Environmental Research and Consultancy Department

Civil Aviation Authority

ERCD REPORT 1207

Tranquillity: An overview

K Jones

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Summary

This report aims to provide an overview of the current area and state of knowledge of tranquillity and tranquil spaces within the UK. It forms part of the CAA's activity to support the Department for Transport's objective that the Directorate of Airspace Policy should pursue policies that will help to preserve the tranquillity of the countryside. This overview provides a summary of key research into tranquillity with special attention to aviation.

June 2012

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Glossary of Terms

A-weighting A frequency weighting that is applied to the electrical signal within a noise-measuring instrument as a way of simulating the way the human ear responds to a range of acoustic frequencies.

dB Decibel units describing sound level or changes of sound level.

dBA Levels on a decibel scale of noise measured using a frequency dependent weighting, which approximates the characteristics of human hearing. These are referred to as A-weighted sound levels.

L_A The A-weighted sound level (in dBA).

L_{Amax} The maximum A-weighted sound level (in dBA) measured during an aircraft fly-by.

L_{eq} Equivalent sound level of aircraft noise, often called equivalent continuous sound level. L_{eq} is most often measured on the A-weighted scale, giving the abbreviation L_{Aeq}.

L_{den} Equivalent sound level of aircraft noise in dBA for the 24-hour annual day, evening, and night where the evening movements are weighted by 5 dB and night movements are weighted by 10 dB.

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1 Introduction

1.1 This report aims to provide an overview of the current area and state of knowledge of tranquillity and tranquil spaces within the UK. The paper will aim to describe the importance of tranquillity for health and wellbeing, how tranquil spaces play a role in the tourist industry and economy, the methodology implemented for measurement and mapping of tranquillity, how possible threats may impact the tranquil environment, and how may be the best ways to protect tranquillity in the UK. The paper has resulted from technical meetings with key stakeholders with the aim of exchanging knowledge on tranquillity and its measurement. Such stakeholders include:

- Campaign to Protect Rural England;
- Natural England;
- National Association of AONBs;
- Aviation Environmental Federation;
- National Trust; and
- NATS.

2 What is Tranquillity?

2.1 Tranquillity is defined as 'the quality or state of being tranquil; calmness; serenity, a disposition free from stress or emotion and a state of peace and quiet'. It is also described as an untroubled state, free from disturbances. The interpretation of tranquillity is often linked to engagement with the natural environment, which is the understanding of the term that will be concentrated on for the purpose of this paper. Tranquillity can be defined as 'a sense of calm or quietude' – this is the definition employed by the CAA (CAA, 2007). The Campaign to Protect Rural England (CPRE) explain that tranquil areas provide a means to escape the stress of built-up cities and towns due to the absence of intrusive man-made structures and noise that natural environments and areas offer. CPRE has defined tranquillity as 'the quality of calm experienced in places with mainly natural features and activities, free from disturbance from manmade ones' (CPRE, 2006).

3 The Importance of Tranquillity

3.1 It is accepted that the need to escape and 'get away from it all' can be very therapeutic in terms of reducing stress and improving feelings of calmness and wellbeing. There has been convincing evidence that there is an important link between natural spaces and improved mental health and children's development. There is evidence to suggest that exposure to the natural environment can contribute to both physical and psychological wellbeing. Others report that natural tranquil surroundings have profound physiological effects on people suffering from stress. For example Ullrich (1991) found that stress (as measured by blood pressure, muscle tension and skin conductance response), induced by showing videos of workplace

injuries, improved significantly quicker following further viewing if videos included natural surroundings rather than busy traffic or shopping scenes. A recent study has demonstrated the benefits of simulating such environments for pain relief during bone marrow aspirate and biopsy.

3.2 The Campaign to Protect Rural England (CPRE) highlights the importance of tranquil areas, and the need to protect them from future threats. Exposure to nature has been shown to reduce blood pressure, reduce heart attacks, increase mental performance and soothe anxiety. Studies have found that playing in nature has a positive impact on children's development. And children who visit the countryside are less likely to be obese.

3.3 There is convincing evidence of the importance of the natural environment in helping people to recover from stress. A recent review of over 100 studies shows that the primary reasons for visiting natural environments include escape from the stress of urban areas and the experience of tranquillity and solitude.

4 Economic factors

4.1 Seeking tranquillity is an important reason why many people visit the countryside, the presence of tranquil areas helps boost rural tourism. Since rural tourism in the UK directly supports 380,000 jobs and £13.8 billion annually to the economy, and a recent survey showed that tranquillity is the main reason why 49% of visitors go are attracted to the countryside, one can conclude that tranquillity is worth 186,200 jobs and £6.76 billion a year to the economy.

4.2 Total spending by all visitors to the countryside is estimated to be around £11.5 billion in 1998, of which 77% is associated with day visitors from home, 17% with UK holiday makers and 6% with overseas tourists. Total employment directly supported by recreation and leisure visitor activity in the countryside is estimated to amount to 290,000 jobs in 1998 and a further 50,000 indirectly in other sectors of the rural economy (DEFRA, 2000).

5 History of Tranquillity Research

5.1 There is a wealth of literature concerning soundscapes and tranquillity. It is not the aim of this report to include every published paper, and the work that is referred to is considered pertinent to current tranquillity issues within the UK. It should be noted that reference is made to research conducted outside of the UK, although such research is deemed of interest to the area of tranquillity as a whole.

5.2 The Rural White Paper 'Our Countryside: The Future – A fair deal for Natural England' (DEFRA, 2000) states that it is not 'just the physical features which gives the countryside its unique character; there are also less tangible features such as tranquillity and lack of noise and visual intrusion, dark skies and remoteness from the visible impact of civilisation'. The white paper states that our most valuable landscapes have long been designated as national parks and areas of outstanding natural beauty (AONB). National parks cover 10.7% of the land area of England, including the South Downs, which has recently been given National Park status in April 2011. There are 37 AONBs in England, covering some 15.6% of the country.

The paper proposed that the countryside should be protected and enhanced, in particular with respect to biodiversity, tranquillity, heritage and landscape character.

5.3 In its guidance to the CAA (DTLR, 2002) the Department for Transport (DfT) states that there is no legislation or guidance that precludes over-flights of national parks or AONBs as this would be impractical. It goes on to state that Government policy will continue to focus on minimising over flight of more densely populated areas below 7,000 feet. However, where it is possible to avoid over flight of national parks and AONBs below this altitude without adding to the environmental burdens on more densely populated areas, it clearly makes sense to do so. The Director of Airspace Policy is encouraged to pursue policies that will help to preserve the tranquillity of the countryside where this does not increase significantly the environmental burdens on densely populated areas.

5.4 In 2004 the Countryside Agency used a method called Participatory Appraisal (PA) consultation, with the aim of gaining a broader understanding of tranquillity and why it is important. The study was conducted in the North East of the UK, in Northumberland National Park and West Durham Coalfield, before being extended to the Chilterns. The reasoning for using PA was that it allows participants the freedom to express their responses in their own words, without traditional directional questioning, using visual tools such as maps, spider diagrams and charts to produce flexible responses that are uniquely personal to each respondent. Key local stakeholders from industries such as tourism, conservation, heritage and local government were invited to take part, along with members of the general public that use the countryside. One of the aims was to try and establish a consensus as to what is meant by the term 'tranquillity'. There was a large and wide range of responses linking tranquillity to aspects of perceived 'nature'. Such links included aural and visual aspects, for example the importance of 'natural sounds', such as 'hearing wildlife' or 'wind rustling through trees'. For many people, experiencing the landscape and scenery was an important aspect of defining tranquillity, including large scale elements such as rolling hills, or the sea, from more specific details such as beautiful flora and fauna. Again, the importance of sound was highlighted, with running water being given a high degree of importance, and also colours often being described, such as 'plenty of greenery' and 'natural colours' as being strongly linked to perception of tranquil areas.

5.5 Tranquillity as a state of mind was often given a high degree of response, with feelings of peace and quiet, calmness and feeling at ease all cited as important aspects, along with solitude being often mentioned. The question 'what is not tranquillity' was also addressed, with the responses highlighting the presence of too many people, visual and noise disturbance and general development all being given as perceived elements that would constitute a non-tranquil area.

5.6 It was concluded that there was a general degree of agreement between respondents, and that when considering tranquil areas in terms of policies and reviews, the element of experience should also be included alongside more objective measures.

5.7 Natural England commissioned a report in 2009 entitled Experiencing Landscapes: capturing the cultural services and experiential qualities of landscape. The work was conducted, in part, to prepare for the updating of England's 159 National Character Area (NCA) descriptions. The aim of the study was to assess the range of services that England's landscapes provide. These include the improvement in quality of life, ranging from spiritual enrichment, cognitive development, reflection, recreation and aesthetic enjoyment. The study set out to investigate whether such services relate to

particular landscape characteristics or features. No attempt was made to assess the economic valuation of cultural services provided by the landscapes.

5.8 The study comprised two phases; the first being a comprehensive literature review, followed by a qualitative social research programme with representative members of the public. The research was conducted in 8 NCAs across England and included a mix of landscape status. Participants came from varying socio-economic backgrounds, both genders and different age groups and included people living in, working in or using the area concerned. The eight cultural services examined included:

- A sense of history (or heritage)
- A sense of place (identity; home)
- Inspiration (stimulus)
- Calm (relaxation; tranquillity)
- Leisure activities (recreation)
- Spiritual
- Learning (education)
- Escaping (getting away from it all)

5.9 The responses from participants were grouped into five sections: general landscape experiences; findings that are cultural service specific; findings relating to features in the landscape; issues specific to NCAs; and attitudes to other landscape issues such as 'variety and simplicity' and 'openness and enclosure'. The study report discusses each section in detail, but the main points of discussion can be summarised as follows.

5.10 The study confirmed the importance of landscape to people and the wide range of services that it provides. Landscapes were found to provide a wide range of interlinked cultural services that are valued for their contribution to well-being and quality of life. In addition to the eight cultural services listed, the responses uncovered other services such as health and exercise, stress-relief, quality time and relationships.

5.11 With respect to location, the study suggests that landscape features will deliver the same range of services regardless of where they are in the UK. Findings suggest, however, that the setting is important in terms of perception, and may affect the level of service delivery, and may also affect the nature and intensity of service provision.

5.12 The study concluded that all landscapes matter, including local unremarkable ones and people will seek out different landscapes for different purposes and to fulfill different needs.

5.13 Natural England is conducting an integrated monitoring system entitled CQuEL (Character and Quality of England's Landscapes). The purpose of the study is to gain evidence regarding the character and function of landscapes and the quality of

ecosystem services provided by England's natural environment. The work will provide an understanding of Natural England's contribution to the improvement of the natural environment. It is expected that the study will be completed by mid-2012, with an updated review of landscape and ecosystem service trends.

5.14 UK researchers recently published the results (Pheasant et al, 2008) of a study of visual and auditory stimuli in open spaces and how they interact in the perception of tranquillity. This study proposes a measure of tranquillity based on a combination of the noise levels and proportion of natural features. The study proposed formulae for a tranquillity rating being a linear combination of proportion of natural features and noise level measured using either equivalent continuous sound level (L_{eq}) or maximum sound level (L_{max}) as appropriate.

5.15 In 2009 the same researchers at the University of Bradford in the UK published a paper concerning the validation of the tranquillity rating prediction tool. The background to the development of the tool was that in the Government's Rural White paper (2000) tranquillity is given as an important element, with the acknowledgement that tranquillity and a lack of noise and visual intrusion are key factors that contribute to the make-up of the British countryside. Due to previous attempts at quantifying tranquillity in terms of distance away from urban development, noise intrusion and manmade structures, it is explained that although it is often assumed that tranquil areas are only to be located in rural England, this incorrectly excludes the 27,000 parks and public gardens which are within some of Britain's largest towns and cities. It is argued that such 'restorative urban environments' are more important for well-being because they enable people to easily escape the stresses of modern living and provide a place that in conducive to rest and reflection. Such stresses are concentrated predominantly in urban areas where the population is involved in wealth creation, service and voluntary sectors. The concept of 'soft fascination' is defined by the balance between aspects that stimulate interest and also allow a calm neutral environment to encourage and allow people to reflect, relax and recuperate. In contrast, directed attention requires a significant degree of concentration, understanding and mental effort, which can lead to fatigue, the inability to absorb information and have a negative impact on individual performance. Bearing in mind the identified and perceived benefits of 'soft fascination', it is desirable, if not essential, that planning and regeneration strategies and processes should allow for the maintenance of existing, and creation of further tranquil areas.

5.16 The aim of the study was to obtain validation of a tranquillity rating prediction tool that can be used in both urban and rural environments. Participants made subjective assessments of perceived tranquillity of different environments in a psycho-acoustic suite. This was in response to audio only, video only and combined audio-video stimuli. By reconciling the mean subjective tranquillity rating (TR) for each location, it was possible to develop a model of responses through the production of linear equations:

$$TR = 13.93 - 0.165LA_{max} + 0.024\ NF \qquad (1)$$

$$TR = 8.57 - 0.11LA_{eq} + 0.036\ NF \qquad (2)$$

5.17 Where LA_{max} is the maximum A-weighted sound pressure level, NF is the percentage of natural features contained within a scene and LA_{eq} is the continuous A-weighted sound pressure level.

5.18 Nine sets of data were recorded at three different locations; city centre garden, a large urban park, and a 12th Century rural churchyard. The three environments

largely fell into LA_{max} 55-65 dBA, 65-75 dBA and 75-85 dBA respectively, and between them they contained 20 -100% natural features. These environments cover some of the gaps in the original dataset used to develop the original model in terms of the acoustic dynamic range and proportion of natural features present within the landscape. Dynamic range of LA_{eq} was 53-74dB, with three 120 degree video clips filmed, enabling participants to experience three contrasting visual environments and for each location that contained differing, although very similar, soundscapes. A control environment was also included. Eighteen participants were included, (9 female and 9 male), with an average age of 30.5 years, and each location was scored on a scale of 0-10, with 0 representing 'not at all tranquil' and 10 representing 'most tranquil'. Participants were told to that a tranquil environment was one that they should consider to be quiet, a peaceful place to be i.e. to get away from everyday life. Following the rankings, they were asked to complete a questionnaire on how strongly certain factors influenced their subjective assessments.

5.19 The percentage of natural features versus man-made features was mapped objectively in the laboratory by overlaying a 10x10 grid at three points during the 32 second recordings, and measuring the composition of the scene. A further objective measure assessed was the affect that cultural and contextual features had on the perception of tranquillity. This was entitled 'Natural and Contextual Factors' (NCF), and included a range of man-made features that directly contributed to the overall visual context of the environment. These included, for example, listed buildings, religious and historic buildings, landmarks, monuments and man-made elements of the landscape that are in keeping with the tranquil environments. Measurements of LA_{max}, LA_{min}, LA_{eq}, LA_{10}, LA_{50} and LA_{90} were obtained for each condition.

5.20 The results suggested that the weighted mean Tranquillity Ratings related most with the equation 2 described above, but the model could be further improved by replacing the Natural Features variable with the new NCF variable, which can therefore allow for factors such as historic features to be included. The authors discuss that support for this theory has been suggested by Herzog et al (1992) who claimed that optimum 'tranquil space' is characterised by five main visual descriptors;

1. Mystery (relating to how much a location promises more to be seen if you were to walk into it)
2. Focus (the extent to which a setting contains one or more focus points)
3. Coherence, (linked to context, and ease of the person to organise the components of a scene)
4. Unstructured openness
5. Surface calmness

5.21 The conversion to NCF allows for more accurate tranquillity assessments to be made in areas with low levels of vegetation, but high levels of cultural and historic value (for example churches). The results also suggested that the variable LA_{eq} is a more robust measure to use, with the outcomes of multiple regression analysis showing a high degree of correlation of LA_{eq} and NCF as $R2 = 0.86$, with coefficients both being statistically significant at $p = 0.03$ and 0.04 respectively. When LA_{max} was tested, no significant correlation was found.

5.22 The study concludes with the recommendation that the tranquillity raring prediction tool is a robust method of assessing tranquillity, with the improvement of changing

the sound metric to LA_{eq} in preference to LA_{max}, and the inclusion of NCF rather than the previous NF variable. There are plans to further investigate these results in more extensive studies, but the outcome is thought to be of interest to those bodies responsible for land management such as National Park Authorities, local government and other agencies.

5.23 Watts has recently presented a conference paper at Internoise 2010, which has the updated formula to include NCF:

$$TR = 9.68 + 0.041\ NCF - 0.146\ LA_{eq}$$

5.24 Where TR is the tranquillity rating on a 0 to 10 ratings scale. NCF is the percentage of natural and contextual features and LA_{eq} is the equivalent constant A-weighted level. 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.

5.25 Herzog and Barnes (1999) published a paper on tranquillity and preference revisited, building on the five concepts listed above. 399 participants were asked to rate 66 colour slides of natural settings for both variables of tranquillity and preference independently, and for the five descriptor variables. Equal numbers of settings from the categories: field/forest, deserts and large waterscapes were included. The tranquillity and preference ratings were correlated in all settings, although it was possible to distinguish between both. Tranquillity ratings were higher in the field/forest and large waterscapes categories and preference was rated higher for deserts. Mystery and focus tended to be positive predictors of preference but not of tranquillity in the field/forest category, with unstructured openness was a negative predictor of preference but not of tranquillity in the field/forest setting. Surface calmness was a stronger negative predictor of preference than of tranquillity for deserts.

5.26 Following on from this Herzog and Chernick investigated tranquillity and danger in urban and natural settings in 2000. Similar in design to the previous study, 231 participants rated each of 48 colour slides, evenly divided between urban and field/forest natural settings, for only one of the five variables. The purpose was to investigate perceived tranquillity and perceived danger, the relationship between them, and to a set of three predictor variables: openness, setting care (how well cared for the given setting appeared) and nature (amount of foliage and vegetation). The main results showed that tranquillity was rated higher in natural than in urban settings, with the reverse being true for danger. Tranquillity and danger were negatively correlated across all settings, and finally the three predictor variables were generally positively related to tranquillity and negatively related to danger. In addition, the negative relationship between setting care and perceived danger was stronger for urban than for natural settings, and openness was a significant predictor of danger but not of tranquillity.

5.27 In 2007 Swedish researchers conducted a study into noise and well-being in urban residential environments, and the potential role of perceived availability to nearby green areas. A cross-sectional questionnaire-based study was performed in urban residential areas of Stockholm. 500 residents participated, 367 of which lived in dwellings with access to a quiet side (LA_{eq}, 24h ≤ 45 dB; noise/quiet condition), 133 of which had no access to a quiet side (noise/noise condition). The aim of the study was to extend current stress models to identify and include any environmental factors that may moderate transport noise exposure-effect relationship by promoting health and well being. This idea of moderating factors has been backed up by previous work, for example in 1976 when a large survey on 3,000 people in 53 residential sites of the

Greater London Council, Langdon, suggested that high neighbourhood quality in terms of attractive appearance, presence of parks and green spaces, lowered dissatisfaction with traffic noise to a significant degree. Other previous research lending support for this theory includes a review by Kaplan and Kaplan (1989), which reported that nearby trees, opportunities for gardening and places for walking (within three minutes) were important for increased satisfaction and well-being in urban residents.

5.28 The researchers in the Swedish study were trying to assess whether availability to nearby green spaces can act as a moderator and further attenuator to the adverse stress effects of noise, over and beyond the effect of access to a quiet side, which has previously been reported by the same study group. They also wanted to investigate whether the effect of green-area availability varies with the two noise conditions (quiet side versus no quiet side). The participants were all exposed to high road traffic noise exposures of $LA_{eq,\ 24h}$ = 60-68dB at the most exposed facade of the dwelling.

5.29 The results revealed that for both of the groups, better availability to nearby green areas is important for their well-being and daily behaviour by reducing the long-term noise annoyance, prevalence of stress-related psychosocial symptoms, and by increasing the use of outdoor spaces. When residents had better availability to green areas, fewer of them perceived noise as a neighbourhood problem, whereas those with poorer access more frequently reported that the noise regularly disturbs the desire to stay outdoors. Reported disturbance was approximately twice as high in residents with poorer than with better access to green areas. In addition, better availability to green areas was also associated with a higher proportion of residents walking and exercising in the neighbourhood every day or once/few times each week. The results also indicated that residents with no access to a quiet side of the dwelling benefit most by availability to green areas. The authors suggest that for planning health-promoting urban environments, it is essential to provide easy access to nearby green areas that can offer relief from environmental stress and opportunities for rest and relaxation.

5.30 In 2005 Miller produced a review of US national parks and management of park soundscapes. The review covered the main questions that need to be addressed in the management of national soundscapes, the types of noise issues that are dealt with and the various approaches used in identifying, measuring and collecting data. In terms of aircraft tours, a Public Law was passed in 1987 entitled The National Parks Overflights Act, following a mid-air collision causing 25 fatalities over the Grand Canyon in 1986. This led to a detailed design of the airspace over the Grand Canyon National Park, and ultimately the National Parks Air Tour Management Act that sets out a process Air Tour Management Plans for any park where air tours operate. Although very high numbers of passengers taking the tours report enjoying the experience and claim they allow people to view large areas in a short space of time, and are important for physically restricted people, reactions from people on the ground vary widely. In 1992 a National-Park System-wide park exit survey explored visitor awareness and reactions to aircraft sound. Thirty nine parks were surveyed in the US, between 8% and 82% reported hearing aircraft, with those who had heard aircraft noise answering questions on annoyance and interference with their appreciation of the park. The results generally increased in a dose-response relationship, with the percentage of people annoyed increasing with the percentage of people who heard aircraft. The review deals with several studies and dose-response relationships for specific sites within US national parks. Several limitations were explained, such as the specific relationships possibly being too site-specific, based on too few visitors, reflecting only visitor expectations rather than management

objectives and addressing only visitor reactions to aircraft noise. The authors conclude that despite such limitations, there is useful information to be taken, which is in summary:

- Visitor sensitivity to aircraft noise varies considerably between site;
- Visitors who take a short hike to access a more remote park location appear to be more sensitive to aircraft noise than visitors that remain at look-out points close to car parks;
- Visitors distinguish between annoyance and interference; annoyance is an emotional feeling that persists, interference is an objective term that describes something that temporarily prevents them doing what their current activity;
- Aircraft noise that interferes with appreciation of natural quiet does not always result in annoyance;
- Visitors understand the concept of 'natural quiet and the sounds of nature';
- The louder the aircraft noise with respect to background levels, the greater the percentage of visitors who feel annoyed and who feel the noise interfered with their appreciation of the sounds of nature;
- The longer aircraft noise is audible, the greater the percentage of visitors annoyed and who feel the noise interfered with their appreciation of the sounds of nature;
- Visitors who are aware of the possibility of hearing human produced sounds (of aircraft overflights) are less annoyed by those sounds than are visitors who have no knowledge beforehand.

5.31 The author stresses the importance of expectation management and how it can help reduce visitor annoyance, and that identification of different sensitivities for different areas and developing approaches to reduce both the level and duration of human-produced sounds are appropriate actions for improving the overall visitor experience.

5.32 Mace et al (1999) published the results from a study in the US into the aesthetic, affective and cognitive effects of noise on natural landscape assessment. The study focussed on helicopter noise in the Grand Canyon national park, and included 44 psychology students as participants, with a slide projector and audio playback representing the Grand Canyon. Two sound levels were examined, 40dBA and 80dBA. The slides were assessed on naturalness, preference and scenic beauty, and additional dimensions of freedom, annoyance, solitude and tranquillity. Compared to a neutral control condition of background natural sounds (for example birds or brooks) noise conditions negatively affected all of the measures. Annoyance was found to be significantly different between the two noise conditions.

5.33 Kaplan (2005) explored the components that comprise restorative environments in his paper on the restorative benefits of nature. As mentioned previously, the idea that directed attention can result in stress and needs to be mitigated somehow in order to reduce fatigue was discussed, with the ways in which natural settings are likely to meet the requirements for a restorative environment. These are given as:

1. Being away – such as the seaside, mountains, lakes, streams and forests etc. In urban settings the sense of being away does not require that the setting be distant, natural environments that are easily accessible offer an important resource for resting directed attention.

2. Fascination – soft fascination such as clouds, sunsets, snow etc that hold the attention but in an undemanding way that allows for thinking about other things.

3. Extent – even a relatively small area can provide a sense of extent, for example paths and trails. Settings that include historic buildings can promote a sense of being connected to past eras and past environments and therefore to a larger world.

4. Compatibility – the feeling that there is a special resonance between the natural setting and human inclinations, with for many people finding that functioning in the natural setting seems to require less effort than functioning in more 'civilised' settings.

5.34 Academic work on tranquillity in the United States has tended to focus on the impact of flights over national parks such as the Grand Canyon. Research (Tarrant et al, 1994) indicates that visitor evaluations of aircraft overflight are multi-dimensional. Other research (Mace et al, 1999) examined to what extent visitor evaluation was affected by the presence of aircraft noise at the Grand Canyon. It found that the three out of seven factors were strongly influenced by aircraft noise – annoyance, solitude and tranquillity.

5.35 In September 2010 a report entitled "Quietening Open Spaces – towards sustainable soundscapes for the city of London" was published by Environmental Protection UK. The report begins with a quote from the Westminster Open Spaces Report in 2009, which says:

"Tranquillity is a complex concept. It is both a state of mind as well as an indicator of environmental quality. For example, a Buddhist monk can find tranquillity in the noisiest of spaces whilst some rural households complain bitterly about noise levels taken for granted in the city."

5.36 Environmental Protection UK was commissioned by the City of London to research and summarise current best practice in protecting quiet spaces for a liveable city, and to review the methods that can be applied to open spaces in the City of London to reduce the impact of noise on users of open spaces. EPUK looked at research in the UK and beyond which:

- Assessed public perceptions of quiet or tranquil spaces

- Looks at defining and identifying quiet spaces in urban areas an 'quietening' them – either through reducing noise levels or by improving other qualities of the space to induce greater tranquillity

- Reviews current knowledge on noise management and mitigation and work on soundscape design

5.37 Research was found to be undertaken in the context of the Environmental Noise Directive, to establish definitions/descriptors for what constitutes a quiet area. Very

little work has been undertaken in practice aimed specifically at protecting or enhancing spaces, in terms of either measurable noise reduction, or perceptions of quiet or tranquillity.

5.38 The report highlights the suggestion that people's perception of the space is an important contribution, alongside simple noise levels, and summarises the findings as follows:

- Acoustic design and management should be integrated into other aspects of local environment quality. i.e. noise is just one aspect of the perception of tranquil spaces

- Measures suggested that will improve the acoustic environment have additional benefits for environmental quality, and support policies and initiatives aimed at improving the local urban environment, environmental health, and aesthetic and monetary value of an area.

- Non-acoustic measures can enhance a sense of tranquillity, including in places where noise reduction is not immediately possible.

5.39 In terms of recommendations for the open spaces in the City of London, suggestions include enhancing heritage sites and improving the quality of space to encourage exercise. Doing so, also results in compliance with the European Environmental Noise Directive, and contributes to mitigating the effects of climate change.

5.40 A recent Iranian study by Abkar et al (2010) examined the role of urban green spaces on mood change. The basis of the study was the link between nature and wellbeing, based on earlier research by Ulrich, which suggests a stress-reduction theory that exposure to natural environments leads to a decline in stress and nature of any kind is associated with relaxation. Most research has been conducted in the west, and the author of this paper was interested in Yazd city in Iran, and focused on a survey into factors stopping people visiting urban green spaces, motives for visiting them, and the perceptions of the effect of urban green spaces on mood change. The survey was conducted in a park within the city of Yazd where the landscape resembles desert. Participants (N =48) were chosen randomly from visitors to Ghadir Park, one of the city's gardens, and asked to complete a questionnaire whilst at the location. The questions related to utilisation of urban green spaces, the amount of usage of green area, and beliefs about usage and functions. 57% of people said they visited the park one a month, with 44% indicating that they visited once a year. When asked about obstacles preventing them from visiting urban green spaces more frequently, the main response was because of a busy lifestyle (53%), with the second response (43%) being that there are insufficient green spaces, particularly around residential parts. Distance to green spaces was also a common response. The main reasons for regular visitation were for relaxation, and to 'improve mentally' (46%). The response 'to get away from stressful urban environments' accounted for the next majority response, with 33% of people giving this answer. In terms of an emotional dimension, the main reactions following visitation were relaxing, feeling refreshed, calmer and better equipped to deal with worries. Physical features that were given as main contributors to emotional improvement were given as water and green space. The study concluded that urban green spaces play an important role in the regulation of mood within the residents of Yazd.

5.41 The recent publication by Kuo (2010) on behalf of the National Recreation and Park Association of America describes the importance of parks and green environments in the context of a healthy human habitat. The report examines the benefits of nature in

terms of social, psychological and physical health outcomes, and suggests that people living in areas with access to green space are more connected with others, have a greater sense of community, trust and willingness to help. Less green environments are associated with increased aggression, violence and violent crime. In terms of psychological functioning, it is reported that green environments aid cognitive behaviour, mental health outcomes and greater resilience and ability to cope with stressful events, compared to increased rates of clinical depression, anxiety and sadness in areas that have less access to green spaces. Physiologically, the benefits of nature are believed to include assistance in the recovery process following surgery, a role in supporting the immune system and the encouragement of physical activity. The report stresses that such benefits are found even when socioeconomic status is controlled for, and that the importance of green areas and parks play an important role in human health.

5.42 The University of Essex, and Mind (the leading charity for mental health in England and Wales) produced a report (Peacock et al, 2007) on the possible benefits of green exercise to people with mental illness. In this study 108 members of Mind participated and completed a questionnaire designed to measure the positive physical and mental health benefits of taking part in green exercise activities. Nearly 90% of participants stated that the combination of exercising in the presence of nature was the most influential factor in determining how they felt. Participants stated that they enjoyed being part of a group and socialising with likeminded people, felt less stressed, more alert and happier and more relaxed. Overall mood was improved along with confidence and self esteem.

The study highlighted four key reasons which people particularly enjoyed green exercise, notably:

- Natural and social connections - social (friends and family), animals and wildlife, memories and knowledge (for example childhood memories), and a spiritual dimension.
- Sensory stimulation - colours and sounds of nature, fresh air, and excitement (for example a sense of adventure).
- Activity - manual tasks and physical activity,
- Escape – sense of getting away from everyday life, peace, tranquillity and ‘clearing one’s head’,

The report includes a discussion on the methodological constraints of research into this area, which is predominantly qualitative, and the suggestion of future research into mapping available green spaces against concentration of the population who have mental illness, to investigate any correlation that may be present.

The main proposed future research directions are the valuation of the provision of green space for health, estimating the health benefits from the supply of green space relative to where people live, and enhanced monitoring and evaluation of green exercise and green care activity programmes.

5.43 In 2000 the Rural White Paper entitled The Natural Choice: securing the value of nature, was published. As part of stressing the importance of nature the main objectives to be derived from the report were:

i. the facilitation of local action to protect and improve nature

ii. creating a green economy, in which economic growth and the health of our natural resources sustain each other, and markets, business and Government better reflect the value of nature;

iii. strengthening the connections between people and nature to the benefit of both; and

iv. showing leadership in the European Union and internationally, to protect and enhance natural assets globally.

5.44 A Community Organisers scheme was established, to train in the region of 5000 people to work with local communities to help drive improvements in their area in terms of quality and quantity of green spaces.

6 Noise action plans

6.1 The European Noise Directive (Directive 2002/49/EC) relating to the assessment and management of environmental noise is being implemented in England through the Environmental Noise Regulations (2006). The regulations require that Noise Action Plans for agglomerations include provisions that protect existing quiet areas against an increase in noise.

6.2 The requirements of the directives are:

- Monitoring the environmental problem; by requiring competent authorities in Member States to draw up "strategic noise maps" for major roads, railways, airports and agglomerations, using harmonised noise indicators Lden (day-evening-night equivalent level) and Lnight (night equivalent level). These maps will be used to assess the number of people annoyed and sleep-disturbed respectively throughout Europe

- Informing and consulting the public about noise exposure, its effects, and the measures considered to address noise.

- Addressing local noise issues by requiring competent authorities to draw up action plans to reduce noise where necessary and maintain environmental noise quality where it is good. The directive does not set any limit value, nor does it prescribe the measures to be used in the action plans, which remain at the discretion of the competent authorities.

- Developing a long-term EU strategy, which includes objectives to reduce the number of people affected by noise in the longer term, and provides a framework for developing existing Community policy on noise reduction from source.

6.3 A first round agglomeration is defined as having a population in excess of 250,000, and a population density equal to or greater than 500 people per square kilometre. The results of the first round noise mapping can be found on the Department for Environment, Food and Rural Affairs (DEFRA) website http://noisemapping.defra.gov.uk

6.4 In his presentation at Euronoise (2009), Colin Grimwood from Bureau Veritas talked about the possible approaches to the protection of quiet areas during the implementation of noise action plans in England. It was explained that it has been recognised that noise is an inevitable consequence of a mature and vibrant society meaning that a balance has to be struck between the aim for noise control, the protection of Quiet Areas and many other equally valid economic, social and environmental goals. It was, therefore, decided that in England, END Noise Action Plans would be developed to assist the management of environmental noise in the context of sustainable development. This reflects an emerging National Noise Strategy for England which seeks to promote good health and a good quality of life through the management of noise within the context of sustainable development. The requirement to seek to protect Quiet Areas in agglomerations is also highlighted in the Major Roads Noise Action Plan, the Major Railways Noise Action Plan and is formally brought to the attention of airport operators in the relevant guidance document, with the aim of avoiding conflict between any element of the proposed noise management measures for major transport sources and the obligation to protect Quiet Areas in first round agglomerations. The draft Noise Action Plans noted that the protection of Quiet Areas in an agglomeration should not automatically take precedence over the protection of quiet open spaces (and other areas where environmental noise quality is good) outside an agglomeration. There is a strong argument that any policy to protect Quiet Areas should apply both inside and outside an agglomeration but this is not currently a requirement of END.

6.5 DEFRA is proposing to support further research on the identification and protection of Quiet Areas, and to understand the importance of relatively quiet open spaces that may not be regarded as quiet in absolute terms but which may nevertheless provide an important local resource. Research on the economic valuation of quiet areas is under consideration. DEFRA is also proposing to keep under review any possible refinement to the noise mapping exercise that would strengthen the contribution of the strategic noise maps in the identification of Quiet Areas.

6.6 It is envisaged that the protection of Quiet Areas can be undertaken as an extension of existing local authority open space management activities and that this will be seen as an opportunity to improve the existing management of open spaces in our largest cities rather than as an additional burden. Ultimately, DEFRA will formally identify the Quiet Areas and will also determine whether adequate measures are in place for their protection.

7 Tranquillity conference papers

7.1 Tranquillity has been included in various noise conferences in Europe over recent years. In the UK, the Greater London Authority held a one day ‘Tranquil Spaces’ conference that explored how new research into tranquillity and soundscapes can help achieve practical improvements in the use and enjoyment of green spaces. The conference was well attended and included speakers from Natural England, Bob Pheasant, Greg Watts and David Whittaker from the University of Bradford, representatives from DEFRA, Environmental Protection UK and John Stewart from the UK Noise Association. The Mayor of London, Boris Johnson also spoke on the vision for a quieter, cleaner London.

8 Tranquillity mapping

8.1 The concept of mapping areas according to their tranquillity was developed by Simon Rendell of ASH consulting, in 1991 as part of a study commissioned by the Department for Transport to examine the effect of a new transportation corridor in Hertfordshire and Bedfordshire. Undisturbed countryside was mapped as a resource and led to the production of Tranquil Area maps, produced by Rendel and published by CPRE and the Countryside commission in 2005. These maps showed areas which were defined as 'sufficiently far away from the visual or noise intrusion of development or traffic to be considered unspoilt by urban influences'.

8.2 In 1999 Bell conducted tranquillity mapping for the Forestry Commission, in Sherwood Forest in Nottinghamshire. He elaborated on the definition of tranquillity to include the concept of 'naturalness in the countryside' as well as the absence or inclusion of noise and visual impacts. Bell used the following factors in his assessment of tranquillity in the forest area:

- Noise from roads, railways, airports, low-flying aircraft, powerboats, blasting and industrial sites
- Visual intrusion from built-up areas, holiday/caravan parks, industrial sites, power stations, grid stations, overhead lines, mineral extraction activities, decommissioned airfields, derelict land, windfarms, glasshouses, dish aerials and masts
- Recreational use: numbers of visitors, effects of facilities, car parking and associated noise and visual intrusion.

8.3 In 2000 Levett from CAG consultants produced a critique on the tranquillity mapping to date and although acknowledged the benefits of the methodology, he pointed out that it did not take into account factors that may influence perceptions of tranquillity.

8.4 CPRE have conducted extensive work on tranquillity mapping, to produce detailed maps of the UK based on tranquillity assessments in each area. CPRE commissioned researchers from Northumbria University's Centre for Environmental and Spatial Analysis and Participatory Evaluation and Appraisal in Newcastle upon Tyne and Newcastle University's Landscape Research Group, to use a new measurement approach to assess tranquillity. A tranquillity pilot study was conducted in the North East in 2004 and a follow-up study was done in the Chilterns in 2005. The national project that followed by CPRE was an extension of these studies and comprised a national survey to assess the meaning of tranquillity, and perceptions of the factors that add and detract from the experience of tranquil spaces. This comprised locating study areas where public consultation could be conducted, and producing a list of factors that are relevant to how people experience tranquillity. The members of the public were then given a number of option choices that were split into those which could be seen and those which could be heard, and categorized as positive or negative in terms of perceived tranquillity. Three responses were selected from each category per person, and then the total numbers of responses for each option were weighted as a percentage across the 44 possible choices that contributed or detracted from tranquillity. This gave a list of relevance for each option within the two categories, positive and negative.

8.5 Threshold analysis was undertaken to examine if there were predictable patterns in terms of distance and whether special thresholds could be measures for various features relating to land cover, people and urban development. During this stage of

the research, illustrations of various land cover types were chosen to obtain information from the public on 'perceived naturalness', in contrast to an expert-led scoring system that had been used in previous research.

8.6 Finally, using a Geographical Information Systems model (GIS), the survey responses were associated with a range of national datasets and locations; thus enabling the relative tranquillity score of each location to be determined, and to create a map showing how likely each location was to make people feel tranquil.

The top ten survey responses for what tranquillity is are:

1. Seeing a natural landscape
2. Hearing birdsong
3. Hearing peace and quiet
4. Seeing natural looking woodland
5. Seeing the stars at night
6. Seeing streams
7. Seeing the sea
8. Hearing natural sounds
9. Hearing wildlife
10. Hearing running water

The top ten responses given for things that are not considered to be tranquil are:

1. Hearing constant noise from cars, lorries and/or motorbikes
2. Seeing lots of people
3. Seeing urban development
4. Seeing overhead light pollution
5. Hearing lots of people
6. Seeing low flying aircraft
7. Hearing low flying aircraft
8. Seeing power lines
9. Seeing towns and cities
10. Seeing roads

8.7 CPRE explain that the tranquillity map is made up of many layers of information based on what people say adds to and detracts from tranquillity, weighted according to how important those factors are and taking into account the country's topography.

The individual layers enable analysis of the positive or negative impact on tranquillity of the following aspects:

- a natural landscape, including woodland
- rivers, streams, lakes and the sea
- birds and other wildlife
- wide open spaces
- cars, motorbikes, trains and aircraft– and roads and railways
- light pollution
- towns, cities and villages
- large numbers of people
- pylons, power lines, masts and wind turbines.

8.8 The tranquillity map is based on quadrants of 500m by 500m covering all of England. Each square has been given a tranquillity score, based on the 44 different factors which add to or detract from people's feelings of tranquillity. The scores were colour coded with the darkest green for places with a high tranquillity rating, and brightest red for those least likely to be scored as tranquil. Squares that are the same colour and have the same score may differ markedly in the different 'components' of tranquillity – both positive and negative – which determine their overall score. The relative tranquillity for England map is shown in Figure 1.

8.9 CPRE has also produced tranquillity maps for each county within the UK, which are available on their website, and are committed to further investigating tranquillity and helping to protect tranquil spaces within the UK, by collaborating with policy makers and offering solutions to potential threats to tranquil areas.

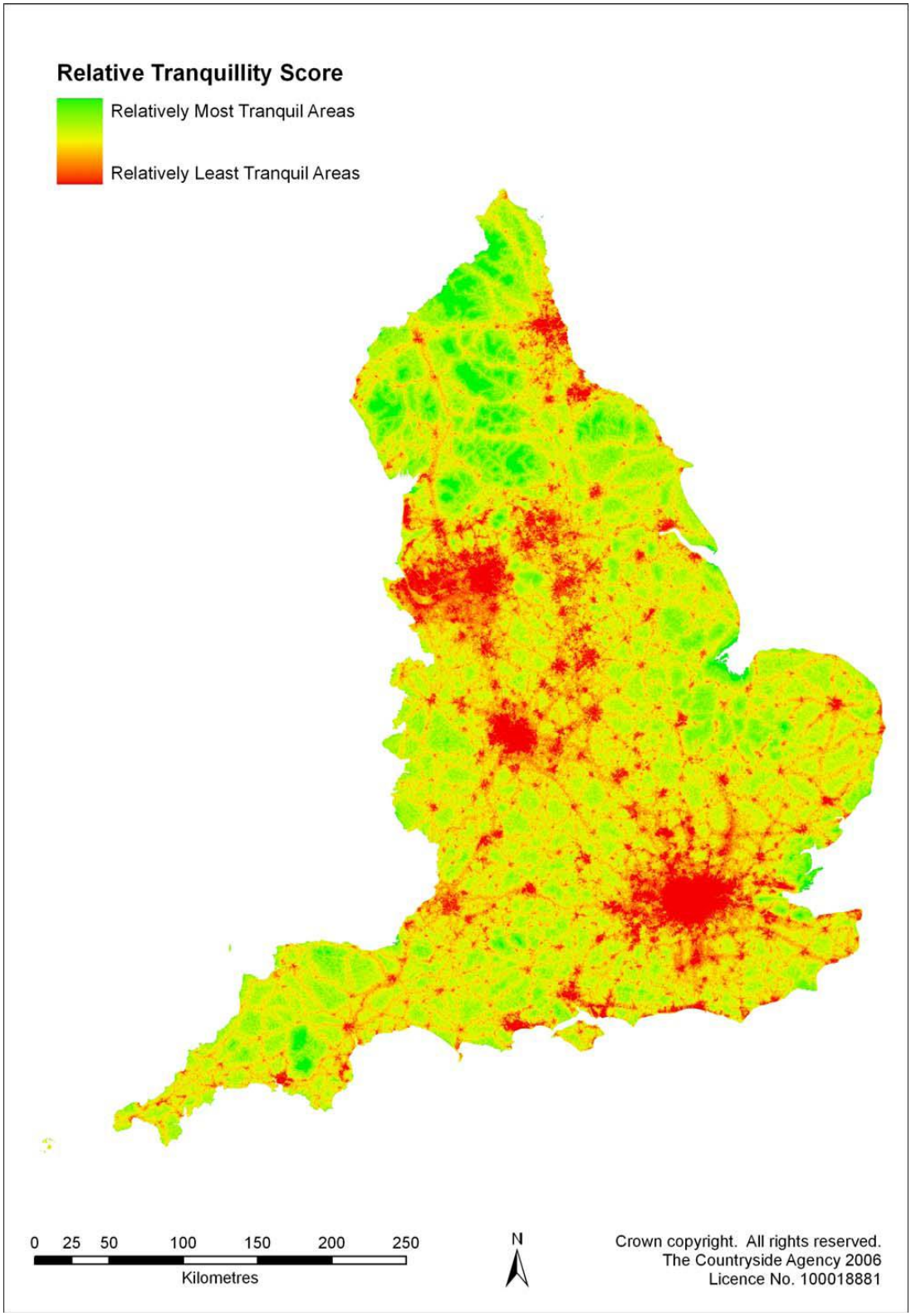

Figure 1: Map of relative tranquillity in England. Reproduced without permission.

9 Threats to Tranquillity

9.1 CPRE has highlighted the main threats to tranquillity currently faced in the UK. These include:

- New buildings and infrastructure, such as the provision of new housing estates which are often constructed on greenfield areas
- New roads – the projected increase in traffic levels of 30% by 2015 means that there are potential implications for road noise that may impact countryside areas. CPRE are campaigning for the effects of road traffic to be controlled and then reversed by examining the possible alternatives to increased road development.
- Aviation – with the projected increase in air traffic, the issue of aircraft noise and visual intrusion over tranquil areas is an important consideration for the future.
- Light pollution – dark skies and the ability to see the stars are an important aspect of tranquillity. With the increased use of artificial light and a 24-hour society, CPRE say that between 1993 and 2000, light pollution increased 24% nationally and the amount of truly dark night sky fell from 15% to 11%. Light pollution maps have been produced and now intrusive lighting is treated as a statutory nuisance.

10 Conclusion

10.1 This report forms part of the CAA's ongoing activity to support DFT's objective that the Director of Airspace Policy should pursue policies that will help to preserve tranquillity of the countryside. This overview provides a summary of key research into tranquillity with special relevance to aviation.

10.2 The importance of recognising and preserving tranquil spaces, both in rural areas and urban environments has been described in this report. This subject is an ongoing area with more research and developments expected. This is likely to include methodologies used to measure and quantify tranquillity and its benefits to society within the UK. Recent work has highlighted the need to incorporate perceptions of the meaning of tranquillity, alongside measurements of noise and visual intrusion, and the requirement for this to be taken into account by policy makers and planning organisations going forward.

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