Research paper

Forest Scenic Esthetic Assessment – A Case Study of *Taiwania cryptomerioides* Plantations in the Liouguei Experimental Forest

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【Summary】

This study adopted integration of Scenic Beauty Estimation (SBE) and a cognition model as the research method to understand a sustainable approach to scenic esthetics of Taiwania plantations. The study site was located in Taiwania plantation forests in the Fang-Kang area of the Liouguei Experimental Forest. The respondents were investigated to reveal their scenic preferences, biophysical attributes, and perceptions of cognitive factors including formal esthetic attributes using projected photo images. RMRATE software was used to transfer scores of scenic preferences into SBE values. Then, all data were analyzed by a variance analysis and regression technique. The results indicated that no significant difference was shown in SBEs between students and non- students. It was shown that the "unity" and "graduation" of formal esthetic attributes of the investigated cognitive factors had positive effects on scenic preferences. In the analysis of the effect of biophysical attributes on scenic preferences, respondents preferred forest near-view scenes with greater percentage of herbaceous ground cover, less downed wood/debris on the ground, and a higher height to crown base of trees. Furthermore, it was observed that a greater percentage of herbaceous ground cover and less downed wood/debris resulted in higher ratings in the formal esthetic attributes of "unity" and "graduation" which positively influenced scenic preferences. Apparently, dealing with relationships of formal attributes ("unity" and "graduation") and biophysical attributes (percentage of herbaceous ground cover and downed wood/debris) should be seriously considered in designing scenic esthetics of Taiwania plantations.

Key words: landscape assessment, SBE, Environmental esthetics.

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研究報告

森林景觀美學之研究—以六龜鳳崗林區台灣杉人工林為例

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摘 要

本研究透過心理物理學派Scenic Beauty Estimation (SBE)模式及認知模式兩種研究方法的結合為基礎，主旨在瞭解朝向永續發展經營之台灣杉人工林類型，民眾景觀偏好、認知因子(含形式美學)知覺、生物物理因子及其間關係。研究地點為林業試驗所六龜鳳崗山林區台灣杉人工林。受測者景觀評估程序為受測者針對每張照片影像，先評量每張照片影像的森林景觀品質，其次再就認知因子感受程度進行評估。在資料分析部分，森林景觀偏好數值先經RMRATE軟體轉化為SBE值，接著所有調查數值經由差異性分析來瞭解受測者基本資料對森林景觀偏好及因子之差異，並透過多元迴歸模式來分析森林景觀偏好、認知因子與調查樣區生物物理因子間的關係。研究結果顯示：學生和社會人士在森林景觀偏好無顯著差異。認知因子中形式美學屬性之「統一性」及「層次性」對森林景觀偏好具正面影響。在樣區生物物理因子對景觀偏好影響分析上顯示，高地被覆蓋度、低地下枯枝木率及高枝下高會顯著正向影響認知因子之評值，包括能正面影響景觀偏好的「統一性」及「層次性」兩個形式美學屬性。明顯的，處理「統一性」及「層次性」兩個形式美學屬性及高地被覆蓋度及低地下枯枝木的關係應用，應是台灣杉林下景觀美學設計所需思考的要項。

關鍵詞：景觀評估、景觀美質、森林美學、形式美學。

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INTRODUCTION

These days, due to a conservation commitment to sustainable forestry, much of the work in forestry management emphasizes ecological values. However, being a scenic resource, forests also provide affective and esthetic values to humans (Ribe 1994, Tahvanainen et al. 2001, Lin 2002). Therefore, determining how to emphasize the visual esthetics of a forest with an ecologically sustainable approach will be valuable in this bio-centric era.

Formal esthetics (based on formal design principles) are defined as an esthetic experience induced by the form or structure of an objective (Lang 1987, Åsa 2003). Formal esthetic attributes such as coherence, order, complexity, unity, openness, graduation, proportion, and contrast were investigated in previous studies (Wohlwill 1976, Carlson 1979, Nasar 1987, 1988, 1994, Chen and Lin 1997, Stamps 2000, Chiang and Chen 2007). Thorne and Huang (1991) demonstrated that the design feature is the form quality which can provide an attractive natural environment. Landscape architects also often use formal design concepts to visually manage forest landscapes (Gobster 1999). Apparently, formal esthetic attributes should be investigated

in studies of forest scenic esthetics.

Among the various assessment approaches in scenic esthetics, both psychophysical and cognitive models based on the perspectives of non-experts are widely used in studies of scenic assessments (Penning-Rowsell 1981, Garlindo and Rodriguez 2000). Both perception-based models have generally achieved high levels of reliability in contrast to the expert approach (Daniel 2001).

The Scenic Beauty Estimation (SBE) developed by Daniel and Boster (1976) is the most common psychophysical assessment model utilized to evaluate scenic preferences. It is utilized to study relationships between biophysical attributes of the environment and scenic preferences without considering the possible intermediary process that may affect preference judgements (Santayana 1896, Zube et al. 1982, Daniel and Vining 1983, Russ and Terry 2002). In particular, the SBE model is usually applied to scenic beauty assessments of near-view sightseeing of the forest understory (Zube et al. 1982, Brown and Daniel 1986).

The cognitive method is mainly based on a model proposed by Kaplan and Kaplan (1989). The cognitive model knows that the cognitive process should exist between environmental stimuli and responses of scenic preferences or evaluations (Brown and Daniel 1984). Some cognitive factors such as coherence, spaciousness, complexity, mystery, naturalness, neatness, value for conservation, and style were investigated in previous studies (Kaplan and Kaplan 1989, Herzog 1992, Nasar 1994, Sevenant and Antrop 2009). It was indicated that scenic preferences can be affected by cognitive factors which include formal esthetics (Nasar 1994, Sevenant and Antrop 2009). Apparently, perceptions of formal aesthetics can be sorted using a cognitive model (in all following sections, the term cognitive factors include formal esthetic attributes).

In some previous studies, preference values were found to be correlated with physical, formal design principles, and psychological landscape attributes to state theoretical and empirical issues in landscape esthetics (Gobster and Chenoweth 1989). Purcell (1992) also stated that a scenery/landscape is based on abstract (e.g., cognitive factors mentioned above) rather than concrete physical attributes. Thus, the cognitive meanings (including formal esthetics) should be considered in comprising various bio-physical attributes if a good scene can be observed through the beholders' eyes. Therefore, integration of the SBE and cognition models was used in this study.

It was shown that sightseeing is an important visiting purpose for the public to participate in forest recreational areas of Taiwan (Lo et al. 1990). However, few studies assessing forest scenic esthetics are available in Taiwan (Lo et al. 1990, Huang 1996); in particular, no studies of scenic assessment have focused on a sustainable approach to forestry management. Taiwania (*Taiwania cryptomerioides*) is the major plantation species in the Liouguei Experimental Forest. An inventory showed that, by the end of 1991, approximately 51.6% of the plantation area was covered by Taiwania (Wang et al. 2007). The purposes of this study were to assess scenic preferences of a sustainable approach to Taiwania plantations, and also to investigate relationships among scenic preferences, perceptions of cognitive factors, and biophysical attributes. The results of this study are expected to provide useful information to managers in planning Taiwania plantations using a sustainable approach with attractive scenes.

MATERIALS AND METHODS

Site description

The sites of this study were located in the Fang-Kang area of the Liouguei Experimental Forest, Taiwan Forestry Research Institute, Koahsiung County, southwestern Taiwan. Taiwania plantations with alternative treatments were the main criteria for selecting sampling sites. After completing a preliminary on-site survey and discussing with forestry experts, 10 sampling sites within Taiwania plantations were selected from the sites of the preliminary on-site survey. The investigated sites were mainly distributed on Fang-Kang forest roadsides including site 1 at 7.7 km (upslope, thinned), site 2 at 8.2 km (upslope, no thinning), site 3 at 10.3 km (upslope, trimmed groundcover), site 4 at 12.9 km (upslope, no thinning and no pruning), site 5 at 13.8 km (downslope, no thinning and with pruning below 3.6 m), site 6 at 13.9 km (downslope, thinning with pruning below 3.6 m), site 7 at 13.75 km (downslope, thinning without pruning), site 8 at 13.7 km (downslope, no thinning), site 9 at 12.7 km (upslope, no thinning), and site 10 at 10.5 km (upslope, thinned with trimmed groundcover).

Questionnaire design

The questionnaire of this study consisted of 3 parts including background characteristics of respondents, evaluation of scenic preferences, and evaluation of perceptions of cognitive factors. A close-end questionnaire survey was chosen for this study. The contents of this questionnaire are described as follows: 1. background characteristics of respondents: investigated items included gender, age, respondent group, occupation, residence, preferences for forest types, activity frequency in natural settings per year, and preferences for nature tourism; 2. scenic beauty assessment: the respondents had to choose a preferred score for each photo (the scenic quality of each photo was assessed on a 10-point scale); and 3. evaluation of perceptions of cognitive factor. The items of cognitive factors selected in the questionnaire were from previous studies including Kaplan and Kaplan (1989), Nasar (1994), Chen and Lin (1997), Lin (2002), and Chiang and Chen (2007) with modifications to fit the needs of this study. The investigated items included 2 symbolic esthetic attributes, "naturalness" and "neatness" (to know respondents' perceptual experiences in overall sightseeing in forestry plantations) and 5 formal esthetic attributes of "unity", "openness", "harmony", "graduation", and "order" (to determine respondents' perceptual experiences in a good formal composition of forestry plantations) which were selected for evaluation on a 5-point Likert scale.

Photographic sampling

It was shown that photographs can be utilized with confidence for visual assessments (Shafer and Richards 1974, Daniel and Boster 1976, Brown and Daniel 1984, Palmer and Hoffman 2001); therefore, a photo-taking approach was used in this study. A Canon EOS400D digital camera (Japan) with a 35-mm lens was used to take photos for this study. Taking the horizontal visual on slopeland of the study areas into account, all photos were taken by fixing the level at 1.5 m in height; and photographs were taken at 09:00~16:00.

Photo-taking methods of Lin (1991) and Haider (1994) with some modifications were utilized in this study (Fig. 1). At each site, the central position for taking photograph was randomly determined; subsequently, a 20× 20-m plot was laid out. Photos were taken from the center to 4 corner positions and from

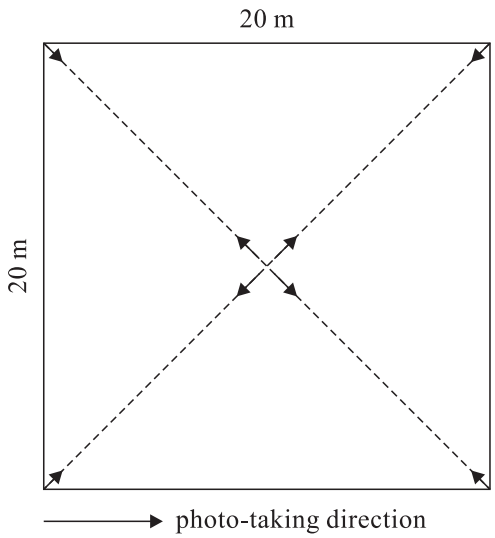


Fig. 1. Photo-taking method.

each of the 4 corners to the center of the plot. Thus, 8 photos were taken at each site, and 80 photos were collected at 10 different sites surveyed in this study. After removing unsuitable photos, 3 photos were randomly selected from photos at each site. Thirty photos in total were collected from 10 different sites.

Respondent sampling

Generally, for scenic beauty estimations, students are often chosen as the representative of the assessment of preference (Daniel and Boster 1976, Anderson and Schroeder 1983, Haider 1994, Chen and Lin 1997). Some studies indicated that different student groups show high levels of consensus for assessing scenic beauty (Daniel and Boster 1976, Anderson and Schroeder 1983). Furthermore, previous studies also indicated a similar result of landscape preference assessments between the general public and students (Anderson and Schroeder 1983, Brown and Daniel 1986, Haider 1994, Chen and Lin 1997). Thus, the respondents of this study were mostly chosen from students of the Department of Leisure and Recreation Business Management, Southern Taiwan University of Technology (STUT), Yongkang, Taiwan, and the Department of Nature Resource Application, Aletheia University (AU), Tainan, Taiwan. Students attending the weekend classes of master program of STUT were chosen as the social- worker group. Overall, there were 101 respondents from STUT, 69 respondents from AU, and 28 respondents from the social-worker group. Totally, 198 effective questionnaire samples were obtained.

Evaluation procedures of scenic preferences and perceptions of cognitive factors

Selected photos were shown to respondents by way of projection, and respondents evaluated the projection of digital photos one by one. The procedures used for scenic-beauty estimation and perception of cognitive factors in this study are described as follows. First, respondents were assembled to take the assessment in a classroom; second, the investigator explained the contents of the questionnaire survey; third, respondents were told to assess the projection of selected digital photos by personal instincts without judgment based on photography technique; fourth, each photo was projected for 5 s to be previewed by respondents to understand the contents of the assessment, and fifth, each selected photo was projected for 70 s, and respondents were requested to fill in the scenic preference scores as well as answer related questions including cognitive factors.

Measurement of selected biophysical attributes

Both on-site investigations and photo grid measurements were applied in this study. The biophysical attributes of each sampling site were investigated by researchers. The items of biophysical attributes selected for on-site investigation and photo grid measurement

were from previous studies done by Daniel and Boster (1976), Lin (1991), Haider (1994), and Huang (1996) with modifications to fit the needs of this study. Selected biophysical attributes, including tree density, diameter at breast height (DBH), density of small trees, percentage of herbaceous ground cover, height of herbaceous ground cover, height of small trees, and height to the crown base of trees, were investigated on site. A photo-grid measurement approach was used to measure the occupied grid area of each kind of biophysical attribute in each photo (Shafer et al. 1969, Buhyoff et al. 1980). A transparency with a total of 384 grids (1×1 cm for each grid) was used in this study. The biophysical attributes measured included the percentage of visible sky, percentage of trunks/branches, percentage of visible greenness, percentage of ground cover, and percentage of downed wood and debris.

Data analysis

Data of scenic preferences were analyzed using RMRATE (Brown and Daniel 1990, Brown et al. 1990) to transfer the scores of the scenic preference assessment into scores of SBE for judging the level of scenic beauty. The SBE scores were utilized in the subsequent statistical analysis. In addition, analysis of reliability, *t*-test, analysis of variance (ANOVA), and multiple regressions were conducted in this study using SPSS software (SPSS, Chicago, IL, USA).

RESULTS

Demographic characteristics of respondents

The total sample size in this study was 198 respondents. As to gender, 68% were female, and 85% of respondents were 20~25 yr of age. Regarding the occupations of respondents, 85.9% were undergraduate students. The respondents represented 3 groups, 51% of respondents were students from STUT, 34.8% were students from AU, and 14.1% of respondents were a working group. As to residence, 26.6% of respondents were from northern Taiwan, 13.1% from central Taiwan, 57.2% from southern Taiwan, and 3% from other areas.

In the preference of forest types, 56.1% of respondents preferred the forest environment without modifications, while 43.9% preferred a modified forest environment. As for the frequency of outdoor activities in natural settings per year, 59.1% of respondents had 1~3 times in frequency, 23.2% had 4~6 times, and 16.7% had > 10 times in frequency. In addition, over 82% of respondents liked and liked very much nature tourism on the preference scale.

The SBE

In the analysis of reliability, it was found that Cronbach's α of SBEs in all 30 sampling photos was 0.966. Apparently, consistency of scenic preferences using photos can be proven.

Table 1 lists the SBEs of each projected photo and sampling site for the various groups of respondents. It was noted that photo no. 25 was in the preferred top 3 places among the various groups, while photo no. 3 was always positioned in the least preferred place. Among all photos, nos. 25 (SBE = 87.28), 19 (SBE = 57.32) and 23 (SBE = 47.05) were evaluated as ones having the highest value as the top 3 ones in the group containing all respondents (Fig. 2), while nos. 3 (SBE = -122.06), 2 (SBE = -58.07) and 11 (SBE = -57.02) were ranked the lowest 3 (Fig. 3).

Tests of differences in respondent profiles to scenic beauty

Table 2 shows the results of tests of

Table 1. Descriptive statistics of scenic beauty estimates (SBEs)

Sampling site	No. of the photo	SBEs by group				
		AU	STUT	Social worker	All	Average SBEs of sampling sites
1	1	-18.69	3.71	-32.85	-8.61	-62.91
	2	-40.21	-57.40	-58.41	-58.07	
	3	-105.71	-120.78	-118.18	-122.06	
2	4	-11.11	-7.40	12.37	-5.54	3.66
	5	-21.59	-19.85	5.83	-16.20	
	6	18.93	22.82	61.45	32.72	
3	7	-12.00	36.38	24.79	21.37	8.86
	8	4.94	34.60	55.77	32.09	
	9	-39.17	-16.45	-28.42	-26.87	
4	10	43.17	30.99	5.64	30.65	-19.91
	11	-38.75	-56.42	-70.59	-57.02	
	12	-21.99	-30.72	-43.92	-33.37	
5	13	16.76	19.71	-13.87	14.15	5.25
	14	-18.65	-4.11	-19.32	-10.79	
	15	29.94	7.52	-11.15	12.38	
6	16	-48.58	-18.24	-72.92	-42.69	-8.69
	17	8.40	26.01	54.86	25.78	
	18	37.30	-27.09	-52.51	-9.15	
7	19	41.64	54.95	68.89	57.32	19.38
	20	-1.85	-9.71	-6.45	-9.62	
	21	7.52	11.14	1.69	10.45	
8	22	-5.61	-0.38	9.95	1.51	11.96
	23	50.93	36.91	48.13	47.05	
	24	-9.66	-16.88	2.79	-12.67	
9	25	119.20	69.17	64.38	87.28	34.37
	26	-6.75	11.87	-33.85	-3.48	
	27	14.65	15.30	29.19	19.30	
10	28	-11.23	-16.46	52.49	-3.92	8.02
	29	17.49	29.07	69.73	32.57	
	30	0.67	-8.24	-5.50	-4.60	

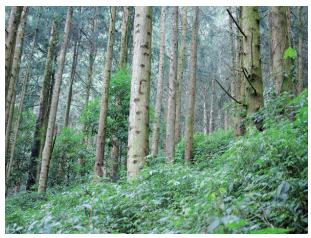
AU, Aletheia University, Tainan, Taiwan; STUT, Southern Taiwan University of Technology, Tainan, Taiwan.

differences in respondent profiles to SBEs. No significant difference in SBEs between background characteristics of respondents was detected with the exception of gender in the *t*-test. It was shown that males had higher SBEs than females.

Evaluation of cognitive factors

In the analysis of reliability, it was found that Cronbach's α of perceptions of cognitive factors in all investigated photos was 0.798~0.896. Apparently, high reliability for the questionnaire measurement of cognitive


No. 25 SBE = 87.28


No. 19 SBE = 57.32

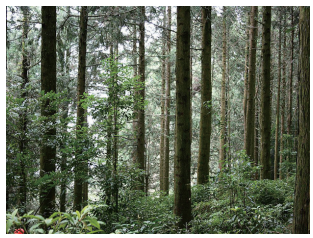
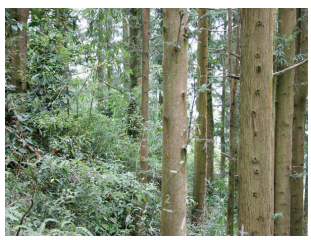

No. 23 SBE = 47.05

Fig. 2. Photos with the top 3 scenic beauty estimate (SBE) values.


No. 3 SBE = -122.06


No. 2 SBE = -58.07


No. 11 SBE = -57.02

Fig. 3. Photos with the lowest 3 scenic beauty estimate (SBE) values.

factors can be proven.

Table 3 displays the descriptive statistics for cognitive factors for SBEs ranking the top 5, and the lowest 5 projected photos, respectively. In fact, among 30 photos, photo no. 25 was ranked with the highest mean value in all cognitive factors except "openness" by all respondents. In contrast, photo no. 3 was regarded as one with the lowest value for all cognitive factors.

Tests of differences of respondent profiles to perceptions of cognitive factors

Table 4 lists the test of differences of respondent profiles to perceptions of cognitive factors. A perception of "naturalness" showed significant differences by age, group, and occupation. Gender showed a significant difference in "order". Males had higher mean than females for "order". Except for "order" and "naturalness", no significant difference was found in the perceptions of other cognitive factors among all other background characteristics of respondents.

Multiple regression of scenic preferences and perceptions of cognitive factors

In this section, relationships of scenic beauty and perceptions of cognitive factors were analyzed by a stepwise regression. All cognitive factors were treated as independent variables, and scenic preferences were tested as dependent variables. Thus, the effects of cognitive factors on scenic preferences were evaluated by a stepwise regression.

Table 5 shows the effects of cognitive factors on scenic preferences. It was found that there was a positive relationship between scenic preferences and the 2 formal esthetic attributes, "unity" and "graduation". This means that both formal esthetic attributes expressed positive contributions to the scenic preferences of Taiwania plantation. R^2 for this model was 0.956.

Table 2. Tests of differences in respondent profiles to scenic beauty estimates (SBEs)

Sample profiles			
Gender	a. Male	*t*	2.43
	b. Female	*p*	0.02*
		Post hoc	a > b
Age (yr)	a. ≤ 20	*F*	1.55
	b. 21~25		
	c. 26~30	*p*	0.18
	d. 31~35		
	e. 36~40	Scheffe's	
	f. ≥ 41		
Group	a. Department of Leisure at STUT	*F*	3.10
	b. Department of Nature Resource at AU	*p*	0.05
	c. Social workers	Scheffe's	
Occupation	a. Teacher/Civil/Servant/Army/Police	*F*	1.25
	b. Service Industry	*p*	0.29
	c. Student	Scheffe's	
Residence	a. Northern Taiwan	*F*	1.86
	b. Central Taiwan	*p*	0.14
	c. Southern Taiwan		
	d. Others	Scheffe's	
Preference of forest type	a. Modified forest environment	*t*	-1.74
	b. Forest environment without modification	*p*	0.08
		Post hoc	
Outdoor activity frequency in natural setting per year	a. 1~3 times	*F*	0.47
	b. 4~6 times	*p*	0.62
	c. ≥ 7 times	Scheffe's	
Preference of nature tourism	a. Like very much	*F*	1.17
	b. Like		
	c. Fair	*p*	0.33
	d. Dislike		
	e. dislike very much	Scheffe's	

* $p < 0.05$.

STUT, Southern Taiwan University of Technology, Tainan, Taiwan; AU, Aletheia University, Tainan, Taiwan.

Multiple regression of scenic preferences and biophysical attributes

A stepwise regression method was used to investigate relationships between scenic preferences (dependent variables) and selected biophysical attributes (independent variables). The effects of biophysical attributes investigated on site on scenic preferences are shown in Table 6. It was shown that both the percentage of herbaceous ground cover and the height to crown base of trees had positive effects on scenic preferences of Taiwania plantations. R^2 for this model was 0.840.

Table 7 shows the effects of biophysical

attributes in photo grid measurements on scenic preferences. It was found that the percentage of downed wood/debris had a negative contribution to scenic preferences of Taiwania

Table 3. Descriptive statistics of perceptions of cognitive factors for scenic beauty estimates (SBEs) ranking the top and last 5 photos

Factor.	Naturalness		Neatness		Unity		Openness		Harmony		Graduation		Order	
Ranking (photo no.)	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
1 (no. 25)	4.38	0.83	3.83	1.00	4.12	0.92	3.58	1.11	4.01	0.90	3.96	0.97	3.94	1.01
2 (no. 19)	4.19	0.81	3.71	0.96	3.91	0.90	3.41	0.99	3.91	0.88	3.68	0.96	3.88	0.88
3 (no. 23)	4.16	0.86	3.72	0.96	3.87	0.95	3.72	1.06	3.71	0.95	3.58	1.06	3.68	0.98
4 (no. 6)	4.22	0.85	3.65	0.93	3.77	0.97	3.36	1.04	3.80	0.88	3.59	1.08	3.62	0.97
5 (no. 5)	3.62	1.01	3.76	0.91	3.69	0.98	3.71	0.98	3.55	0.96	3.28	1.05	3.44	0.96
26 (no. 9)	3.43	1.05	3.41	0.98	3.27	1.08	3.43	1.03	2.99	1.03	2.93	1.06	2.97	1.07
27 (no. 16)	3.80	1.07	2.96	1.13	2.94	1.06	2.67	1.05	3.11	1.15	3.18	1.10	3.10	1.13
28 (no. 11)	3.63	1.04	2.78	1.01	2.60	0.93	2.44	0.93	2.98	1.07	2.92	1.04	3.04	1.04
29 (no. 2)	3.60	1.02	2.64	0.99	2.71	1.05	2.59	1.02	3.13	0.98	3.01	1.05	3.08	1.09
30 (no. 3)	3.22	1.25	1.97	0.91	2.01	0.83	2.26	0.98	2.20	0.99	2.31	1.05	2.09	0.98

Table 4. Tests of differences in respondent profiles to perceptions of cognitive factors (naturalness and order) showing a significant difference

Significant background	Significant cognitive factors including formal attributes	
Characteristics of respondents	Naturalness	Order
Gender*		Male > Female (t = 2.115; p = 0.036)
Age* (yr)	26~30 > 21~25 (f = 3.972; p = 0.002)	
Group*	Social workers > Department of Leisure at STUT > Department of Nature Resource at AU (F = 9.083; p = 0.000)	
Occupation*	civil servants > teachers> students (F = 6.436; p = 0.002)	

STUT, Southern Taiwan University of Technology, Tainan, Taiwan; AU, Aletheia University, Tainan, Taiwan.

Table 5. Multiple regression analysis summary of scenic beauty estimates (SBEs) and cognitive factors

Significant formal esthetic factors	R^2	B	Beta	*t*	*p* value
	0.956				
Unity		72.930	0.774	11.587	0
Graduation		29.498	0.241	3.612	0.001
Constant		-342.749		-21.080	0

Table 6. Multiple regression of scenic beauty estimates (SBEs) and biophysical attributes investigated on site

Significant biophysical characteristics investigated on site	R^2	B	Beta	*t*	*p* value
	0.840				
Percentage of ground cover		1.360	0.907	5.901	0.001
Height to crown base of trees		6.821	0.375	2.442	0.045
Constant		-151.476		-5.726	0.001

Table 7. Multiple-regression analysis of scenic beauty estimates (SBEs) and biophysical attributes with photo grid measurements

Significant physical attributes in photo	R^2	B	Beta	*t*	*p* value
	0.291				
Downed wood/debris (%)		-8.867	-0.593	-3.387	0.002
Constant		9.795		1.435	0.162

plantations. R^2 for this model was 0.291.

Multiple regression of cognitive factors and biophysical attributes

The effects of biophysical attributes investigated on site on cognitive factors are shown in Table 8. It was shown that the percentage of herbaceous ground cover had positive effect on all cognitive factors except "naturalness". Apparently, the percentage of herbaceous ground cover plays a key role in influencing the investigated cognitive factors in this study. In addition, significant negative correlations between "openness" and biophysical attributes including tree density, and height of small trees, and in contrast, significant positive effects of the percentage of herbaceous ground cover and the height of herbaceous ground cover on "openness" were shown in this study.

The effects of biophysical attributes measured by the photo grids on formal esthetics are shown in Table 9. It was shown that the percentage of downed wood/debris had negative effects on all cognitive factors. Therefore, avoidance of downed wood/debris should be good for scenic esthetics of Taiwania plantations. In addition, significant positive correlations between the percentage of visible sky and formal esthetic attributes including "unity", "openness", and "order" were shown in this study.

DISCUSSION

From the results of the tests of differences, it was shown that none of the respondent profiles showed significant differences

Table 8. Multiple regression of cognitive factors and biophysical attributes investigated on site

Variable		R^2	B	Beta	*t*	*p* value
Cognitive factors	Biophysical attributes investigated on site					
Naturalness		0.713				
	Small tree height		0.099	0.844	4.455	0.002
	Constant		3.520		44.095	0.000
Neatness		0.858				
	Percentage of herbaceous ground cover		0.017	0.926	6.955	0.000
	Constant		1.924		9.146	0.000
Openness		0.963				
	Percentage of herbaceous ground cover		0.022	0.992	9.814	0
	Density of Taiwania trees		-3.467	-0.469	-4.763	0.005
	Small tree height		-0.168	-0.652	-4.875	0.005
	Height of ground cover		0.488	0.338	2.879	0.035
	Constant		1.864		10.292	0
Unity		0.802				
	Percentage of herbaceous ground cover		0.016	0.896	5.693	0
	Constant		1.967		7.845	0
Harmony		0.684				
	Percentage of herbaceous ground cover		0.011	0.827	4.162	0.003
	Constant		2.499		10.598	0
Graduation		0.504				
	Percentage of herbaceous ground cover		0.110	0.710	2.850	0.021
	Constant		2.938		21.226	0
Order		0.672				
	Percentage of herbaceous ground cover		0.012	0.819	4.044	0.004
	Constant		2.358		9.070	0

in scenic preferences, except for gender, and the SBEs of males were obviously higher than those of females. It may be inferred that females are more rigorous than males in evaluating scenic beauty. In addition, no significant differences in SBEs between students and social-workers group were found in this study. This result is similar to previous studies showing no significant differences in SBEs between students and non-student groups (Daniel and Boster 1976, Brown and Daniel 1986).

From the analysis of the effects of cognitive factors on scenic preference, it was shown that the formal esthetic attributes of "unity" and "graduation" but not the symbolic/meaning attributes of naturalness or neatness had positive effects on scenic beauty. It is obvious that there are positive correlations between scenic preferences and perceptions of formal esthetics. This study confirms a previous study that showed correlations of cognitive rating variables and landscape esthetic preferences (Sevenant and Antrop 2009).

From the analysis of the effects of biophysical characteristics on scenic preferences, it is obvious that the percentage of herbaceous ground cover and the height to the crown base

Table 9. Multiple regression of biophysical attributes from photo grid measurements and cognitive factors

Variable						
Cognitive factors	Biophysical attributes measured by photo grid measurement	R^2	B	Beta	*t*	*p* value
Naturalness		0.336				
	Percentage of downed wood/debris		-0.039	-0.375	-2.340	0.027
	Constant		4.056		49.925	0
Neatness		0.401				
	Percentage of downed wood/debris		-0.101	-0.633	55.862	0
	Constant		3.474		-4.327	0
Openess		0.497				
	Percentage of downed wood/debris		-0.102	-0.569	-3.790	0.001
	Percentage of visible sky		0.068	0.388	2.617	0.015
	Constant		2.803		22.175	0
Unity		0.423				
	Percentage of downed wood/debris		-0.117	-0.683	-4.399	0
	Percentage of visible sky		0.055	0.331	2.132	0.042
	Constant		3.420		47.797	0
Graduation		0.24				
	Percentage of downed wood/debris		-0.065	-0.490	-2.973	0.006
	Constant		3.370		58.319	0
Order		0.352				
	Percentage of downed wood/debris		-0.057	-0.373	-2.251	0.033
	Percentage of visible sky		0.011	0.348	2.101	0.045
	Constant		3.142		18.366	0

of trees had positive effects on scenic preferences. On the contrary, it was shown that the percentage of downed wood/debris had a negative effect on scenic preferences. The results indicated above are consistent with findings of previous studies, in which respondents preferred forest near-view scenes with greater herbage percentage and less downed wood/debris on the ground (Schroeder and Daniel 1982, Brown and Daniel 1986, Haider 1994). A higher height to the crown base of trees was seen as good for scenic preferences, a finding consistent with previous work done by Lin (1991). In this study, density of Taiwania trees did not show any significant effect on scenic preferences, which is also consistent with a previous study of Brown and Daniel (1984) who indicated that tree density was not the main factor affecting scenic preferences of viewers.

An interesting observation was the presence of significant correlations of biophysical attributes and cognitive factors. In particular, the percentage of herbaceous ground cover contributed significant positive effects to all cognitive factors except “naturalness”, while the percentage of downed wood/debris had significant negative effects on all cognitive factors. Our study methodologically confirms that there are correlations of park landscape preferences of cognitive factors and visual quality (SBE model) as found by Chen and Lin (1997).

CONCLUSIONS

It is insufficient to understand which scenic condition is esthetically better; we should determine how to make scenes better by assessing criteria of scenic esthetics. To integrate a comprehensive forest management plan toward a sustainable approach, an appropriate esthetic design inventory and management should be applied to forest landscapes for sightseeing by visitors. This refers to the importance of forest scenic esthetics.

Moreover, because 2 formal esthetic attributes of "unity" and "graduation" had positive effects on scenic preferences, it is suggested that the unity of the entire forest understory and graduating distinction should be considered as design principles for Taiwania plantations toward a sustainable approach to raise scenic quality. In practice, due to the effects of the percentage of herbaceous ground cover (positive) and downed wood/debris (negative) on scenic preferences and the formal aesthetics of "unity" and "graduation", it is suggested that enhanced scenic preference of Taiwania plantation management toward a sustainable approach can be obtained from increasing the herbaceous ground cover, raising the height to crown base of trees, and decreasing the amount of downed wood/debris. Dealing with the relationships of formal attributes ("unity" and "graduation") and biophysical attributes (the percentage of herbaceous ground cover and downed wood/debris) should be seriously considered in designing scenic esthetics of Taiwania plantations.

In this study, all findings should be regarded as preliminary because this is the first investigation of scenic esthetics in Taiwania plantation management toward a sustainable approach. Most sampling respondents were chosen from undergraduate and graduate students. This may have resulted in limiting the interpretative efficacy of the study. Therefore, expanding the variety of background characteristics of respondents such as occupation, age, and education is suggested to produce a more-confident validity of the findings' interpretation. It is also highly recommended that the systematic combination of expanding investigated forestry types (e.g., broadleaf and mixed forest types), and imposing appropriative sets of interrelated cognitive items and biophysical attributes related to forestry management toward a sustainable approach will make a more-solid predictable model of forest scenic esthetics.

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