6 DEVELOPMENT OF A PREDICTIVE MODEL

6.1 Tree Characteristics

Analysis of the data for factors which could be used in a predictive model of the amenity value of scattered and isolated trees commenced with an examination of the correlation coefficients between the characteristics of the trees that have been identified. There were 43 characteristics (Table 34).

Table 34 Summary of Characteristics

	Characteristics Grades			
	1	2	3	4
Tree Characteristics				
Tree height	Low	Medium	High	Very high
Trunk height	Low	Medium	High	*
Trunk diameter	Narrow	Medium	Thick	Very thick
Trunk verticality	Vertical	Slight lean	Moderate lean	*
Canopy form	Narrow	Medium	Wide & high	Very wide & V. high
Canopy density	Very open	Open	Dense	Very dense
Tree health	Dead	Poor	Fair	Good
Tree spacing	Isolated	Open scattered	Canopy overlap	*
Number of trees	1	2 – 5	6 – 12	>12
Species	Red gum	Blue gum	Pink gum	Other gum
Context Characteristics				
Terrain	Flat	Sloping	Hilly	*
Land use	Pasture	Natural	Cereals	Vines

* Grade included but no scenes classified

6.2 Correlations

It is to be expected that there would be close correlation between many of these characteristics – for example between tree height and trunk diameter, tree spacing and tree number. A high correlation may suggest overlapping in the nature of the two characteristics, implying one may be redundant in analysis. A correlation matrix between the characteristics is shown by Table 35.

Table 35 Correlations between Characteristics

	height	trunkht	diameter	vertical	form	density	health	species	spacing	number	terrain	landuse
height												
trunkht	0.19											
diameter	0.41	-0.10										
vertical	-0.12	0.01	0.03									
form	0.08	-0.29	0.54	0.02								
density	-0.07	-0.10	0.01	-0.07	0.24							
health	-0.06	-0.15	-0.19	-0.10	0.14	0.58						
species	-0.43	-0.15	-0.31	0.16	0.03	0.09	0.05					
spacing	-0.15	-0.01	-0.46	-0.04	-0.34	0.21	0.29	-0.01				
number	-0.18	0.15	-0.44	0.00	-0.37	0.13	0.14	0.14	0.77			
terrain	-0.20	-0.10	-0.25	-0.12	0.07	0.15	0.22	0.05	0.07	0.13		
landuse	-0.08	0.04	0.03	-0.05	-0.03	0.09	-0.02	-0.06	-0.12	-0.13	0.05	

The correlations are relatively low (i.e. generally below 0.40) because the three or four categories used for each characteristic provide only a coarse discrimination. Categories with, say, ten grades would provide much higher correlations but be more difficult to apply in the field.

The correlation table indicates the following strong correlations (in descending order):

0.77	Tree spacing and tree number	0.41	Tree height and trunk diameter
0.58	Canopy density and tree health	-0.37	Canopy form and tree number
0.54	Canopy form and trunk diameter	-0.34	Canopy form and tree spacing
-0.46	Trunk diameter and tree spacing	-0.31	Trunk diameter and species
-0.44	Trunk diameter and tree number	-0.29	Canopy form and trunk height
-0.43	Tree height and species		

The negative correlations reflect the arrangement of the grades of each characteristic. Dense tree spacing correlates positively with a large number of trees (both grade 4). In an example of a negative correlation, thick trunk diameter comprises grades 3 and 4 whereas tree spacing becomes denser for these grades, so while there is a high correlation (-0.46) it is negative reflecting a relationship between thick trunks and isolated or open scattered tree cover (i.e. grades 1 and 2).

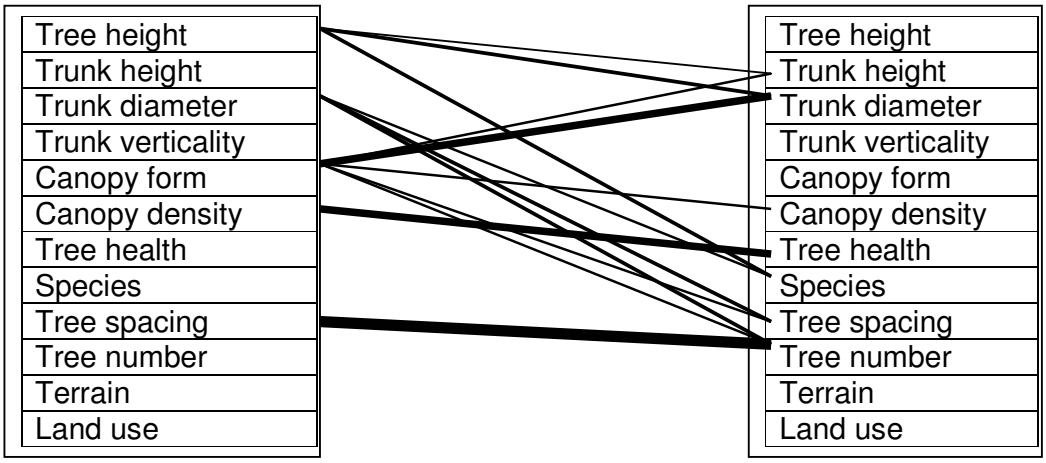


Figure 53 High correlations between tree characteristics

Figure 53 illustrates the stronger correlations between the tree characteristics. This indicates:

- Canopy form correlates with five: Trunk height, trunk diameter, canopy density, tree spacing and tree number
- Tree height correlates with three characteristics: Trunk height, trunk diameter and species
- Trunk diameter correlates with three: Species, tree spacing and tree number
- Tree number correlates with three: tree diameter, canopy form and tree spacing
- Trunk height, trunk diameter, species and tree spacing each correlate with two characteristics

These suggest the following key overlaps between characteristics:

- Canopy form may provide a surrogate of trunk height, trunk diameter, canopy density, isolated & open scattered tree spacing and few tree numbers
- Tree height may provide a surrogate of trunk height, trunk diameter and red gums
- Trunk diameter may provide a surrogate of red gums, isolated & open scattered tree spacing and tree numbers

6.3 Multiple Regression Model

Multiple regression was used to identify the characteristics and a formula by which the scenic amenity of the isolated and scattered trees can by quantified. Four methods of multiple regression are available: enter, backward, stepwise, forward, and remove, each of which sequentially add or remove characteristics from the model. The amount by which each characteristic changes the multiple R^2 (i.e. correlation coefficient) decides whether or not to continue. Stepwise is the most commonly used method. All models are based on an entry probability for F of 0.05 and a removal probability of 0.10. Table 36 summarises the models derived based on inclusion of all of the tree characteristic but excluding the context characteristics (i.e. terrain, land use).

Table 36 Multiple Regression Models

Method	Characteristics	R2	Equation for scenic rating (Y)	Significance
Enter (all variables)	Height, trunk height, diameter, verticality, canopy form, canopy density, health, species, spacing, number (10)	0.533	Y = 3.22 + 0.31 height – 0.11 theight – 0.12 tdiameter + 0.31 verticality + 0.11 cform – 0.17 cdensity + 0.33 health – 0.26 species + 0.05 spacing + 0.34 number	F = 11.53, df 10, 101, p = 0.000
Backward	Height, trunk height, verticality, canopy density, health, species, number (7)	0.517	Y = 3.16 + 0.27 height – 0.11 theight + 0.30 verticality – 0.17 cdensity + 0.38 health – 0.23 species + 0.37 number	F = 15.93, df 7, 104, p = 0.000
Forward	Height, verticality, canopy density, health, species, spacing, number (7)	0.506	Y = 2.92 + 0.25 height + 0.30 verticality – 0.17 cdensity + 0.38 health – 0.20 species + 0.11 spacing + 0.29 number	F = 15.19, df 7, 104, p = 0.000
Stepwise	Height, verticality, canopy density, health, species, number (6)	0.502	Y = 2.98 + 0.24 height + 0.30 verticality – 0.17 cdensity + 0.40 health – 0.21 species + 0.35 number	F = 17.65, df 6, 105, p = 0.000

Note: theight = trunk height, tdiameter = trunk diameter, cform = canopy form, cdensity = canopy density

The highest R^2 derived from the enter method, 0.533, however this would require the measurement of all ten characteristics which would necessitate considerable field work. Both the *backward* and forward methods required seven characteristics to be measured. By contrast, the *stepwise* method used six characteristics and yielded an R^2 of 0.502, a difference of only 0.03 or 6% compared with the *enter* method and even lower for the other two methods. Because it will involve less measurement in the field than the other formulae, the stepwise regression equation is therefore the preferred formula to use in calculating the scenic amenity of isolated and scattered trees. It needs to be recognised however, that it will not yield quite as accurate an estimate of scenic amenity as the formulae derived from the other methods.

The equation for quantifying the scenic amenity of isolated and scattered trees therefore is:

Y = 2.98 + 0.24 height + 0.30 verticality – 0.17 canopy density + 0.40 health – 0.21 species + 0.35 number

where:

Code	1	2	3	4
Height	Low	Medium	High	Very high
Verticality	Vertical	Slight lean	Moderate lean	
Canopy density	Very open	Open	Dense	Very dense
Health	Dead	Poor	Fair	Good
Species	Red gum	Blue gum	Pink gum	Other gum
Number of trees	1	2 – 5	6 – 12	>12

It needs to be noted that the species grading represents different types of trees and there is therefore no sequence across the grades. This is the nature of a categorical number. Nevertheless for the purpose of the model it is useful to include the type of species.

6.4 Testing the Model

The formula is applied to several hypothetical examples and then to actual scenes of known scenic rating.

A scene of healthy group of five vertical tall red gums of open foliage would be expected to score:

Y = 2.98 + 0.24 (3) + 0.30 (1) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(2)
= 2.98 + 0.72 + 0.30 – 0.34 + 1.60 – 0.21 + 0.70
= 5.75

A scene of two medium height red gums of fair health with very open foliage and with a slight lean would be expected to score:

Y = 2.98 + 0.24 (2) + 0.30 (2) – 0.17(1) + 0.40(3) – 0.21(1) + 0.35(2)
= 2.98 + 0.48 + 0.60 – 0.17 + 1.20 – 0.21 + 0.70
= 5.58

A scene of a large group (>12) of other gums, vertical, low height, dense foliage and in good condition would be expected to score:

Y = 2.98 + 0.24 (1) + 0.30 (1) – 0.17(3) + 0.40(4) – 0.21(4) + 0.35(4)
= 2.98 + 0.24 + 0.30 – 0.51 + 1.60 – 0.84 + 1.40
= 5.17

The following tests actual scenes showing rating obtained from the survey and by formula.

Scene 36 Rating 5.80

Y = 2.98 + 0.24(3) + 0.30(2) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(1)
= 2.98 + 0.72 + 0.60 – 0.34 + 1.60 – 0.21 + 0.35
= 5.70

Scene 53 Rating 4.17

Y = 2.98 + 0.24(2) + 0.30(1) – 0.17(2) + 0.40(2) – 0.21(1) + 0.35(1)

= 2.98 + 0.48 + 0.30 – 0.34 + 0.80 – 0.21 + 0.35
= 4.36

Scene 55 Rating 6.77
Y = 2.98 + 0.24(3) + 0.30(1) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(4)
= 2.98 + 0.72 + 0.30 – 0.34 + 1.60 – 0.21 + 1.40
= 6.45

Scene 89 Rating 6.52
Y = 2.98 + 0.24(3) + 0.30(2) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(2)
= 2.98 + 0.72 + 0.60 – 0.34 + 1.60 – 0.21 + 0.70
= 6.05

Scene 111 Rating 5.40
Y = 2.98 + 0.24(3) + 0.30(2) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(1)
= 2.98 + 0.72 + 0.60 – 0.34 + 1.60 – 0.21 + 0.35
= 5.70

Scene 114 Rating 5.43
Y = 2.98 + 0.24(3) + 0.30(1) – 0.17(2) + 0.40(4) – 0.21(1) + 0.35(1)
= 2.98 + 0.72 + 0.30 – 0.34 + 1.60 – 0.21 + 0.35
= 5.40

Table 37 Summary of test ratings

Rating	Equation	Difference (R – E)	% difference
5.80	5.70	- 0.10	-1.7
4.17	4.36	+ 0.19	+4.5
6.77	6.45	- 0.32	-4.7
6.52	6.05	- 0.47	-7.2
5.40	5.70	+ 0.30	+5.5
5.43	5.40	- 0.03	-0.5

Table 37 summarises these ratings and the differences. These average a difference of 4.01% which is considered acceptable.

Having tested the predictive model against a sample of scenes, it was then tested against all 112 scenes. Figure 54 compares the results from the model with the original ratings. Appendix 2 provides the data set.

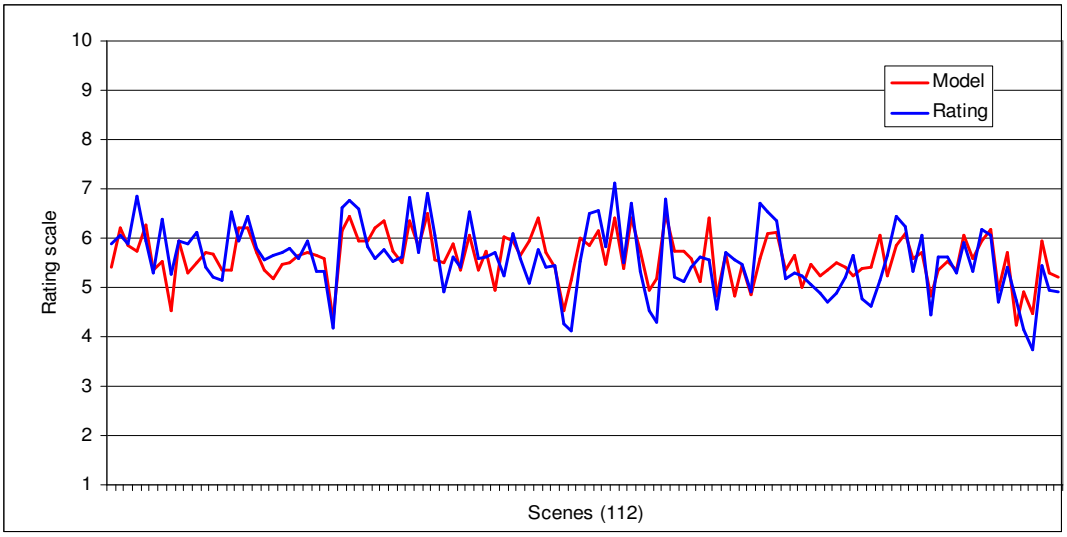


Figure 54 Comparison of model results and original ratings

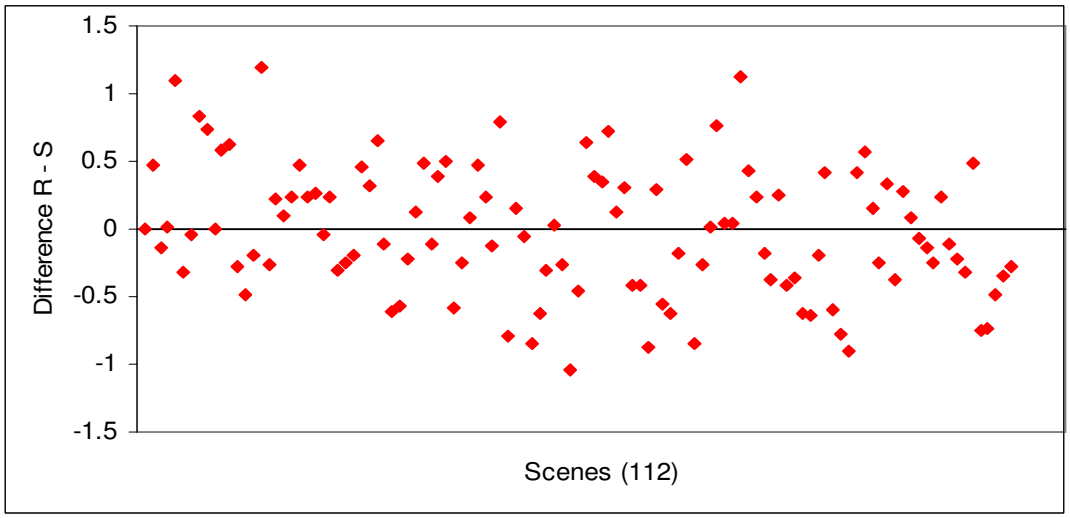


Figure 55 Difference between rating and model results

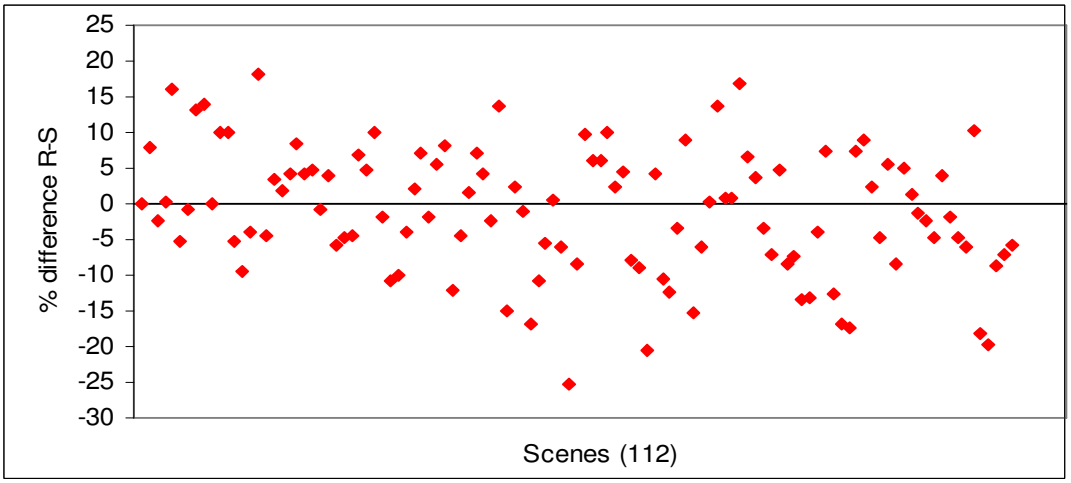


Figure 56 Percentage difference between rating and model results

Figure 55 indicates the difference between the ratings and the model and Figure 56 shows this difference in percentage terms compared with the original rating. Overall the model results averaged 0.017 or 1.06% below the ratings. Having more negative than positive scenes indicates that the model will yield slightly conservative results which are slightly lower than if ratings were used. Figure 57 provides a histogram of the results and Figure 58 provides a QQ plot which indicates the distribution is normal.

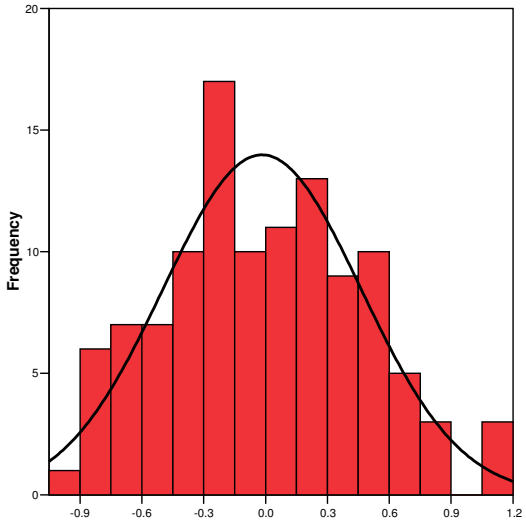


Figure 57 Histogram of differences

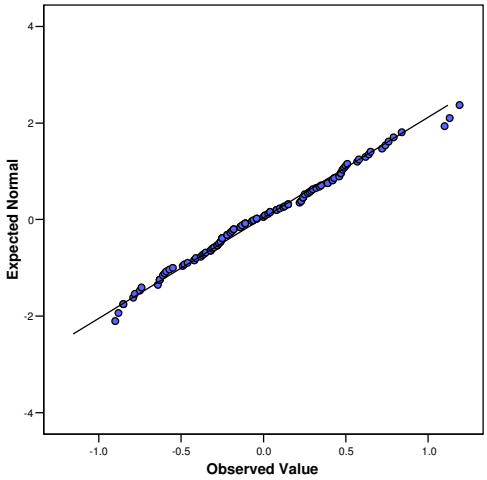
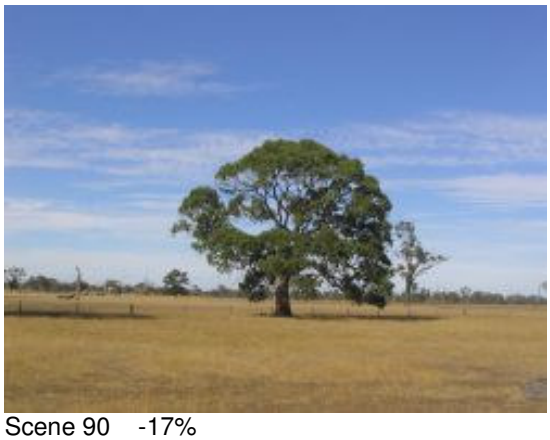


Figure 58 QQ plot of normality of differences

These results indicate that overall the model provides an excellent basis for estimating the amenity value of isolated and scattered trees.

The outliers were examined to assess whether these comprise a particular type of scene and whether the model should exclude these. Scenes that were +/- 10% of the ratings were examined.



Scene 90 -17%

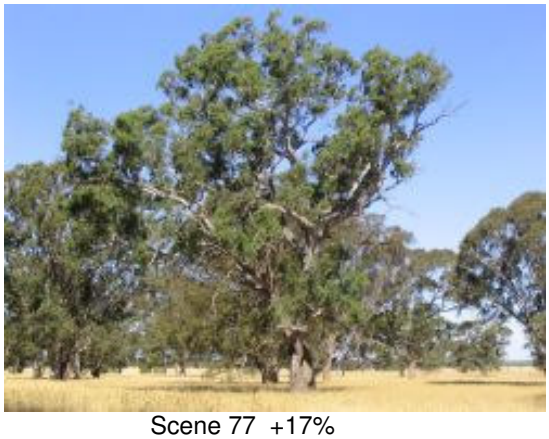
Scene 12 -13%

Figure 59 Examples of negative outlier scenes

Scenes which were negative outliers (e.g. -15%) were consistently those showing bare overgrazed ground surface, one of a few isolated trees without any lower stratum and generally a degraded farm environment (Figure 59).

Conversely, the positive outlier scenes often contained dense vegetation in the background, a range of higher and lower vegetation strata, trees of varying sizes and ages, and the presence of ground cover of pasture or other vegetation (Figure 60).

Scene 4 +16%
Note dense background vegetation



Scene 77 +17%

Figure 60 Examples of positive outlier scenes

These findings complement the comments provided by participants that were examined earlier in this report and indicate the need for rating guidelines to specifically exclude consideration of the state of degradation or ecological integrity of the scene being rated.

7. DEVELOPMENT OF WORKBOOK FOR EVALUATING SCENIC AMENITY OF ISOLATED AND SCATTERED TREES

The regression model that has been developed provides the basis for calculating the approximate scenic value of isolated and scattered trees in the field.

The model is as follows:

Y = 2.98 + 0.24 height + 0.30 verticality – 0.17 canopy density + 0.40 health – 0.21 species + 0.35 number

where:

Code	**1**	**2**	**3**	**4**
Height	Low	Medium	High	Very high
Verticality	Vertical	Slight lean	Moderate lean	
Canopy density	Very open	Open	Dense	Very dense
Health	Dead	Poor	Fair	Good
Species	*E. camuldulensis*	*E. leucoxylon*	*E. fasciculosa*	Other eucalypts
Number of trees	1	2 – 5	6 – 12	>12

To operationalise the model for field use, the procedure needs to be simple, quick and easy to apply and require minimal or no prior training.

7.1 IDENTIFICATION OF SCENE TO BE ASSESSED

Identify the tree or trees within the viewshed to be assessed. The scene should contain isolated or scattered trees. They can be in clumps or groups but should not be dense – canopies should be very open or open, or dense but with plenty of light showing through. Canopies can overlap but should not be so dense that no light shows through. The land can be flat, sloping or hilly but should not be steep.

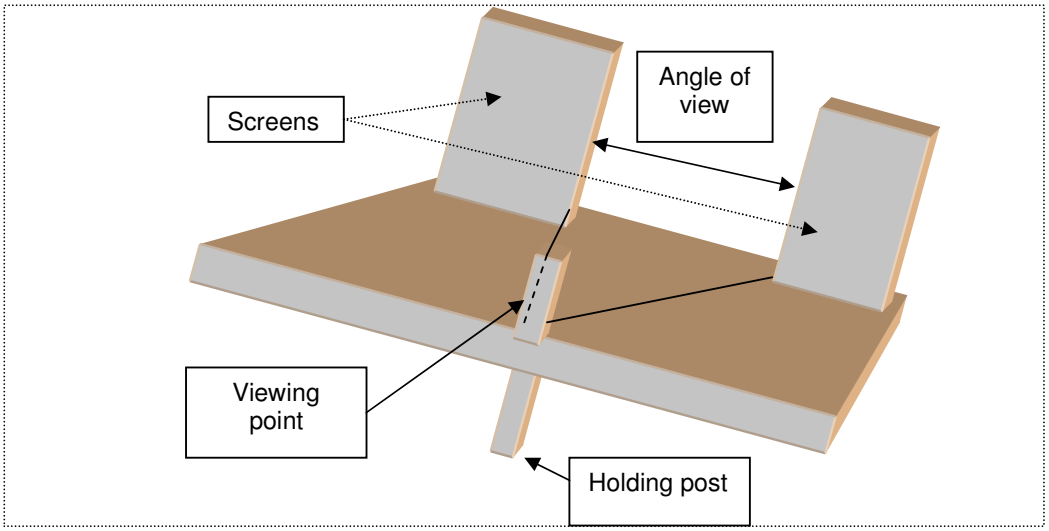


Figure 61 Hand held viewing scope

The angle of view of the scene should be approximately 34º which is the angle of view of a 70 mm lens. While a wider angle can be used, this will include considerably more

trees and a greater variety of forms which can make it too complex. The narrower view simplifies assessment of the scene. A small hand held viewing device can be used to define the viewshed for rating purposes (Figure 61). Alternatively 34º is nearly exactly one third of a right angle (33º) and can be readily defined by segmenting a right angle into thirds.

7.2 ASSESSMENT OF THE SCENE

Assess the trees in the foreground and middleground, ignore trees that might comprise the background and trees that are peripheral to the viewshed.

Concentrate on the trees, ignore the state of degradation (if present) of the ground surface (e.g. bare, overgrazed) and ignore also any lack of ground vegetation strata. Do not consider the ecological integrity of the scene as this is not being assessed.

Height	Low	Below 10 metres
	Medium	10 - 20 m
	High	20 - 30 m
	Very high	Above 30 m

Low 112

High 94

Medium 47

Very high 84

Verticality	This refers to the overall appearance of verticality in the tree, dominated by its main trunk.	
	Vertical	essentially vertical, 80 - 90º from horizontal
	Slight lean	70 - 80º
	Moderate lean	60 - 70º


Slight lean 12


Moderate lean 9

Canopy density This is a measure of the density of the foliage cover assessed on the basis of the amount of light showing through the canopy. Where the foliage is dense, masses of leaves are present which block out most of the light. It is assessed from the side elevation, not from underneath.

Very open	Extensive light showing through
Open	Much light showing through
Dense	Masses of leaves with some light showing through gaps
Very dense	Virtually no light showing through the canopy


Very open 74


Dense 31


Open 29


Very dense 101

Health Assess the entire tree including its trunk, branches and foliage.

Dead	The tree is dead
Poor	Many dead branches, thin foliage cover
Fair	Some dead limbs (often the extremities), infected foliage (eg lerps, Mundallo Yellows), thin foliage cover
Good	Healthy tree without dead limbs or infected foliage


Dead 61


Fair 80


Poor 59


Good 88

Species The main species to be assessed will be the River Red Gum (*E.camaldulensis*). Other species which may occur in isolated or scattered formation include the South Australian Blue Gum (*E. leucoxylon*) and the Pink Gum (*E. fasciculosa*).

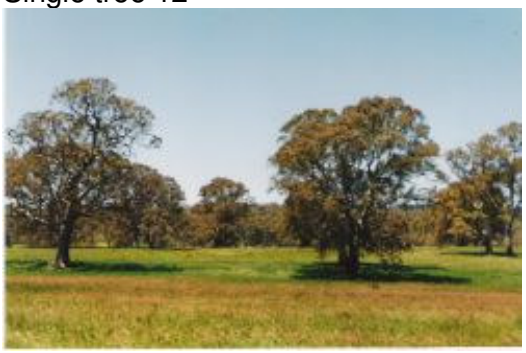

Blue Gum *E. leucoxylon* 48


Pink Gum *E. fasciculosa* 73

Number of trees Count the number of trees in the scene and code:
1. 2 – 5, 6 – 12, >12

Single tree 12

6 – 12 trees 33



2 – 5 trees (ignore background trees) 4

- 12 trees 66

7.3 CODING THE ASSESSMENT

As the scene is being assessed, the results would be coded on an appropriate form.. The following is suggested.

Date

Location

Latitude **Longitude**

Coding of characteristics

	1	2	3	4
Height	low	medium	high	v. high
Verticality	vertical 80-90	slight lean 70-80	mod lean 60-70	strong lean 50-60
Canopy density	Very open	Open	Dense	Very dense
Tree health	v poor (dead)	poor	fair	good
Species	*E. camuldulensis*	*E. leucoxylon*	*E. fasciculosa*	Other
Tree number	single	2 – 5	6 – 12	> 12

Coding of scene

	1	2	3	4
Height				
Verticality				
Canopy density				
Tree health				
Species				
Tree number				

7.4 CALCULATION OF THE RATING

Following completion of the scene codings, their ratings would be calculated. An Excel spreadsheet can be created with the following columns.

Scene No.	Height	Verticality	Density	Health	Species	Number	Rating
1	C2	D2	E2	F2	G2	H2	
2	C3	D3	E3	F3	G3	H3	
3	C4	D4	E4	F4	G4	H4	
..							
..							

The assessed numbers for each characteristic would be entered across the spreadsheet. The following formula would be entered under the rating column:

Rating = 2.98 + (0.24*$C2)+(0.3*$D2)-(0.17*$E2)+(0.4*$F2)-(0.21*$G2)+(0.35*$H2)

Where: C2 = height
D2 = verticality
E2 = density
F2 = health
G2 = species
H2 = tree number

8. CONCLUSIONS

This report is considered to fulfill the requirement of the Native Vegetation Council to research the amenity value of scattered and isolated trees.

The report describes the photography of trees, the selection of scenes and development of the Internet survey, the conduct of the survey and the analysis of the results leading to the development of a predictive model and a workbook for conducting rating.

The workbook should enable the rapid but accurate assessment of scenes leading to determining the scenic rating of the scattered and isolated trees.

The consultant appreciated the opportunity given by the Native Vegetation Council to carry out this research.

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