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FORM DISORDERS OF MARITIME PINE (*Pinus pinaster*) GROWING ON EX-PASTURE SITES IN WESTERN AUSTRALIA

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Summary

Two surveys have been conducted that examined form disorders in *Pinus pinaster*. The first by P. Ritson used data collected as part of the Maritime Pine Yield Study and included plots from throughout the wheatbelt with trees that ranged in age from 8 to 65. The second by I. Dumbrell was designed specifically to examine form disorders in maritime pine growing on ex-farmland north of Perth. The majority of the trees assessed in the latter survey were 4 year-old but included older trees up to age 16. The methods used and the defects assessed in each survey consequently were different. The assessment by Dumbrell was more stringent in regard to defects, which led to a lower percentage of crop trees[1] (between the ages of 7 – 16) (14%), than that of Ritson (48% ex-pasture; 74% ex-bush). This adversely reflected the potential merchantable yield of these sites but fully documented the severity and extent of stem malformations associated with lammas growth, proleptic and sylleptic shoots. However, because the type and height (at which it occurred) of each defect was recorded, this data can be used to predict recovery of various log products from each site.

There were two common factors from both studies. Firstly the percentage of trees with stem disorders was higher on ex-pasture sites than on ex-bush sites, and secondly stocking did not affect the percentage of trees with stem disorders (up to approx 1800 sph). In the 4 year-old plantations north of Perth, height growth was strongly correlated to stem malformations and concentration of foliar phosphorus was strongly linked to growth. Phosphorus supply is most likely a major contributing factor to both predetermined spring growth and abnormal late-season growth that manifests itself in rapid height growth in these early years.

[1] Crop trees in this instance are defined as single stem trees with no defects.

Introduction

It is evident that maritime pine plantations growing on ex-farmland north of Perth are subject to severe form disorders, mainly stem forking, stem kinks, multi-leaders, ramicorns and basket whorls. A survey of planting's (both private and sharefarm) in January 1998 showed an average of 60% of trees had forks or multileaders. This compares poorly with ex-bush sites in Yanchep plantation, which had an average of 12% malformations.

P. pinaster is among a group of species that exhibits a fixed (or predetermined) growth pattern. Fixed growth involves the elongation of preformed stem units after a rest period. Shoot formation is therefore divided into two stages; differentiation in the bud during the first year (n) and extension of the preformed parts into a shoot during the second year (n+1). For *P. pinaster* the first stage is normally complete by late summer and stage two normally commences in July after winter dormancy (Lanner 1976, Kramer and Kozlowski 1979).

Some trees however, produce an abnormal late-season burst of shoot growth from opening of recently formed buds that would not normally open until the following spring. The two main types of late-season shoots are; lammas shoots, which result from elongation of a terminal bud and proleptic shoots, which occur from the expansion of lateral buds at the base of the terminal bud. Lammas and proleptic shoots may be found alone or in combination (Rudolph 1964).

4 year-old maritime pine showing lammas and sylleptic shoots.

Growing tip of the tree on the left.

Proleptic shoots forming on 4 year-old maritime pine

It has been reported from overseas that lammas and proleptic shoots may be under genetic control (Kramer and Kozlowski 1979, Magnussen and Kremer 1994). They are often stimulated to form by abundant late-season rainfall. On our farmland sites it is an annual occurrence that is most likely initiated by abundant supply of stored soil water and a high nutrient loading (in particular phosphorus).

Lammas and proleptic shoots can cause poor stem form as they compete for apical dominance. Stem forking and multi-leaders are caused by proleptic shoots if a lammas shoot does not form, or if a lammas shoot does form but does not survive the winter or gain dominance. Ramicorns arise from a single proleptic shoot competing for dominance.

Less well known than lammas and proleptic shoots are late-season sylleptic shoots. These form when axillary buds of elongating shoots develop into branches before the buds are fully formed and can lead to the formation of basket whorls. Sylleptic shoots may form earlier than lammas or proleptic shoots (when the normal early shoots are still expanding) and as such may not be noticed.

Sylleptic shoots on central leader with proleptic shoot on right

More advanced sylleptic shoots on the central leader

As mentioned earlier the abnormal late-season shoots are thought to be under genetic control. For *P. pinaster* the Atlantic provenances, in particular the Portuguese, are most prone to this growth pattern, while at the same time they exhibit the best early growth in our climate. The Corsican provenance is at the other end of the scale. It exhibits slow early growth but is not prone to abnormal late-season growth (Danjon 1994, 1995). Early hybrid trials between these two provenances at Gnangara failed to produce a tree that exhibited suitable early growth. The influence of genetic x environment interactions on our ex-pasture sites will need to be qualified to determine if genetic gains can be made in reducing the occurrence or severity of late-season growth.

Results and Discussion

From the survey by Dumbrell (1999) the extent and severity of the stem malformations associated with abnormal late season growth is summarised in Table 1. Form disorders were evident at all sites surveyed. The percentage crop trees for individual plots ranged from 0% at McKinley's and Yatheroo to 100% at Talwyn. Mean percentage crop trees for each site ranged from 2% at McKinley's and 2.75% at Yatheroo to 78% at Talwyn. Mean percentage crop trees for all sites combined was 36%. Mean percentage crop trees for the 4 year-old trees across all sites was 58%, while this reduced to 14% for the older trees.

Table 1. Summary of Tree Form Rating for all sites

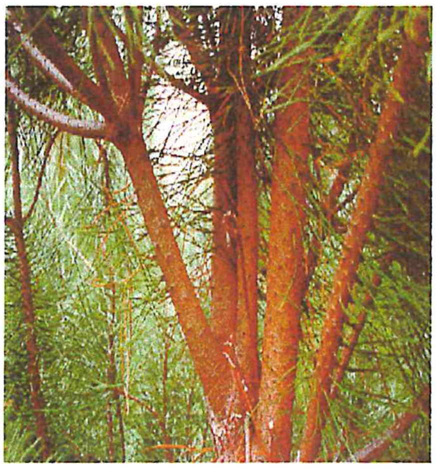
Site	Age	M.A.I. Ht (m)	% TFR 0	% TFR 1 - 5	% TFR 6+
Talwyn (-P)	4	0.27	88	11	1
Talwyn (+P)	4	0.64	68	26	6
B/Leonard[1]	4	0.82	27	51	22
Steffanelli	4	0.61	57	28	15
Reinke	4	0.74	56	46	18
B/Leonard[2]	4	0.87	60	35	5
MEAN		0.66	58	32	10
B/Leonard[2]	5 & 7	1.14	9	50	41
Yanchep	7	0.74	46	35	19
McKinley	7	1.04	2	50	48
Millstead	10	1.00	10	22	68
Woods	11	0.98	20	36	44
Vogen	15	0.97	13	27	60
Isbister	15	0.90	7	43	50
Yatheroo	16	0.94	3	23	74
MEAN		0.98	14	36	50

1. Barrett-Leonard Sharefarm NPK Fertiliser Trial.
2. Barrett-Leonard Private Plantation (ex-bush).

Tree Form Rating (TFR) figure as follows:

TFR
0: Trees with no defects – crop trees
1 – 5: Trees with some defects
6+: Tress with severe or multiple defects – possibly unharvestable

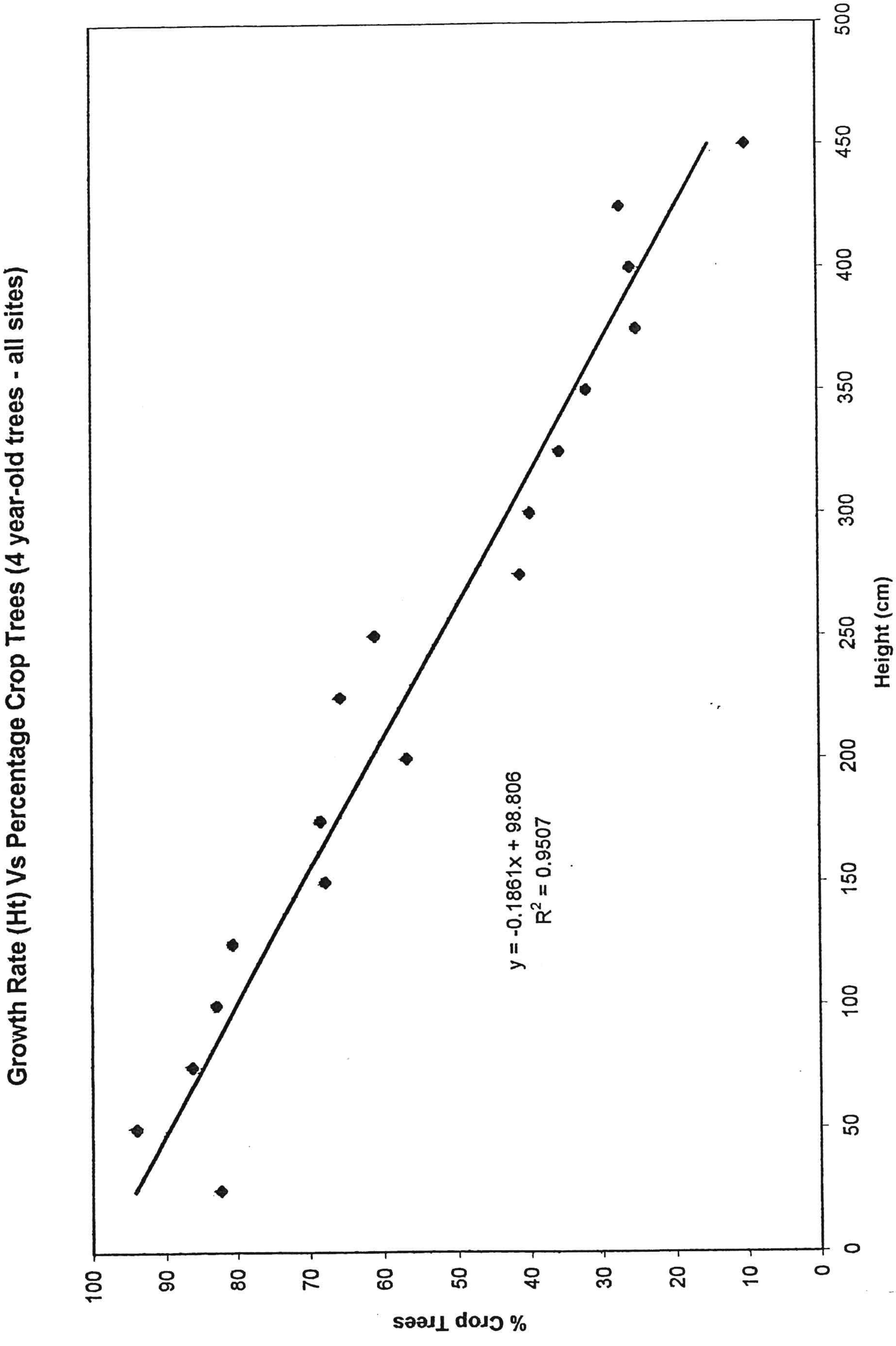
Proleptic shoots 2 years after formation.



In both cases the central leader is still evident but very

Generally, as height increased the percentage of crop trees decreased linearly (r^2 0.95). Percentage crop trees declined from 94% for trees of 50 cm height to 10% for trees of 450 cm height. Figure 1 clearly show the relationship between growth rate (as expressed by tree height) and percentage crop trees for 4 year-old trees.

Figure 1: Relationship between height and percentage crop trees for 4-year-old trees on farmland north of Perth.



MANAGEMENT OPTIONS

Management of this form disorder can be divided into operational and research options for both existing and future plantations.

Operational Options

Existing Plantations

- Form Pruning – commence at age 3 or 4 and continue until a desired log length is reached.
- Form Assessment – include form assessment in all EGM plots and assess on an annual basis. Simplify establishment and clarify marking of EGM plots in the field.

Future Plantations

- Establishment Stocking – on sites identified as likely to experience form problems, increase stocking to 2000+ sph. This will increase both the competition for water and nutrients (which will possibly lessen the occurrence of late-season growth) and increase the total number of defect free trees available (providing percentage crop trees at least remain constant).
- Form Assessment – Consider establishing EGM plots at age 3 and commence form assessment.

Research Options

- Phosphorus - quantify relationship between soil phosphorus concentrations, foliar phosphorus concentrations and degree of stem malformation.
- Water - examine the availability and quantity of stored soil water in ex-pasture sites. This in combination with the phosphorus relationships would provide a means of identifying sites likely to have poor form.
- Trace Element Relationships – identify any possible link between abnormal late-season growth and trace elements (in particular Mn, Cu, Zn and B).
- Monitor existing *Pinus pinaster* family trials.
- Genetic Link – re-examine the viability of Portuguese x Corsican hybrids of *P. pinaster* under conditions of high nutrient and water availability. Plant advanced Corsican and Corsican X Leirian hybrids at Wongan Hills experimental site in 1999. Initiate pot trial using Corsican and Corsican hybrid seedlings to assess form under accelerated growth conditions.
- Alternate Species – examine the possibility of using other species such as the *P. halepensis* group, *P. roxburghii* or *P. greggii* x *P. radiata* hybrid. Consider the use of *P. radiata* in the cooler wetter areas such as the Sth Stirlings. Examine the use of eucalypts on ex-pasture sites (eg *E. maculata, E. sideroxylon, E. occidentalis*, and *E. cladocalyx*)(light and dark coloured woods).
- Growth Hormones - examine the use of either growth promoting hormones to stimulate dormant buds to compete with proleptic shoots, or growth retarding hormones to halt late-season growth.
- Investigate the use of physiologically aged *P. pinaster* cuttings to slow growth on ex-pasture sites.

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