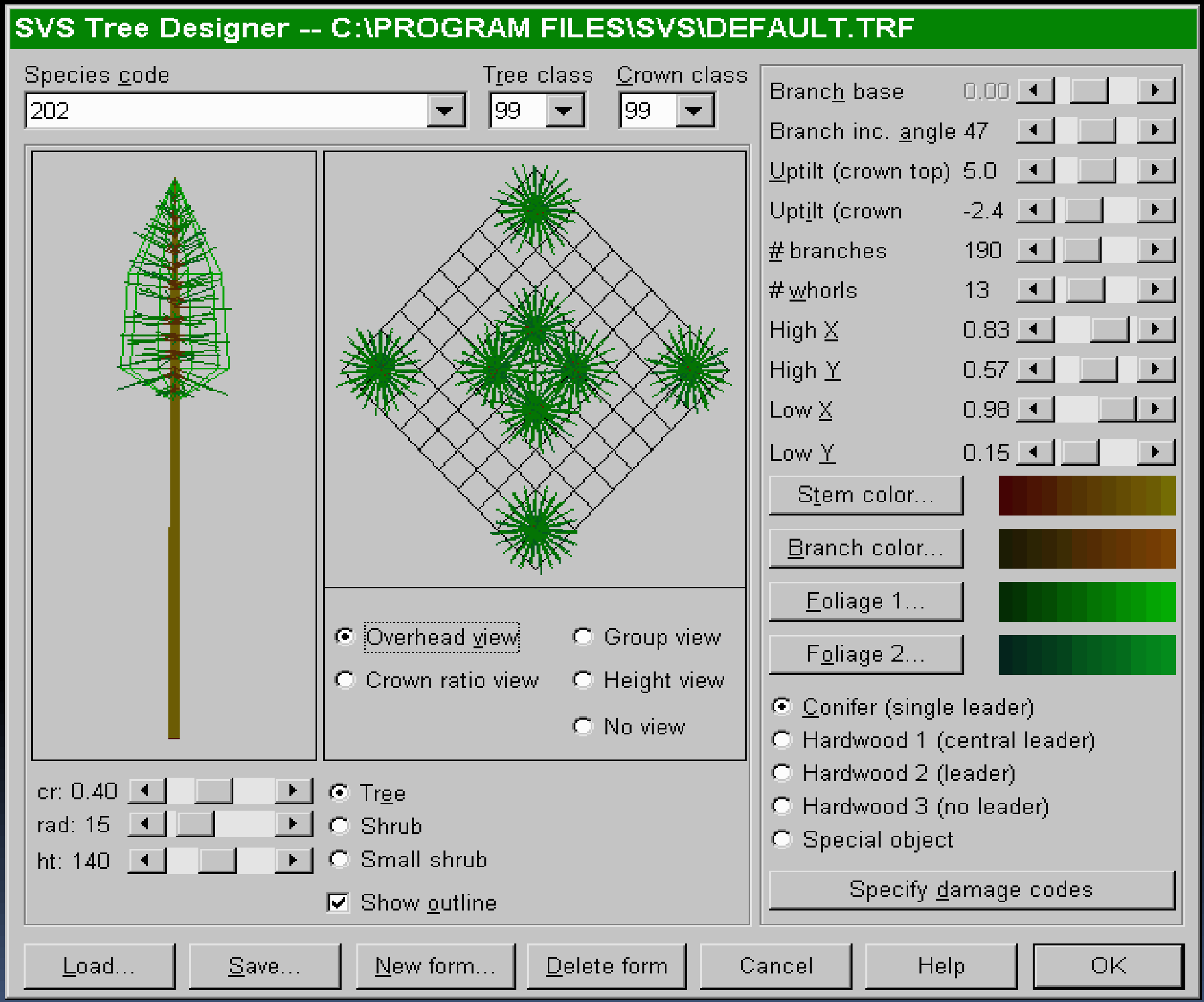


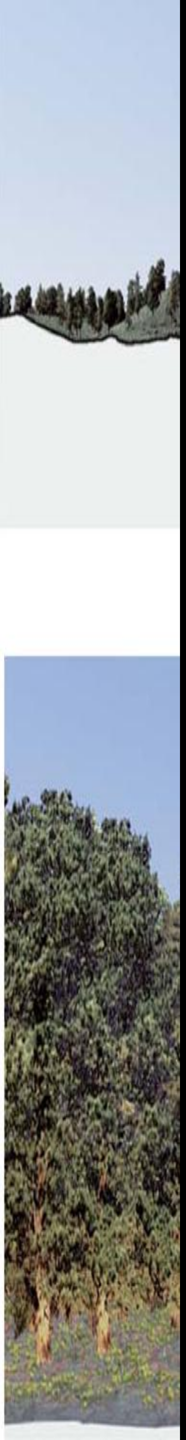
Stand Visualization System

- Species code
- Plant ID
- Plant status (0-3)
- Diameter (Dbh)
- Height
- Lean angle - Felling angle
- End diameter
- Crown radius (4)
- Crown ratio (4)
- Marking status
- X – Y - Elevation

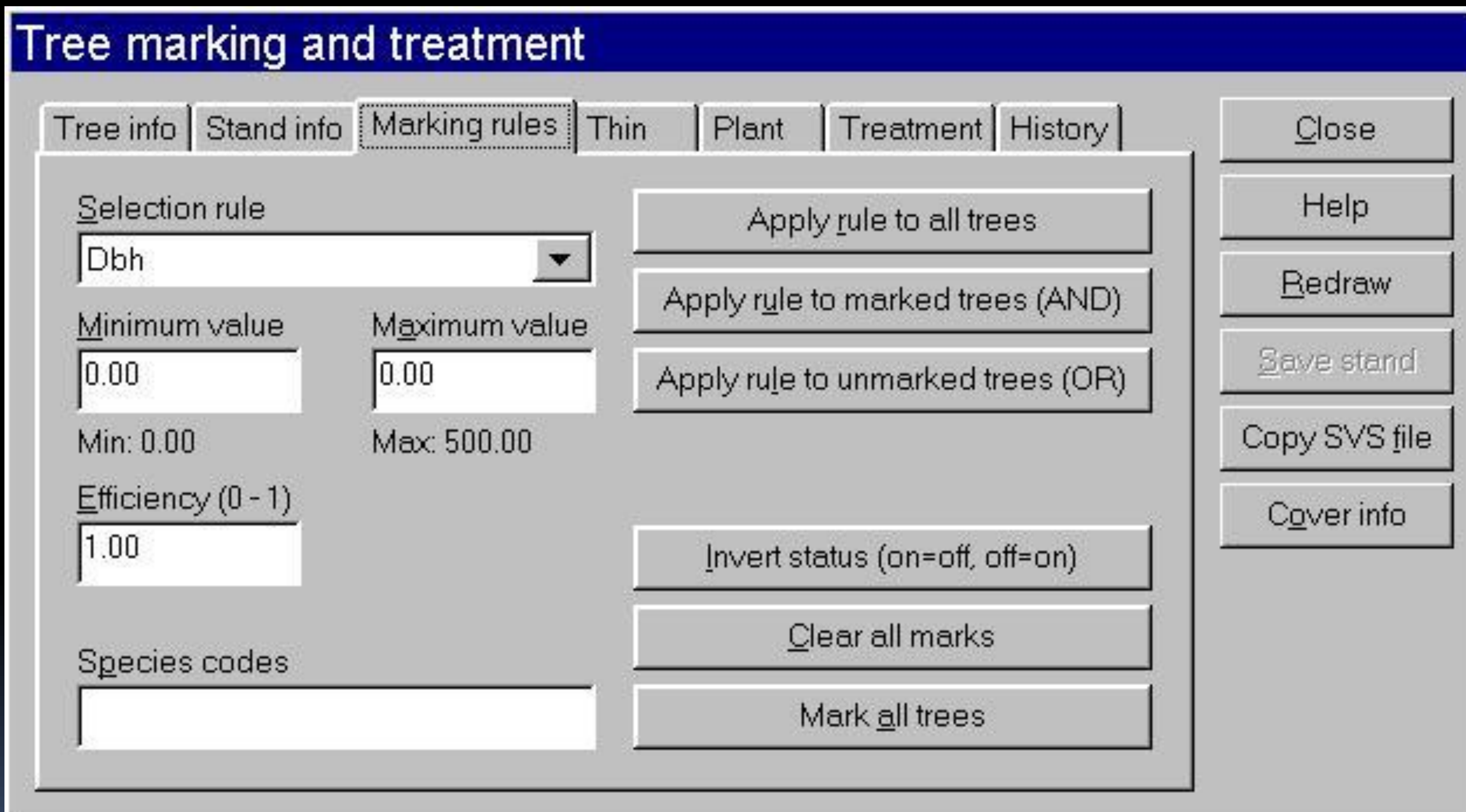
} **Treelist**

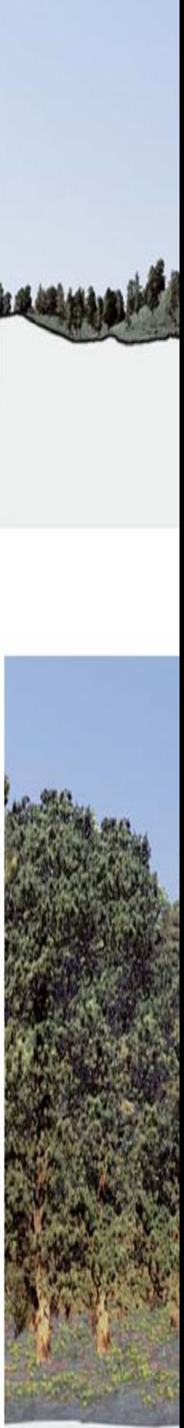
Stand Visualization System

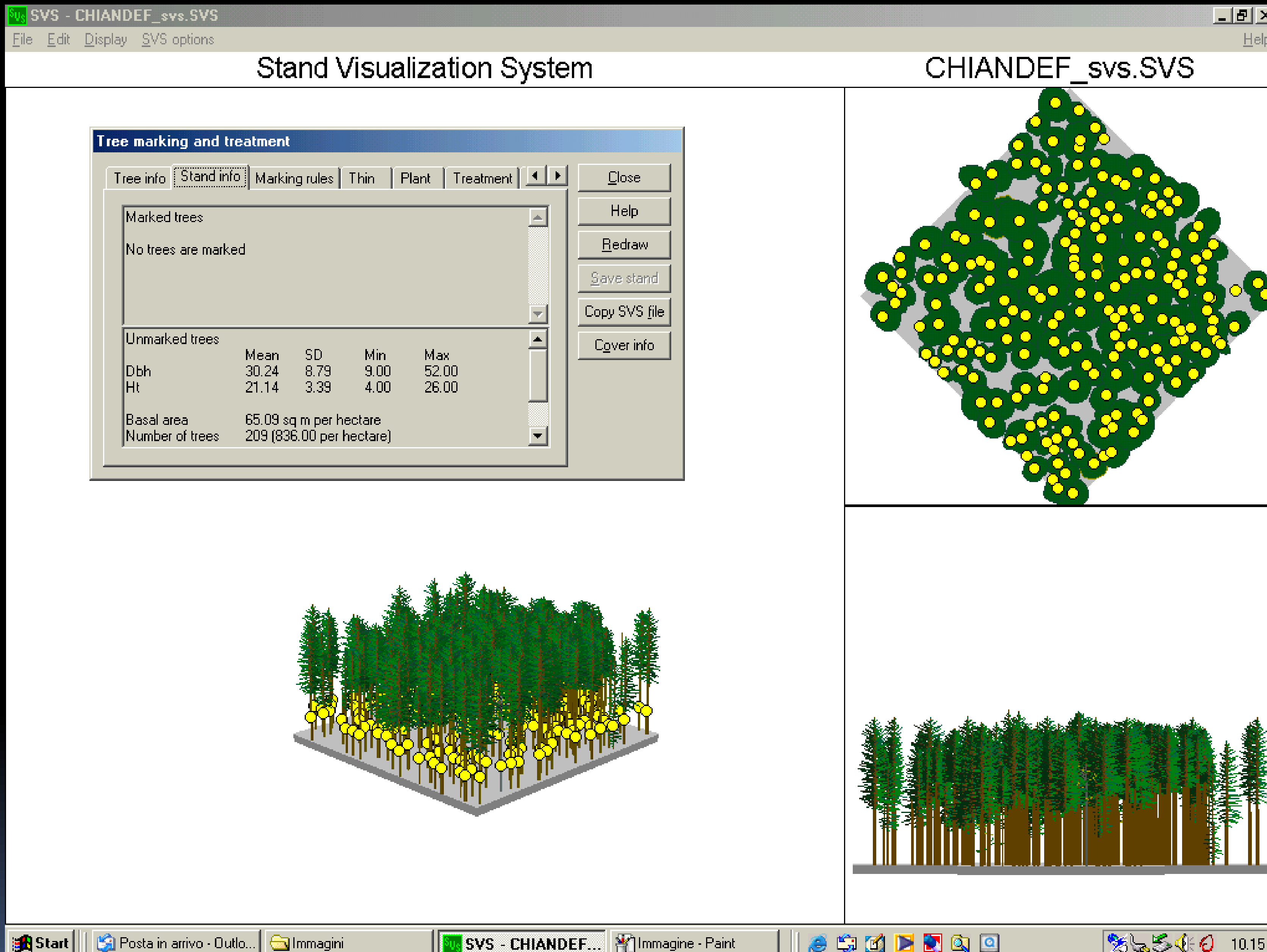


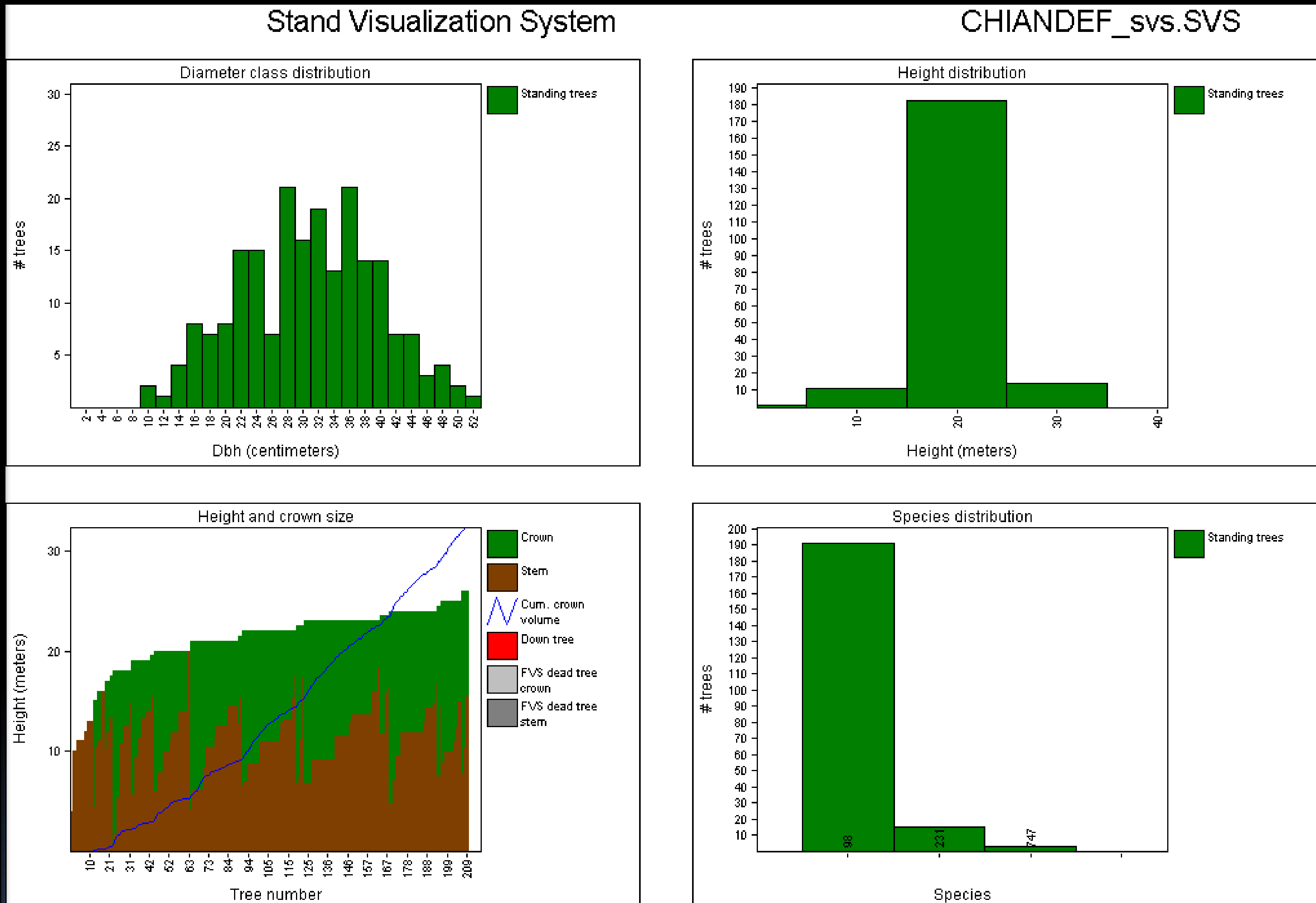


Stand Visualization System

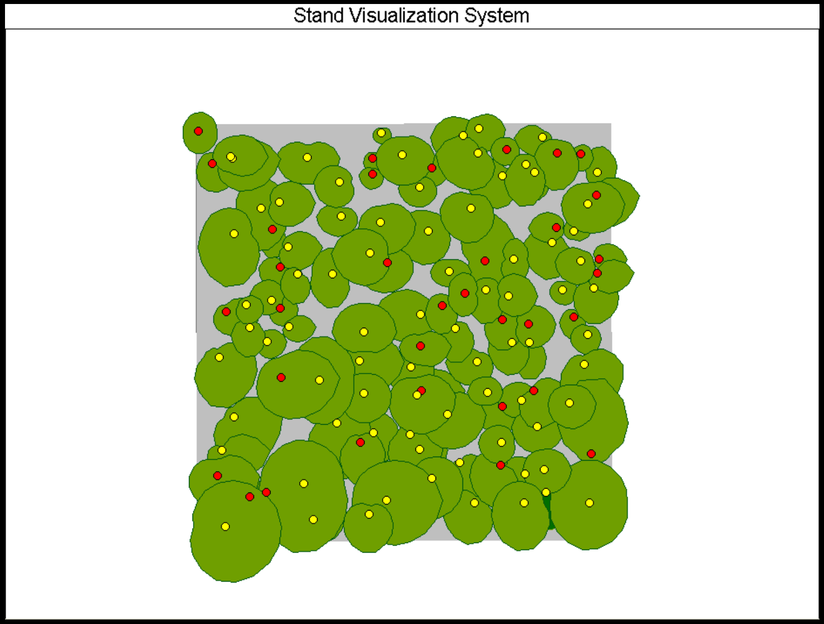


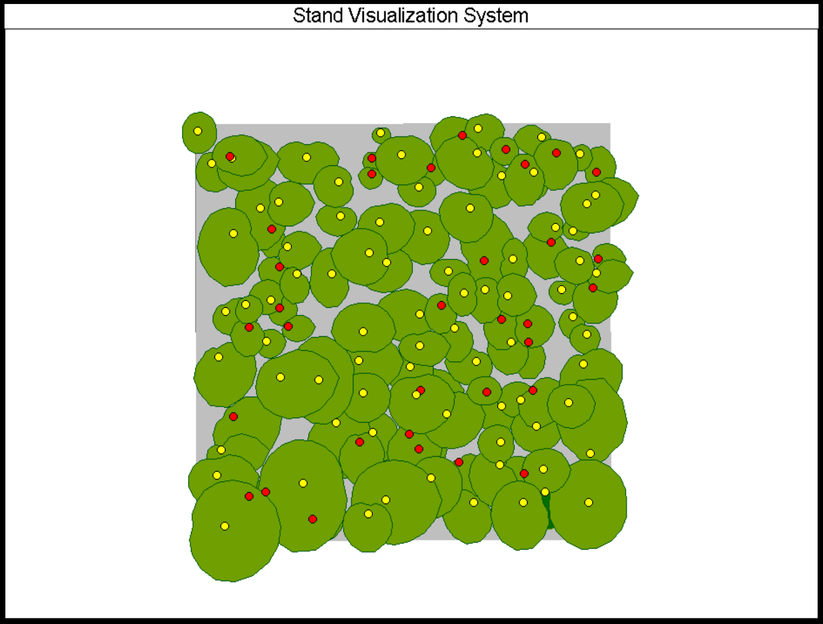


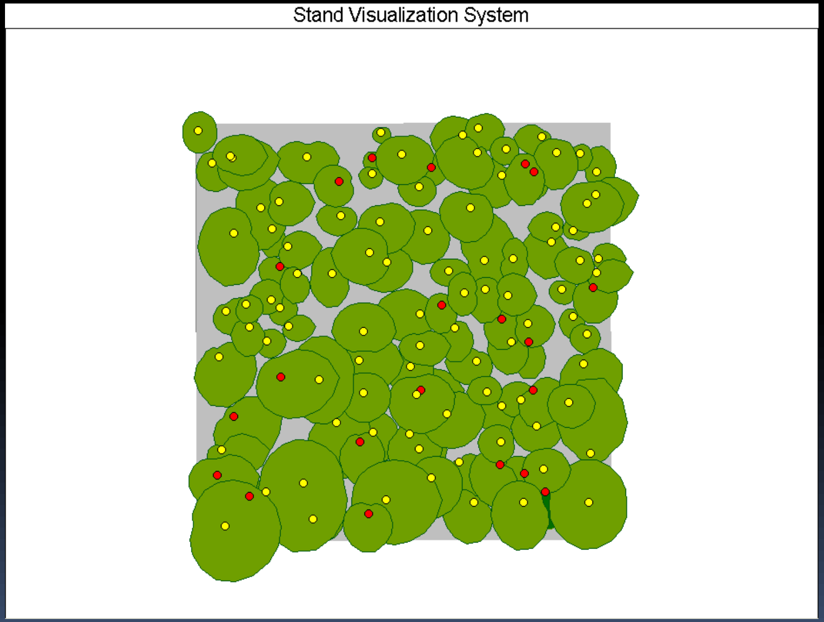

SVS - CHIANDEF_svs.SVS
File Edit Display SVS options
Help
Stand Visualization System
CHIANDEF_svs.SVS
Tree marking and treatment
Tree info
Stand info
Marking rules
Thin
Plant
Treatment
Close
Help
Redraw
Save stand
Copy SVS file
Cover info
Marked trees
No trees are marked
Unmarked trees
Mean SD Min Max
Dbh 30.24 8.79 9.00 52.00
Ht 21.14 3.39 4.00 26.00
Basal area 65.09 sq m per hectare
Number of trees 209 (836.00 per hectare)
Start
Posta in arrivo - Outlo...
Immagini
SVS - CHIANDEF...
Immagine - Paint
10.15

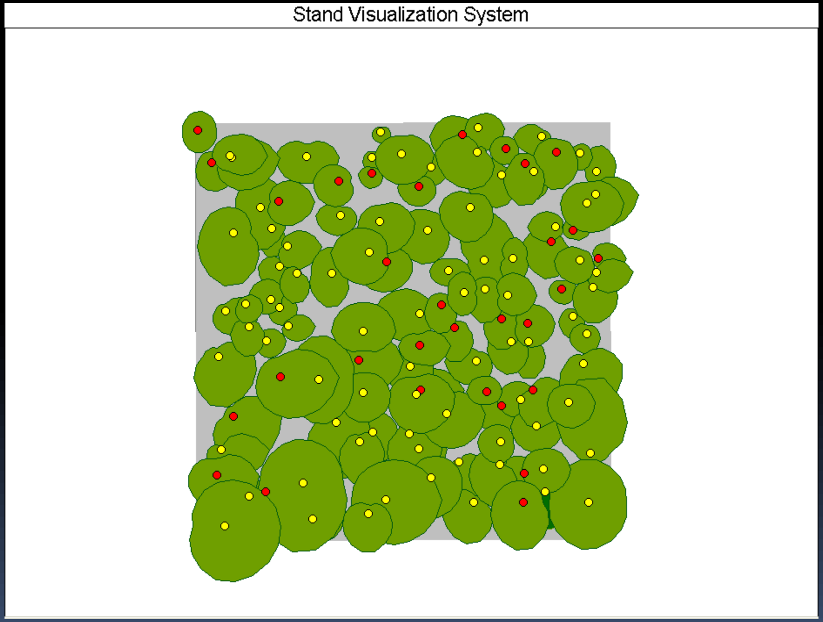


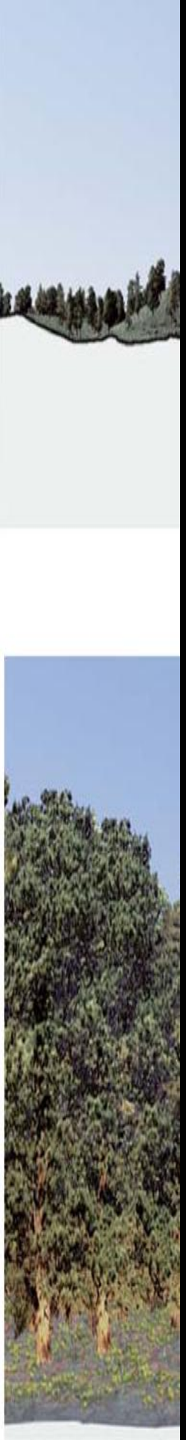
Stand Visualization System
CHIANDEF_svs.SVS
Diameter class distribution
Standing trees
trees
Dbh (centimeters)
Height distribution
Standing trees
trees
Height (meters)
Height and crown size
Crown
Stem
Cum. crown volume
Down tree
FVS dead tree crown
FVS dead tree stem
Height (meters)
Tree number
Species distribution
Standing trees
trees
98
231
747
Species

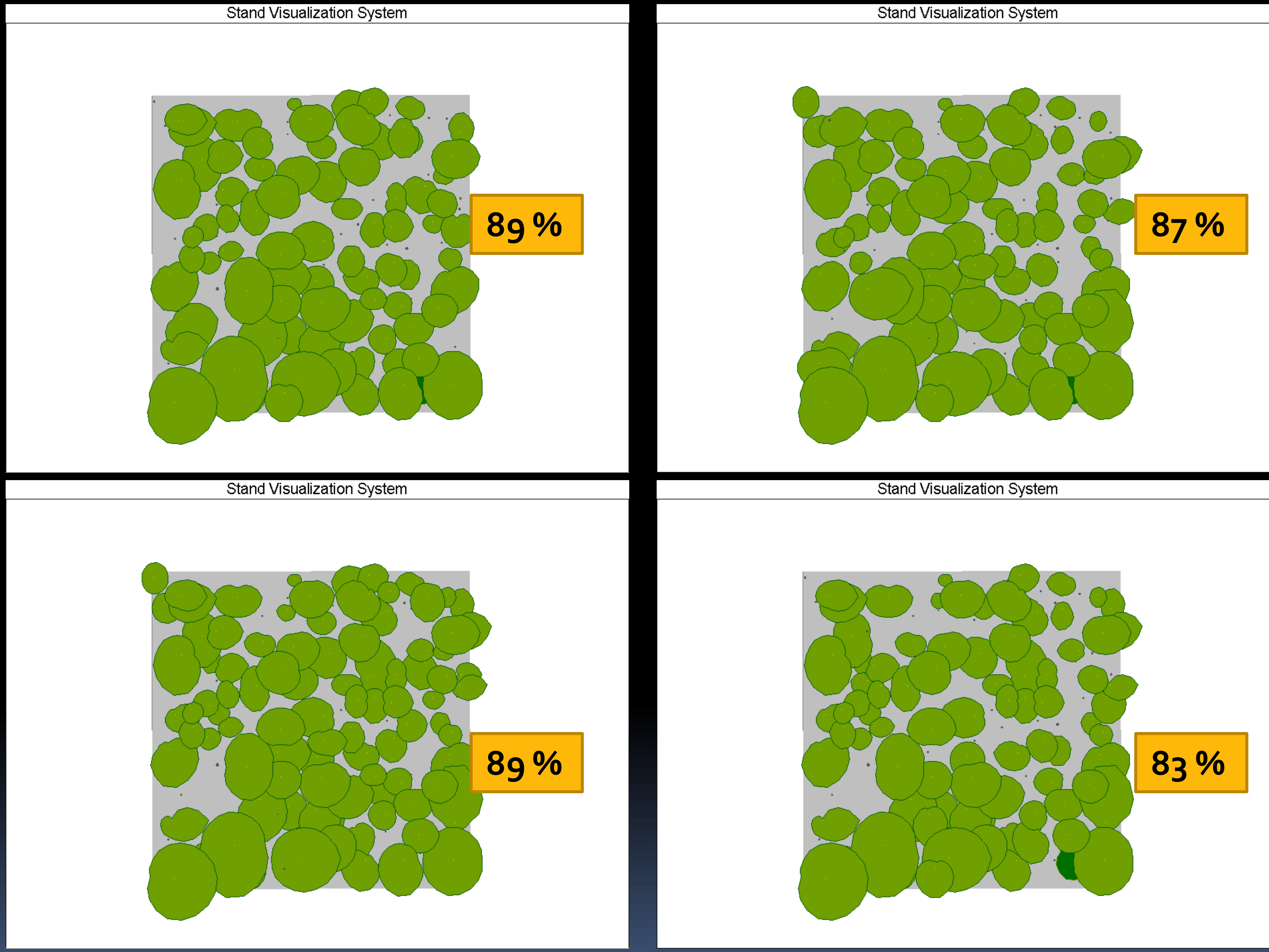

Stand Visualization System

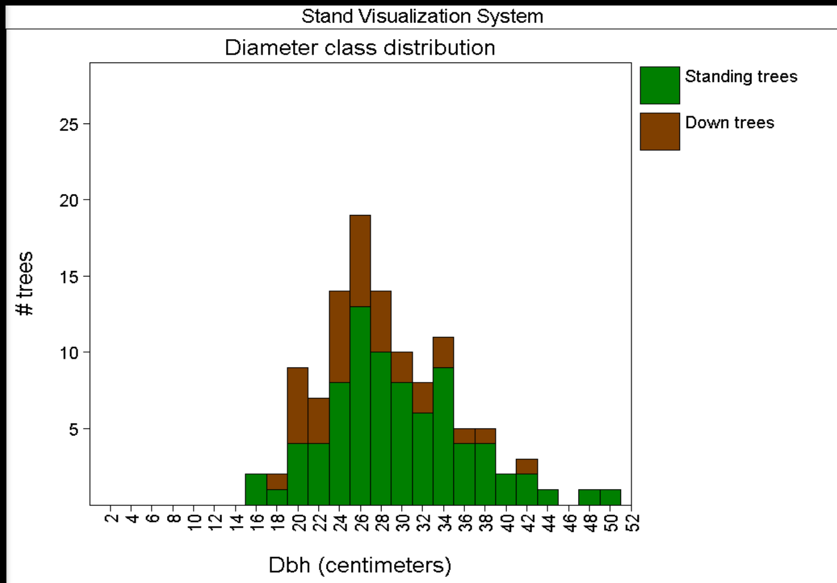

Stand Visualization System

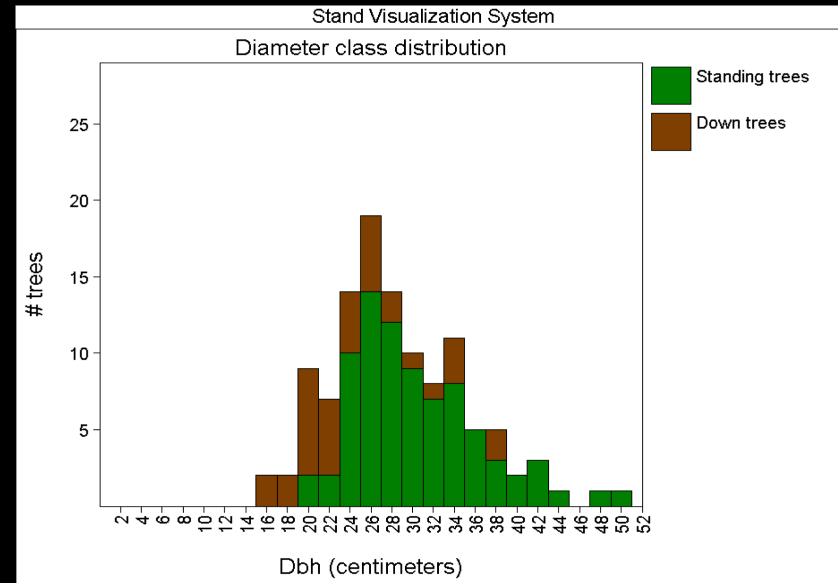

Stand Visualization System

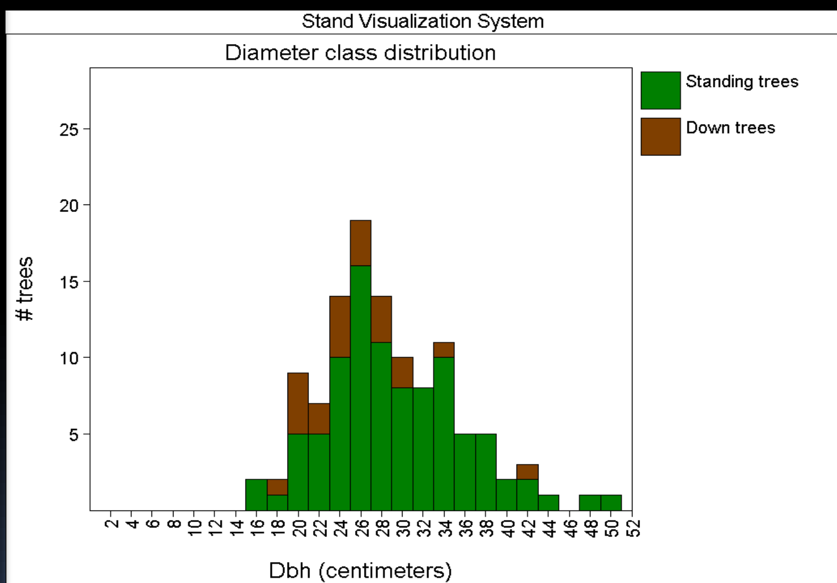

Stand Visualization System

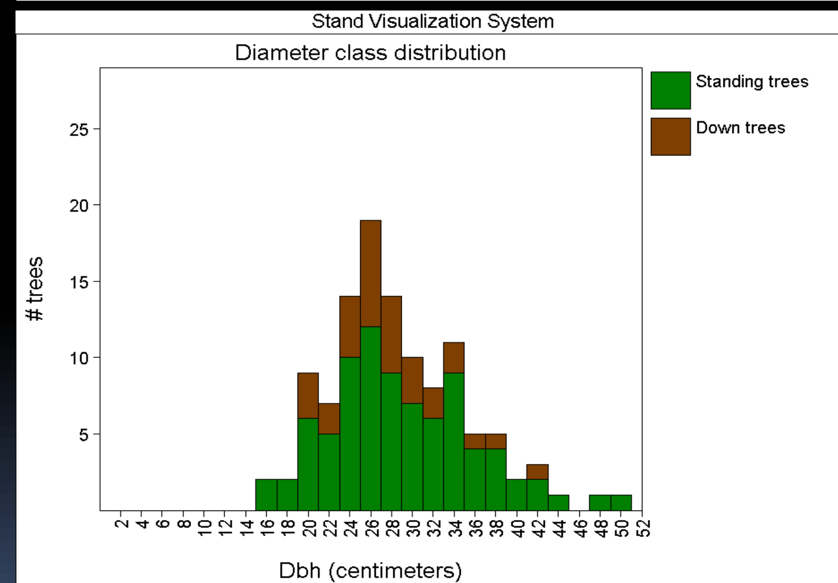



Stand Visualization System
89 %
Stand Visualization System
87 %
Stand Visualization System
89 %
Stand Visualization System
83 %

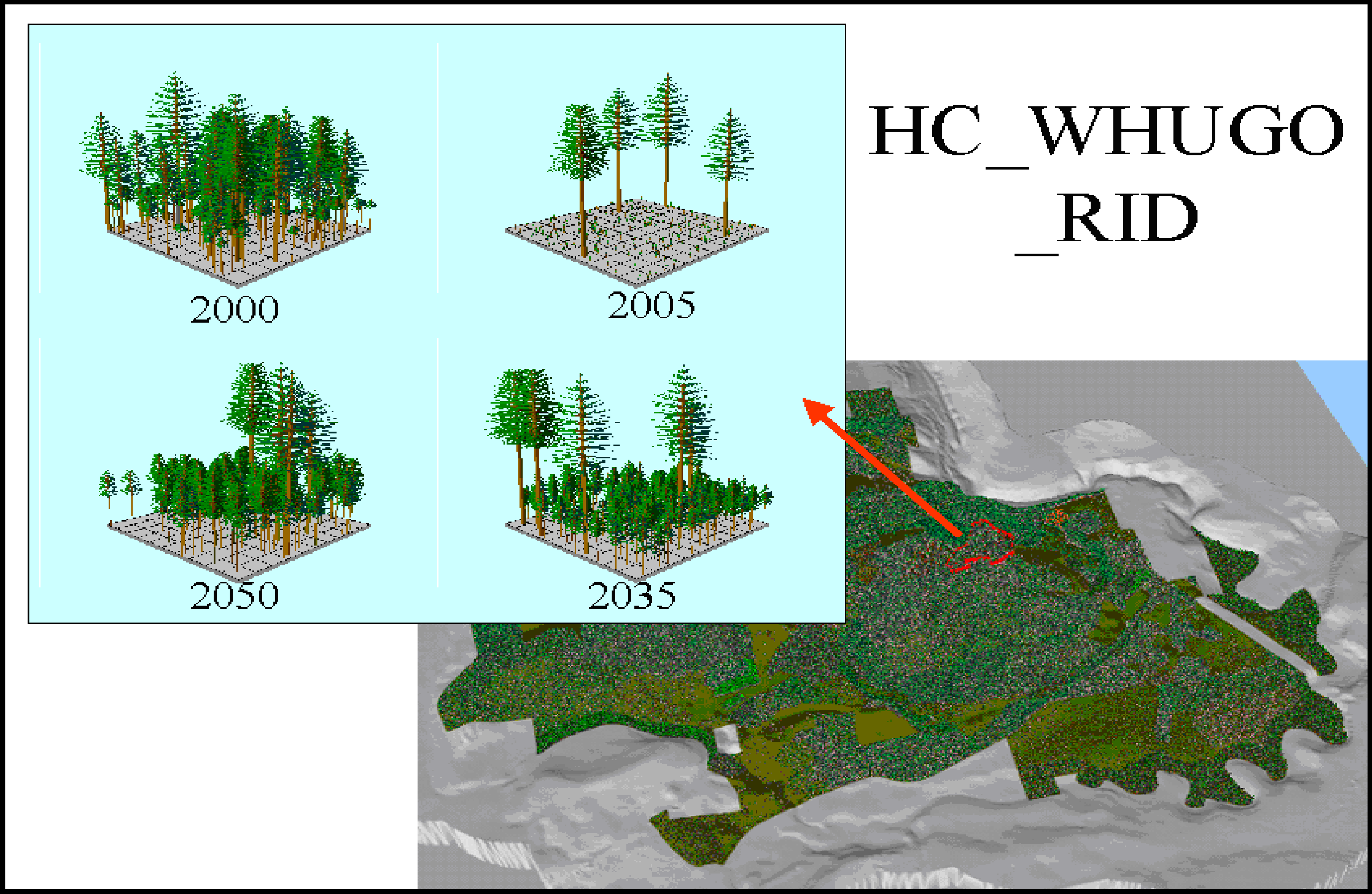

Stand Visualization System
Diameter class distribution
Standing trees
Down trees
trees
Dbh (centimeters)


Stand Visualization System
Diameter class distribution
Standing trees
Down trees
trees
Dbh (centimeters)

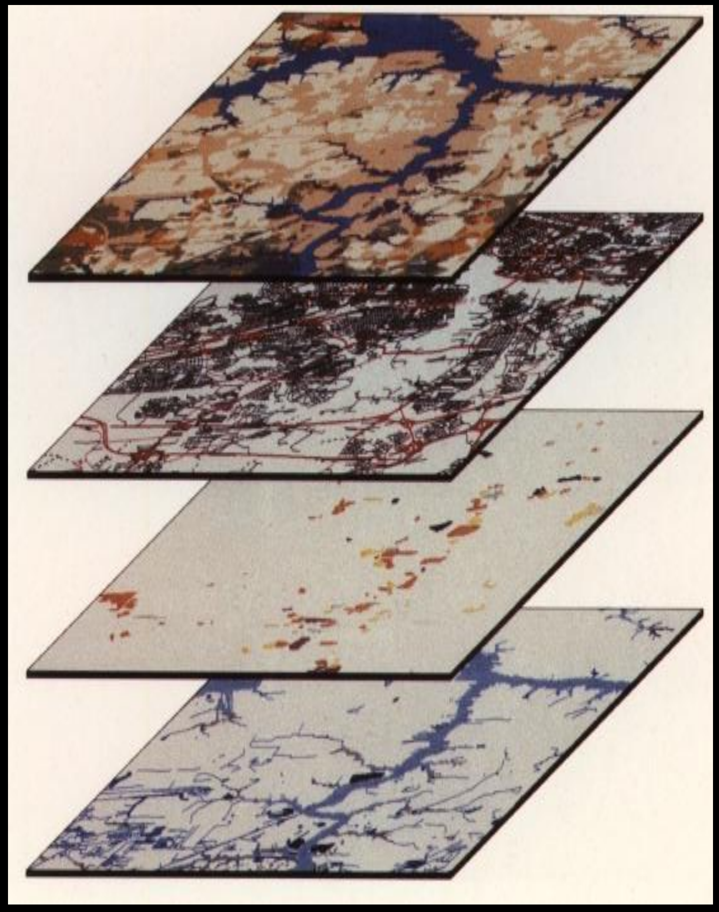

Stand Visualization System
Diameter class distribution
Standing trees
Down trees
trees
Dbh (centimeters)

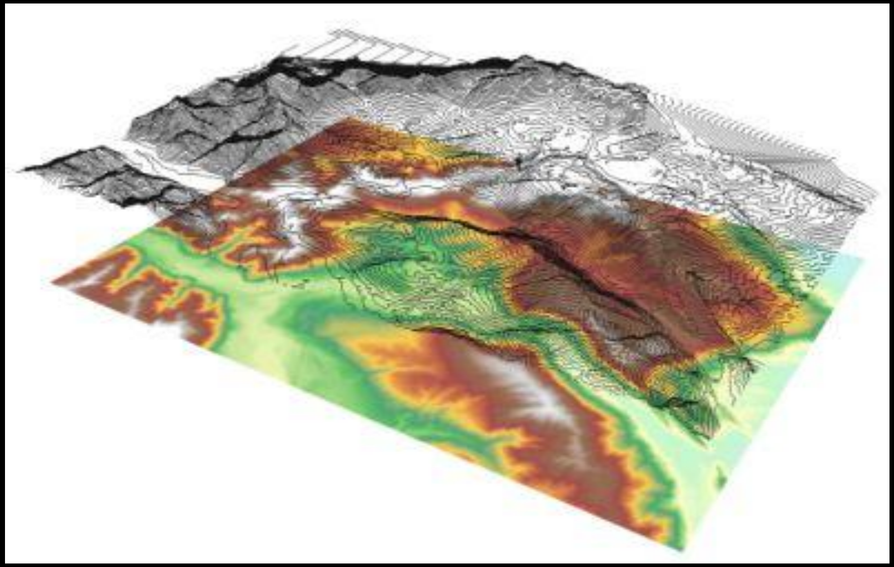

Stand Visualization System
Diameter class distribution
Standing trees
Down trees
trees
Dbh (centimeters)

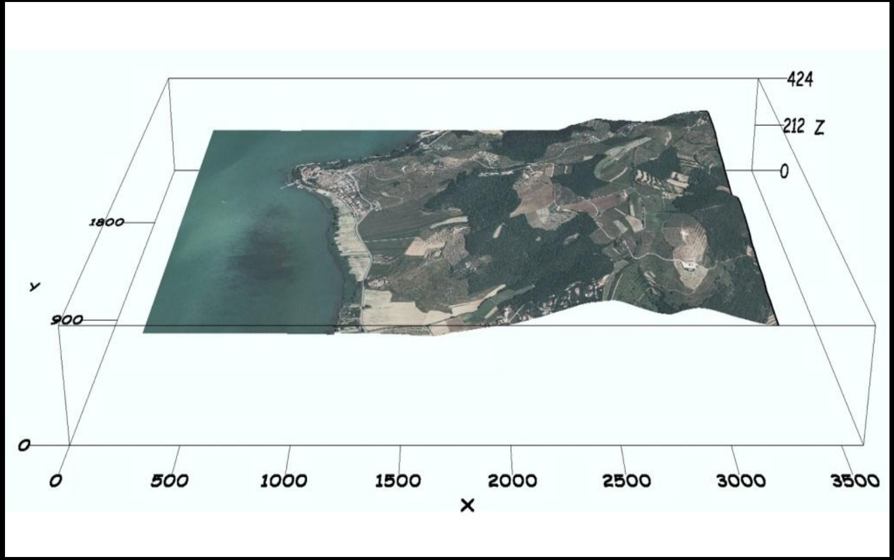
Landscape Management System



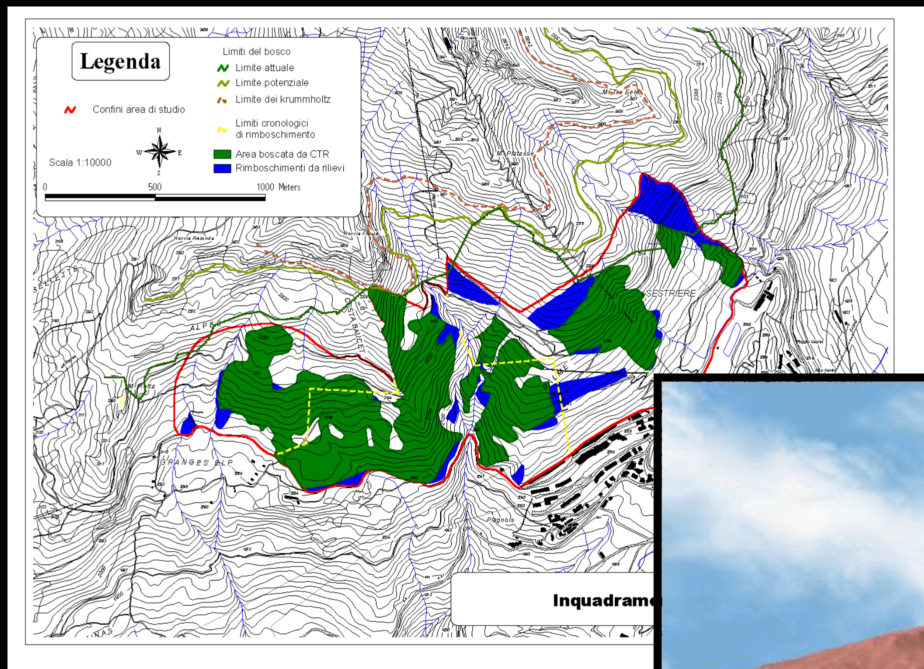
GIS





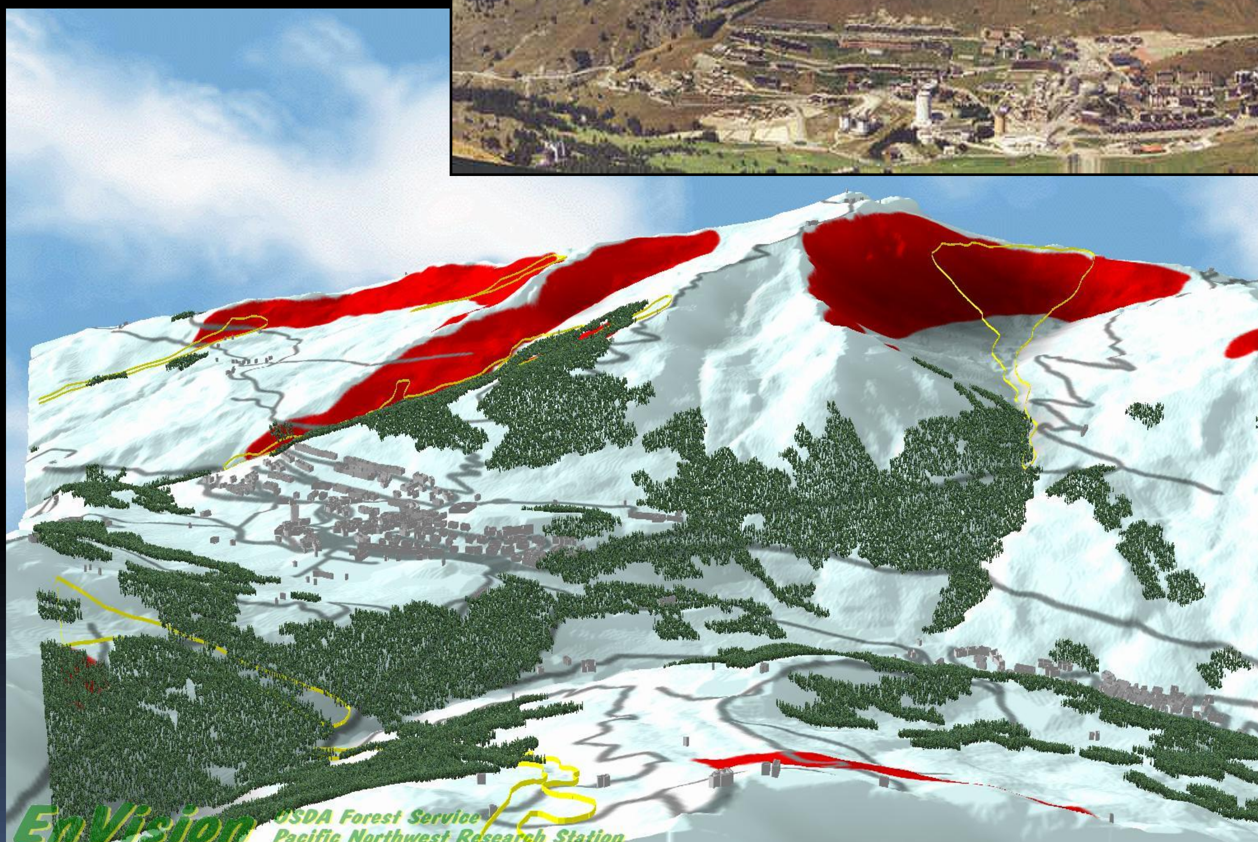


EnVision



EnVision Environmental Visualization System

EnVision


EnVision
USDA Forest Service
Pacific Northwest Research Station

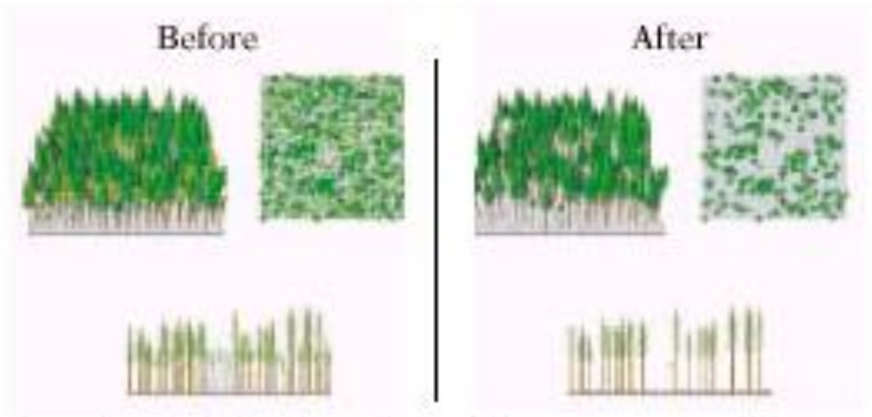

EnVision
USDA Forest Service
Pacific Northwest Research Station

EnVision

FVS

Stand Visualization System

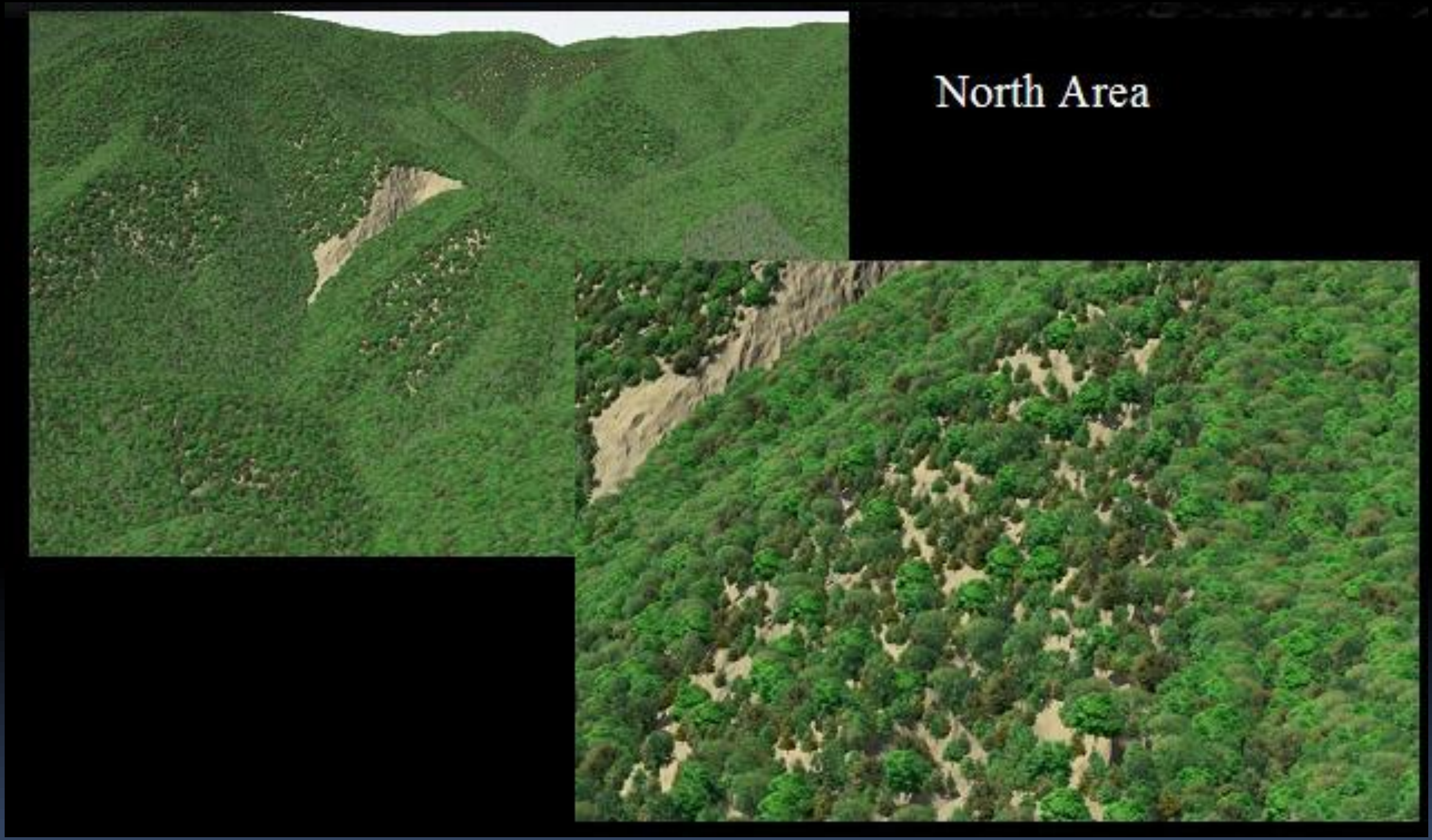
EnVision
Environmental Visualization System



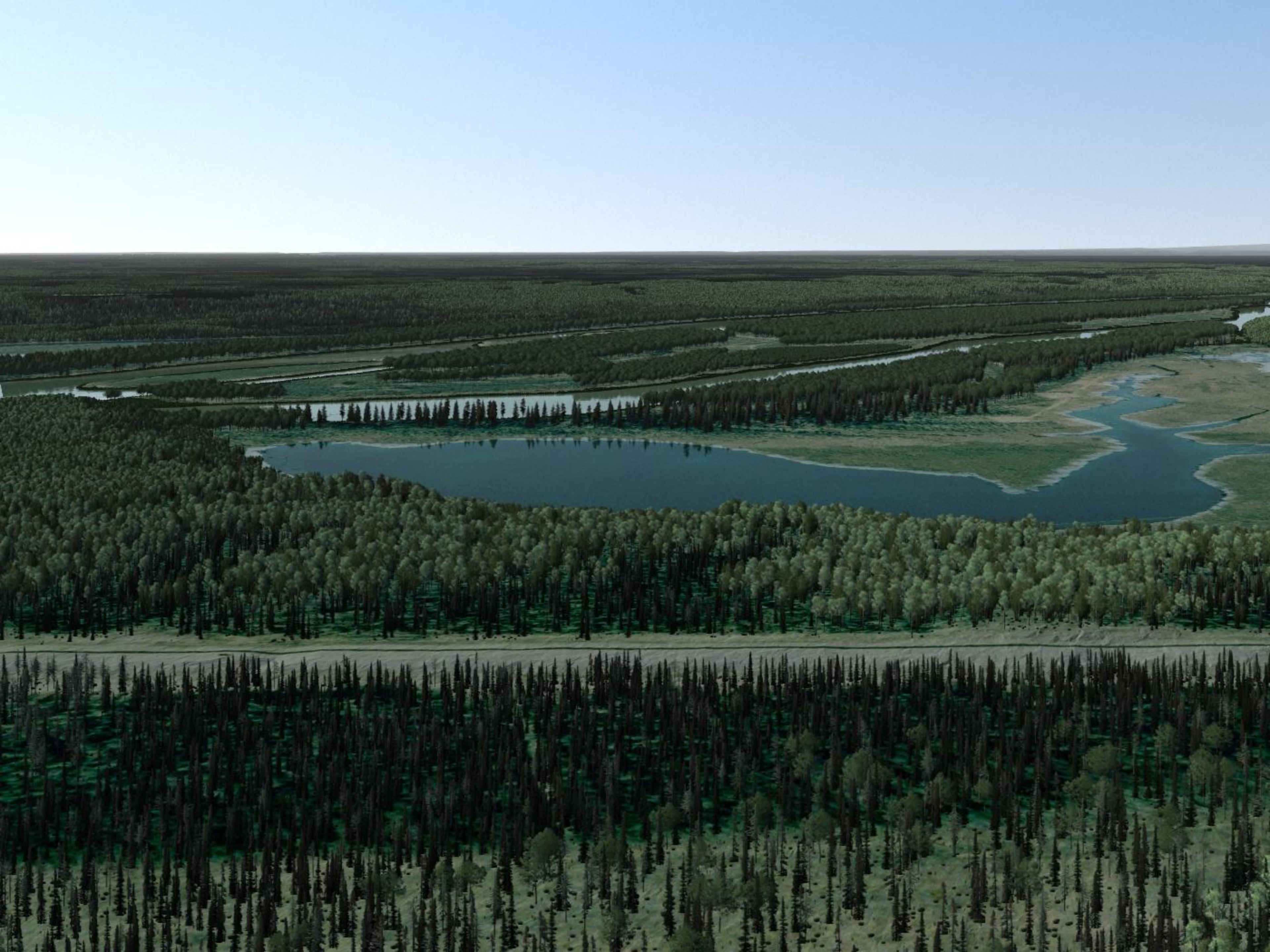
Stand visualizations show 1- hectare areas before and after treatment.

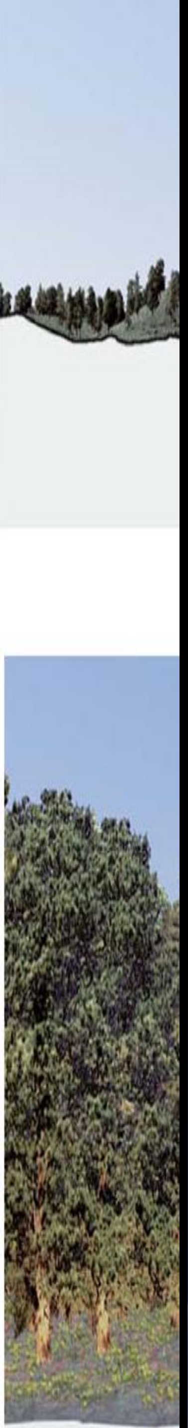
Landscape visualizations show stand characteristics within a landscape context.

Visual Nature Studio



Visual Nature Studio





Riferimenti utili

- Stand Visualization System
  http://forsys.cfr.washington.edu:80/svs.html
- EnVision
  http://www.fs.fed.us/pnw/envision/
- Landscape Management System
  http://silvae.cfr.washington.edu/lms/lms.html
- 3d Nature software (commerciale)
  http://3dnature.com/