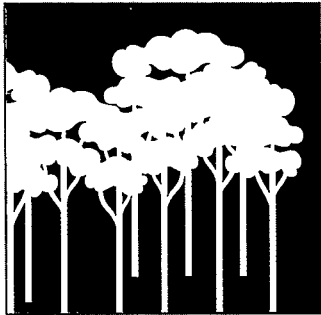


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INCIDENCE OF STEM AND
BRANCH DEFECTS IN
PINUS RADIATA D. DON
ON FORMER PASTURE SITES
IN SOUTHERN NEW SOUTH WALES

By *Elaine Birk*



FORESTRY COMMISSION OF NSW
RESEARCH DIVISION

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ELAINE BIRK

**RESEARCH DIVISION
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ABSTRACT

Radiata pine plantations established on former pastures in south-eastern Australia grow vigorously but develop poor tree form compared with plantations on sites which previously carried native eucalypt forests. In this study, the incidence of stem and branch defects including dieback, multiple leaders, kinked and sinuous stems, butt sweep, heavy branching and ramicorn branching were determined in stands on previously unimproved pastures (partially cleared, native grasses) and improved pastures (cleared with introduced legumes). Stands in five age classes (1973, 1979, 1982, 1984 1986) ranging from 2- to 15-years of age were assessed in 1988 in Buccleuch State Forest near Tumut, New South Wales, Australia. None of the stands had been thinned and stocking ranged from 958 to 1591 stems ha⁻¹. A second assessment was carried out in 1991 in the 1984 and 1986 age classes.

Trees were deformed on both types of former pasture but defects were more frequent and severe in stands on ex-improved pastures. Stands of all ages were malformed; minor stem kinks, leader defects and heavy branching were common, affecting more than 50% of trees in most sites. Several defects, particularly heavy branching and leader defects, were strongly associated with one another. There were few (generally < 150 ha⁻¹) non-deformed, high quality trees on either type of pasture but stands on previously improved pastures had more severely deformed trees (583 to 1042 trees ha⁻¹). The incidence of sinuosity increased in young stands between the two assessments and "basket" tops were found to be the most common leader defect on ex-improved pasture sites.

Previous land use can be used to indicate the potential risk of 'poor form' in radiata pine plantations. Site-specific management practices including early low and form pruning, the use of improved genetic stock and cuttings, and varied stocking levels are expected to reduce the problem of 'poor form'.

Keywords: growth disorder, malformation, defects, stem deformation, tree form, previous land use

INTRODUCTION

A shift in the land base available for radiata pine (*Pinus radiata* D. Don) plantations in Australia has resulted in a significant increase in the area of plantation established on pasture country over the past decade (Birk, 1990; Turner and Lambert, 1991). Radiata pines on former pastures grow vigorously but 'poor tree form' (Carlyle *et al.*, 1989; Birk, 1990) is a problem with the potential to reduce timber yields and utilization. Trees with 'poor form' have one or more defects including tip die-back, multiple leaders, crooked or sinuous stems and heavy branching, all of which affect timber recovery and/or wood quality (Birk *et al.*, 1991). 'Poor form' is not limited to Australia; similar problems have been observed in radiata pine in New Zealand (Will, 1986), South Africa (Grey¹, *pers. comm.*) and Chile (Torro², *pers. comm.*), in *P. carribea* and *P. oocarpa* in Liberia (Zech and Drechsel, 1992) and Douglas-fir (Carter and Klinka, 1986) and Fraser fir (Hinsley and Campbell, 1992) in North America.

Stem and branch defects observed in pines on former pastures are superficially similar to defects previously described for radiata pine (Jacobs, 1938b; Fielding, 1960; Will, 1985) although their causes differ. Numerous factors affect the development of defects in radiata pine. They include silvicultural practices (Jacobs, 1938a; Black, 1948; Cromer and Pawsey, 1957; Larsen, 1963), environmental factors such as wind or frost (Jacobs, 1938a, b; Fielding, 1967), nutrition (Kessel and Stoate, 1938; Stoate and Bednall, 1953; Will, 1971; Will and Hodgkiss, 1977), site quality (Jacobs, 1938a; Fielding, 1967, Lambert and Turner, 1977) and topography (Wright *et al.*, 1967). Many defects are also subject to strong genetic control (Fielding, 1960, 1967; Larsen, 1963; Bannister, 1980; Bail and Pederick, 1989). While deformation in plantations established on land cleared of native eucalypt forests has

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² Dr. J. Torro, University of Chile, Santiago

been relatively localized and primarily due to one or more of the factors noted above, 'poor form' in ex-pasture plantations is wide spread and exhibited in stands on a range of soil parent materials (Carlyle *et al.*, 1989), with different genetic stock (Pederick *et al.*, 1984; Bail and Pederick, 1989) and various silvicultural regimes. Deformation on ex-pastures is thought to result from a combination of site, stand and genetic factors (Bail and Pederick, 1989; Birk, 1990; Birk *et al.*, 1991) although soil mineral nitrogen is regarded as the major cause of the problem (Carlyle *et al.*, 1989; Birk, 1990; Hopmans and Flinn, 1991).

Silvicultural practices carried out in New South Wales plantations were designed for stands established on land which previously carried native eucalypt forest. Here, the usual practice is to thin for pulp at 14 years and for sawlogs and pulp at later ages followed by clearfelling at about 35 years. Generally 350+ saw log stems are retained after a normal first thinning. In contrast, ex-pasture stands frequently have less than 200 saw log quality stems and early clearfelling has been carried out (Orman³, Hobson⁴, *pers comm.*). Many stands need to be more heavily thinned than normal to remove the malformed trees; this reduces yields from later thinnings and alters the product mixes. Rebates are paid for defects due to crooked stems and multiple leaders. Overall, 'poor form' on former pastures in New South Wales is resulting in reduced yields and increased operational costs.

The study reported here was designed to quantify the various types of defects occurring in radiata pine in ex-pasture plantations. It is part of a comprehensive study of 'poor form' examining effects of previous land condition on productivity, nutrition, nutrient availability (Birk, 1991, 1992), biomass (Birk, 1993) and nutrient distribution (Birk, *unpubl data*), yields of merchantable timber, losses due to defects and changes in wood quality (Birk *et al.*, 1991).

MATERIALS AND METHODS

1. Study Area

The study area was located in Buccleuch State Forest near Tumut, in the southern highlands of New South Wales. Sites in five age classes of plantation, established in 1973, 1979, 1982, 1984 and 1986 were selected on previously improved and unimproved pasture. The stands selected were 2- to 15-years of age when the study was initiated in 1988. Three replicate 20 x 20 m plots (0.04 ha) were established at each site. The nominal planting rates for these age classes was 1333 stem ha⁻¹.

All sites were on red earth soils derived from Young Granodiorite parent material at elevations ranging from 670 to 840 m above sea level (see Table 1). Average rainfall for the period 1979-1987 was 1152 mm at Bondo weather station (840 m elevation); 1153 mm were recorded in 1988 and 1600 mm in 1989. Mean summer (December to February) maximum and minimum temperatures at Bondo are 24°C and 13°C, respectively and average winter (June to August) maximum and minimum temperatures are 9°C and 2°C, respectively.

The previous pasture condition of most sites had to be determined retrospectively and several approaches were adopted to do this including aerial photography and plantation management records. Plantation established between 1973 (the oldest substantial area on pasture) and 1986, on what had been either fully cleared, legume improved country, or partially cleared, native grass country were identified and mapped from aerial photographs taken prior to planting. On-site inspection helped to verify the previous land condition. For example, windrows in the ex-unimproved sites selected confirmed the presence of trees prior to site preparation and pasture species were still present in the inter-row areas of 2- to 6-year-old stands; subterranean clover (*Trifolium subterraneum*) in the previously improved sites, kangaroo grass (*Themeda australis*), snow grasses (*Poa* spp.) and/or bracken ferns in the unimproved sites.

³ Mr. R. Orman, Sales Manager, Softwood Region, Forestry Commission of New South Wales, Albury

⁴ Mr. D. Hobson, District Forester, Forestry Commission of New South Wales, Tumut

Table 1. General characteristics of the previously unimproved (UP) and improved (IP) pasture sites.

Pasture type	Stand age in 1988 (y)	Elevation (m)	Slope position	Parent material	Total soil N (kg ha ⁻¹) *	Total P (kg ha ⁻¹)*
Ex- UP	2	670	mid-upper		2194	360
Ex- UP	4	803	lower		2155	218
Ex- UP	6	848	upper	Young Grano- diorite	2311	222
Ex- UP	9	776	upper		2088	367
Ex- UP	15	750	mid-lower		1663	305
Ex-IP	2	678	middle		3647	561
Ex-IP	4	815	lower		2406	262
Ex-IP	6	857	upper	Young Grano- diorite	2862	283
Ex-IP	9	764	upper		2862	330
Ex-IP	15	767	upper		2086	292

* top 8 cm surface soil

Suitable age classes were selected from the maps according to the following criteria:

- (i) all sites were on the same parent material;
- (ii) no fertilizers were used at or after planting;
- (iii) herbicide treatments were similar within each pasture type (strip spray at planting on ex-unimproved sites and a repeat strip spray treatment in the second year on the ex-improved sites); and
- (iv) close proximity between the ex-improved and ex-unimproved sites in each age class.

2. Growth Measurements and Deformity Assessment

Heights and stem diameters over bark at 1.3 m height (DBHOB) were measured in the winter of 1988 and 1989. Stem and branch defects were assessed in 1988 according to the procedure of Birk *et al.* (1989) for every tree in each plot. Defects were grouped into three major types: (i) leader defects - forks, multiple leaders including basket tops, suppression and dieback; (ii) stems defects - lean, butt sweep, kinks and sinuosity; and (iii) branch form - a score integrating branch number, size and angle to the stem, plus a count of ramicorn branches.

All deformities were assessed regardless of their potential impact on merchantability to characterize the features of 'poor form'. Deformities considered to be severe enough to limit future utilization

(severe butt sweep or sinuosity and/or heavy branching) were used to calculate a non-Utilization Index (non-U.I.) (Birk *et al.*, 1989). Non-deformed trees, were trees with a single leader, no large ramicorn branches and fine to moderate branching. Mildly deformed trees had one or two minor kinks or bends in the stem, no large ramicorns and fine to moderate branching.

The effect of pasture type on stand density, stem diameter, dominant height, basal area and current growth increments was tested using one way analysis of variance (Proc ANOVA; SAS, 1987) with pasture type as the main effect. The Log-Likelihood ratio test (G-statistic) was used in conjunction with contingency table analyses (Proc Freq; SAS, 1987) to (i) test the hypothesis that there was no effect of pasture type of the frequency of defects observed and (ii) examine patterns of association between defects.

RESULTS

1. Growth

Stem diameter and basal area results (Table 2) indicate that the growth rates were higher on the previously improved pasture sites (ex-IP), which is consistent with results of previous ex-pasture studies (Skinner and Attiwill, 1981). However, ex-unimproved pasture (ex-UP) trees were taller than the ex-IP stands; SQ III (27.5 m) compared with SQ IV (26 m) at 20 years based on the South Australian Site Quality Curves for dominant height (Lewis *et al.*, 1976). This difference in taper could be due both to different spacings and different levels of soil nitrogen in the two types of former pasture (Cromer and Pawsey, 1957; Larsen, 1963; Will, 1971). Higher rates of mortality increased spacing in the ex-IP stands and soils in these sites had higher levels of mineral nitrogen (Birk, 1992). Furthermore, fertilizer trials being carried out in New South Wales show that trees treated with nitrogen alone at establishment are shorter than those treated with N and P (Ryan⁵, *pers. comm.*).

2. Deformity in Relation to Pasture Type

Significantly more trees than expected (in the statistical sense) were deformed in the ex-IP sites compared with the ex-UP sites (Table 3). Levels of deformity also varied considerably between and within age classes. Previous land use affected the frequency of leader defects (Figure 1), kinks, stem sinuosity (Figure 2) and moderate to heavy branching. Butt sweep was not common, although there were more moderate and severe cases in ex-IP sites (Figure 3). This could be a response to site preparation and planting methods similar to juvenile tilting.

As a broad generalization, stands on ex-IP sites had twice as many trees with leader defects including multiple leaders and suppressed or dead leaders and two to three times more trees with sinuous stems. Heavy branching was more common in the ex-IP sites (Figure 4) whereas fine branching was more common in ex-UP stands (Table 4). Forks were equally common in both types of former pasture when the data were pooled across all age classes (Table 3) but in 2- and 15-year-old stands less trees on the ex-UP sites were affected (Figure 5).

Minor stem kinks were very common in all sites (52 - 91% trees affected) but a relatively small proportion of trees overall had severely distorted stems (Table 4), mostly in the 9- and 15-year-old trees (up to 29 % trees affected). Leader defects were common and in the worst case (2-year-old ex-IP), 73% of trees had at least one occurrence of either displaced, double or multiple leaders (Figure 3). More than 75% of trees in all but one site (6-year-old ex-UP) had moderate or heavy branching.

⁵ Dr. P. Ryan, Research Division, Forestry Commission of New South Wales

Table 2. Mean growth measurements (1989) and mean growth increments (1988-1989) in stands on previously unimproved (UP) and improved (IP) pasture sites.

Growth parameter	1986 age class		1984 age class		1982 age class		1979 age class		1973 age class	
	UP	IP	UP	IP	UP	IP	UP	IP	UP	IP
Density (st ha ⁻¹)	1333a	1375a	1292a	1192a	1092a	958b	1350b	1591a	1125a	1117a
Mortality (st ha ⁻¹)	8	58	0	8	0	17	25	17	33	158
Mean dom. ht. (m)	3.0a	3.2a	5.4a	5.5a	8.8a	7.8b	16.3a	14.7a	24.0a	22.9a
Mean dom. ht. inc.(m)	1.55a	1.57a	1.92b	1.98b	2.14a	1.52b	2.4a	1.89a	1.65a	1.39a
Dbhob (cm)	3.1a	3.4a	6.8b	9.3a	12.7b	15.2a	19.0a	18.6a	22.6a	24.1a
Dbhob inc. (cm)	n.d	n.d	n.d	n.d	3.63a	4.40a	1.67a	1.79a	1.79a	1.14a
Basal area (m ² ha ⁻¹)	1.01a	1.24a	5.38b	8.24a	14.66b	17.87a	40.70b	46.98a*	40.96a	50.49a
B.A. inc (m ² ha ⁻¹)	n.d	n.d	n.d	n.d	7.05a	8.73a	6.28b	8.25a	0.43a	3.12a

Means with different superscripts within each age class indicate significant differences between pasture types at P = 0.5

* difference not significant when stocking was used as a covariate in the analysis of variance

n.d. not determined

More non-deformed trees were found in the ex-UP stands than in the ex-IP stands (Figure 6a) and substantial numbers of the ex-UP trees had only minor defects (Figure 6b compared with Figure 6a). The majority of ex-IP trees had major defects; the non-Utilization Indices show that 45 to 91% of the trees (583 to 1042 stems ha⁻¹) in ex-IP stands had stems which were sinuous throughout, heavy branching and/or severe butt sweep, compared with 8 to 55% (92 to 750 stems ha⁻¹) in the ex-UP stands (Table 4).

Table 3. Contingency Tables and Log-Likelihood ratio (G-statistic) values for the occurrence of defects in relation to previous pasture type (numbers in parentheses indicate the number of expected defects per pasture type).

A. Forks				B. Sinuosity							
	Absent	Present	Total		Absent	Present	Total				
Ex-UP	611 ^O (609) ^E	127 (129)	738	Ex UP	675 (661)	63 (77)	738				
Ex-IP	610 (612)	132 (130)	742	EX-IP	650 (664)	92 (78)	742				
Total	1221	259	1480	Total	1325	155	1480				
G = 0.087, df = 1, P = .769 (n.s.)				G = 5.919, df = 1, p = .015							
C. Branch form					D. Butt sweep						
	Fine	Mod.	Heavy	Total		Mild	Mod.	Severe	Total		
Ex-UP	176 (132)	326 (290)	236 (314)	738	Ex-UP	717 (674)	19 (59)	2 (5)	738		
Ex-IP	90 (134)	257 (292)	395 (316)	742	Ex-IP	634 (677)	99 (59)	9 (5)	742		
Total	266	583	631	1480	Total	1351	118	11	1480		
G = 76.98, df = 5, P = .000					G = 69.33, df = 2, P = .000						
E. Leader defects#						F. Kinks*					
	None	Dead/br	Disp'd.	'Basket'	Total		0	1-3	4-7	8+	Total
Ex-UP	500 (460)	83 (99)	134 (148)	21 (31)	738	Ex-UP	166 (137)	406 (416)	155 (174)	11 (10)	738
Ex-IP	442 (462)	115 (99)	163 (149)	42 (32)	742	Ex-IP	110 (138)	430 (419)	193 (174)	9 (10)	742
Total	922	198	297	63	1480	Total	276	836	348	20	1480
G = 21.76, df = 3, P = .000						G = 16.47, df = 3, P = .001					

^O = observed frequency; ^E = expected frequency;
 # dead/br = dead tip or broken tops; disp. = displaced leader;
 'basket' = basket whorl at leader; * = number of kinks per stem.

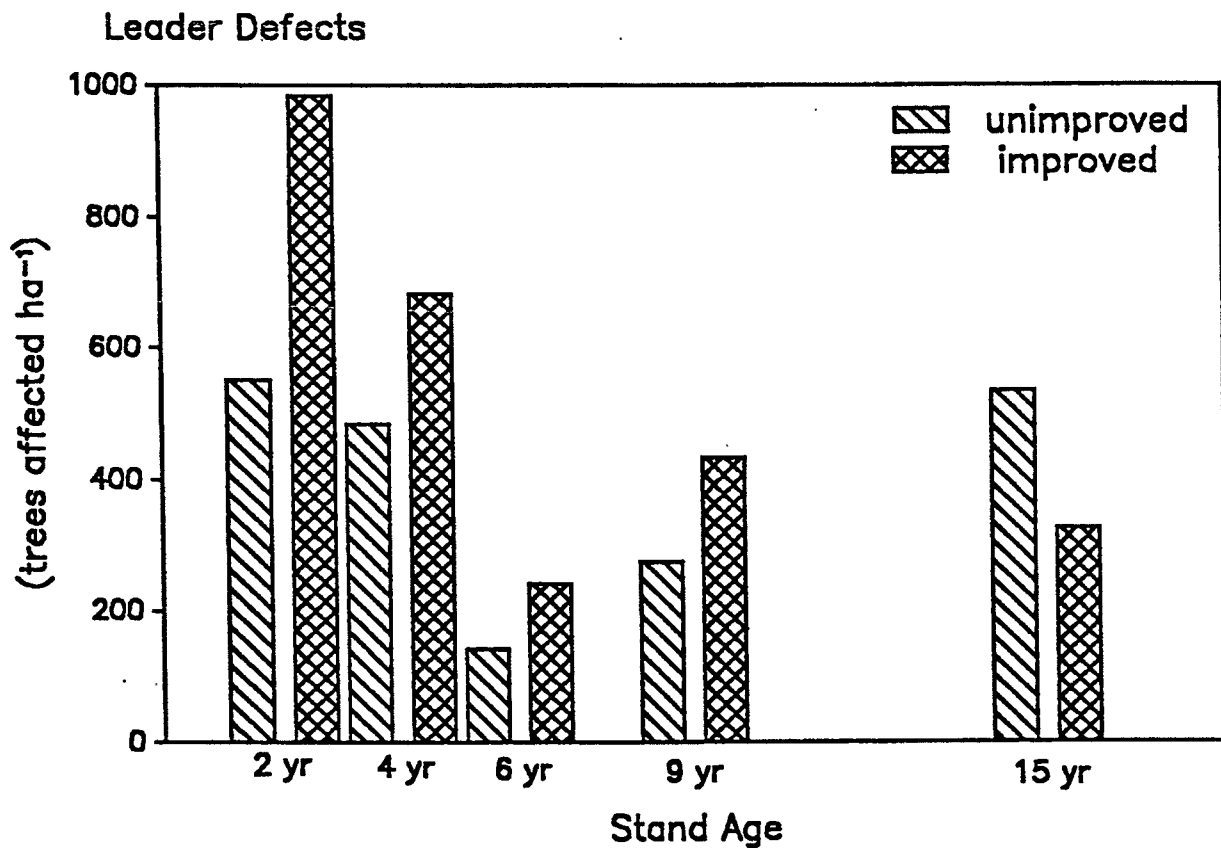


Figure 1. Number of trees (stems ha⁻¹) with leader defects on ex-unimproved and ex-improved pasture sites.

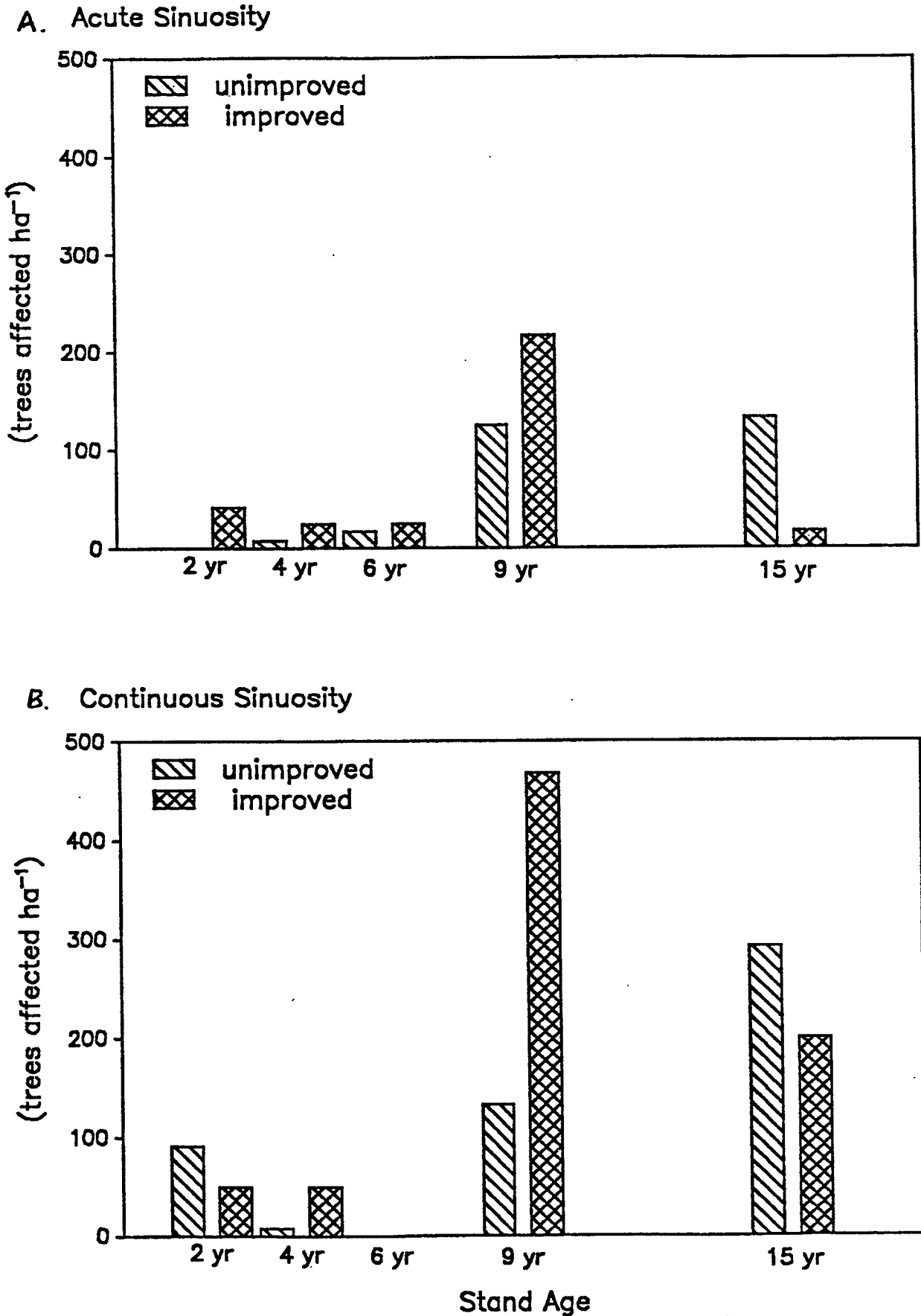


Figure 2. Number of trees (stems ha⁻¹) with A) acute and B) continuous sinuosity on ex-unimproved and ex-improved pasture sites.

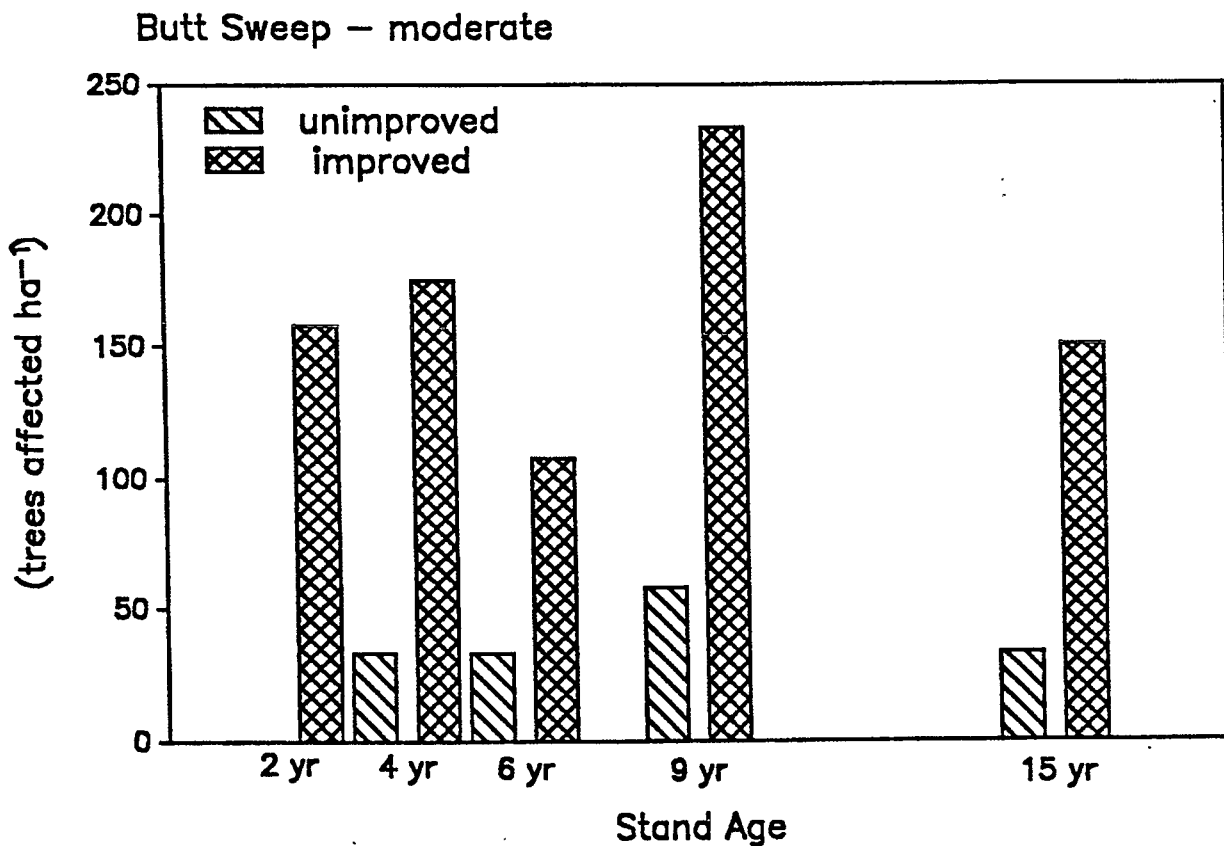


Figure 3. Number of trees (stems ha⁻¹) with moderate butt sweep on ex-unimproved and ex-improved pasture sites.

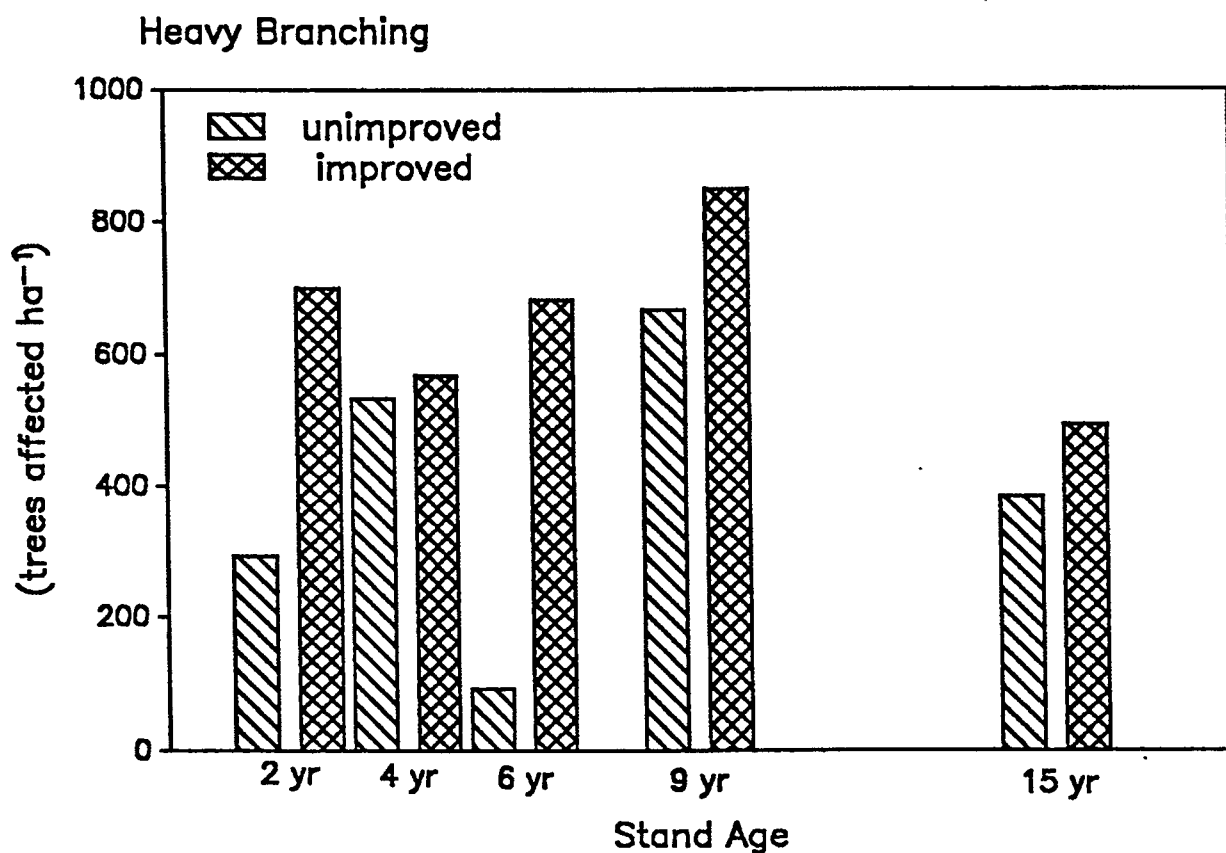


Figure 4. Number of trees (stems ha⁻¹) with heavy branching on ex-unimproved and ex-improved pasture sites.

Table 4. Proportion (%) of trees affected by deformities on previously unimproved (UP) and improved (IP) pasture sites.

Deformities	1986 age class 2-year-old stands		1984 age class 4-year-old stands		1982 age class 6-year-old stands		1979 age class 9-year-old stands		1973 age class 15-year-old stands	
	UP	IP	UP	IP	UP	IP	UP	IP	UP	IP
Forks	11	9	7	10	8	16	19	23	43	31
Leader defects	42	73	38	58	13	25	20	27	47	29
Stem sinuosity										
- acute	0	3	1	2	2	3	9	14	12	1
- continuous	7	4	1	4	0	0	10	29	26	18
Kinks	52	75	88	91	86	97	88	83	73	84
Butt sweep										
- mild	99	84	97	85	97	87	96	85	96	87
- moderate	0	12	3	15	3	11	4	15	3	13
- severe	1	4	0	0	0	2	0	0	1	0
Branch form										
- mild	24	13	18	9	43	3	18	16	19	16
- moderate	54	35	40	43	49	25	33	30	47	40
- heavy	22	52	42	48	8	71	49	53	34	44
Non-deformed	17	4	4	2	10	0	4	2	9	3
Mildly deformed	42	11	18	11	46	6	20	5	15	14
Non-Utilization Index	26	52	41	49	8	70	55	91	46	46

Non-Utilization Index (percentage of trees with severe defects including continuous sinuosity, heavy branching and/or severe butt sweep).

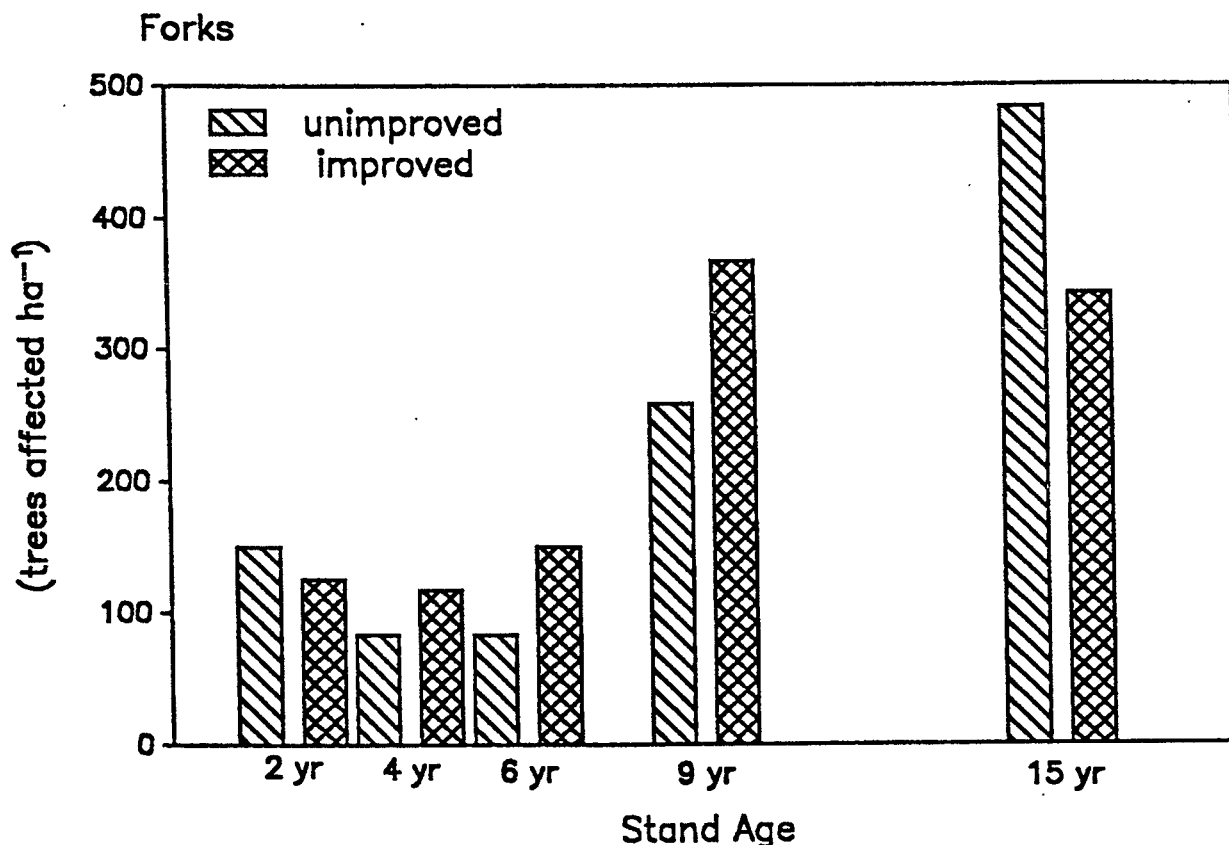


Figure 5. Number of trees (stems ha⁻¹) with forks on ex-unimproved and ex-improved pasture sites.

DISCUSSION

Symptoms of 'poor form' include lack of apical dominance, excessive branching and distorted stems. These characteristics were exhibited by trees on both types of pasture although more trees in the ex-improved site were affected and the defects were more severe. 'Poor form' is characterized by a broad spectrum of defects and improved sites exacerbate the problem.

Some deformities were clearly associated with one another (results not shown); trees with leaders defects were more likely to have larger branches than trees with normal leaders. Leaders arising from lateral branches were more likely to be sinuous than normal leaders. Jacobs (1938b) noted the coincident development of defects in *P. radiata* and regarded aberrant branch characteristics as the source of most bad form in radiata pine. Carter and Klinka (1986) considered that late-season flushing of the sub-terminal branches was the main source of defects contributing to distorted growth in juvenile Douglas-fir on moist, fertile sites in British Columbia. There are many similarities between the characteristics of 'poor form' in radiata pine and those reported by Carter and Klinka (1986) for Douglas-fir.

When this study was initiated, 'poor form' was thought to be limited to plantations on legume-improved pastures, but this assumption has had to be reconsidered in light of the high incidence of deformity on previously unimproved pasture sites. High levels of mineral nitrogen in ex-pasture soil are consistently associated with 'poor form' (Carlyle *et al.*, 1989) and levels considerably higher than expected for pine forest soils were found in the ex-unimproved and particularly in the ex-improved sites examined in the present study (Birk, 1992). Hopmans and Flinn (1991) have shown that applications of nitrogenous fertilizers induce and exacerbate sinuosity and other defects in radiata pine

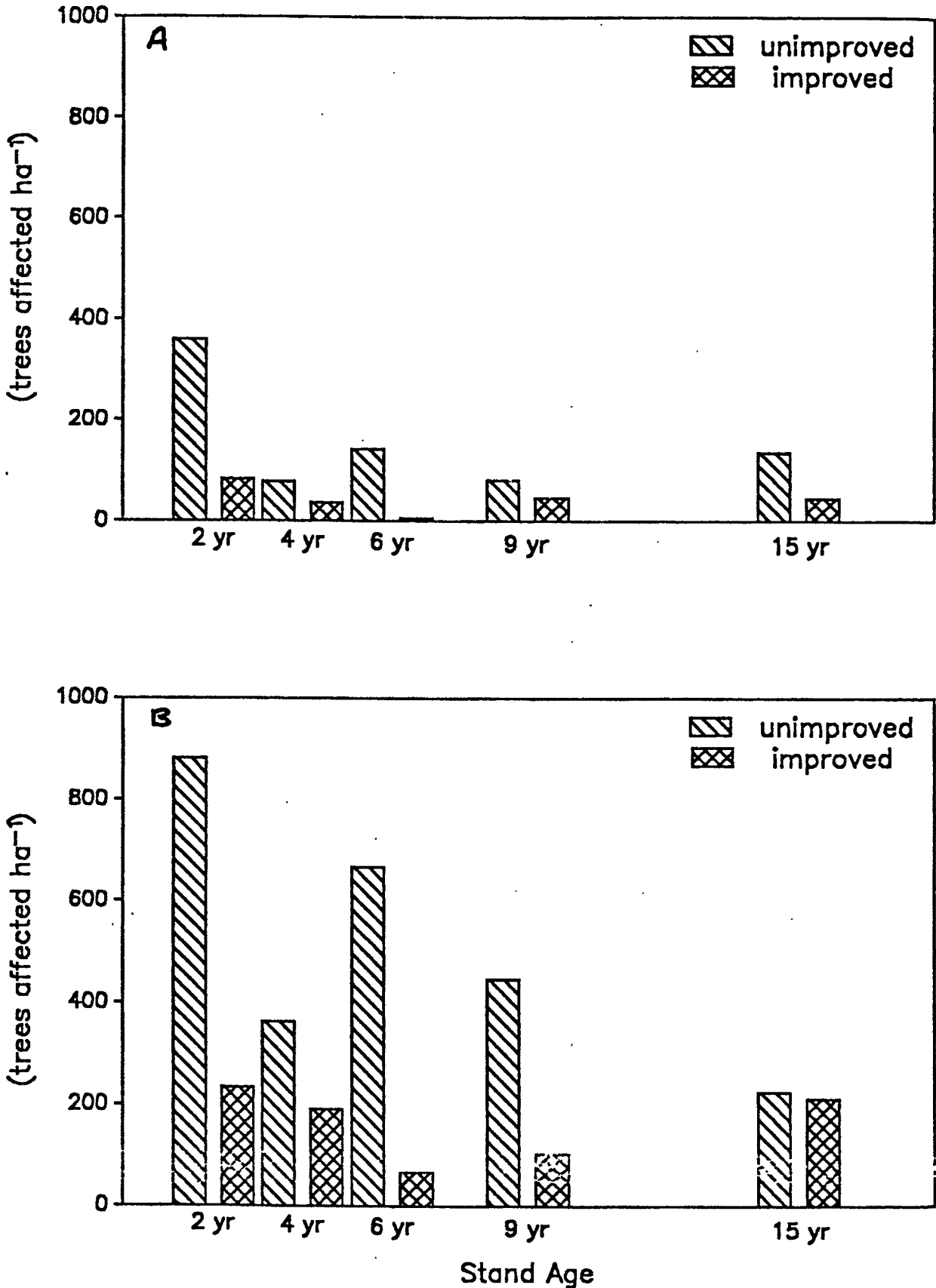


Figure 6. Number of non-deformed and slightly deformed trees in 2- to 15-year-old stands on improved and unimproved pasture sites. A) Non-deformed trees have a single leader, straight stems, no ramicorns greater than 10 cm diameter and fine to moderate branching. B) Slightly deformed trees have up to two minor stem kinks.

in pasture and non-pasture sites. *P. radiata* and other species which develop sinuous stems have high levels of foliar nitrogen (Carter *et al.*, 1986; Zech and Drechsel, 1992; Hinsley and Campbell, 1992; Birk, *unpubl. data*).

There is little published data on the frequencies of defects in pine plantations to provide a baseline against which to assess the results obtained in this study. Kessel and Stoate (1938) suggested that about 10% of trees could have deformities not associated with any particular growth disorder. Data from recent surveys of ex-native forest stands are in line with this estimate; Carter⁶ (*pers. comm.*) found multiple leaders in 12% and distortions in 2% of 13-year-old trees in Buccleuch State Forest. Birk (1991) assessed 20-year-old stands in Sunny Corner State Forest and found 18% of trees with leader defects, 5% had heavy branching and <1% had distorted stems.

Some defects in ex-pasture sites could be symptoms of other problems which cannot be identified separately because the defects are the same as those of 'poor form'. Frost, for example, causes leader damage and in some circumstances wind can cause stem distortions (Jacobs, 1938a; Fielding, 1967). However, these defects should be relatively localized; one might expect the level of defect due to frost to be similar at least within the various age classes examined here, due to the close proximity and similar characteristics of the sites selected. Previous land condition is the site factor which distinguishes the sites within an age class and the factor which potentially had the major effect on growth.

Although age-related changes in the occurrence of defects are not clear from the data, high levels of deformity in 2- and 4-year-old trees indicate that problems occur within the first few years after planting. Many early defects may be masked during later growth; for example, bent seedlings sometimes appear to straighten as stem girth increases relative to the distortion, thereby reducing the visual evidence of sinuosity over time. To examine changes with time further, the two younger age classes (1986, 1984) were reassessed for defects in 1991, three years after the original survey, when the stands were 5- and 7-years old. This assessment showed a decrease in the number of leader defects, indicating that apical dominance had been regained in many trees which previous had dead, suppressed or multiple leaders (Table 5). "Basket tops" were the dominant type of leader defect, resulting in 3 to 10 leaders per tree, particularly in the ex-improved sites. The proportion of trees with forks increased slightly in both age classes and pasture types. The incidence of sinuosity increased in the three years between assessments, particularly in the 1984 ex-improved sites.

Masked or hidden defects, such as those associated with displaced leaders, do not cease to be a problem just because they are not visible. Compression wood and sloping grain reduce wood quality in the longer term, particularly if the heart-in wood (juvenile) is used for structural purposes. Initial studies of ex-pasture trees indicate that there are problems with lower wood densities, large knots and grain deviations in ex-pasture trees. The strength and value of this timber is significantly lower than that of timber from comparable ex-native forest trees (Birk *et al.*, 1991; Grant⁷, *pers. comm.*).

Site-specific management practices are required in the longer term to improve tree form in ex-pasture plantations. Previous land use and condition are factors which can be used to guide the selection of appropriate strategies including the choice of planting stock, fertilizer treatments and thinning schedules. Remedial actions, such as early low pruning or form pruning, could ameliorate some defects in stands less than five years old. The severity of most defects can be determined within five years although their impact on merchantability may be difficult to assess at this age. Site condition prior to planting is being used in New South Wales to assess the potential risk of 'poor form' and to determine appropriate management regimes to reduce deformation. Sites with a high risk of deformation are to be planted with improved genetic stock and cuttings. Planting densities will be varied with the aim of achieving sufficient stems for selection as saw logs at first thinning. In some cases, stocking will be reduced with a substantial increase in the management input per tree. These measures are expected to increase the quality and value of ex-pasture trees and capitalize on the high growth potential of the ex-pasture sites.

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⁷ Mr. D. Grant, Research Division, Forestry Commission of New South Wales

Table 5. Proportion (%) of trees in the 1986 and 1984 age classes with deformities, three years after the initial survey.

Deformities	1986 age class 5-year-old stands		1984 age class 7-year-old stands	
	UP	IP	UP	IP
Forks	12	22	14	14
Leader defects	16	26	7	15
Sinuosity				
- acute	3	18	3	1
- continuous	4	8	9	19
Kinks	78	88	70	81
Heavy branching*	4	20	15	58

* All stands were pruned of lower branches between assessments which resulted in a decrease in the proportion of trees perceived to be heavily branched

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