SOIL PREPARATION STUDIES IN WESTERN AUSTRALIAN PINE PLANTATIONS.

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BACKGROUND.

With the move to establish new pine plantations exclusively on cleared farmland, there has been an upsurge in requests by plantation managers for information relating to the need, or otherwise, for soil preparation strategies for the different site types that are being accepted for plantation establishment. The superior nutritional status of farmland compared to virgin land has increased the potential for a wider range of site types to be economically viable for plantation establishment.

Improvements in the design and availability of mound ploughs, and new drainage strategies, has enabled large areas of swampy land to be considered for conversion to plantations. While establishment on these sites is now comparatively straightforward and success is high, the longer term viability of these sites remains in doubt. Many "swampy" sites are characterised by the presence of lateritic or organic pans. These vary in depth from <30 centimetres to >2.0 metres. There is evidence of reduced stability and inadequate soil depth on some sites. The possibility of ameliorating sites identified as having "shallow" soils is the subject of debate and research effort.

Mound ploughing has become an accepted method of preparing sites for planting *P. radiata* in Western Australia; so much so that the practice is being prescribed on all soil types, irrespective of whether the site is wet or not. There is some danger in mounding, particularly in relation to effective herbicidal weed control and erosion. Trials are underway to identify sites where mounding will provide economic responses by trees.

Ripping is widely practiced as a means of improving establishment of trees. While there appears to be substantial evidence to support some form of cultivation on agricultural land in Western Australia, there is a dearth of information to support deep ripping. A feature of most agricultural land in Western Australia is the presence of a "traffic" pan between 20 and 40 centimetres below the soil surface. Fracturing this appears sufficient to successfully establish trees on all sites currently accepted for *P. radiata* plantations. However, there is a widely held view that deep ripping on shallow duplex soils will be beneficial by providing a larger volume of root penetrable soil and hence plantations will be less prone to drought. Observations suggest that, on some sites, ripping may be detrimental to survival and growth of *P. radiata*. Deaths of trees were recorded in a ripped area of the Blackwood Valley. A study showed that all dead trees were infected with the root rotting fungi *Phytophthora megastima* and *Phytophthora citricola*. It was noticeable also that a higher proportion of trees in the ripped area had tilted compared to an adjacent unripped area. It is hypothesised that ripping reduces the mechanical strength of the soil and creates zones of severe waterlogging. Under these conditions the effects of wind are magnified. Stress fractures occur at the root collar and with ideal conditions fungi invade the tree.

Ripping to a depth of 40 centimetres costs approximately $45/ha^{-1}$. Increase the depth to 80 centimetres and the cost rises to between $85 and $120/ha^{-1}$. Assuming an average product value of $33/m^3$ over a 30 year rotation, and adding a 75% overhead, this would require between 20 and $26m^3/ha^{-1}$ increase in volume to break even. Increase the depth of ripping to 120 centimetres and an extra $74m^3/ha^{-1}$ is required.

SUMMARY OF RESULTS FROM RECENT SOIL PREPARATION TRIALS

1. Ripping.

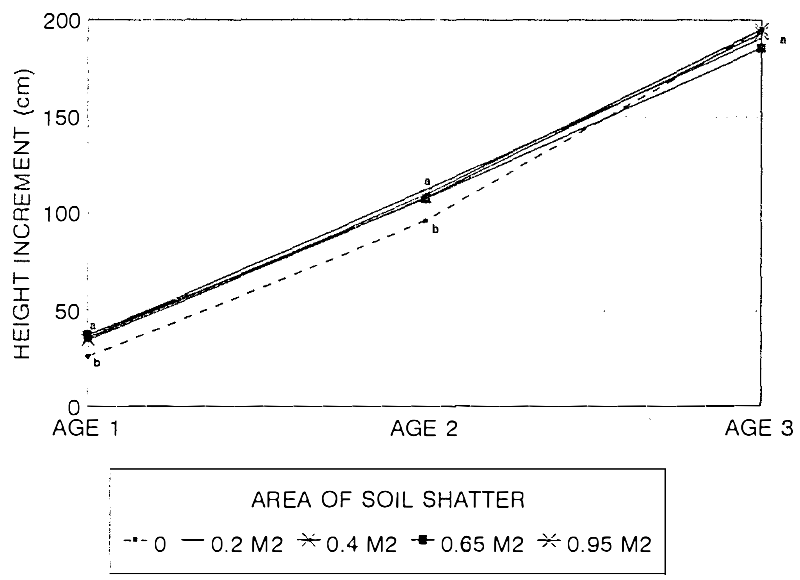
In 1988 a trail was established on a severely eroded duplex soil in the Blackwood Valley. Soils are red sandy loam over loamy clay at 0 to 25 centimetres. The site had grown potatoes continually for 9 years before it was purchased for conversion to *P. radiata* plantation. Over much of the trial site the 'A' horizon was totally eroded.

Five treatments were replicated in 5 blocks. The blocks were arranged to account for the degree of erosion. Treatments were:

		Cross-sectional area of shatter	depth
1.	Standard ripper on an agricultural tractor	0.2 m^2	43 cm
2.	Standard ripper on a D7 bulldozer	0. 4 m^2	53 cm
3.	Small winged ripper on a D7 bulldozer	0. 65m^2	62 cm
4.	Large winged ripper on a D8 bulldozer	0. 95m^2	60 cm
5.	Control (no ripping)	-	-

For 2 years. height increment of ripped treatments was significantly ($p<0.05$) greater than the control (fig. 1). Thereafter. there has been no difference. An assessment at age 2 years showed that between 8 and 10% of trees in ripped treatments were leaning. No abnormal wind events had occurred. There were no leaning trees in the control plots.

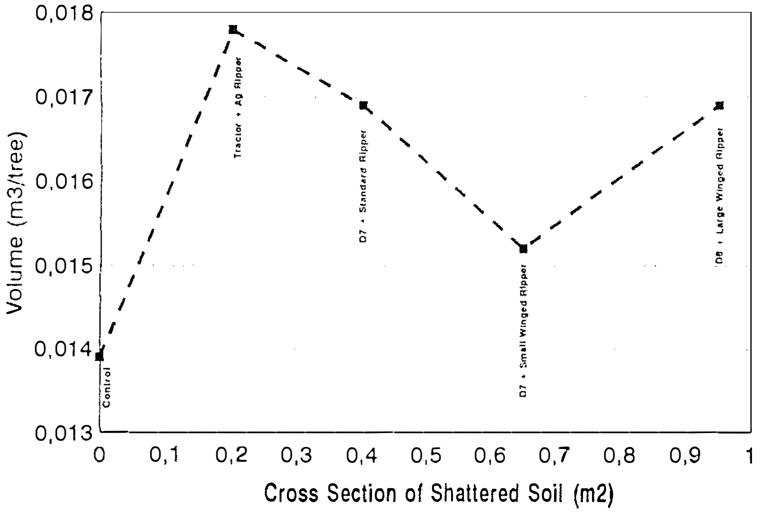
Figure 1. HEIGHT INCREMENT OF P. RADIATA FOLLOWING RIPPING TREATMENTS



The mean tree volume of all except treatment 3 (small winged ripper) were significantly greater than the control at age 4.3 years (fig. 2). Some interaction between treatments and blocks was evident. However, the factors involved have, as yet, not been studied .

Figure 2. EFFECT OF AREA OF SOIL SHATTER ON THE GROWTH OF P. RADIATA

Growth data at age 4.3 years



A series of soil preparation trials were established in 1992 across a range of sites. Three mound sizes, rip and no rip, with and without ploughing are being compared in a factorial arrangement on three different sites. Riplines were established using a "winged" ripper. The depth was 70 cm. An initial assessment showed that survival of trees on a ripped, seasonally wet site was significantly lower than better drained sites (fig. 3). There was a lower growth rate on the wettest site also. Trees grew faster when planted in the riplines on the two other sites. At the wet and moderately wet sites the rate of growth of trees on small mounds over a ripping treatment was less than for non ripped plots. The opposite was true for trees on large mounds (fig. 3). It appears that all soils, other than sands, are best mounded and ripped to $\pm$ 40 cm to avoid problems associated with localised waterlogging. Large-profile mounds appear to be preferable to small mounds. In another trial established in 1990, a positive response to ripping was recorded on a seasonally wet site, in the absence of mounding. The difference between this and other trials was that the soil was light textured, and gradational with ripping running across the contour. It is hypothesised that water logging in the rip line did not occur.

2. Mounding.

A trial in the Donnybrook Sunklands established in 1990 is designed to compare mound size, with and without ripping on three different sites. The first (site 1) is on a ridge-top, is flat and waterlogged for long periods in winter. Soils are loamy sand grading to clayey sand to 1 metre over sandy loam clay. The second site (site 2) is low in the landscape, on a 2^{o} slope and is waterlogged from July to September. This surface soil on this site is a sand becoming slightly heavier at depth (gradational). An organic pan occurs between 60 and 150 centimetres. The last site (site 3) is on a ridge-top also, but is distinguished from site 1 by having some relief. This site, although subject to short periods of waterlogging, is comparatively free draining.

Tree growth on mounds formed by a Savannah HD636 mound plough and a small "Napier" type mound plough are being compared with the growth of trees not planted on mounds. The Savannah plough forms a mound 2.8 metres wide and approximately 0.6 metres high. The "Napier" forms a mound 1.1 metres wide and 0.3 metres high. After 1.2 years the survival of *P. radiata* in non mounded plots was significantly ($p < 0.01$) lower than mounded treatments. Survival of *P. taeda* was not effected by treatment (fig. 4).

Figure 3. EARLY RESPONSE TO RIPPING BY P. RADIATA

TREES AGED 0.8 YEARS

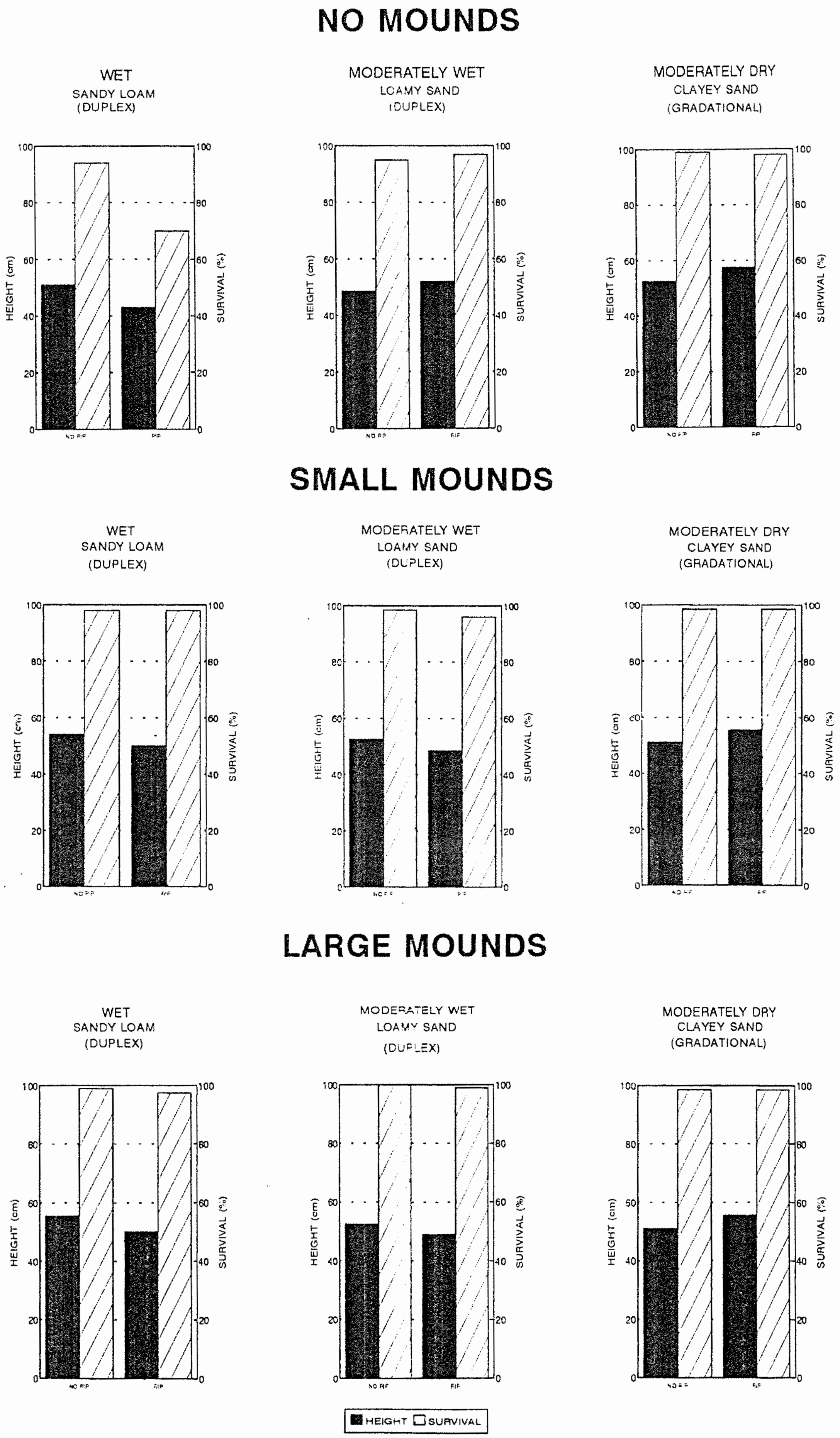
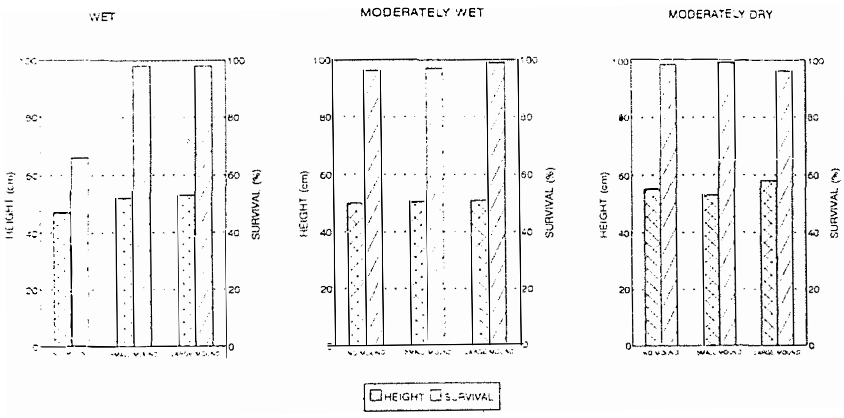


Figure 4. SURVIVAL AND EARLY GROWTH OF P. RADIATA ON DIFFERENT SIZE MOUNDS

TREES AGED 0.6 YEARS



Across all sites growth of *P. radiata* was best on large mounds and worst in control plots. This was true of *P. taeda,* except on the moderately dry site where the reverse was true. *P. radiata* performed best on the moderately wet site while *P. taeda* preferred the wet site (fig.. 5). The uniformity of the crop improved when trees were planted on mounds, particularly large mounds (fig. 6).

Figure 5. GROWTH OF P.RADIATA AND P.TAEDA ON DIFFERENT SIZE MOUNDS

TREES AGED 1.2 YEARS

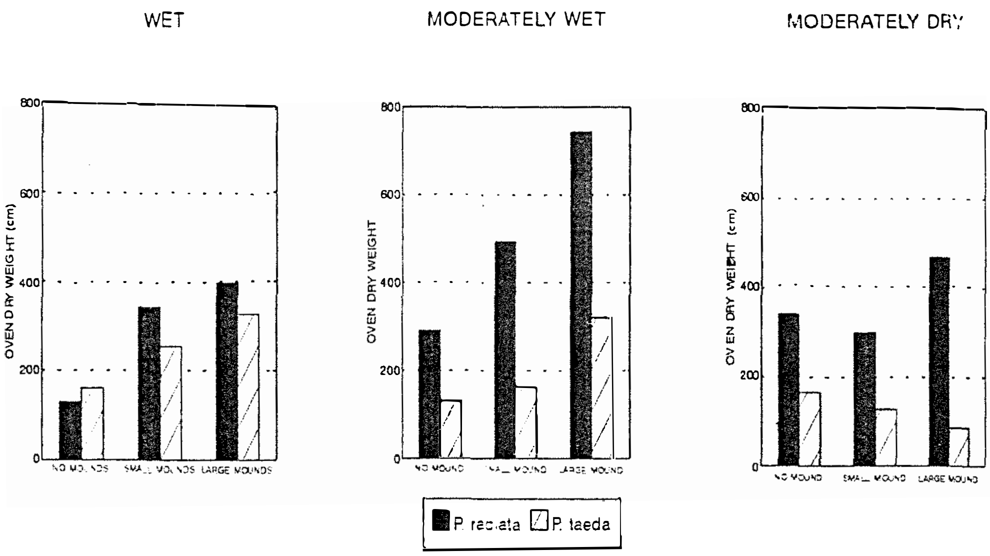
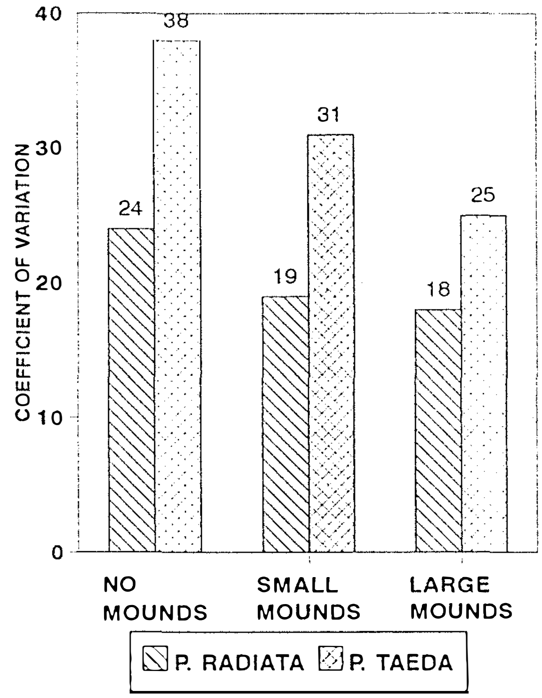


Figure 6.

VARIATION OF TREE HEIGHT ASSOCIATED WITH DIFFERENT SIZE MOUNDS

TREES AGED 1.2 YEARS

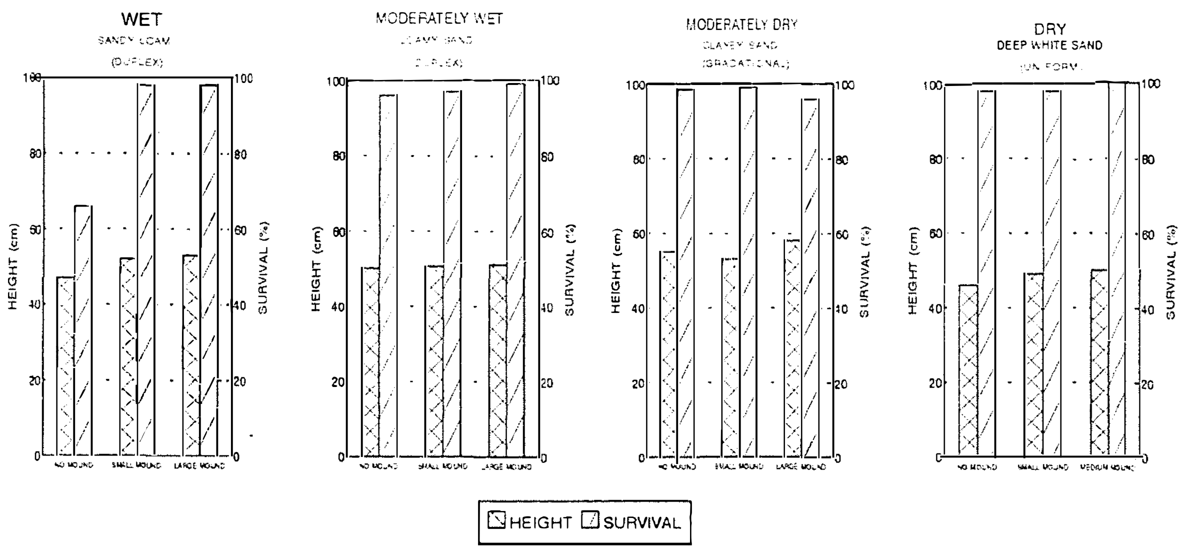


In the 1992 trials early survival and growth figures show that responses to mounding can be expected on all soil types, even deep uniform sands (fig. 7). Mounding improved survival on wet sites only. The trend suggests a positive correlation between mound size and growth.

Figure 7

SURVIVAL AND EARLY GROWTH OF P. RADIATA ON DIFFERENT SIZE MOUNDS

TREES AGED 0.8 YEARS



DISCUSSION.

The indications that ripping on heavy textured soils may, in some circumstances, be detrimental to survival, early growth and stability is important when planning soil preparation activities. At this stage of knowledge, it appears that it is prudent to mound all soils of a loamy texture or heavier that have been ripped to ensure that trees do not suffer from waterlogging or become unstable. Mounds that will lift trees substantially above the waterlogged zone should be considered.

Shallow ripping (< 500mm) on sandy, well drained soils is consistently beneficial to growth and survival. The factors contributing to this response appear to include fracturing the agricultural pan ("traffic pan"), breaking the non wetting layer common to sandy soils in Western Australia, and the fact that ripping facilitates easier planting, particularly by hand.

The absence of data supporting deep ripping (>500mm) is surprising given the practice is widespread. It may be that on drought-prone sites the benefit of deep ripping may be manifested later in the rotation. However, the current practice in Western Australia is to exclude sites that are considered drought-prone, and unless ripping substantially improves productivity on what are, at best, marginal sites, it is unlikely that the investment will return a dividend.

Results to date suggest that mounding is beneficial to survival, early growth and crop uniformity across all the sites currently accepted for the establishment of *P. radiata* plantations in Western Australia. Recent studies show that the timing of installation of mounds, relative to spraying is important to ensure effective control of weeds throughout the first season. Early instalment appears to be the key factor to allow sufficient time for the mounds to settle. Fitting compacting rollers to mound ploughs aids this process. The design of compacting rollers has been the subject of some study and debate. Results suggest that the best profile for a mound is a flat "M" shape.