Link to publisher's version: *https://doi.org/10.1016/j.ufug.2017.05.010*

Citation: Watts G (2017) The effects of "greening" urban areas on the perceptions of tranquillity. Urban Forestry & Urban Greening. 26: 11-17.

The effects of "greening" urban areas on the perceptions of tranquillity

By G R Watts, University of Bradford. Published on-line: Urban Forestry and Urban Greening

http://dx.doi.org/10.1016/j.ufug.2017.05.010

Abstract

Tranquil environments can provide relief from stresses of everyday of life and can be considered restorative environments. This paper considers the effects of "greening" urban environments to enhance tranquillity and ultimately well-being and health benefits. A number of studies have been conducted at the Bradford Centre for Sustainable Environments at the University of Bradford which have examined the effects of natural features on ratings of tranquillity. These include quantifying the effects of the percentage of natural and contextual features and soundscape quality on rated tranquillity. Recently the resulting prediction equation TRAPT (Tranquillity Rating Prediction Tool) has been used to examine a number of scenarios including city parks and squares, country parks and moorland areas and validated using tranquillity ratings made by visitors to these green spaces and their reported levels of relaxation. In this paper TRAPT is used for predicting tranquillity in city squares of different sizes, to examine rated tranquillity behind natural (green) and manufactured noise barriers and to predict changes in urban streets of introducing avenues of trees, hedges and grass verges. Using such scenarios this paper demonstrates how the application of TRAPT can enable changes in tranquillity to be estimated. This can provide planners, environmentalists, civic leaders and concerned citizens with a further tool to guide improvements in the urban environment by "greening" measures and noise reduction of various kinds and to help counter threats such as over development, tree removal or traffic densification that might threaten existing benefits. 242 words

1. Introduction

The many benefits of green infrastructure have been well documented including climate change mitigation, economic growth and investment, land regeneration, wildlife and habitat improvements, more resilient communities and increased health and well-being [1]. This paper concentrates on an aspect of health and well-being that has received little detailed attention i.e. improvements in perceived tranquillity of a place. Tranquil spaces are characterized by a soundscape dominated by natural sounds and low levels of man-made noise. The presence of vegetation and wild life has been shown to be an important contributory factor to rated tranquillity while litter and graffiti have a negative impact. In the town centre dense vehicle and pedestrian traffic create largely non-tranquil environments. However, our green spaces and watersides can be a refuge from the din of town life and these environments provide shelter for wildlife and bird song and water sounds may be heard. Numerous studies have shown a link between such tranquil environments and stress reduction, well-being, longevity, pain relief and how the brain processes auditory signals [2–7]. It is therefore important to consider its protection, enhancement and promotion in a variety of urban landscapes and especially where visitors are likely to seek relief from the stresses and strains of everyday life.

Recent studies [8] have demonstrated that the tranquillity construct is essentially composed of two components i.e. pleasantness and calmness. It has been found that over the population as a whole most people prefer natural soundscapes to man-made sounds and green environments to built environments [9]. To translate these ideas into a practical prediction tool that can be validated has been the focus of studies at the Bradford Centre for Sustainable Environments. Both controlled laboratory studies and surveys in green spaces have been employed.

Our work on elucidating the tranquillity of open spaces in town and country and inside health facilities has concentrated on identifying and quantifying important influential factors. The initial laboratory study identified the key factors influencing perceived tranquillity [10]. This resulted in a practical method called TRAPT (Tranquillity Rating Prediction Tool) [11] that has been validated and calibrated for urban green spaces [12]. This prediction method includes two important factors: the level of man-made noise (usually traffic noise) in the soundscape and the percentage of natural and contextual features in the visual scene. Note that other sensory inputs were considered less important e.g. olfactory and tactile and therefore were not included in these studies though they may be addressed at a later stage. Figure 1 shows this in diagrammatic form together with the influence of other factors (moderating factors) which are generally not so dominant e.g. the presence of litter and graffiti that that affect tranquillity ratings adversely and water sounds that can improve it [13,14].

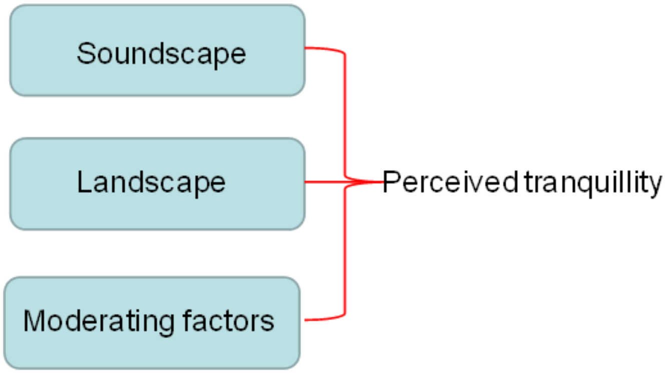

Figure 1*: Influential factors affecting the tranquillity of a place*

The percentage of natural features in view in the landscape or nature picture and murals for building interiors includes vegetation, water and geological features e.g. exposed rock outcrops. 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. Based on these factors TRAPT allows the prediction of the tranquillity of a place on a 0 to 10 scale. The TRAPT equation was based on laboratory studies where a number of subjects were asked to rate video clips of a range of environments from busy market place to natural coastal location far from any development. Figure 2 shows an experimental subject rating a video clip. The video recorder was mounted on top of a dummy head (“Marina”) as can be seen in the figure. Microphones placed in the artificial ear canals allowed binaural recordings to be made which contributed to the realistic environment on playback as it created a 3-D stereo sound sensation for participants.

Figure 2*: Experimental subject rating a video clip taken using "Marina"*

It was shown that for urban areas the form of the prediction equations is [12]:

$$TR = 10.55 + 0.041\ NCF - 0.146\ L_{day} + MF \quad (1)$$

Where *TR* is the tranquility rating on a 0 to 10 rating scales. *NCF* is the percentage of natural and contextual features in view and L_{day} is the equivalent constant A-weighted level, in dB, during daytime (e.g. from 7am to 7pm) from man-made noise sources.

The behaviour of this equation has been studied by examining trends in *TR* with L_{day} at different levels of *NCF*. It was noted that at the extremes of L_{day} where *TR* becomes greater than 10 or less than 0 then *TR* values are set to 0 and 10 respectively. *MF* is a moderating factor that was added to the equation following earlier studies [13,14], and is designed to take account of the presence of litter and graffiti that would depress the rating, or natural water sounds that would improve it. This minor adjustment, in *TR* scale points, is designed to take account of the actual environmental conditions at the time of assessment and is unlikely to influence the calculated *TR* by more than ±1 scale point.

Predicted *TR* values in eight urban open spaces have been related to the level of rated relaxation (i.e. "less relaxed", "no change", "more relaxed") of people after visiting such spaces where there was found to be highly correlated $r = 0.98$ ($p < 0.001$) [12]. For example, for a *TR* value of 5.0 nearly 50% of visitors report that they are "more relaxed" after visiting the park while at a value of 8 approximately 80% report being "more relaxed". These results can be used to calibrate the following category limits for *TR* defined previously based on the judgements of the research team [15]:

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

These category labels have proved useful in describing the benefits of changes in the *TR* value.

To illustrate the nature of equation (1) Figure 3 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 visible (*NCF* = 0%) it can be observed that at the mid-range urban noise level of 50 dB(A) *TR* reaches only 3.3 ("unacceptable") while with *NCF* = 50% the value is predicted to rise to 5.3 ("just acceptable"). However, with *NCF* = 100% the

TR value is 7.4 i.e. "good". This graphically demonstrates the importance for rated tranquillity of the natural components of the visual scene. In addition, the equation allows trade-offs to be made to improve tranquillity. 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.

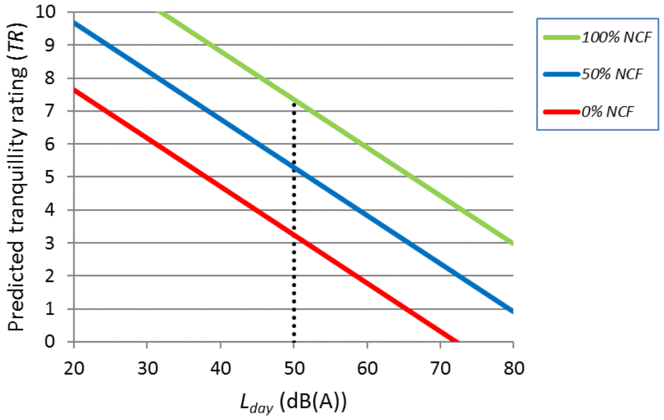

Figure 3: Linear variation of Tranquillity Rating (TR) with L_{day} at levels of Natural and Contextual Features (NCF) of 0, 50 and 100%

Using a wide range of scenarios this paper sets out to demonstrate how the application of TRAPT can enable changes in tranquillity to be estimated. This can enable planners, environmentalists, civic leaders and concerned citizens to consider options to improve the urban environment by "greening" measures and noise reduction of various kinds or threats such as over development, tree removal or traffic densification that might threaten existing benefits. For the first time the degree of benefit can be quantified and related to changes in the tranquillity rating which in turn can, if needed, be used to estimated improvements in levels of relaxation that can be expected.

2. Method

Using equation (1) a number of common urban scenarios were modeled. These covered a wide range of situations though clearly available resources put a practical limit on numbers considered. The aim was to illustrate the approach so that the tool could be applied in specific situations as required.

2.1. Scenarios

The scenarios examined included:

1. City squares of various sizes where a main road was adjacent to one side. The effects of minor road traffic on the other three sides was not considered significant. For each size of park predictions were made in the centre of the square with a 90 degree angle of view of the main road due to the presence of tall buildings on each side of the square (see Figure 4). High traffic flow is assumed.

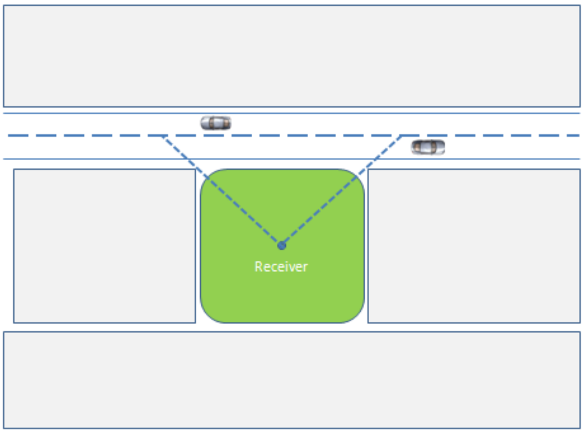

Figure 4: City square showing receiver at the centre with 90 degree view of main road due to tall buildings

2. A park adjacent to a main road where the effect of distance from the kerb was examined and screening of the road and buildings opposite was studied (see Figure 5). It was assumed that the road is very long so the angle subtended by the road is approximately 180 degrees. High flow conditions were assumed.

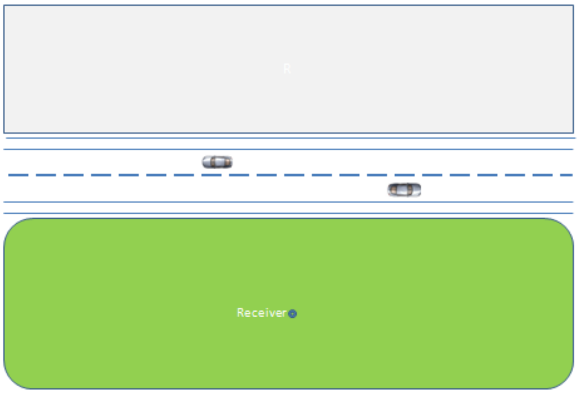

Figure 5: Park adjacent to long straight road with receiver placed at different distances from road

3. Similar to scenario 2 except a 4m high barrier is used to screen the road (see Figure 6) from a garden. The barrier is either "natural" or "manufactured". Examples of the former type are earth banks, barriers constructed from growing willow or dead woven willow covered with growing ivy or simply a manufactured barrier screened from view with vegetation. Examples of a range of such natural barriers are described in reference [20]. Examples of manufactured barriers would be those fabricated from metal, plastic or timber planking. In both cases the barrier is placed at a distance of 4m from the kerb. Again the effects of distance are examined and the presence of a line of residential buildings 10m high and 10m behind the receiver is in addition assessed.

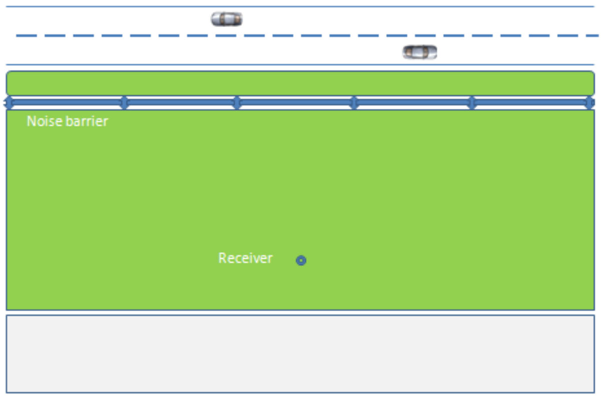

Figure 6: Garden behind noise barrier with effects of 10m high building facades behind the receiver examined

4. In this scenario (see Figure 7) a residential road has tall hedges/row of trees near the front gardens (6m deep) adjacent to the pavement (2m wide) so that the 10m high facades on both sides of the road are wholly or partially screened from view. This represents an avenue and is compared with the situation where there is no screening. The receiver is 1m from the kerb. Because of low traffic flow, average L_{day} values of 45 and 55dB(A) were assumed in calculations to cover a range of typical measured values. Unlike the other scenarios, the effect of distance from the traffic noise source on *TR* is not examined as the aim here is to model a typical residential street.

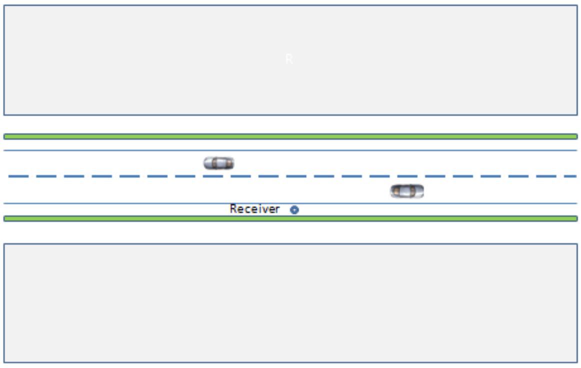

Figure 7: Effects of screening facades 10m tall on both sides of a residential road with vegetation in front gardens adjacent to the pavement

Note that in all these scenarios it is assumed that the screening vegetation has an insignificant effect on noise levels. Usually wide belts of dense vegetation (e.g. 30m) are required to achieve significant reductions in traffic noise of several decibels when compared with the typical grassland assumed in these scenarios [21].

2.2. Noise predictions

Noise predictions of $L_{A10,18hr}$ were carried out using the UK traffic noise prediction method "Calculation of Road Traffic Noise" [16] and subsequently converted into L_{day} [17]. Typical traffic flows and compositions were assumed to cover main road situations. For this purpose a two way flow of 1200 veh/hr with 10% heavy vehicles was assumed. Note that because the noise model includes a distance term then *TR* calculations using TRAPT will consequently reflect the effects of distance. For residential streets average spot readings of L_{Aeq} measured over 1 minute periods along typical urban road were used since predictions under low flow conditions common in suburban areas are inaccurate. These were based on previous surveys of traffic volumes on radial routes and measurements on residential roads in the cities of Bradford and Guildford in the UK. A hard bituminous surface for these roads was also assumed and the speed limit in all cases was 30mile/hr (48km/h). The road width in all scenarios was assumed to be 8m. The receiver height for prediction purposes was 1.5m which is similar to the average ear height of a standing adult [18].

2.3. Percentage of natural and contextual features

As in previous studies in order to calculate the percentage of natural and contextual features an eye height of 1.5m was also assumed (similar to the average ear height). The field of view was restricted in the vertical plane to ± 20 degrees. This was approximately the angle of view using a standard camera lens and relates well to studies of the eye's central field of view i.e. the angle over which objects can be recalled without moving the eyes [19]. In the horizontal plane calculations were made over 360 degrees in the simulated environments as it is assumed that the observer would make scanning movements in the horizontal plane to take in the full scene. These assumptions were made in earlier surveys which found a close relationship between predicted tranquillity using such a measure and average ratings given by participants visiting a variety of open spaces [12].

Calculations were made of the variable *NCF* at 5 degree intervals over 360 degrees in the horizontal plane and the average value taken. The value *NCF* is given by:

$$NCF = \frac{\sum_{\theta=0}^{N} \frac{An_\theta \cdot 100}{(At_\theta)}}{N} \qquad (2)$$

Where An_θ and At_θ are the angles in the vertical plane subtended by natural features and total angle excluding sky respectively, at angle θ measured in the horizontal plane. Note that as distance is changed this will necessary affect the angles of objects observed at the receiver and this is taken into account in the calculations below and will consequently affect the *TR* values predicted from TRAPT.

A further consideration is that in all the calculations below it was assumed for simplicity that there were no water sounds audible or litter or graffiti visible. Thus, the moderating factor *MF* was set to zero.

3. Results

3.1 Scenario 1

Figure 8 shows the effects of area on the predicted tranquillity rating. Two plots show the effects of different levels of *NCF* i.e. 0% and 100%. In the case of 0% it is assumed that the ground is hard and in the case of *NCF* = 100% the squares are grass covered with trees and hedges screening façades at the park boundary and consequently soft ground corrections are applied in these cases [16].

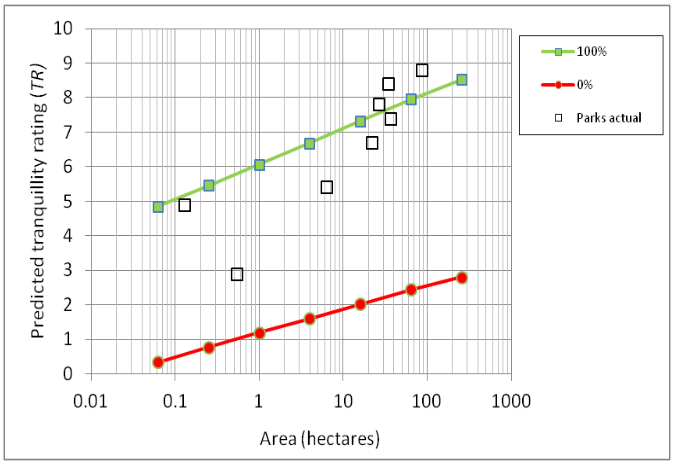

Figure 8: Predicted Tranquillity Rating (TR) at the centre of city squares of different areas

Also plotted are average tranquility ratings given by park visitors from surveys carried out in 8 parks of different sizes in the Bradford metropolitan area [12]. It can be seen that with full screening of surrounding buildings a small square of side 32m (0.1 hectares) is predicted to have a tranquillity rating of 5. From previous studies this is considered ("just acceptable"). However, with no screening and an acoustically hard surface (e.g. paving stones with no vegetation) the rating would be close to zero. A much larger square of side 1km (100 hectares) would produce an "excellent" *TR* of 8 at its centre if buildings on the perimeter were screened and ground was grass covered. However, with a hard surface and no screening it is predicted that the *TR* would remain low at <3 over the range of distances examined. Note that for the parks sampled in the park surveys [12] there was a tendency for *TR* for the smaller parks to be below predictions based on *NCF* = 100% and approaching that for *NCF* = 0%. This was due to tendency for smaller parks in the sample to have little screening with few trees or hedges whereas the larger parks were not simply grass covered but had an abundance of shrubs and trees that effectively screened buildings and roads at the boundary.

3.2 Scenario 2

Figure 9 shows the effects of distance from a long straight road where the ground is grass covered and the road and adjacent buildings are screened by vegetation. Also shown is the case with a hard surface and unscreened buildings.

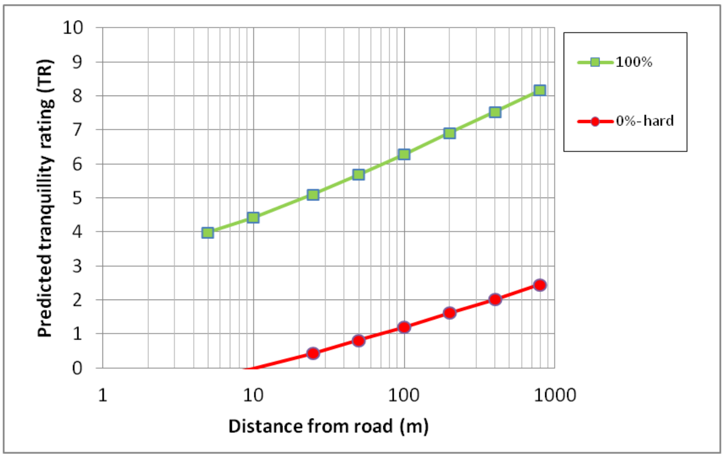

Figure 9: The effects of distance from a main road on Tranquillity Rating (TR) under two conditions

In the case with grass covered ground and screened road and buildings it is predicted that at a distance from the kerb of 20m a "just acceptable" *TR* value of 5 is achieved. To obtain a *TR* value of 8 ("excellent") it is estimated that a distance of approximately 800m from the road is required. Without screening and with a hard surface it is not possible to achieve a *TR* of 5 even at a distance of 800m. In fact at that distance the predicted *TR* value is only 2.5.

3.3 Scenario 3

Figure 10 shows the effects of introducing a 4m high noise barrier alongside the main road described above. In the first case the barrier is assumed to be a natural barrier (or a manufactured barrier screened from view with vegetation). Examples of natural barriers for transportation noise control have been described previously [20]

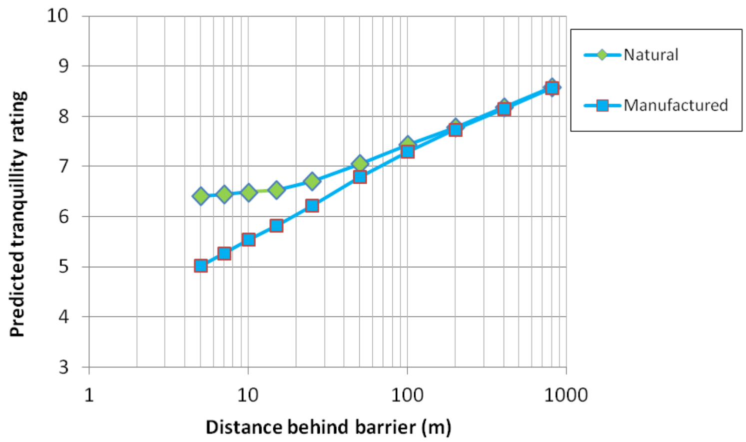

Figure 10: Variation of predicted Tranquillity Rating (TR) with distance behind a 4m high barrier with natural and manufactured barriers

In the second case the barrier is manufactured and is unscreened. There is a 1.5 scale point difference at 5m but beyond 25 m the difference is less than 0.5 units due to the fact that the visual angle subtended by the barrier at the receiver position becomes insignificant. In both cases the *TR* values are ≥5 for the distances examined.

Figure 11 examines a related case with a manufactured barrier but with the addition of unscreened building facades behind the receiver.

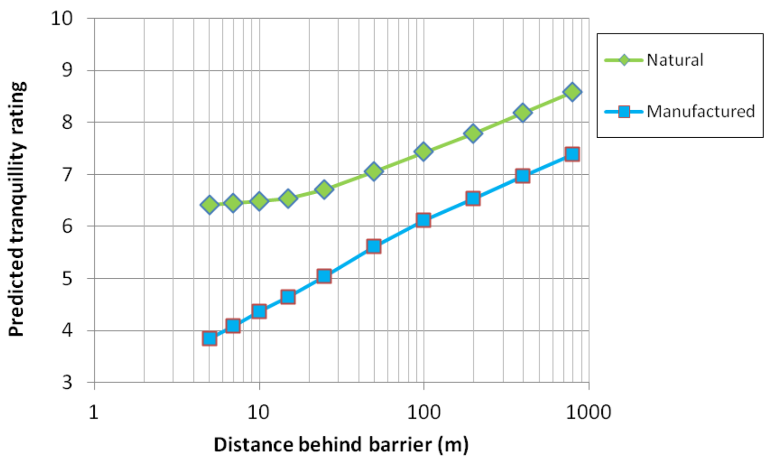

Figure 11: Predicted Tranquillity Rating (TR) as a function of distance behind a 4m high barrier with natural barrier and screened façades behind the receiver compared with a manufactured barrier aand unscreened façades

It can be seen that close to the barrier (i.e. 5m) there is now a larger difference of 2.5 units between *TR* values predicted for natural and manufactured barriers. Beyond this distance there are smaller differences but there is always at least a 1 unit difference. The natural barrier provides “fairly good” to “very good” tranquillity ratings at all distances examined if buildings behind are fully screened from view with vegetation.

3.4 Scenario 4

In this cases the effects of distance were not examined as the scenarios envisage residential buildings relatively close to the road. However, different levels of visual screening were assumed as number of trees or shrubs considered acceptable would vary depending on circumstance. In these cases low flow conditions were assumed and appropriate values of L_{day} of 45 and 55 dB(A) were employed. Figure 12 shows the variation in *TR* values with both degree of visual screening and average noise level.

It can be seen that "greening" these residential streets can have a very beneficial effect on tranquillity under both high and low noise assumptions. Under the assumption of the lower noise level and *NCF*=50% a *TR* value of value of 6.0 ("fairly good") is achieved which rises to 8.1 (excellent) when *NCF*=100%. With no "greening" *TR* value is quite low at 4 ("unacceptable"). With the higher noise level *TR* values varied from 2.5.to 6.6 so that even with these more onerous assumption regarding traffic noise it was possible to reach a *TR* value in the "fairly good" category .

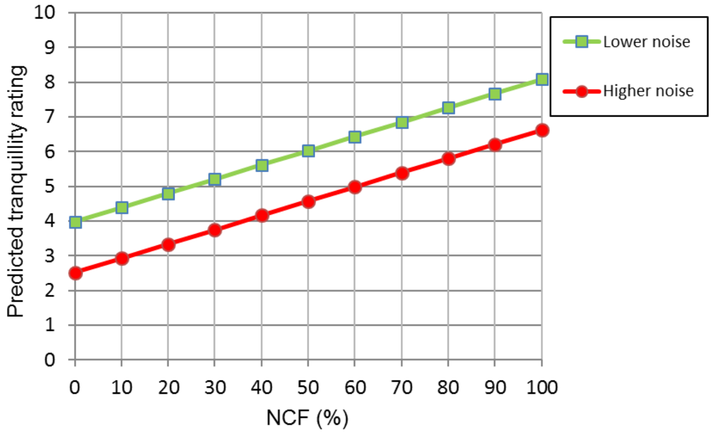

Figure 12: Predicted Tranquillity Rating (TR) as a function of the percentage of Natural and Contextual Features (NCF) with assumed range of noise levels in a residential street

4. Summary and conclusions

There is abundant evidence in the literature that tranquil environments can provide relief from stresses of everyday of life and can be considered restorative environments. For example, it has been established that tranquillity levels relate well to a measure of well-being such as state of relaxation [12]. The prediction tool (TRAPT) has been used to make estimates of the benefits of "greening" in terms of perceived tranquillity. The tool has been validated by relating *TR* predictions in green spaces with average ratings obtained from visitors [12]. It was found that there was a good correlation between these two sets of values r = 0.94 (p < 0.001) indicating that the tool can be used with some confidence. The effects on predicted perceived tranquillity of town squares, city parks alongside major toads and residential roads and gardens under varying conditions have all been examined. This illustrates the approach that can be taken by concerned groups such as planners, environmentalists, civic leader and citizens in order to determine changes in tranquillity levels brought about by various interventions both positive and negative.

It is clear that visual screening of buildings with vegetation, noise reduction through the use of soft ground (e.g. grassy areas) and sufficient distance from the major road can all be used to obtain substantial benefits. One large effect of greening on predicted tranquillity was found to be in city squares that were surrounded by buildings with a major road adjacent to one side. Excellent *TR* results were predicted at the centre of a large grass covered square of side 1 km (100 hectares) with visual screening of buildings at the boundary. Even a small square of side 32m (0.1 hectares) is predicted to have a "just acceptable" rating. However the situation is significantly different if hard ground is assumed e.g. paving or asphalt surface and where there is no visual screening of buildings. In this case the range of *TR* values is not predicted to exceed 5 ("just acceptable") even for the largest square of side 1600m (256 hectares).

Another case where large benefits of greening were predicted was for a park alongside a long straight main road with buildings on the farside. When these were fully screened from view it was shown that with grass covered ground a distance from the road of just 25m is required before *TR* values are "just acceptable". At a distance of 800m the *TR* value reaches "excellent". In contrast where there is no visual screening of buildings and the ground is acoustically hard the *TR* value is not predicted to be "just acceptable" even at the large distance of 800m. Note that where a natural noise barrier (or manufactured barrier screened from view with vegetation) was introduced into this situation tranquillity ratings were increased substantially and were predicted to be “fairly good” even at the closest distance of 5m behind the barrier. At a distance of only 300m the *TR* value was “excellent”.

Similar benefits from greening emerged for other scenarios i.e. adjacent to residential roads with both lower and higher traffic noise levels. With lower traffic noise a predicted *TR* value of >8 was found where a 100% visual screening of buildings was achieved. Even with a more likely screening of 50% the *TR* value reached 6.0 (“quite good”). It is interesting to note that these benefits are reflected in the distribution of greened spaces in different types of neighbourhoods. For example, it has been shown that people with higher incomes tend to live in places with more street greenery [22]. An explanation is that greater income can allow the purchase of larger residential plots with the associated larger scope for planting of trees, shrubs and lawns with the associated benefits of higher levels of tranquillity. It can be observed that estate agents frequently stress such advantages in their promotional material. In this respect policies to green public spaces where there is little scope in private residences due to small or non-existent gardens could bring well-being and perhaps health benefits to the inhabitants. Local government policies of planting avenues of trees is of course one obvious means of redressing this imbalance. In New York 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 [23]. 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. In London a charity has been set up to provide funding for a new footbridge over the Thames that will be planted as a garden with both shrubs and trees. The Garden Bridge will provide a tranquil space for thousands of residents and tourists [24].

To realise the full potential of greened open spaces it is important to consider them as an important resource in the urban environment and to promote their use if it is considered the numbers using them is relatively low. Some clearly need improvement because of the amount of litter and graffiti present and this has been shown to lower levels of tranquillity and has the potential to deter visitors. Large crowds or high densities of people are also likely to have a detrimental effect on *TR* values due to increased noise and possibly perceived threat due to invasion of personal space. However, in many cases this is likely to be a transient event in any given green space occurring only at certain times of the day or coinciding for example with holidays or staged events. Further work is required to elucidate these possible links between people density and *TR* values.

Tranquillity Trails (TTs) are a means of encouraging urban dwellers to visit tranquil spaces using relatively quiet paths, lanes, roads [25]. As well as aiding relaxation and reducing stress the physical exercise of completing should contribute to health and well-being. In previous studies TRAPT has been used to identify tranquil spaces and quiet links to provide circular urban walking routes Three TTs designed for contrasting areas have been described and then predictions of *TR* have been made along these widely different walking routes. The *TR* profiles of the TTs have then be compared and contrasted by examining the percentage of time a walker would spend experiencing the different levels of *TR* described above. Feedback using a self-completion questionnaire from users of one TT showed that overall, well over half those completing the route experienced were relaxation and reported reduced anxiety [25]. All these TTs are available in paper form from the relevant Tourist Information Centre and on-line as a downloadable pdf file. One is also available as a mobile phone app that can guide the walker around the route and provide interesting nature notes and historical information at key points on the route.

Finally, the “greening” of urban areas should for completeness also include interior spaces where many people spend a large percentage of their lives. Preliminary studies into this aspect that was informed by TRAPT have been completed in a health care facility where the aim was to improve levels of tranquility, relaxation and anxiety in a waiting room. Significant benefits were achieved by replacing a radio playing popular music with recordings of natural sounds (small waves breaking on a shingle beach) and by using the large notice boards to display high quality nature scenes (coastal scenes, views of lake with mountains beyond and park with an abundance of spring flowers) [26]. Further studies are being considered for other health care facilities and office environments.

Acknowledgement

This project has been funded by the Bradford Centre for Sustainable Environments in the Faculty of Engineering and Informatics at the University of Bradford.

References

[1] Forest Research. Benefits of green infrastructure, Report by Forest Research. Forest Research, Farnham, UK, 2010.
[2] Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. Stress recovery during exposure to natural and urban environments. J Environ Psychol 1991;11:201–30.
[3] Takano T, Nakamura K, Watanabe M. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. J Epidemiol Commun Health 2002;56:913–8.
[4] Grahn P, Stigsdotter UA. Landscape planning and stress. Urban Forest Urban Greening 2003;2:001–18.
[5] Lechtzin N, Busse AM, Smith MT, Grossman S, Nesbit S, Diette GB. A randomized trial of nature scenery and sounds versus urban scenery and sounds to reduce pain in adults undergoing bone marrow aspirate and biopsy. J Altern Complem Med 2010;16(9):965–72.
[6] Hunter MD, Eickhoff SB, Pheasant RJ, Douglas MJ, Watts GR, Farrow TFD, et al. The state of tranquility: subjective perception is shaped by contextual modulation of auditory connectivity. Neuroimage 2010;53(2):611–8.
[7] Van den Berg M, Wendel-Vos W, van Poppela M, Kempera H, van Mechelena W, Maas J. Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. Urban Forestry & Urban Greening, 14(4), 2015, 806–816.
[8] Watts GR, Pheasant RJ, Tranquillity in the Scottish Highlands and Dartmoor National Park – The importance of soundscapes and emotional factors. Applied Acoustics 89, 2015, 297-305.
[9] Lam KC, Chau KC and Chan PK. Characterizing natural soundscapes and understanding human response to human-caused noise in a Hong Kong country park. Proc. 153rd Meeting of Acoustical Society of America, Salt Lake City, Utah: USA, June 2007.
[10] Pheasant RJ, Horoshenkov KV, Watts GR, Barrett B. The acoustic and visual factors affecting the construction of tranquil spaces in urban and rural environments. Journal of the Acoustical Society of America, 123 (3), 2008, 1446-1457.
[11] Pheasant RJ, Horoshenkov KV, Watts GR. Tranquillity rating prediction tool (TRAPT). Acoustics Bulletin November/December, 2010, 18-24.
[12] Watts GR, Miah A, Pheasant RJ. Tranquillity and soundscapes in urban green spaces - predicted and actual assessments from a questionnaire survey. Environment and Planning B: Planning and Design 40(1), 2013, 170–82.
[13] Watts GR, Pheasant RJ, Horoshenkov KV. Validation of tranquillity rating method. Proc. Institute of Acoustics and Belgium Acoustical Society, Noise in the Built Environment, Ghent, April 2010.
[14] Watts GR, Pheasant RJ, Horoshenkov, KV and Ragonesi L, 2009. Measurement and subjective assessment of water generated sounds, Acta Acustica with Acustica 95, 2009,1032-1039.
[15] Watts GR, Pheasant RJ, Horoshenkov KV. Predicting perceived tranquillity in urban parks and open spaces. Environment and Planning B: planning and design, 38 (4), 2011,585-594.
[16] Department of Transport and Welsh office: Calculation of Road Traffic Noise. HMSO, London, 1988.
[17] Abbott PG, Nelson PM. Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping. Project Report PR/SE/451/02, TRL Ltd, Wokingham, UK, 2002.
[18] Ergotron. Ergonomics data – mounting heights, 2017a, https://odm.ergotron.com/Portals/0/literature/whitePapers/english/ergonomics_arms_data.pdf
[19] Cambridge in colour, Camera vs. the human eye, 2017b, http://www.cambridgeincolour.com/tutorials/cameras-vs-human-eye.htm
[20] Watts GR, Pheasant RJ and Horoshenkov KV. Towards "natural" noise mitigation for surface transport. New Zealand Acoustics 24 (1), 2011, 13-19.

[21] Huddart L. The use of vegetation for traffic noise screening. Research Report RR238, TRL Ltd, Wokingham, UK, 2002.
[22] Lia X,JA Zhanga C, Lia W, Kuzovkinab JA, Weinera D. Who lives in greener neighborhoods? The distribution of street greenery and its association with residents' socioeconomic conditions in Hartford, Connecticut, USA. Urban Forestry & Urban Greening. 14(4), 2015, 751–759.
[23] Schwartz M. Urban planning needs green rethink. BBC, April 2008, http://news.bbc.co.uk/1/hi/sci/tech/7372184.stm
[24] Garden Bridge Trust, 2017, https://www.gardenbridge.london/
[25] Watts GR. Tranquillity in the city - building resilience through identifying, designing, promoting and linking restorative outdoor environments. Proceedings of Acoustics'17, Acoustical Society of America, 2017, Boston, USA, June 2017.
[26] Watts GR, Khan A and Pheasant RJ. Influence of soundscape and interior design on anxiety and perceived tranquillity of patients in a healthcare setting. Applied Acoustics. 104, 2016, 135-141.