Using light interception measurements to assess site quality and treatment responses

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iPAR/PAR overview

- Photosynthetically active radiation, intercepted/incident.
- Drives photosynthesis.
- Strong relationship between iPAR and stem volume growth (Cannell et al. 1987, Will et al. 2000, Balster and Marshall 2000, Chmura and Tjoelker 2008), as well as BA growth and biomass production (Dalla-Tea and Jokela 1991, Law et al. 1992).

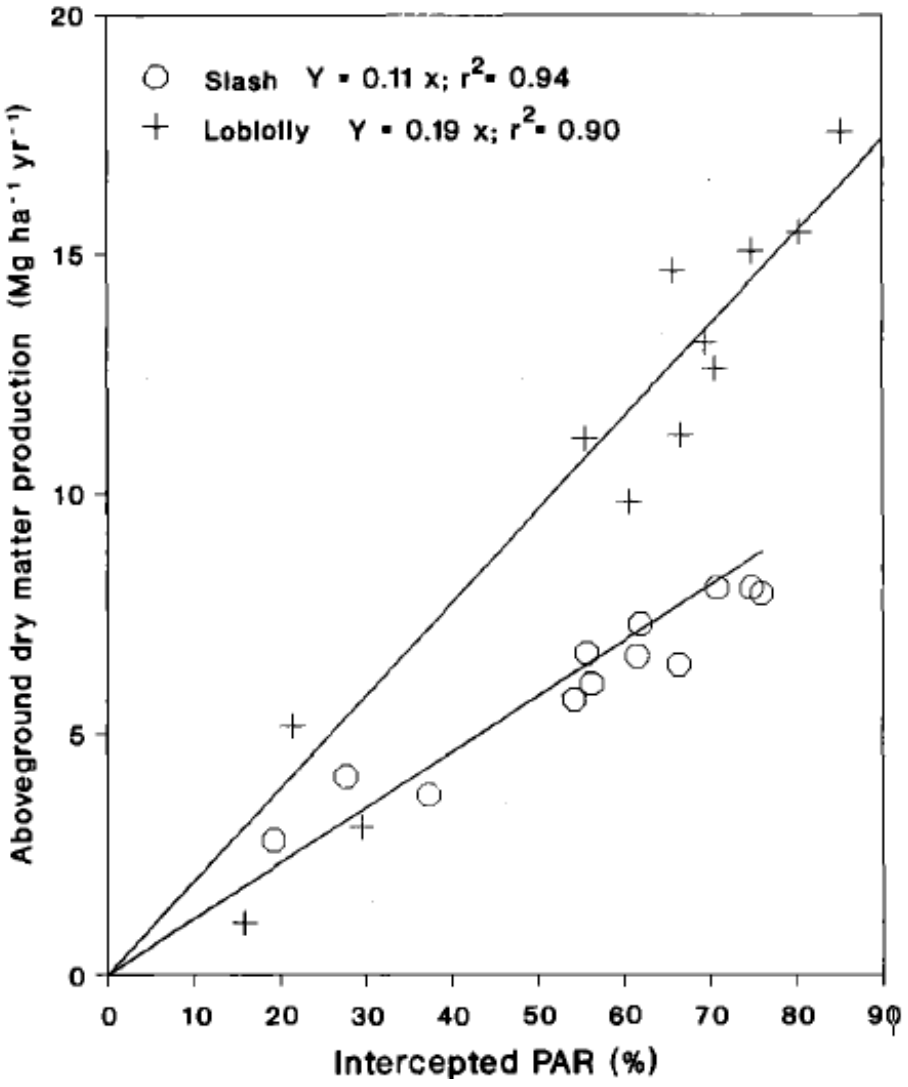
Importance of understanding iPAR

- Increased PAR interception usually equates to increased productivity.

- Knowing iPAR for a stand should help approximate productivity and site quality.

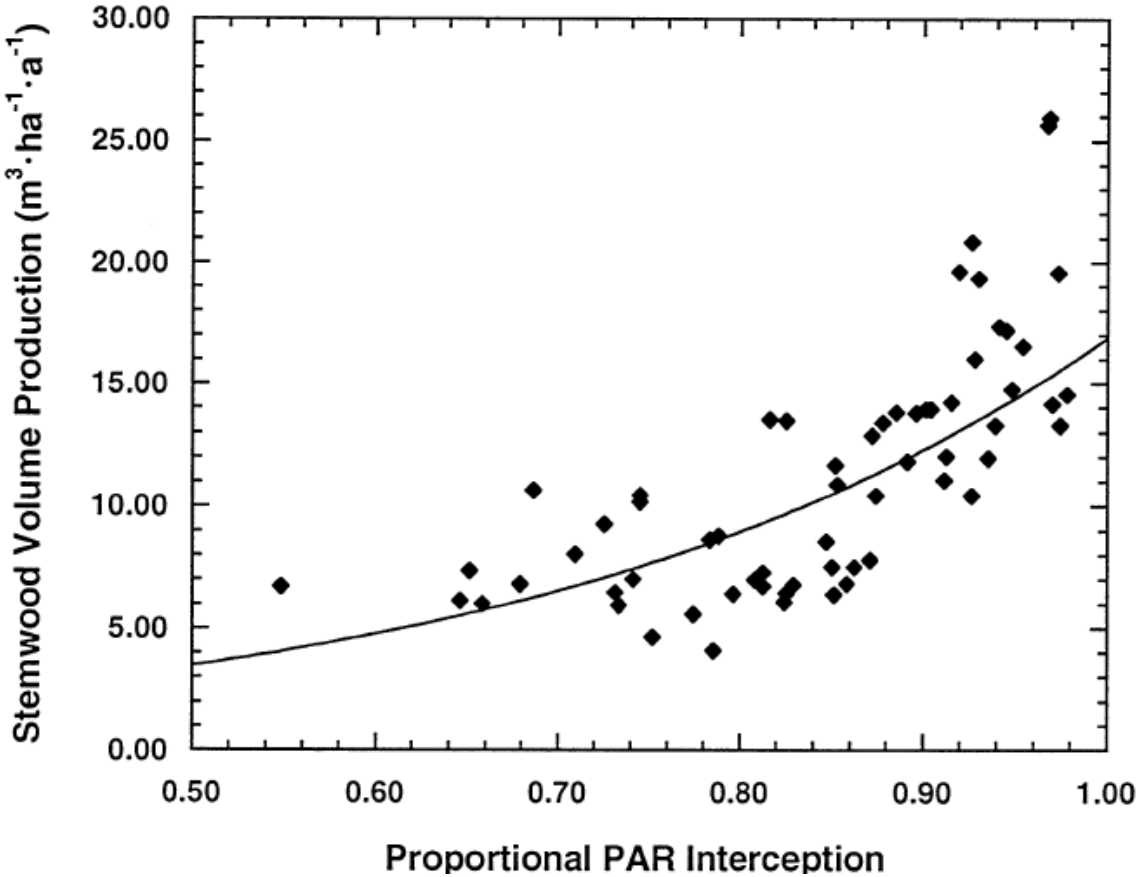
Relationship between annual aboveground dry matter production (in Mg ha^{-1} yr^{-1}) at year 6 and intercepted PAR for slash (○) and loblolly (+) pine.

(Dalla-Tea and Jokela 1991).

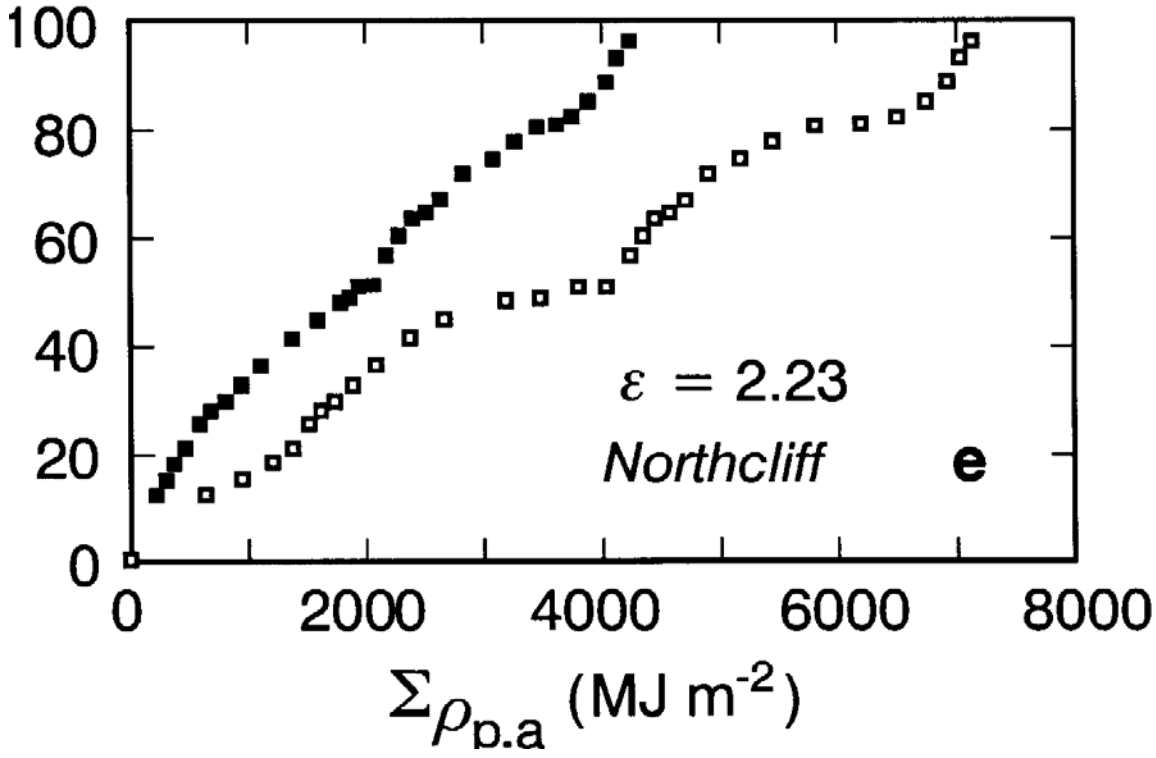


Relationship between biomass production and intercepted photosynthetically active radiation in a coniferous forest.

(Balster and Marshall 2000).



Cumulative aboveground eucalyptus biomass plotted against absorbed photosynthetically active radiation. Units in Mg ha^{-1}. (Landsberg and Hingston 1996).



Radiation Use Efficiency, ε

Hypothesis:

If canopy activity increases with resource availability then Radiation Use Efficiency will increase

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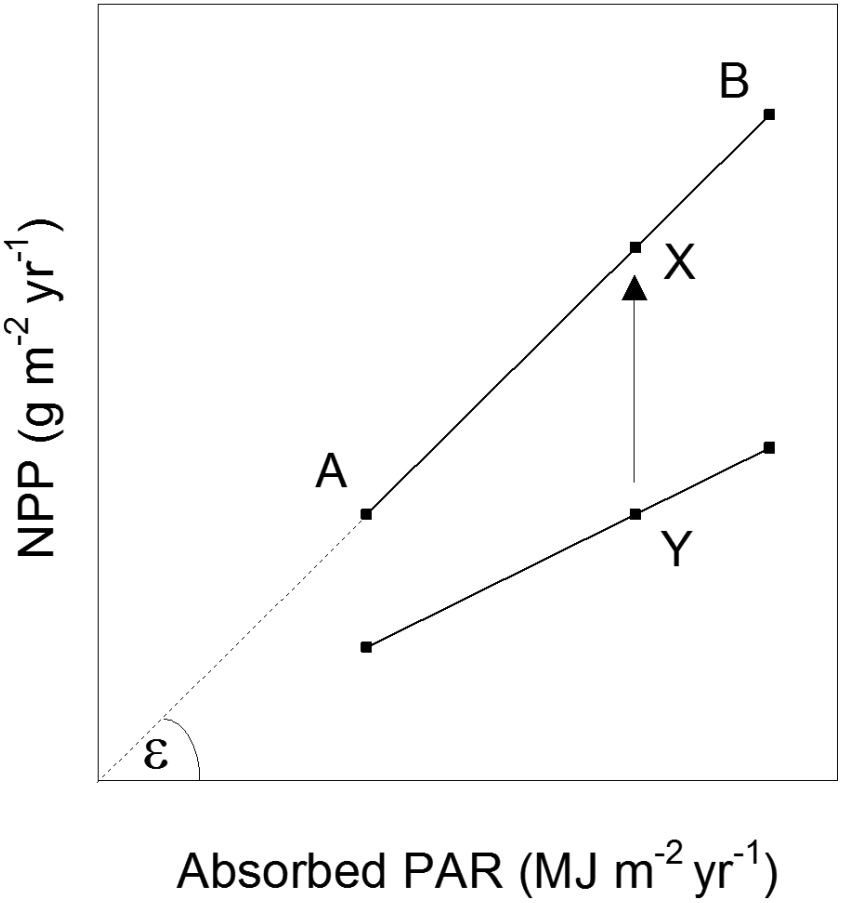
- Monteith 1977, Jarvis and Leverenz 1983, Landsberg 1997



Using and quantifying iPAR

- Common physiologically based forest productivity models use intercepted radiation as an input

- 3-PG, Forest-BGC, Biome-BGC, BIOMASS

- iPAR is usually calculated for these models from short-wave incoming radiation readings

(Running and Coughlan 1988).

iPAR measurements in the field

- Below-canopy PAR recorded by a ceptometer.
- Above-canopy radiation recorded simultaneously, or available from weather stations.
- iPAR calculated.

Objectives

- 1. To quantify response to silvicultural treatments using iPAR.

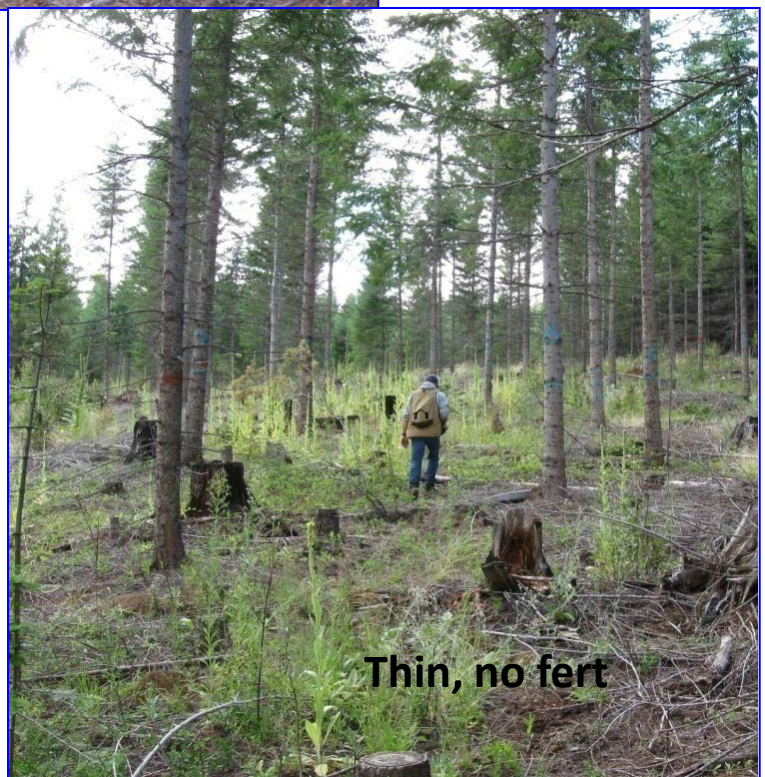
- 2. To develop a method of estimating site quality using iPAR.

Methods

- 16 plots on Potlatch Corporation land.
- Unthinned, 16’, and 20’ thinning.
- Multi-nutrient fertilizer applied in 2007.
- Trees measured in 2007, 2009, and 2011.


No thin


Thin, fert

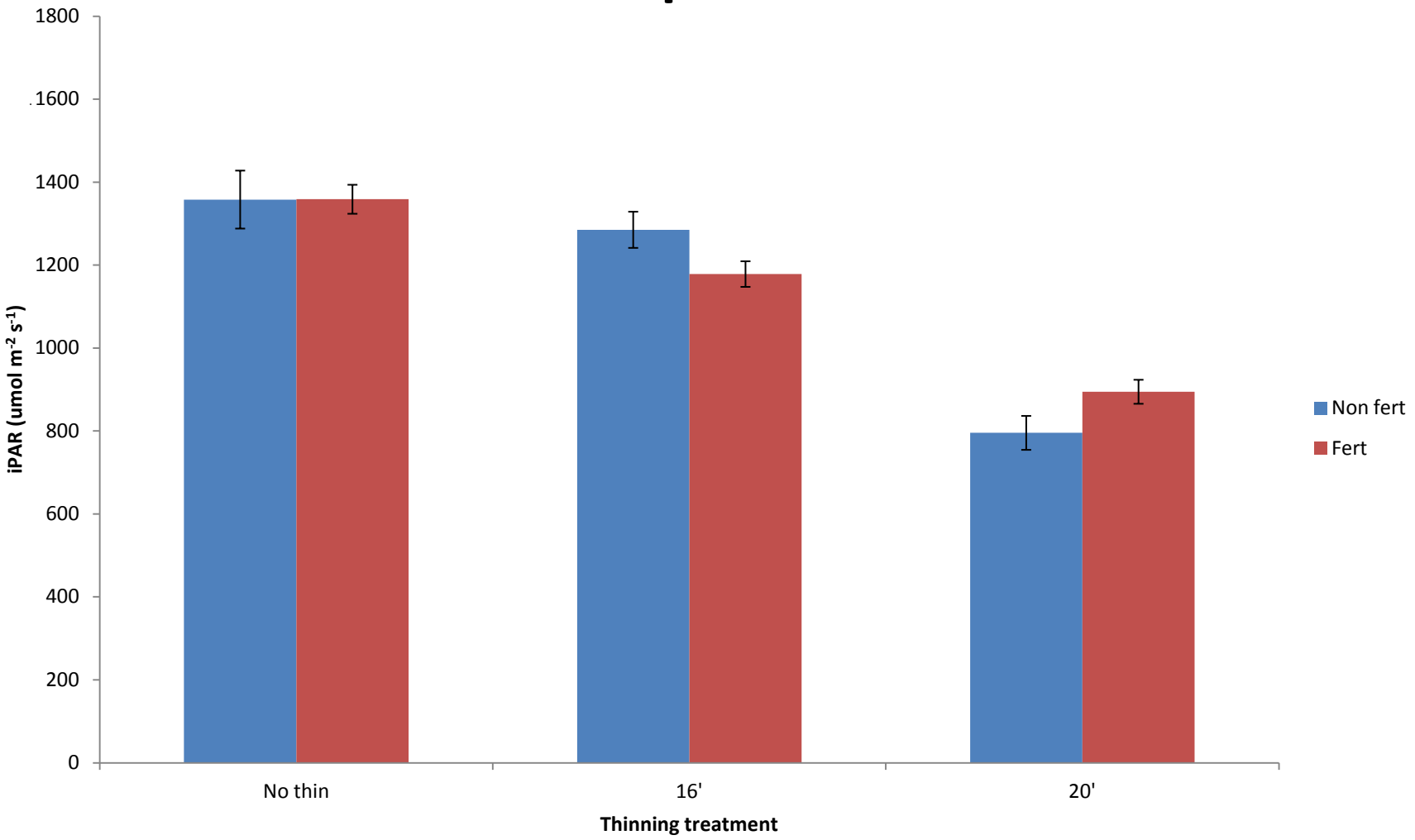

Thin, no fert

Methods

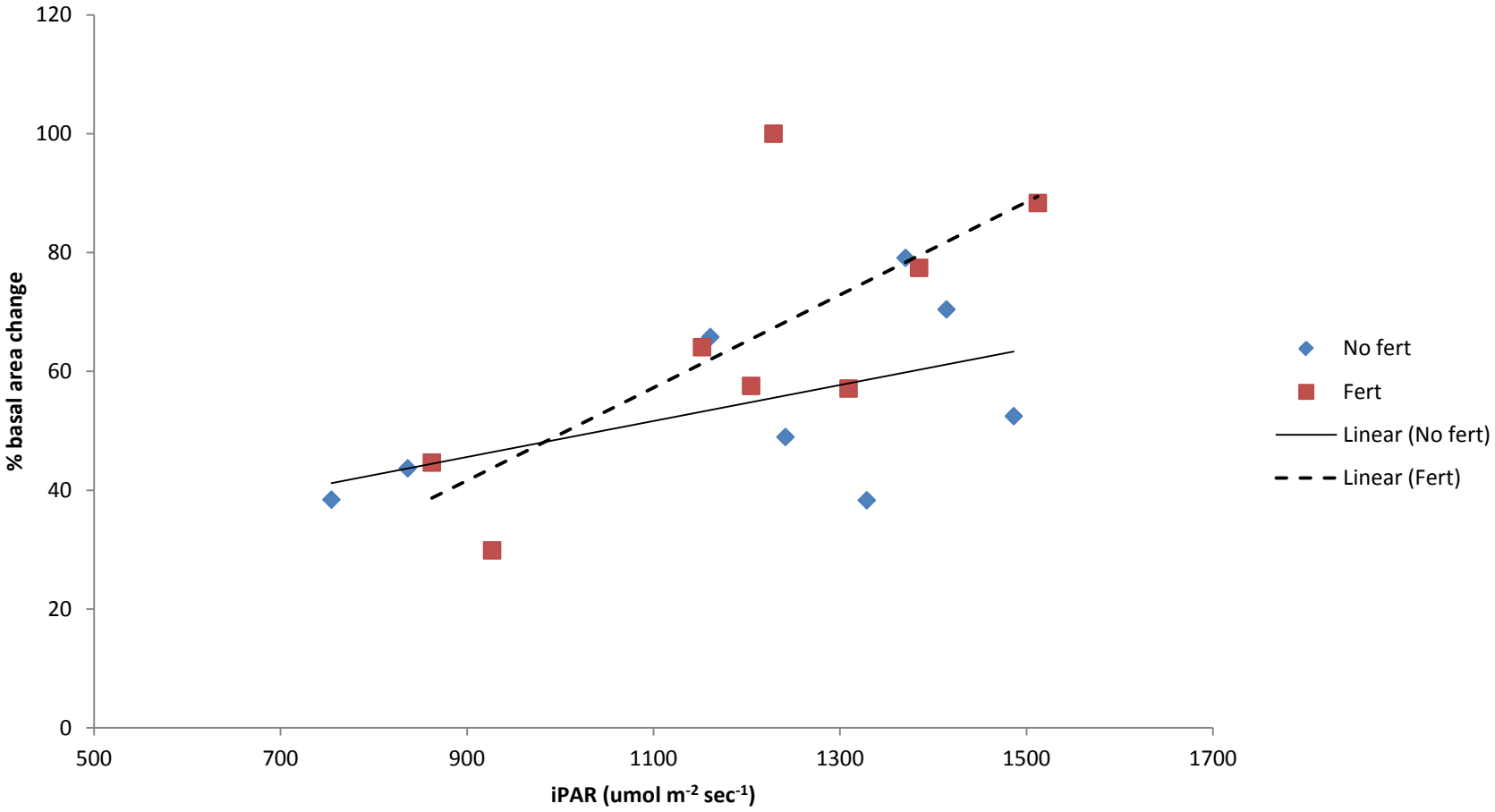
- Below-canopy PAR was subtracted from same-moment incident PAR from nearby clearings.

- Tree growth values plotted against iPAR.

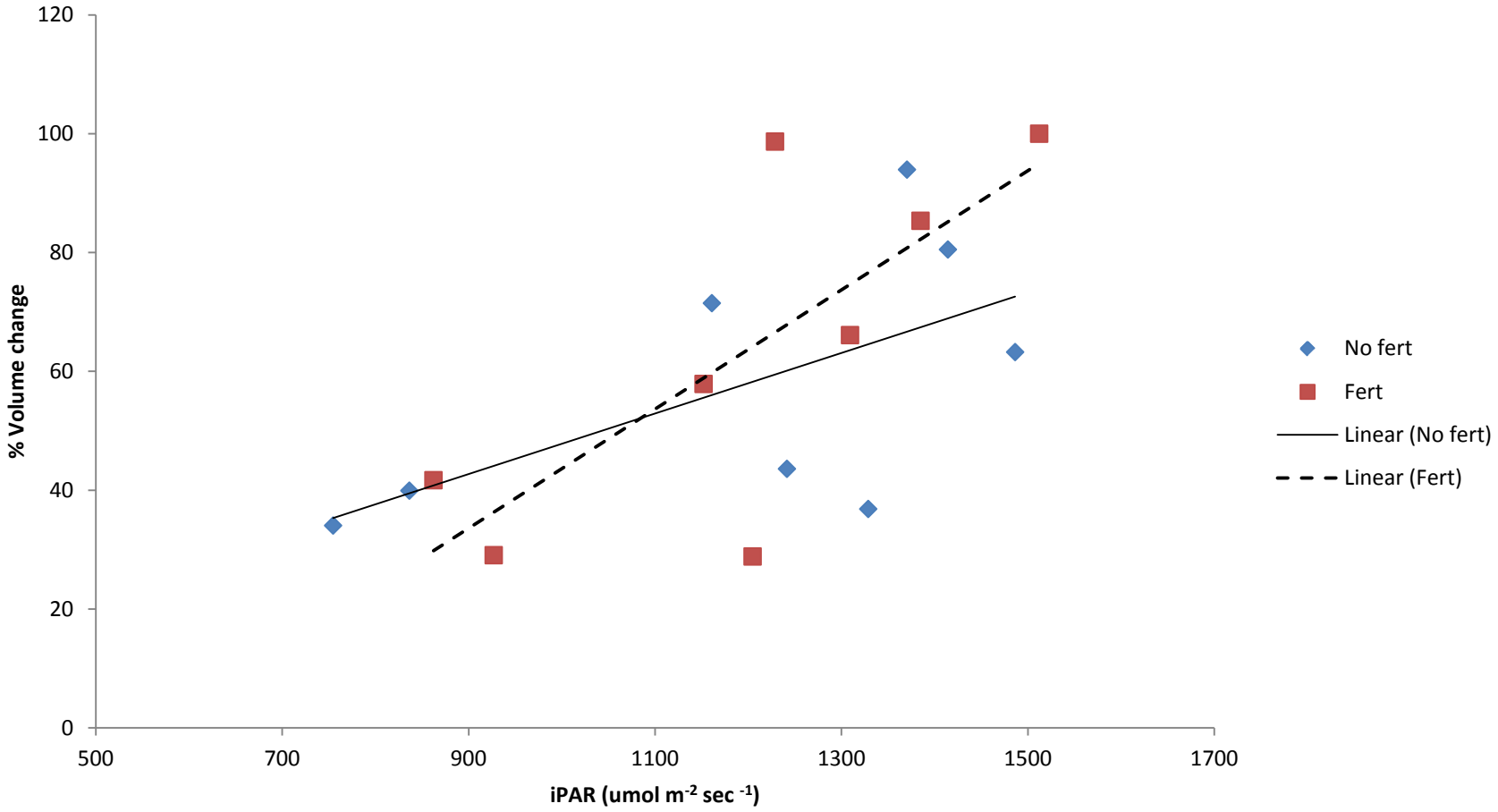
Responses


1800
1600
1400
1200
1000
800
600
400
200
0
iPAR (umol m-2 s-1)
No thin
16'
20'
Thinning treatment
Non fert
Fert

Four year basal area change



Four year volume change



Results summary: Treatment responses

- Positive growth trends with increasing iPAR.
- Fertilizer slightly increased iPAR at the 20’ thinning level.
- Basal area and volume growth increased with fertilizer and increasing iPAR.

iPAR: Fertilizer effect

- How does fertilization affect iPAR?

- Studies show fertilizer application can increase leaf area and iPAR (Dalla-Tea and Jokela 1991, Balster and Marshall 2000, Allen et al. 2004)

iPAR: Thinning effect

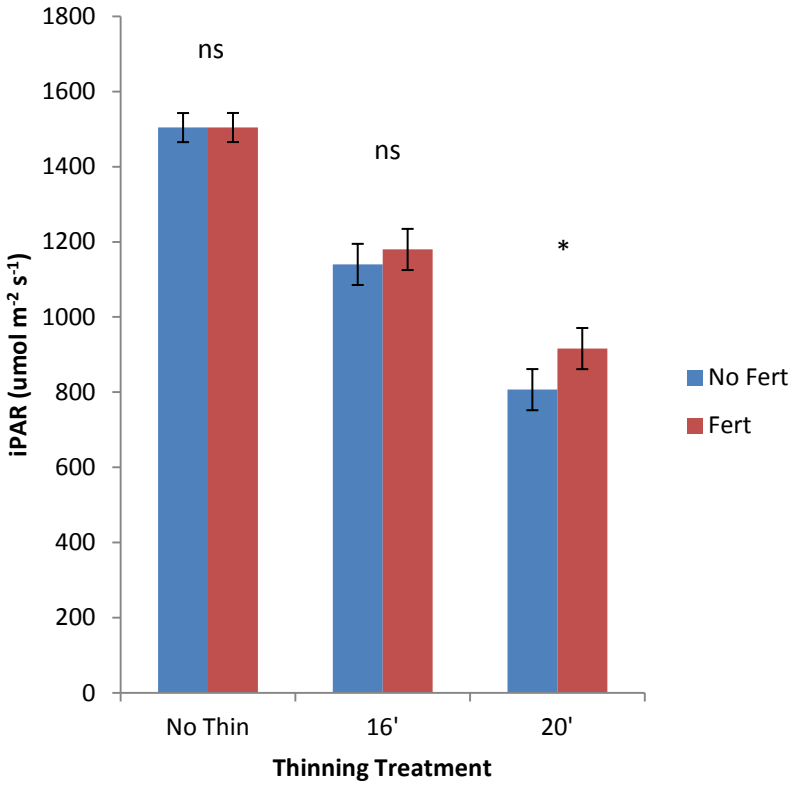
- Thinning decreases iPAR due to canopy removal.
- Thinning has been shown to increase leaf area.
- Increased leaf area can intercept more radiation, leading to higher growth rates.

Using iPAR to evaluate responses to silvicultural treatments

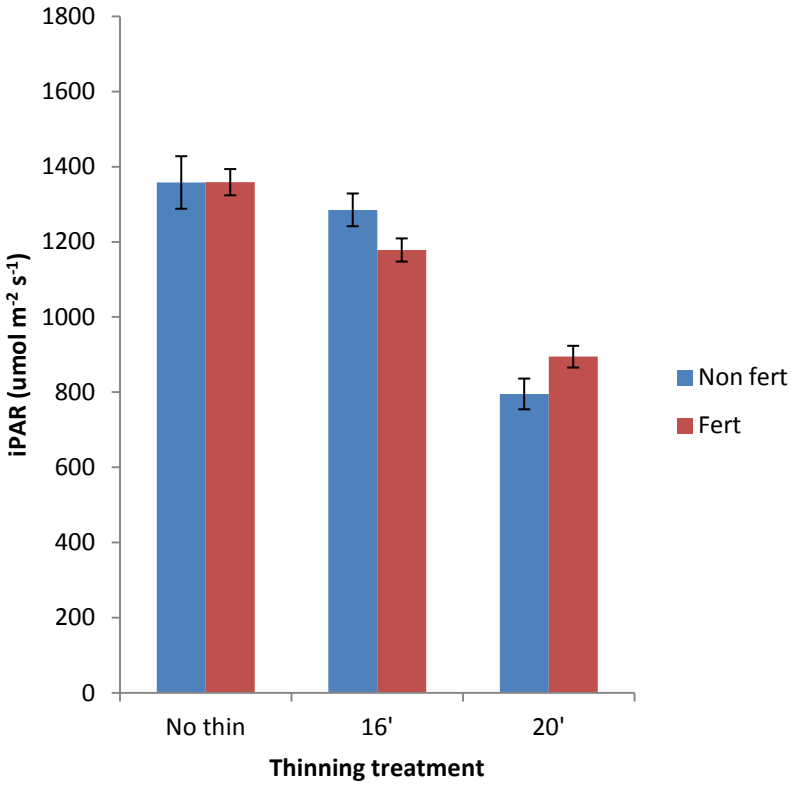
- Increase in tree growth with increases in iPAR.
- Effects of iPAR on the basal area and volume growth percentages over time.
- Agrees with other studies on importance of iPAR.

Effects of treatment on iPAR

2 year results



4 year results



iPAR vs. treatment response

- iPAR plays an important role in showing responses.
- Basal area growth connected with iPAR.
- iPAR data graphed against growth data can show how a plot has responded to treatments.

- Can we use iPAR measurements to determine site quality?

- 1. Take ceptometer readings.
- 2. Measure stand density, trees per acre, basal area, or other growth parameter.
- 3. Compare stand to a graph using iPAR to predict growth.

Site quality and iPAR

- Studies have linked site quality with increased levels of iPAR (Kuuluvainen 1991).
- Higher levels of iPAR should lead to increased growth rates.
- Physiologically based models describe productivity in terms of iPAR.

Site quality: Process models

- Photosynthesis is limited by amount of foliage.
- Foliage amount is influenced by water and nutrient availability
- Trees growing on a poor-quality site are likely to have less foliage than trees growing on a high-quality site (Tissue et al. 2005).

Quantifying site quality: Site index

- Site index—a measure of site quality.
- Relation of site index to leaf area index (LAI).
- Relation of LAI to fertilization and iPAR.

Here we see that site index is linked to leaf area index. Fertilization has been shown to increase leaf area, and this increased leaf area is able to intercept more radiation, which would potentially lead to increased growth rates.

Long and Smith 1990.

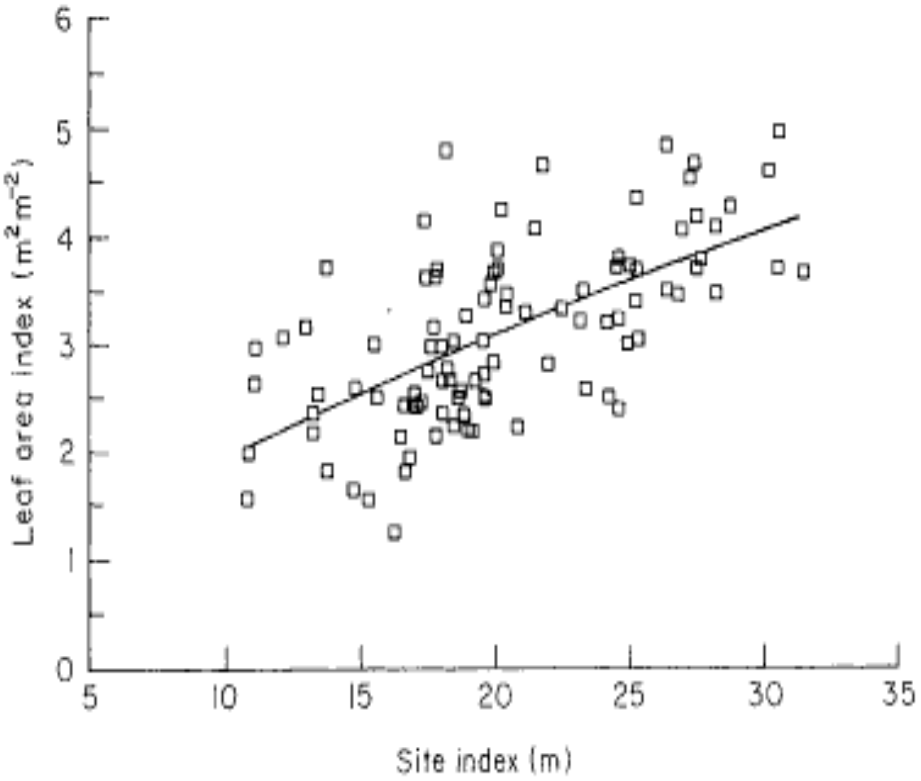


FIG. 2. Leaf area index as a function of site index ($y = 0{\cdot}41x^{0{\cdot}67}$; $r^2 = 0{\cdot}40$).

Recommendations for managers: iPAR response to treatment

- Take PAR measurements at time of treatment.
- Standardize time of comparison.
- Compare iPAR to available growth data to look at treatment response.
- Check against results from studies.

iPAR response to treatment

- If a high amount of radiation is intercepted and growth rates are low, a treatment may be indicated.

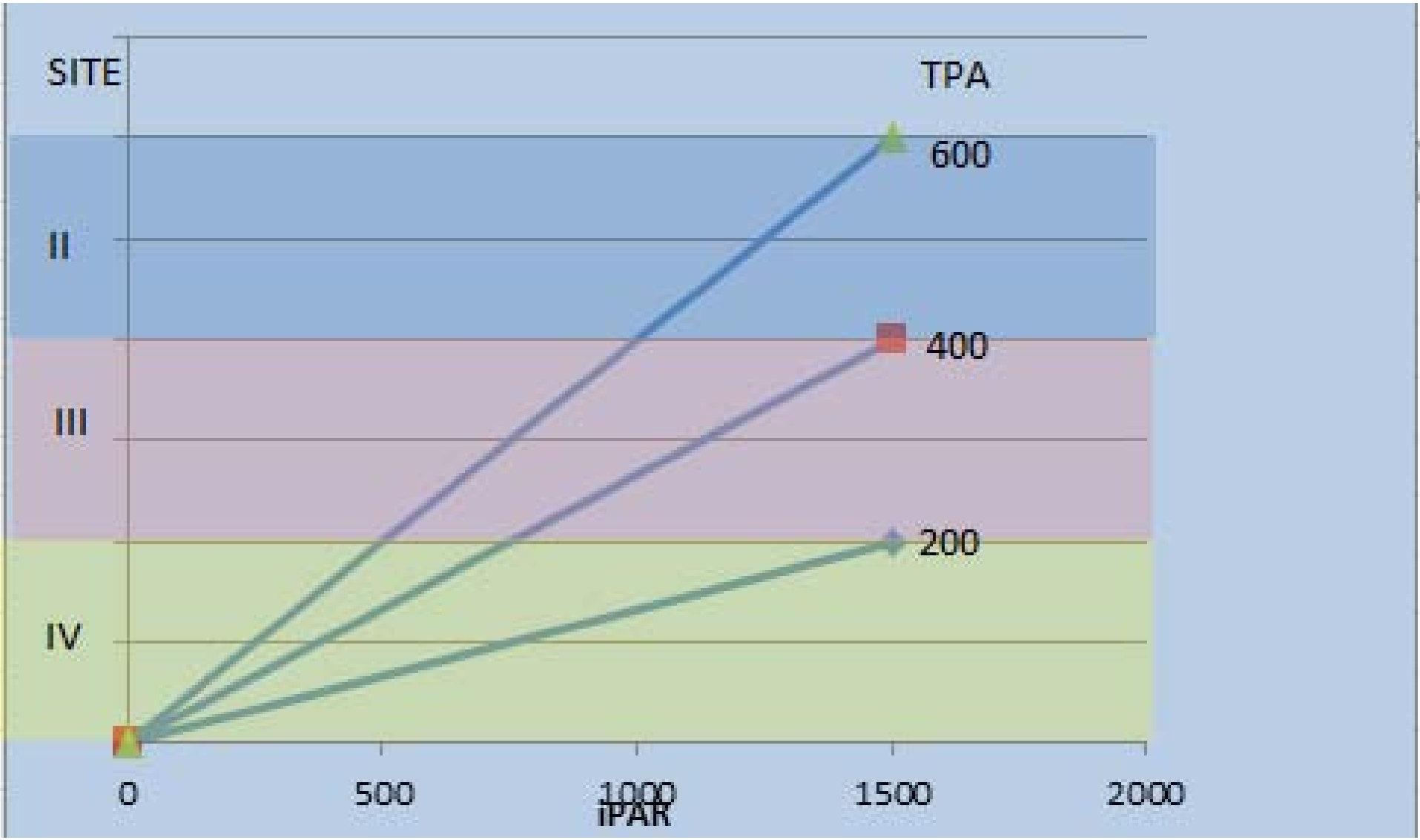
- If iPAR is low and growth rates are high, it may indicate a stand which has recently been thinned.

Management recommendations: Site quality

- Measure stand density such as trees per acre or basal area.

- Use growth predicting graph to estimate site class, fertility, or other growth parameter.

Site class example



The future

- Using in-field iPAR and stand density measurements to quickly predict:
  - Site class
  - Basal area growth
  - Density

Conclusions

- iPAR drives photosynthesis and is related to tree growth.
- iPAR can help identify responses to silvicultural treatments.
- iPAR can predict site quality.

References

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