Eucalypt coppice harvesting costs for stands of varying stump and stem densities, South Africa

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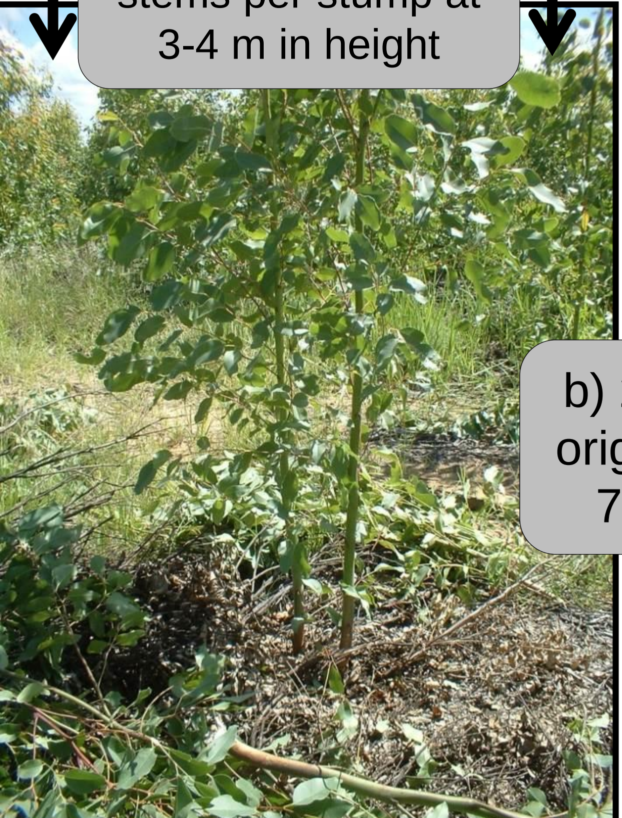
Background

- Data from a number of trials comparing coppice managed stands versus planted stands (over the same rotation and with the same genetic material), have shown that if properly managed:
  - productivity is comparable,
  - establishment costs are reduced, but
  - with an increase in harvesting costs (mainly due to double stems)
- Replanting is advocated if there is/are:
  - improved site x species matching (including risk mitigation),
  - improved genetics,
  - high 1R mortality, or a need to change planting density, or
  - weakly coppicing species

Current coppice management recommendations are geared towards maximised volume production, with a stepwise reduction (2 x thinnings) leaving double stems on selected stumps so as to achieve full stocking

a) 1st reduction to 2 stems per stump at 3-4 m in height



b) 2nd reduction to original stocking at 7-8 m in height

- Although robust, these recommendations do not take into consideration issues related to mechnised harvesting, in particular the efficiency of mechanised harvesting of stumps with two stems

- As a first step towards generating an understanding, data related to the impact of various stump/stem coppice combinations on mechanised harvesting were obtained from 5 coppice management trials

Objectives

- Linking different coppice management regimes with mechanised harvesting in terms of cost:benefits,
- The influence of stump mortality and stem stocking on these cost:benefits,
- The contribution made by the smaller of the double stems to the final volume (where two stems have been left),
- The influence of site, species and productivity on rotation-end volume, and thus the income based on the Internal Rate of Return (IRR), and
- The optimum coppice management regime/s if a fully mechanised CTL system (harvester-forwarder combination) is used.

Site characteristics for four of the five coppice management trials

Magisterial district, Plantation		Lower Umfolozi, Mavuya	Enseleni, Teza A	Enseleni, Teza B	Piet Retief, Vroegeveld Wes
Altitude (m a.s.l.)		30	55	75	1 291
MAT (°C)		21.8	21.8	21.8	17.1
MAP (mm)		990	916	897	858
Selected topsoil properties	Taxonomy	Yellow Fernwood	Yellow Fernwood	Yellow Fernwood	Hutton
	Depth (m)	+1.5	+1.5	+1.5	0.59
	Texture	sand	sand	sand	SaCLLm
Spacing (sph)		3 x 2.5 m (1 333 sph)	3 x 2.5 m (1 333 sph)	3 x 2.5 m (1 333 sph)	3 x 2 m (1 666 sph)
Species planted		*GU*	*GC*	*GC*	*E. dunnii*
Potential productivity	Climate zone	ST8	ST7	ST7	WT4
	Growing conditions	Optimum	Optimum	Risk of drought	Optimum
	MAI $m^3\ ha^{-1}\ yr^{-1}$	38-42	18	17-18	19-22

Treatments

Treat No	Treat description	No. of coppice stems left after 1st reduction		No of coppice stems left after 2nd reduction	Stump stock (%)	Stem stock (%)
		2 m	4 m	8 m		
1	2m_100_s	1	-	-	100	100
2	2m_80_s	1	-	-	80	80
3	2m_8m_100_Or	2-3	-	1-2	100	100
4	2m_8m_80_Or	2-3	-	1-2	80	100
5	2m_8m_60_Or	2-3	-	1-2	60	100
6	2m_8m_100_s	2-3	-	1	100	100
7	2m_8m_80_s	2-3	-	1	80	80
8	2m_8m_60_s	2-3	-	1	60	60
9	4m_8m_100_s	-	2-3	1	100	100
10	4m_8m_80_s	-	2-3	1	80	80
11*	4m_8m_100_OR	-	2-3	1-2	100	100
12*	4m_8m_80_OR	-	2-3	1-2	80	100

Silvicultural input costs (1 Euro = 14.65 ZAR)

- Silvicultural operations were based on a rate of R135 unit^{-1} (€ 9.2)
- Two 2^{ndry} coppice regrowth control operations were included, as well as two weeding, and thereafter two noxious weed control operations over the remainder of the 7-10 year rotation

Cost activities for the management of coppiced stands	No. of labour units (unit's ha^{-1})	Cost (ZAR ha^{-1})
Stump clearing	5	675 (€ 46.08)
1st coppice reduction	10	1 350 (€ 92.15)
2nd coppice reduction	6	810 (€ 55.29)
2^{ndry} coppice regrowth control	3.5	472.5 (€ 32.25)
Noxious weed control	0.8	215.2 (€ 14.69)
Overheads	-	900 (€ 61.43)

Rotation-end calculations

- Merchantable volumes determined per stem
  - top-end, under-bark diameter of 5cm
  - GC and GU volumes based on coppice stems
  - tree volume equations used for *E. dunnii* and *E. smithii*
- Volumes converted to tons ha^{-1}
  - *GC* = 0.75
  - *GU* = 0.70
  - *E. smithii* = 0.81
  - *E. dunnii* = 0.88
- From this the gross income ha^{-1} could be determined for each treatment

Harvesting and transport costs

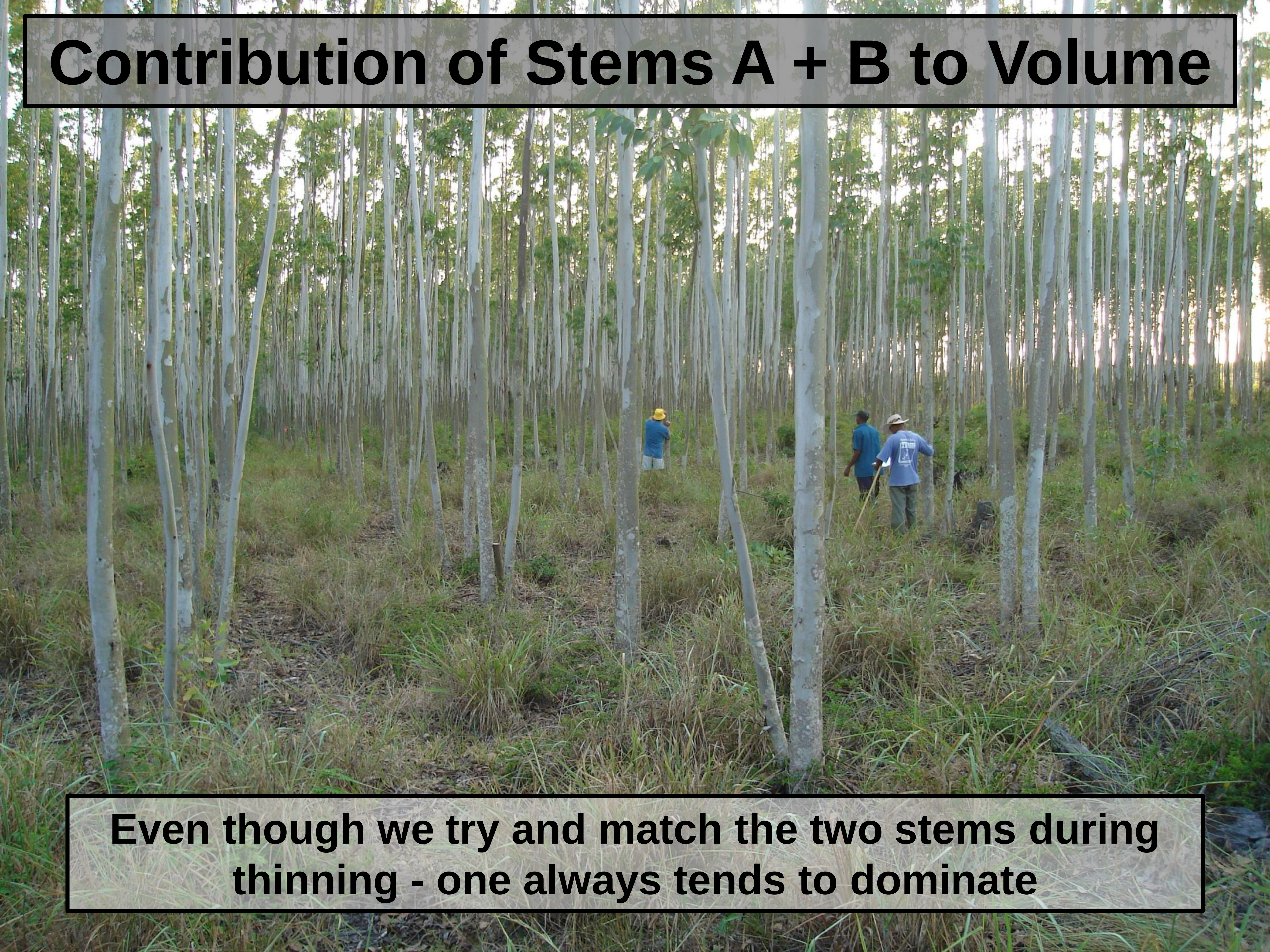
- The stump and stem stocking, together with the individual volumes were used to determine harvesting costs based on the harvesting productivity model developed for coppice (Ramantswana *et al*. 2013).
  - based on *E. grandis* coppice
  - harvester costs were estimated at R1 450 (€ 98.98) per productive machine hour
- Transport costs included primary (short haul), loading and secondary (long haul)
  - R 236.6 (€ 16.15) Standardized
- The nett income could be calculated by subtracting the harvesting and transport cost ha^{-1} from the gross income

Cost calculations

- Net Present Value (NPV) was calculated at a discounted rate 6% over a 7-10 year rotation (dependent on site and species)

- Internal Rate of Return (IRR) could then be determined for the various coppice management scenarios at each of the five sites

Contribution of Stems A + B to Volume



Even though we try and match the two stems during thinning - one always tends to dominate

Mavuya: *E. grandis* x *E. urophylla*

(1 333 sph)

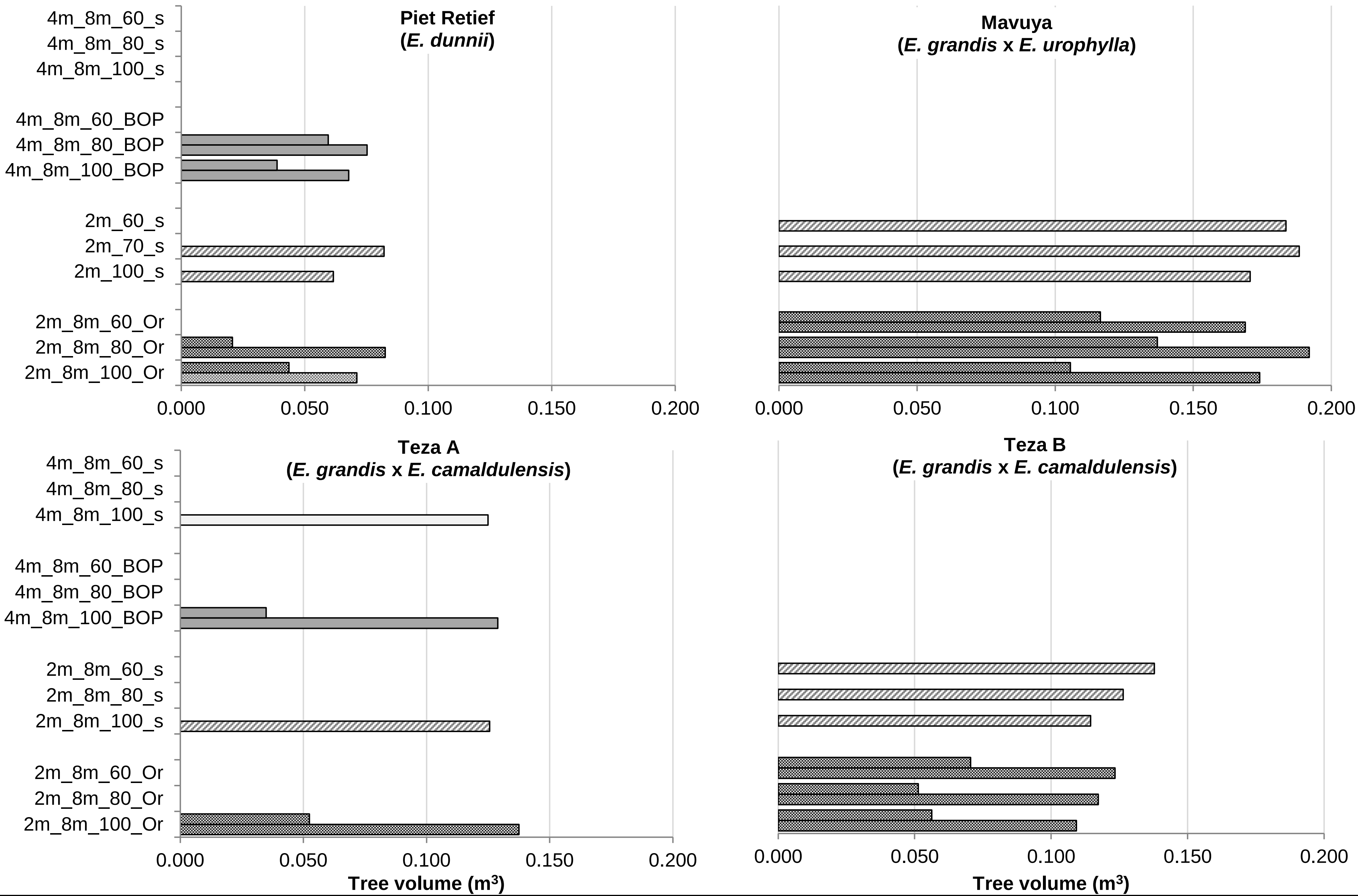
Treat	Stump stock (sph)	Stem stock (sph)		Final stock (sph)	Merch Vol stem^{-1} (m^3)		Merch Vol ha-1 (m^3 ha^{-1})		Total Merch Vol ha-1 (m^3 ha^{-1})	MAI (m^3 ha^{-1} yr^{-1}) Adj. for coppice rotation
		A	B		A	B	A	B		
2m_8m_100_Or	1 144	1 133 **92%**	100 **8%**	1 233	0.174	0.105	197 **95%**	11 **5%**	208	25.7
2m_8m_80_Or	1 000	988 **86%**	166 **14%**	1 154	0.192	0.137	190 **90%**	23 **10%**	212	26.3
2m_8m_60_Or	944	922 **78%**	267 **22%**	1 189	0.169	0.116	156 **83%**	31 **17%**	187	23.1

Teza B: *E. grandis* x *E. camadulensis*

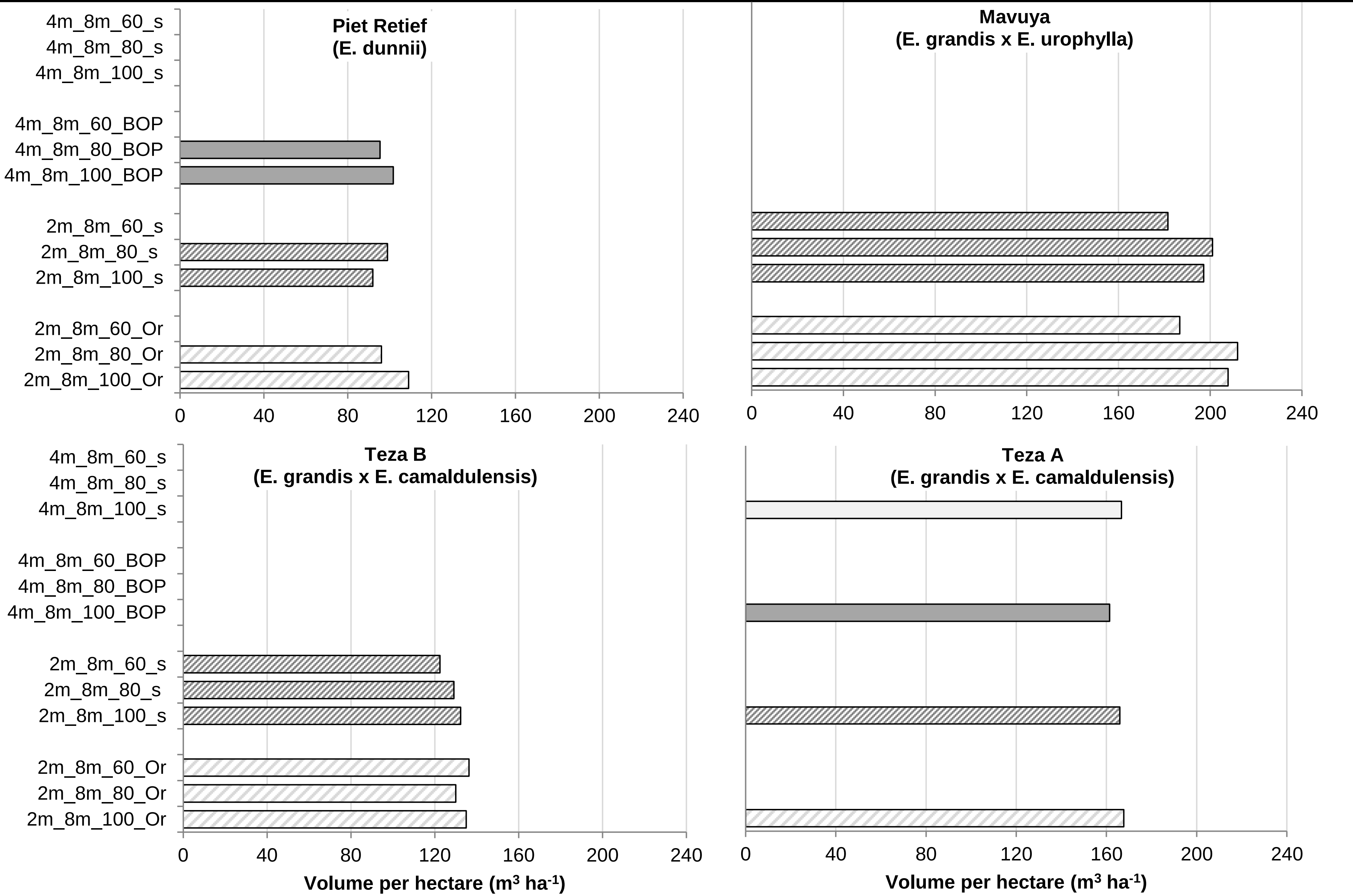
(1 333 sph)

Treat	Stump stock (sph)	Stem stock (sph)		Final stock (sph)	Merch Vol stem^{-1} (m^3)		Merch Vol ha-1 (m^3 ha^{-1})		Total Merch Vol ha-1 (m^3 ha^{-1})	MAI (m^3 ha^{-1} yr^{-1}) Adj. for coppice rotation
		A	B		A	B	A	B		
2m_8m_100_Or	1 230	1 126 **84%**	222 **16%**	1 348 **100%**	0.109	0.056	123 **91%**	12 **9%**	135 **100%**	17.6
2m_8m_80_Or	1 259	993 **79%**	267 **21%**	1 260 **100%**	0.117	0.051	116 **89%**	14 **11%**	130 **100%**	16.9
2m_8m_60_Or	1 274	859 **67%**	430 **33%**	1 289 **100%**	0.123	0.071	106 **78%**	31 **22%**	136 **100%**	17.8

Individual tree volume (m^3)



Volume ha^{-1}

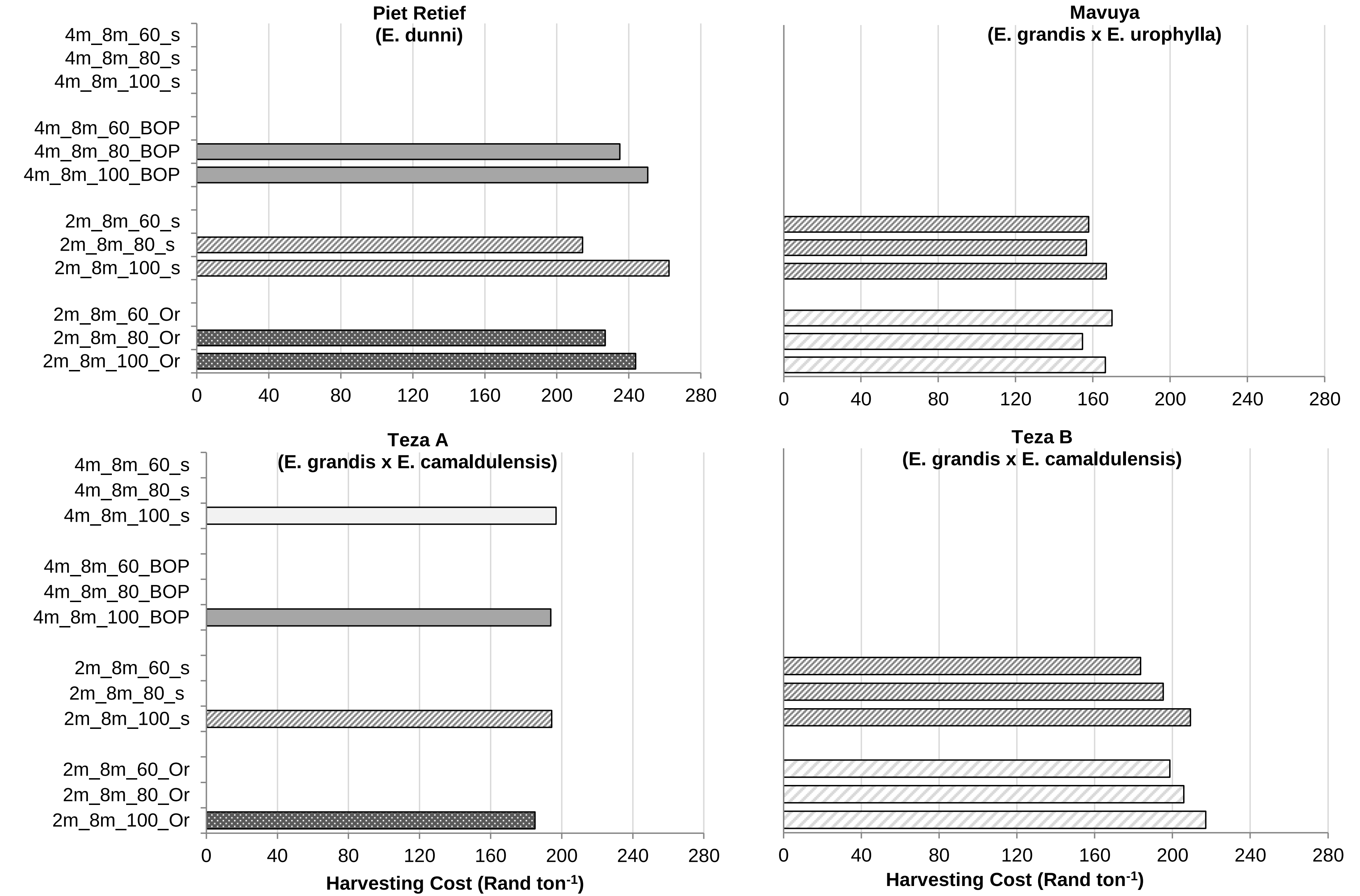


Piet Retief
(E. dunnii)
Mavuya
(E. grandis x E. urophylla)
Teza B
(E. grandis x E. camaldulensis)
Teza A
(E. grandis x E. camaldulensis)
4m_8m_60_s
4m_8m_80_s
4m_8m_100_s
4m_8m_60_BOP
4m_8m_80_BOP
4m_8m_100_BOP
2m_8m_60_s
2m_8m_80_s
2m_8m_100_s
2m_8m_60_Or
2m_8m_80_Or
2m_8m_100_Or
0
40
80
120
160
200
240
Volume per hectare (m³ ha⁻¹)

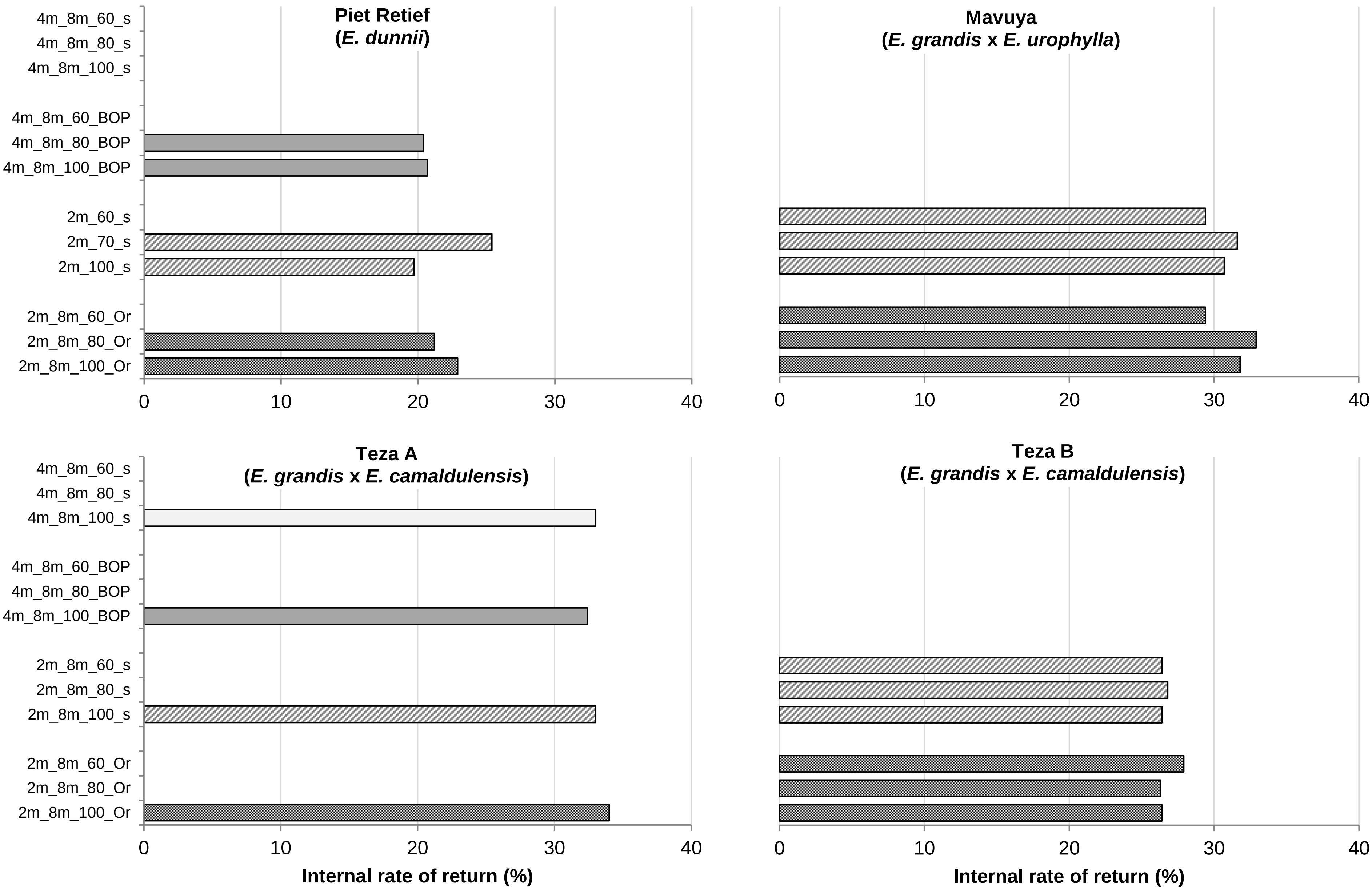
Volume

- Volume differences between sites a function of productivity, species planted and rotation length
  - Piet Retief = drought + felled at 7yrs
- Increasing number of stumps/stems
  - decrease in individual tree volume
  - increase in volume ha^{-1}
- Stem B smaller than Stem A
- Contribution to yield of Stem B disproportionately smaller than Stem A
  - this contribution becomes less the lower the stump stocking & hence the higher the number of double stems

Harvesting cost



IRR (NPV 6%)



Piet Retief
(E. dunnii)
4m_8m_60_s
4m_8m_80_s
4m_8m_100_s
4m_8m_60_BOP
4m_8m_80_BOP
4m_8m_100_BOP
2m_60_s
2m_70_s
2m_100_s
2m_8m_60_Or
2m_8m_80_Or
2m_8m_100_Or
0
10
20
30
40
Mavuya
(E. grandis x E. urophylla)
0
10
20
30
40
Teza A
(E. grandis x E. camaldulensis)
4m_8m_60_s
4m_8m_80_s
4m_8m_100_s
4m_8m_60_BOP
4m_8m_80_BOP
4m_8m_100_BOP
2m_8m_60_s
2m_8m_80_s
2m_8m_100_s
2m_8m_60_Or
2m_8m_80_Or
2m_8m_100_Or
0
10
20
30
40
Internal rate of return (%)
Teza B
(E. grandis x E. camaldulensis)
0
10
20
30
40
Internal rate of return (%)

Costs

- In general the harvesting costs were higher, with a lower IRR on the less productive than the more productive sites
- Higher harvesting costs were also associated with
  - those treatments that resulted in a decrease in individual stem volumes
  - an increase in the number of stumps/stems
  - an increase in the number of double stems
- Trends in IRR "not that clear", although they tend to become normalised across a treatment subset
  - in other words those factors that contribute to increased volumes per hectare (increased stem numbers - including B-Stems), result in increased harvesting costs = reduction in IRR

Conclusions (almost)

- First some things to bear in mind with this data set:
  - data from 5 trials only
  - small treatment plots (12 - 16 measured trees), which means that small differences can become masked and/or magnified
  - variability also present in those plots with lowered stocking due to multiple possible arrangements of missing stumps (gaps within a plot)
  - the treatments were not designed for this kind of study, rather they were cherry-picked from existing trials to help answer key questions related to stump/stem stocking and harvesting costs
  - generic equations were used that may not be the most suitable and/or precise
  - aspects such as windthrow from once-off reductions could not be determined (backwards selection of treatments)

Conclusions

Nevertheless

- Important principles were illustrated, and the data tends to support “common logic”
- The data also indicates the possibilities for alternative coppice management regimes that will favour mechanised harvesting

Way forward

- Specific treatments need to be tested & data generated that will address the highlighted short-comings
- This also needs to take into consideration coppice management regimes that are specifically geared towards maximising the volume of single stems (combined with optimising IRR)

Thank you

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