Author(s): Watts, Gregory R. and Pheasant, Robert J.

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TOWARDS QUANTIFYING THE QUALITY OF TRANQUIL AREAS WITH REFERENCE TO THE NATIONAL PLANNING POLICY FRAMEWORK

G Watts Centre for Sustainable Environments, University of Bradford

1 INTRODUCTION

The UK has recently recognized the importance of tranquil spaces in the National Planning Policy Framework, NPPF. This paper reports on applying the tranquillity rating prediction tool, TRAPT for predicting the perceived tranquillity of a place and using this tool to classify the levels of tranquillity in existing areas. The tool combines soundscape and landscape measures to produce a tranquillity rating on a 0-10 rating scales. For these purposes noise maps, spot noise level measurements, photographic surveys were used to predict tranquillity levels in 8 parks and open spaces in or near the city of Bradford in West Yorkshire in the UK. In addition interviews were conducted with visitors to validate these predictions. It was found that there was a reasonably close relationship between predicted and average assessments given by park visitors which confirmed the usefulness of the tranquillity rating prediction tool for planning and conservation purposes

Tranquil surroundings are important because the number of people visiting their local parks and countryside is increasing according to a recent survey published by Natural England[1] and an important reason given for such visits was to "relax and unwind". Consequently these areas can be considered restorative or tranquil environments giving relief from cognitive overload and reduction of stress. Numerous studies have shown a link between such tranquil environments and stress reduction, longevity, pain relief and how the brain processes auditory signals[2,3,4,5,6]. It is therefore important to consider its protection in a variety of landscapes and especially where visitors often seek relief from the stresses and strains of everyday life, for example in city green spaces and in country parks on the urban fringe. Research for the Campaign to Protect Rural England (CPRE)[7] showed graphically how tranquil areas in the countryside are under threat from intrusive developments and new roads and motorways and the latest UK design guidance for roads and bridges refers to tranquillity in assessing environmental impact of new or altered roads[8]. A consideration of tranquillity involves an assessment of "..the remoteness and sense of isolation, or lack of it, within the landscape, which is often determined by the presence or absence of built development and traffic." In a further section of the guide dealing with noise and vibration assessments it is noted that noise is one characteristic that determines the level of tranquillity[9]. In addition, the NPPF notes that planning policies and decisions should "…identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity" [10].

This paper reports on applying a method for predicting the perceived tranquility of a place and using this approach to classify the levels of tranquility in existing areas. This approach allows factors that degrade tranquility to be identified and means of improvement to be devised that can then be used for identifying and protection. For these purposes noise maps, spot noise level measurements, photographic surveys were used to predict perceived tranquility. For validation measurements were carried out in 8 parks and open spaces and interviews were conducted with visitors. At a country park and surrounding moors more in depth assessments were carried out using jury assessments.

Previous studies at the Bradford Centre for Sustainable Environments has largely focused on prediction and validation of tranquility ratings in city and country parks using the Tranquillity Rating

Prediction Tool, TRAPT[11] and questionnaire surveys of visitors. The tool has been used to classify areas in terms of perceived tranquility using an interval rating scale. TRAPT was developed from laboratory studies where statistically significant factors influencing perceived tranquility of a place were found to be the average noise level and the percentage of natural and contextual features in the visual scene. The formula relating these factors is given by:

$$TR = 9.68 + 0.041\ NCF - 0.146\ L_{day} + MF \quad (1)$$

Where *TR* is the tranquillity rating. Participants were asked to rate the tranquillity of a chosen spot by choosing a number between 0 to 10 where 0 is "least tranquil " and 10 is "most tranquil". *NCF* is the percentage of natural and contextual features in the landscape and L_{day} is the equivalent constant A-weighted level of man-made noise during daytime (7:00am to 7:00pm). Contextual features include listed buildings, religious and historic buildings, landmarks, monuments and elements of the landscape, such as traditional farm buildings, that directly contribute to the visual context of the natural environment. It can be argued that when present, these visually cultural and contextual elements are as fundamental to the construction of 'tranquil space' as are strictly natural features (e.g. grass, shrubs, trees, water, rock etc). The moderating factor *MF* is added to the equation to take account of further factors such as the presence of litter and graffiti that will depress the rating and water sounds that are likely to improve the ratings[12]. This factor is unlikely to be large and it was demonstrated that the presence of litter depressed the rating by one scale point[13].

In some extreme cases, the predicted value of *TR* goes negative due to the linear regression technique used to relate these variables. In these cases, the calculated value is set to zero. Where $TR > 10$ then values are set to 10. Figure 1 shows the relation between L_{day} and *TR* for 3 levels of *NCF* (0, 50 and 100%). Where there are no natural or contextual features (NCF = 0%) it can be predicted that at an average noise level of 55 dB(A) that might be recorded in a paved urban square surrounded by buildings the *TR* value would be at the low level of less than 2. Conversely if the square is grass covered and surrounded by shrubs and trees so *NCF* is 100% the predicted *TR* at the same noise level rises to nearly 6. This graphically demonstrates the importance for tranquillity of the natural components of the visual scene. For example a 50% increase in *NCF* is predicted to raise *TR* by approximately 2 scale points while decreasing noise level L_{day} by 14 dB(A) changes *TR* by approximately the same amount. These trade-offs can be used to identify suitable measures to improve tranquillity.

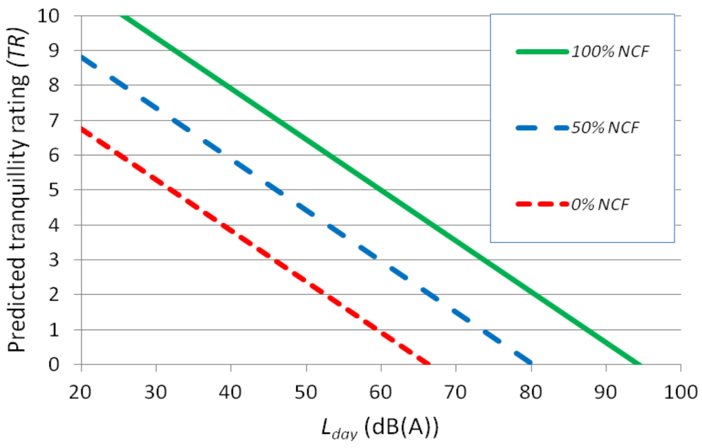

Figure 1: Linear variation of TR with Lday at 3 levels of NCF (0, 50 and 100%)

TRAPT was used in a previous study to assess the tranquillity in 8 green open spaces and later these predictions were validated using a questionnaire survey of park visitors[14]. A later study was completed using a jury approach to rate tranquility at 9 location in a country park[15]. Again it was possible to validate the predictions with average ratings from the jurors. This paper reviews important findings and demonstrates its application to planning issues.

2 TRANQUILLITY SURVEYS

2.1 Approach

A useful initial approach is to identify the most likely tranquil and non-tranquil places in a defined area and calculate the corresponding range of Tranquillity Ratings, *TR*, defined in equation (1) using:

- Noise maps (if available)
- Spot readings of A-weighted sound pressure levels throughout the area
- Noise predictions based on official noise prediction software
- Photographic survey of the percentage of natural and contextual features

2.2 Noise maps

Transportation noise maps covering large agglomerations are published on the UK's DEFRA website[16]. They can be used initially to help identify the likely nosiest and quietest locations in the selected urban areas (parks and green spaces). The noise bands are given in L_{den} and are in 5 dB(A) intervals down to 55 dB(A). Levels below 55 dB(A) are not differentiated so the maps are only useful at a strategic level of investigation. Note that levels of 55 dB(A) and below have been suggested as one criterion for identifying Quiet Areas in response to the Environmental Noise Directive[17,18]. L_{den} by definition includes day, evening and nighttime levels, weighted according to human sensitivity to noise, and therefore is not directly relevant to the daytime use of the parks in question. To convert to L_{day} a formula derived from the UK national survey can be used[19]

$$L_{day} = 0.984\, L_{den} - 0.196 \qquad (2)$$

2.3 Spot readings

During the initial surveys, spot readings of the A-weighted sound pressure level can be taken of background noise levels which are dominated by traffic or other noises. Periods of significant natural sounds should be excluded from the noise sampling (e.g. bird song). Also human voices and the noise from any other mechanical sounds judged to be of only a transient nature e.g. noise from chain saw for tree surgery. In conjunction with the noise maps the quietest and nosiest locations can be determined. GPS co-ordinates of these locations should be recorded using a hand held device.

2.4 Noise predictions

In cities the dominant noise source is often road traffic noise and predictions can be carried out for the sites using the current UK's prediction method "Calculation of Road Traffic Noise" (CRTN)[20]. This method predicts the 18 hour percentile measure $L_{A10,18hr}$ from 0600 to 2400 hours. Classified traffic counts can be carried out during the daytime according to the CRTN procedure (i.e. vehicles with an unladen weight greater than 1525 kg were classified as heavy). The distance to the nearest road can be calculated using GPS co-ordinates previously recorded and Google Earth mapping tool. Road surface type (e.g. porous or non-porous), speed limit and road gradient should be recorded and the corresponding noise level corrections made.

It is suggested that this method is used where an accurate prediction is required. The L_{day} value can then be obtained from the official conversion formulae[21]:

For non-motorways: $L_{day} = 0.95\, L_{A10,18h} + 1.44$ dB (3)

For motorways: $L_{day} = 0.98\ L_{A10,18h} + 0.09$ dB (4)

Note that where CRTN is not the preferred prediction method other validated traffic noise models can be used to obtain L_{day}. If noise from other transportation modes are dominant the L_{day} value can be calculated using the appropriate prediction model. In some cases where no one source is dominating it will be necessary to logarithmically combine individual predicted L_{day} values.

2.5 Photographic survey

Having identified the quietest and noisiest areas within the area from the relevant noise maps and spot readings, the percentage of natural and contextual features can be determined using a camera giving a field of view of approximately 51 degrees in the horizontal plane on a normal (non-zoom) setting and a vertical field of view of approximately ± 20 deg. Seven contiguous pictures should then be taken at a height of 1.5m (close to the average standing eye height of adults in the UK) to give an approximate field of view of 360 degrees. These pictures can then be pasted into Microsoft PowerPoint (or similar software) and analysed using a 10 x 10 grid placed over the images to determine the percentage of natural and contextual features excluding sky. The average values at each location is then used in the calculation of *TR*. In most cases the quietest areas also have the highest percentage of natural features so according to the prediction tool this would also be the most tranquil. Relevant survey positions in parks and green spaces in cities might be pathways if it is observed that relatively few people cross grassy areas or walk through or over plants and vegetation.

2.6 Classification of tranquillity ratings

This survey method provides details concerning the expected range of tranquility ratings in an area. To provide greater detail it is necessary to calculate the tranquility rating throughout the chosen area using a grid sampling approach and to map the resulting levels of tranquillity using suitable contouring software.

To provide informative tranquility maps it is necessary to provide an indication of the quality of the tranquility rating e.g. acceptable and non-acceptable levels. It has been suggested that the following descriptors of tranquility quality should apply for urban parks and green spaces[22]:

<5 unacceptable
5.0 – 5.9 just acceptable
6.0 – 6.9 fairly good
7.0 – 7.9 good
≥ 8.0 excellent

To protect tranquil areas it would be useful to provide plots of tranquility contours which can be monitored in order to indicate changes that might pose a threat. Figure 2 illustrates cases where the noise from traffic varies and indicates the corresponding changes in the areas of tranquil spaces of various quality.

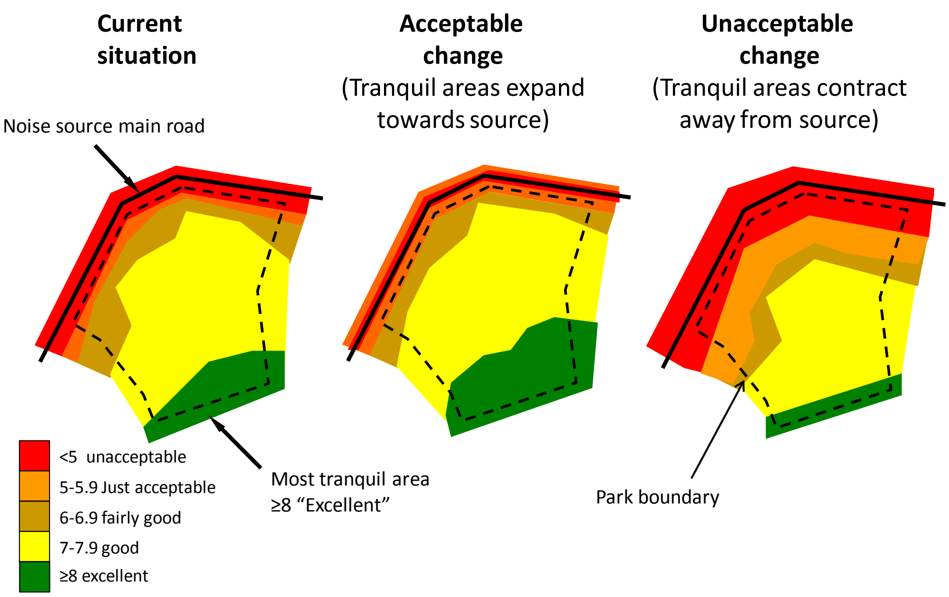

Figure 2: Illustrative tranquillity rating contour plots adjacent to a major urban road

Of particular concern would be significant shrinkage of high quality tranquil areas that might be of particular benefit for local residents. The health and well-being benefits of such spaces has been well documented (see Introduction).

3 PARK SURVEYS

To illustrate the usefulness of using TRAPT results from surveys of urban parks and green spaces are described below.

3.1 Results

The results of predicted and average ratings of tranquillity from the surveys are listed in Table 1 below. Predicted values are for the most tranquil areas in the parks. Average ratings from respondents questioned in Peel Park and Ogden Water were 8.4 and 8.8 respectively which is judged "excellent". In the case of Lister Park and Bowling parks the average ratings were 7.8 and 7.4 respectively placing them in the "good" category. While Horton Park was assessed at a level of 6.7 which is "fairly good", Bradford Moor Park was assessed at 5.4 which is "just acceptable". The Peace Garden and Thackley Green with ratings of 4.9 and 2.9 respectively had "unacceptable" levels of tranquility.

Table 1: Tranquillity ratings

Location	L_{day} (dB(A))	Percentage of natural and contextual features (*NCF*)	Tranquillity rating (0-10)	
			Predicted (*TR*)	Actual (average from survey)*
Ogden Water				
Most tranquil	36.2	100	8.5	8.8±0.2
Least tranquil	45.6	58.9	5.4	
Peel Park				
Most tranquil	44.2	99.2	7.3	8.4±0.2
Least tranquil	58.0	88.3	4.8	
Lister Park				
Most tranquil	51.8	97.7	6.1	7.8±0.4
Least tranquil	71.1	73.7	2.6	
Bowling Park				
Most tranquil	47.3	87.8	6.4	7.4±0.3
Least tranquil	50.8	82.2	5.6	
Horton Park				
Most tranquil	43.5	85.3	6.8	6.7±0.3
Least tranquil	54.5	78.8	5.0	
Bradford Moor Park				
Most tranquil	51.8	90.2	5.8	5.4±0.7
Least tranquil	71.9	79.3	2.4	
Peace Garden				
Most tranquil	60.7	55.6	3.1	4.9±0.8
Least tranquil	70.0	30.9	0.7	
Thackley Green				
Most tranquil	60.4	56.1	3.2	2.9±0.9
Least tranquil	75.7	27.3	0.0	

*95% confidence interval attached to mean values. Number of respondents in each park was 30 except in Thackley Green where due to low numbers of visitors 11 interviews were conducted while due to its large size 62 interviews were conducted at Ogden Water.

Figure 3 shows the least tranquil open space (Thackley Green) with an average rating given by visitors of only 2.9. In contrast, visitors to Lister park gave an average rating of 7.8. The tranquility scale runs from 0 to 10 and scores below 5 are judged unacceptable. A score of 7.8 is “good”. The lack of trees and shrubs in Thackley Green and the high traffic noise level due to its small size and proximity of the A657 are the main contributory factors. On the other hand Lister Park has many mature trees and a lake and is large enough that traffic noise levels near the centre are not excessive despite the presence of a heavily trafficked road on one boundary (A650).

Figure 3:" Non-tranquil" green (Thackley Green) and "Good" tranquil park (Lister Park)

3.2 Analysis

A strong relationship between predicted tranquillity and the average ratings obtained from park visitors would indicate the utility of the model in practice for design and improvement purposes. For this reason the average rating obtained in the open spaces were regressed against the levels predicted in the most tranquil areas of each space. Figure 5 shows the relationship with a linear trend line applied. There is some variation between predicted and actual values due to the subjective nature of the variables involved and the fact that not all variation is taken into account by the two variables in equation (1) L_{day} and *NCF*. Despite this it can be seen that the relationship is close (R^2 = 0.82, p<0.01).

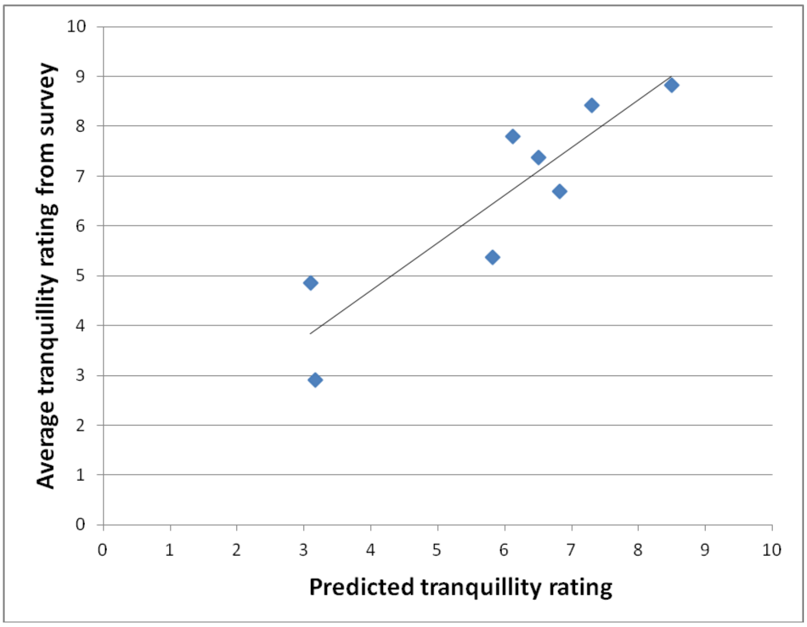

Figure 4: Predicted and average tranquillity ratings from the survey of the 8 parks

3.3 Soundscape

The question: "In this park/ green/ garden what sounds attract your attention the most?" produced a large assortment of replies and these were categorised as:

- "Natural sounds" including sounds made by birds, animals, water and wind through leaves and branches
- "Mechanical noise" including noise from traffic, individual vehicles, aircraft/helicopter noise, industrial noise and powered tools
- "People sounds" including people conversing and laughing, music and electronic sounds from hand-held devices
- "Children playing" including children in playgrounds and playing games in the open spaces

Figure 5 shows the types of sounds attracting attention most in each of the parks. The bars are ordered in terms of the average tranquillity rating from the survey.

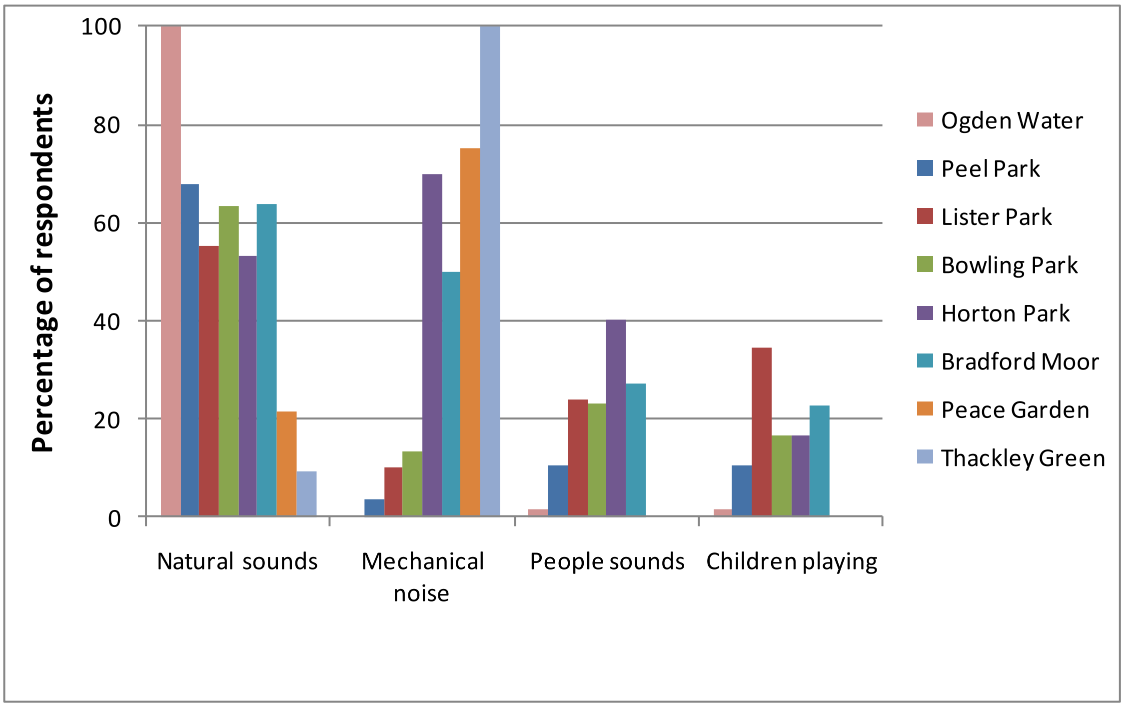

Figure 5: Sounds attracting attention

It can be observed that there are wide variations in the soundscapes across the green spaces due to the differences in the percentages reporting natural sounds and mechanical noises. Overall 54% of respondents reported natural sounds, 40% mechanical noise, 16% reported people noise including music and 13% reported the sounds of children at play. By inspection it can be seen that visitors in the most tranquil parks such as Ogden Water, Peel and Horton more often report natural sounds and fewer mechanical sounds than visitors to the least tranquil spaces such as Thackley Green and the Peace Garden.

3.4 Reported benefits

The benefits of visiting the park were obtained by asking: "Do you feel 'more relaxed', 'less relaxed' or 'no change' after visiting this park/ green/ garden?" The percentage of respondents reporting they were more relaxed was plotted against the average tranquillity rating reported by respondents. This relationship is very strong (R^2 = 0.96, p<0.001) as can be seen in Figure 6.

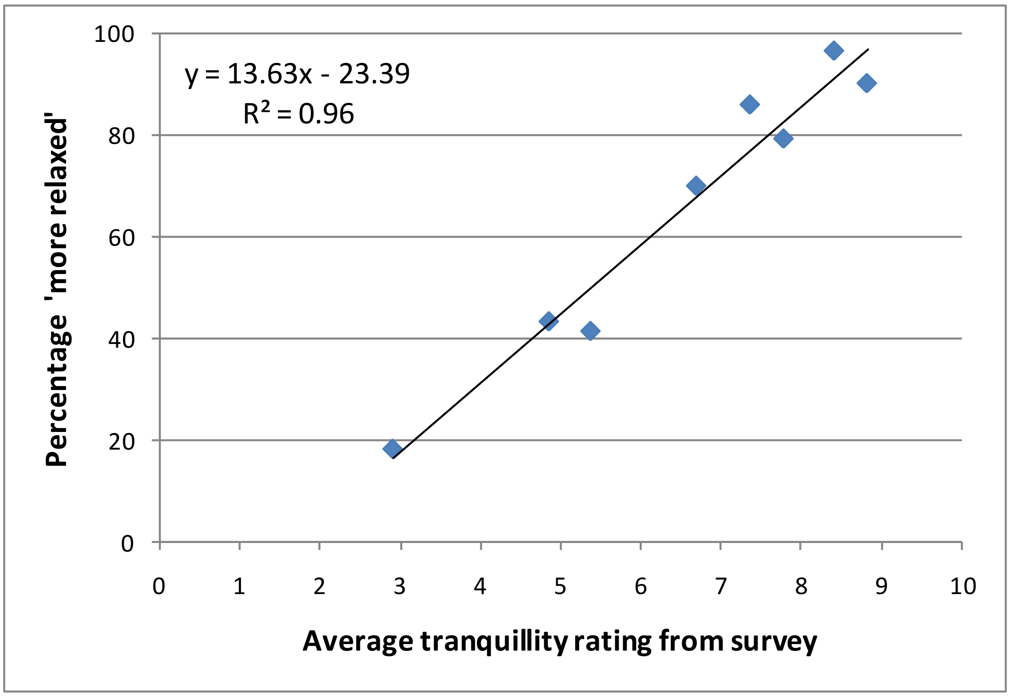

Figure 6: Percentage of respondents reporting they were 'more relaxed' after visiting the green space by average tranquillity rating from the survey

At a rating of approximately 2 it is predicted that no visitors would have reported being 'more relaxed'. Clearly this indicates a lower bound to the tranquillity rating for creating spaces with restorative value. For a 50% response the average tranquillity rating would need to be 5.4 and for a 75% response the rating would need to be 7.2. This lends support to the judgements noted above (Section 2.6) that a "just acceptable" level of tranquillity was considered to be ratings in the range 5.0-5.9 and a "good" level was considered to lie in the range 7.0-7.9.

4 DESIGNING FOR TRANQUILLITY

We can conclude that tranquil spaces exist in green open spaces in cities and that some of them are likely to be judged "excellent". On the other hand some green spaces were found to have "unacceptable" levels of tranquility. In those case where tranquility is low we can use TRAPT to engineer some effective solutions. There are three approaches that can be used separately or in various combinations:

- Reduce man-made noise (usually traffic noise) e.g. re-routing traffic, lorry bans, low noise road surfacing, noise barriers
- Increase the percentage of natural features e.g. introduce trees, shrubs, trellising or vegetated facades[23] to "hide" buildings, roads, signage and advertising and to reduce the amount of brick, concrete or bituminous surfacing visible to park visitors.
- Encourage "natural" sounds by installing appropriate water features. Introduce ponds and lakes which will not only assist with increasing the percentage of natural features but may also encourage water fowl and birds.
- Reduce litter and graffiti

The degree of improvement can be predicted with reasonable accuracy using TRAPT allowing consideration of a range of remedial treatments. The approach could also be used in planning new tranquil spaces which will contribute to health and well being for as we have seen the degree of tranquillity is closely related to the degree of relaxation reported.

5 DISCUSSION AND CONCLUSIONS

The UK has recently recognized the importance of tranquil spaces in the National Planning Policy Framework. Specifically it states that planning policies and decisions should aim to “identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity”. Using TRAPT both soundscape and landscape factors are taken into account in determining the perceived tranquility of a place and can potentially be used for planning purposes. The level of man-made noise can be predicted using appropriate software and the percentage of natural and contextual features in the scene can be captured using photographic surveys. For a detailed analysis it is will be necessary to sample over a grid of points in the area under investigation. This will then allow plots of tranquillity contours using appropriate software tools. Using contour maps it will be possible to identify quality tranquil spaces and regular updates of the maps will enable external threats to tranquillity to be identified and appropriate action taken.

It has been shown that that areas rated highly on tranquillity also frequently bring benefits to visitors in terms of relaxation. Based on the survey of 8 parks it would appear than a tranquility rating of >7.2 is required for approximately 75% of visitors to report being more relaxed. With a 100% of natural features this implies an average day time noise level of 45 dB(A) or less. This would seem a reasonable target for the most tranquil parts of urban parks and would be achievable with adequate consideration of noise mitigation measures and appropriate plantings.

The benefits of tranquil areas in terms of health and well being have been widely reported and a challenge is to enable citizens to have easy access to such areas. In New York City where the concrete jungle compares second to none there is a policy to provide a green space within a 10 minute walk of every citizen[24]. The “High Line” in West Side Manhattan is an excellent example of how NYC authorities prompted by citizen action have risen to the challenge transforming a disused 1.6 km section of railway freight line in a derelict area to provide a linear park abundant with wild flowers, shrubs and trees and a “must see” for the city’s many visitors. The freight line is raised well above street level so intrusive traffic noise is reduced and parts are now maturing providing screening of the buildings on either side.

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