Towards predicting wildness in the United Kingdom

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Abstract

This paper reports the findings of a wildness study that presented bi-modal audio-visual stimuli (video footage), to experimental subjects under controlled conditions, in order to obtain reliable estimates of perceived wildness, naturalness, felt remoteness and tranquillity. The research extends beyond the literature and demonstrates that unlike tranquillity, wildness appears to be a more intellectual construct. However, it does relate well to remoteness and naturalness and is reduced by the presence of mechanical noise. By using the approach previously employed for the development of a Tranquillity Rating Prediction Tool (TRAPT), it has been demonstrated that a similar methodology is also appropriate for wildness. WRAPT (Wildness Rating Prediction Tool) is the first attempt to predict wildness from physical variables, the values of which can be readily obtained from field surveys supplemented by detailed maps where large areas require assessment. The findings of this study will be of interest to those responsible for managing and marketing protected areas such as National Parks, practitioners involved in carrying out landscape character assessments, cartographers wishing to incorporate reliable acoustic data within their vector or raster based stacks and landscape architects involved in designing wild and tranquil spaces across a range of scales.

Keywords: Wildness, Tranquillity, Naturalness, Felt Remoteness, Soundscape

1. Introduction

Prior to the Neolithic or New Stone Age Revolution, which saw the beginning of farming practices that included the use of domesticated animals and crops, the British Isles were extensively covered with woodland. By 500BC half of all the native trees had been lost as timber was harvested for fuel and as a primary building material and by AD1086 it was recorded in the Domesday Book, which was a survey of who owned what throughout England and Wales, that as little as 15% of original woodland remained (Forestry Commission, 2013) . This high rate of attrition continued for nearly one thousand years and by the end of the 19th century England's woodland cover had dropped to an all-time non-glacial low of <5% (Smith, 2010). The progressive decline of Britain's native woodlands and the establishment of present day cultural landscapes brought with it a significant loss of biodiversity across all trophic levels. Primary consumers such as the elk disappeared as early as circa 150BC and apex predators such as the grey wolf and brown bear had all but vanished by AD1500. The result being that nowhere within the British Isles has been left untouched by the progressive urbanization, which over the last 10000 years has left as its legacy a simplified ecology devoid of most of its indigenous wild heritage (Fisher. 2013). This position was acknowledged by Habron (1998) who, when reporting about the visual perception of landscape characterization stated, "that in biophysical terms there is very little, if any 'wildland' left in Scotland as most of the landscape has been altered by anthropocentric activity". Indeed both the visual and acoustic components of the United Kingdom's most remote areas are significantly different today than they were during Neolithic times.

The gradual change in our accepted norm of ecological and environmental conditions is often referred to as the Shifting Baseline Syndrome, which describes the incremental change of standards that emerge as a result of each new generation lacking knowledge of the historical condition of their environment. By defining what is 'natural' or 'normal' according to the environmental conditions that they grow up in, each generation is introducing an almost imperceptible lowering of ecological standards and expectations. The Shifting Baseline Syndrome concept was first elucidated by Daniel Pauly in 1995 (Pauley, 1995) and is useful when attempting to understand how and why various visual and acoustic attributes of a particular environment contribute to, or detract from, the perception of quality indicators such as wildness or tranquillity. Both of these attributes feature on the websites and within the Management Plans of each of the UK's 15 National Parks', where they are often referred to as the most valued 'special qualities' of British landscapes (Dartmoor National Park, 2007). In fact they are so valued that the UK Government amended the 1995 Environment Act to specifically require all National Park Authorities to; "place emphasis on conserving and enhancing the valued attributes of wide open spaces and the wildness and tranquillity perceived within them" (defra. 2010).

It is worth noting at this point that the wording used within the debate on remote and natural areas often introduces a degree of confusion by drawing on descriptors from the English language, such as wilderness, which often means different things to different people and does not translate uniformly across all dialects. This ambiguity was recognised by Scottish Natural Heritage in their Policy Statements 02/03 (2003), which specified that; "while the term 'wilderness' is often used to describe the wilder parts of the globe, it is best avoided within Scotland because it implies a more pristine setting than we can ever experience in our countryside". However, in order to ensure that a polar opposite to wholly urban still exists, they promote the use of the term wildland to describe remote areas that lie mostly beyond contemporary human artefacts and wildness as the perceptive quality that such places are measured by. This terminology has therefore been applied throughout this paper.

Previous qualitative studies into how wild spaces are characterised, such as the one carried out by the Australian Heritage Commission (2003), tend to have focussed on a set of generally accepted attributes of wildness that relate to perceived levels of remoteness and naturalness (Leslie et al. 1993). A refined version of these were used by Carver et al (2012) to underpin the development of a GIS model designed to map wildland contours across Scotland and by Scottish Natural Heritage (SNH), who commissioned the cartographic work. In order to enable to wilderness attributes identified by the Australian Heritage Commission to be refined two uni-modal perception studies were commissioned by SNH, one in 2008 and the other in 2012. The aim of these studies were to identify the key visual components within the landscape that informed the wildness construct and to derive weighting values from them that could be used within the GIS model. The uni-modal perception studies, which used photographs and a questionnaire to illicit responses from a large sample of volunteers, showed the presence of wildlife, noticeable features within the landscape, such as cliff faces and boulder fields, and naturalness of vegetation, to be the visual factors that most contributed to the perception of wildness. Conversely built up areas, energy infrastructure (pylons, wind turbines and dams) and recreational infrastructure, such as four-wheel-drive tracks, hiking paths, ski lifts, and evidence of field sports, all influenced the visual perception of wildness in a negative way. These attributes were used by Carver et al in the development of the GIS model under the generic headings of: perceived naturalness of land cover, the absence of modern human artefacts, the rugged and challenging nature of the terrain and remoteness from mechanised access. The expectation in the study being reported was that the quality of the soundscapes presented to the subjects would provide an element of balance between the auditory and visual modalities within the perception of wildness, that could easily be incorporated within the wildness maps.

Within vision science scene perception involves gathering information from the global properties of the visual world rather than simply from single objects located within it, and this is because our eyes are constantly in motion. Thus a wild land may consist of water, rocks and birds for example, but it only becomes a wild place once context is applied. This happens when the brain groups each of the components together and then seeks an existing template (schemata) against which to compare them to. This context is often referred to as configurational coherence and is an essential aspect of landscape characterization (Kaplan and Kaplan, 1989). If no template exists, perhaps because one or more of the grouped components are out of place or unidentifiable, additional senses are brought on line to try and resolve the ambiguity. An identical process happens with audition, where auditory scene analysis enables us to glean essential information from the soundscape. It should therefore come as no surprise that what we hear (or expect to hear), is also an integral part of the landscape characterization process. This was recognized by Habron (1998) who acknowledged audition as potentially being an important influencing factor in the wildness construct. Unfortunately current landscape character assessment methodologies within the UK rarely, if at all, incorporate objective acoustic measures within their predominantly uni-modal (visual) environmental appraisals, despite there being a growing body of scientific evidence that supports the argument that the perceptive process of landscape characterization is much more than a uni-modal sensory construct (Countryside Service, 2002). In fact research involving brain scanning (fMRI) carried out by the University of Sheffield, has clearly shown audio-visual interaction to be a fundamental component of environmental perception, in particular the construction of tranquil space (Hunter et al, 2010).

For many, the chance to experience tranquillity is what makes the countryside different from cities, and in a survey conducted by the UK's Department for Environment, Food and Rural Affairs (defra) (2001), 58% of people questioned stated that for them tranquillity was the most positive feature of the British countryside. Furthermore the provision of rural 'tranquil space' is also known to have significant economic benefits. A report published by the pressure group, the Campaign to Protect Rural England (2006) lists the safeguarding of over 186,000 jobs and a boost to the UK rural economy of around £6.5 billion per annum, as two of the economic benefits of maintaining tranquil (restorative) areas. It is therefore probably not surprising that within the British Government's Rural White Paper (2000) that tranquillity features as an important element. Previous studies into modelling tranquil space, such as those carried out by Pheasant and Watts et al, (2008 and 2010) led to the development of the following Tranquillity Rating Prediction Tool (TRAPT), which can be used to predict the Tranquillity Rating (TR) of both urban and natural environments:

$$TR = 9.68 + 0.041\ NCF - 0.146\ Lday + MF \qquad (1)$$

TR is the Tranquillity Rating on a 0 to 10 scale, where 0 is least tranquil and 10 is most tranquil, NCF is the percentage of natural and contextual features visible within the landscape and Lday is the equivalent constant A-weighted sound pressure level of man-made noise during daytime hours (7:00am to 7:00pm). Contextual features include listed buildings, religious and historic structures, landmarks, monuments and elements of the landscape, such as traditional farm buildings, that directly contribute to the visual context of the natural environment. It is argued that when present, these visually cultural and contextual elements are as fundamental to the construction of 'tranquil space' as are strictly natural elements (e.g. grass, shrubs, trees, water, rock etc.). MF is a moderating factor that is added to the equation to take account of further factors such as the presence of litter and graffiti that would depress the rating, or sensory features such as water sounds that are likely to improve it. This is essentially a minor adjustment 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. The MF measure resulted out of a study conducted by Watts et al. (2010) that altered the appearance of a number of outdoor environments being assessed for tranquillity, by adding litter and graffiti each time they were revisited by the subjects taking part. In order to check the robustness of the results of the study the same subjects reassessed each location one month later in a psycho-acoustic suite and the results showed that the two assessments were very highly correlated ($R^2 = 0.95$).

The fact that wildness and tranquillity are very often mentioned together within the Management Plans and marketing material of National Parks and bodies charged with developing policy in relation to the management of large scale natural areas, such as Natural England and Scottish Natural Heritage, implies that the two constructs are somehow inextricably linked. If that is the case then it seems reasonable to assume that TRAPT, or a slightly modified version of it, should be able to use bi-modal variables to accurately predict wildness, unless of course the perception of wildness is a less intuitive construct than tranquillity.

The aim of this paper is to report the findings of a study that used a new and unique dataset to determine how audition and vision interact within the perception of wildness and tranquillity. The novelty of the study lies in the fact that it considers both landscape and soundscape characteristics in order to gather information rather than visual properties alone. The hypotheses being tested were that naturalness and remoteness would correlate well with wildness, but that tranquillity would not be so closely associated, and that wildness was a more cognitive construct than the other variables being measured. It is anticipated that the findings of this study will be of use to those responsible for managing and marketing protected areas such as National Parks, those seeking to develop re-wilding strategies similar to the Wild Nephin project in Ireland's Ballycroy National Park, practitioners involved in carrying out landscape character assessments, cartographers wishing to incorporate reliable acoustic data within their vector or raster based stacks and landscape architects involved in designing wild and tranquil spaces across a range of scales.

2. Methods

2.1 Data collection

During the summer of 2012 audio-visual data was captured from 16 locations across England and Scotland using a Canon XM 2 camcorder to record the visual information, and a Bruel and Kjær (B&K) 2250 Sound Level Meter (SLM), to record the auditory and acoustic data. The locations chosen for the study were selected from the Scottish Highlands, Dartmoor National Park and West Yorkshire, as they provided a representative sample of environments that ranged from wholly urban to completely free of any obvious human influence. This spectrum is often referred to as the wildland continuum (Fisher et al. 2010) and includes the urban fringe, agricultural land, semi-natural environments and wildland, within the least wild (i.e. wholly urban) and most wild end points. During filming the camcorder was swept from left to right over a 1 minute recording period, 30 seconds of which settled on the central view. At the same time the associated soundscape was recorded as a WAV file on the B&K 2250 sound level meter that was calibrated in the field using a B&K 4231 94dB (1kHz) sound calibrator. Due to the distances travelled on foot to record the most 'remote' locations the decision was taken not to use a binaural head to simultaneously capture the audio-visual data, as per other studies (Pheasant et al. 2008). The advantage of recording the soundscape on the SLM was that objective acoustic measures for each location such as the average, maximum and minimum A-weighted sound pressure level (i.e. LAeq, LAMax, LAmin respectively) were all taken at the same time as the audio data was recorded. LA10. LA50 and LA90, which are the percentage of time that the A-weighted sound pressure level is exceeded for, were also calculated.

2.2 Data editing

Once the visual and audio information was transferred to a PC it was edited using Adobe Premiere 6.5 software and each WAV file imported and reconciled with its corresponding visual scene. The decision was then taken to either present each of the locations with just the 30 second central view or with the 120^0 panorama. The deciding factor lay in whether the peripheral visual information provided any additional contextual information to the central shot. Based on this criterion the final data set included 5 environments that covered 120^0 and 11 that used the central shot. In both cases the presented stimuli lasted for approximately 30 seconds (±2) as per the exposure time reported by Pheasant et al (2008). The bi-modal stimuli used within the pilot study consisted of 15 locations ranging from the urban fringe to 'most wild' in 3 different experimental conditions and one wholly urban environment. This was a recording of a particularly congested main roadigh in the Devonshire village of Modbury that was left un-edited and used as the control stimuli where wildness and tranquillity ratings were expected to be close to zero. . The three experimental conditions used in the study were:

1. 'As is', i.e. as recorded in-situ
2. With enhanced mechanical soundscape components added
3. With enhanced biological soundscape components added

When each location was edited to incorporate additional mechanical and biological sounds every attempt was taken to ensure that the added components were in context with the environment in which they were being presented. All biological components were downloaded from the British Library and were originally recorded close to the location that they were added to. For example, the sounds of a golden eagle mewing that were added to the soundscape of Glen Etive in Scotland, were recorded close to where the footage for this study was taken, as were the sounds of birds and insects that were overlaid on the footage of mixed farmland within the Dartmoor National Park. A similar approach was taken when adding mechanical noise to the original recordings, with the emphasis being on congruence, rather than effect.

Figure 1 shows a central view of the entrance to Glen Etive in Scotland taken from Rannoch Moor. The links open audio recordings of each of the three experimental conditions presented to the subjects for this environment. The first track contains sounds of running water and wind, the enhanced mechanical track contains running water, wind and the passage of a low flying helicopter, and the track with enhanced biological noise includes running water, wind and the calls of a golden eagle plus moorland birds.

Audio links of Glen Etive

- As recorded in-situ
- Enhanced mechanical noise
- Enhanced biological noise

Figure 1 – A view of the Glen Etive looking west from Rannoch Moor

Table 1 provides a description of each location used in the study and lists the soundscape in each of the three associated experimental conditions. It also includes the Latitude and Longitude coordinates that were obtained using GPS at the time the field data were recorded. For simplicity the locations have been grouped into regions.

Table 1
Overview of the stimuli used in the study. (Bio) refers to enhanced biological and natural sounds. Tors are common features within the Dartmoor National Park and are exposed granite outcrops.

	Original Soundscape	**Enhanced (Man-made)**	**Enhanced (Bio)**	**Latitude and Longitude**
Scotland				
Railway – Corrour	Very quiet	Train horn	Red deer	56^{0} 45' 38"N 04^{0} 41' 44" W
Long view - Corrour	Very quiet	High aircraft	Buzzard	56^{0} 45' 24"N 04^{0} 41' 44" W
Glen Etive	Running water	Helicopter	Eagle	56^{0} 39' 17"N 04^{0} 48' 06" W
Glen Nevis	Cars + people	Military jets	Birdsong	56^{0} 46' 40"N 05^{0} 00' 01" W
River Nevis	River	Hay bailing	Birdsong	56^{0} 45' 38"N 04^{0} 41' 31" W
Dartmoor National Park				
Pylon in field by A38	Passing traffic	Chain saw	Birdsong	52^{0} 25' 30"N 03^{0} 48' 42" W
Farmland – Widecombe	Livestock	Tractor	Birdsong	50^{0} 35' 22"N 03^{0} 50' 58" W
Great Mis Tor	Wind	Military gun fire	Birdsong	50^{0} 34' 04"N 04^{0} 01' 30" W
Moorland ponies	Light wind	Traffic	Birdsong	50^{0} 32' 37"N 03^{0} 50' 34" W
Hangershell Tor	Wind + birds	Distant siren	Water	50^{0} 20' 05"N 03^{0} 49' 23" W
Horn's Cross	Light wind	Cattle grid	Birdsong	50^{0} 31' 26"N 03^{0} 52' 40" W
River Dart	Raging rapids	Low aircraft	Birds	50^{0} 31' 03"N 03^{0} 49' 23" W
Road below Hay Tor	Light traffic	Aircraft	Insects	50^{0} 34' 46"N 03^{0} 45' 04" W
Modbury high street	Congested traffic	N/A	N/A	50^{0} 20' 55"N 03^{0} 09' 26" W
West Yorkshire				
Ovenden Moor	Wind turbines	Motor cycle	Water	53^{0} 46' 38"N 01^{0} 56' 63" W
Denholme pylons	Passing traffic	Tractor	Bird + church bells	53^{0} 47' 44"N 01^{0} 53' 18" W

Each experimental condition was presented by means of a DVD player and large plasma screen to 21 subjects (average age 38, ±15.7 years), in three randomized groups over a 90 minute assessment period. During the first presentation, which was considered a settling down period designed to expose the subjects to the full range of stimuli being used, the volunteers were given time to complete their assessment before the next location appeared on the screen. During subsequent presentations they were given ten seconds between each exposure to record their subjective assessments. After the presentation of each full data set, which contained 46 stimuli (the control condition was only shown in the 'as is' state, the other 15 stimuli were presented in each of the 3 conditions), the subjects were offered a ten minute comfort / refreshment break before proceeding with the experiment. Only assessments made on the second and third presentations of each dataset were used in the final analysis. All of the subjects that took part in the study were 'naïve volunteers' and each was rewarded with a £15 store voucher for taking part.

2.3 Subjective assessment

The experiment was conducted in the University of Bradford's psycho-acoustic suite, where the volunteers sat in pairs and made their subjective assessments in response to the bi-modal stimuli presented via a Pioneer (PDP – 506XDE) plasma screen, a Samsung DVD – R125 player and two sets of ROLAND RH-300 stereo headphones. The headphones had been calibrated using the calibration tone recorded in the field in order to ensure that the audio data was presented at the same sound pressure level as it was recorded. Prior to commencing the experiment the following written information was provided: 'This experiment uses audio-visual (video) information to determine how wild and tranquil 16 locations are perceived to be when responding to bi-modal sensory stimuli. You will be played a series of data streams that last for approximately 30 seconds followed by a 10 second period of silence, in order that you can make your assessments on the monitoring sheets provided. On each exposure you are asked to make an assessments of how wild, tranquil, natural and remote you perceive each location to be, by awarding a score of 0 – 10, with 0 being 'least' and 10 being 'most'. In addition you should record your emotional reaction to the locations by annotating each of the three rows of Manikins (little men), with an "X" indicating how pleasant, excited and controlled, each location makes you feel. Note that you can place the "X" between Manikins if you wish to make an assessment that falls between categories. During the experiment you are to base your assessments on the fact that you are in each location by choice. No locational information is provided to steer you into making your subjective assessment of remoteness', instead you are asked to rate how remote each location feels to you based solely on the audio-visual information provided. You are to draw upon whatever value judgments you see fit to make your assessments. For each location you should assume that what you see is indicative of views in all directions and that the sounds you hear are typical of that location. Note that what you see and what you hear should both be taken into account when considering your ratings on all the scales provided. The data streams are presented to you in random order and will be repeated to obtain better precision'.

In previous wildness perception studies (Scottish Natural Heritage 2008 and 2012) it has not been uncommon for participants to struggle when assessing how remote a location is perceived to be, despite being provided with guiding information, such as distance to the nearest road or railway station. This is largely because these studies have used uni-modal stimuli, i.e. photographs to illicit a response rather a more immersive auditory-visual dataset. This approach potentially prevented the subjects from being able to adequately contextualize the environment on the limited sensory information being provided. In this study we introduced the concept of 'Felt Remoteness' to the subjects, which is an adaptation of 'Felt Intensity', a measure that is often applied to explaining the intangible sensitivities to certain components of the urban environment (Massey et al. 1999) and provided an immersive set of stimuli for them to make their subjective assessments against. Due to the high probability of it being an unfamiliar concept, 'Felt Remoteness' was the only variable explained to the subjects in the pre-experiment brief.

2.4 Self-Assessment Manikin (SAM)

The Self-Assessment Manikin (SAM) is a non-verbal pictorial assessment technique devised by Hades et al (1985) that directly measures the pleasure, arousal, and dominance (PAD) associated with a person's affective reaction to a wide variety of stimuli. These three emotional dimensions are known to be pervasive in organising human judgements (Bradley and Lang. 1994). The advantage of using SAM as opposed to Semantic Differential (SD) for example, is that it requires only 3 judgements using ranked pictures that can be quickly interpreted with little error across a wide range of age groups and cultures (Figure 2). It therefore fitted well with the limited time that the subjects had available to make their assessments. In this study arousal was measured using the polar opposites, excited and calm, which referred to how various components within the presented stimuli, raised levels of alertness and arousal. Control was used as a proxy for dominance and referred to how participants felt they were in control of the situation in various landscapes. For example if they felt threatened because of the presence of animals (e.g. ponies or flying insects) or gun fire, it would be expected that they would tend to rate their situation as more "controlled" rather than "in control". Pleasantness, simply measured how agreeable the subjects felt the environment was. For analysis purposes a 5 point scale was used with the least favourable emotion in each category being scored 1 and the most favourable 5. Figure 2 illustrates how the SAM scales were presented:

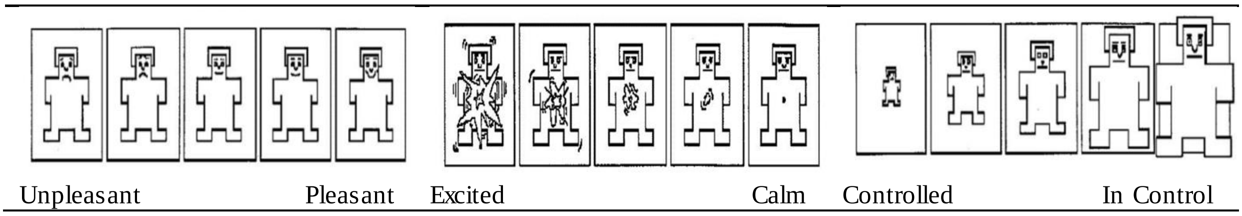


Figure 2 – The Self-Assessment Manikins (SAM) used to illicit emotional response within the pilot study

At the end of the experiment the subjects were asked to respond to questions relating to the visual and auditory components of the stimuli presented that most enhanced and detracted from the perception of wildness and remoteness. It was not necessary to ask these questions in relation to tranquillity as this has been well established in previous studies (Herzog, 1992 and Watts et al, 2011).

2.5 Objective measures

The WAV files used to introduce enhanced mechanical and enhanced biological soundscape components to each of the locations used in the study were analysed by a specially written Matlab code that enabled their A-weighted sound pressure levels (average and statistical noise indices) to be calculated. This was achieved by comparing them against the calibration tones that were recorded onto the sound level meter in the field. During this process the in-situ acoustic data was also analysed in order that the values obtained using the Matlab code could be cross checked with those obtained at the time of recording. This process showed a maximum error of ± 0.5 dB(A), thereby giving confidence in all of the A-weighted measurements used.

The percentage of natural and contextual features (NCF) within the visual scene was also obtained as described in Pheasant et al (2008). These were derived by pasting the landscape images into PowerPoint and overlaying a 10x10 grid. The areas covered by natural and contextual features or wild land, were estimated by counting the number of squares occupied by each and interpolating where necessary. The area of sky above the horizon was not used in the calculation of NCF. If N is the area with natural features and M the total area of man-made features then NCF is given by:

$$NCF = 100\ N/(N + M) \quad (2)$$

For the purpose of calculating the percentage of wild land within the visual scene the areas of cultivated and obviously managed land such as pastures and conifer plantations, were subtracted from N in equation (2) yielding the area of wild land W. The percentage of wild land (%W) was then given by:

$$\%W = 100\ W/(N + M) \quad (3)$$

2.6 Analysis

Microsoft Excel 2010 was used to collate the subjective assessments made by the 21 subjects to each of the stimuli presented and also to determine mean values for wildness, tranquillity, naturalness, felt remoteness, calmness, pleasure and control. It was then used in conjunction with SPSS 20 to determine the effect that the added mechanical and biological soundscape elements had on the perception of each variable and to carry out a detailed statistical analysis in order that the results could be understood and the main hypotheses tested. In the first instance a two-tailed t-test was carried out to determine that the means obtained in each experimental condition were significantly different. Once confidence had been gained as to the overall quality of the raw data a correlation analysis between each pairs of variables (both objective and subjective) was conducted. The results gained from the correlation analysis informed the choice of variables to be included within a multiple regression analysis. They also identified the readily available and most easily identified measures that would be required to develop a practical equation for measuring wildness.

3 Results

3.1 Initial analysis

The results of the correlation analysis identified that wildness is very well correlated with naturalness and remoteness, but less so to sound levels or emotional reactions. It also showed that tranquillity is well related to naturalness and remoteness, but much more so to the emotional reactions of pleasantness, calmness and control, and to the acoustic indices LAeq LA10 and LA90. The results of the correlation analysis are contained in Table 2.

Table 2
Correlation analysis of the variables used in the study and predicted Tranquillity Rating (TR)

	Wild	Tranquil	Natural	Remote	Pleasant	Calmness	Control	LAeq	LAmin	LAmax	LA10	LA90	TR	% NCF	% Wild
Wild	1														
Tranquil	0.76	1													
Natural	0.96	0.86	1												
Remote	0.94	0.86	0.95	1											
Pleasant	0.73	0.97	0.85	0.81	1										
Calmness	0.63	0.97	0.76	0.73	0.97	1									
Control	0.65	0.96	0.78	0.75	0.98	0.99	1								
LAeq	-0.40	-0.74	-0.47	-0.53	-0.69	-0.79	-0.75	1							
LAmin	-0.28	-0.51	-0.29	-0.38	-0.44	-0.52	-0.49	0.83	1						
LAmax	-0.34	-0.70	-0.44	-0.48	-0.66	-0.75	-0.71	0.94	0.67	1					
LA10	-0.41	-0.77	-0.49	-0.55	-0.71	-0.81	-0.78	0.99	0.77	0.95	1				
LA90	-0.40	-0.62	-0.41	-0.51	-0.56	-0.63	-0.59	0.91	0.94	0.75	0.86	1			
TR	0.68	0.98	0.81	0.78	0.99	0.99	0.99	-0.75	-0.48	-0.71	-0.77	-0.60	1		
% NCF	0.52	0.31	0.51	0.38	0.30	0.28	0.29	-0.13	-0.16	-0.08	-0.13	-0.12	0.29	1	
% Wild	0.71	0.32	0.58	0.59	0.33	0.22	0.24	-0.12	-0.16	-0.06	-0.13	-0.19	0.28	0.44	1

Within Table 2 the terms wild, tranquil, natural and remote refer to: perceived wildness, tranquillity, naturalness and felt remoteness. %NCF is the percentage of Natural and Contextual Features and % wild refers to the percentage of unmanaged land within the visual scene. Pleasantness, calmness and control are the variables measuring emotion and LAeq through to LA90 are noise indices

3.2 Effects of man-made and natural sounds

A greater understanding into how these environments were perceived in relation to the variables being assessed can be obtained by examining Table 3, which shows how the added mechanical (Mech) and biological (Bio) noise influenced the overall rating of each category in a negative or in a positive way.

Table 3
Mean influence of enhanced mechanical and biological sounds

	Wildness	Tranquillity	Naturalness	Felt Remoteness	Pleasure	Calmness	Control
Mechanical	-0.9	-3.5	-1.7	-1.9	-1.3	-1.4	-1.3
Biological	0.2	-0.1	0.1	0.0	0.0	0.0	0.0

For example the addition of mechanical noise on average decreased ratings of wildness by 0.9 of a wildness point (p<0.001), whereas a much greater effect was observed on the perception of tranquillity, where ratings reduced by -3.5 points. The addition of biological sounds made a small but significant increase in wildness ratings of 0.2, (p<0.01) but had no significant effect on tranquillity ratings (-0.1, p=0.54).

Interestingly the greatest influence of enhanced mechanical noise on the perception of wildness, tranquillity, naturalness, pleasure, calmness and control, did not relate to the environment that had the highest ambient noise (LAeq 80.5dB), which emanated from a low flying aircraft, but from two short bursts of automatic weapon fire coming from the military firing range within the Dartmoor National Park (Great Mis Tor). The LAeq of this stimulus was 63.5 dB(A), which was 19.9 dB(A) lower than the aircraft. Kang (2006) provides some insight into this apparent acoustic contradiction by explaining that in comparison to visual information sound, which is ubiquitous, is very often information-poor but emotion-rich, adding strength to the argument that environments are only fully characterised using multi-modal, rather than uni-modal information.

The enhanced mechanical noise that most detracted from the feeling of remoteness was a distant ambulance siren that was presented with a recording of Hangershell Tor, which is also situated within the Dartmoor National Park and is approximately 2 miles from the nearest road. This degraded the feeling of isolation by 3.3 points on the ten point scale. The LAeq of this edited recording was low at 44.6 dB(A), but still 10 dB(A) higher than the original (in-situ) sound pressure level. Figure 3 shows the central view of both of these locations and includes links to their corresponding audio tracks. The 'as is' condition for Great Mis Tor was comprised predominantly of intermittent wind noise, the enhanced mechanical noise was associated with an automatic weapon being fired and the biological condition was enhanced with the calling of a curlew and a yellow hammer. Hangershell Tor on the other hand contained a singing sky lark in the 'as is' condition, the ambulance siren in the enhanced mechanical condition and running water in the enhanced biological (natural) condition.

Audio Links of Great Mis Tor	Audio Links of Hangershell Tor
• As recorded in-situ	• As recorded in-situ
• Enhanced (Mech) noise	• Enhanced (Mech) noise
• Enhanced (Bio) noise	• Enhanced (Bio) noise

Figure 3 – Views of the Great Mis Tor and Hangershell Tor plus links to audio recordings in each of the three experimental conditions.

When the environments that were rated the highest in terms of wildness, tranquillity, naturalness, felt remoteness, pleasure, calmness and control are examined it becomes apparent that they also have a higher rating once congruent biological sounds have been added. The main difference being that the room for improvement in overall environmental quality is limited as they are already rated very highly.

The recording of Glen Etive in the Scottish Highlands enhanced with biological sounds (birdsong) (see Figure 1) was the environment rated as being 'most wild'. Subjects rated it as 8.3 (mean) in the original un-enhanced state but 8.7 once enhanced biological sounds (the mewing of a golden eagle) had been added. This was an increase in perceived wildness of (+0.4). This location was also assessed as being the most tranquil (9.1), natural (9.1), pleasant (4.7) and calmest (4.8) of the data set, when presented in its un-edited (original) condition. The soundscape in this 'as is' condition was comprised predominantly of running water and wind. The second most tranquil location in the 'as is' state was Hangershell Tor (9.0) (Figure 3). Note that the SAM rating uses a 5 point scale.

The location assessed as feeling the most remote was a view of moorland on the Corrour Estate in the Scottish Highlands that extended over 15 km. This was recorded 20 km from the nearest road (but only 5 km from Corrour Station) and when presented with enhanced biological noise was rated as 9.2. Although this was only an increase of 0.2 it reflects how transitory noises are continually being processed within auditory scene analysis, to provide as much environmental context as possible. The biological sound added to this location was the distant mewing of an unseen buzzard that lasted for no more than 2 seconds. A view of an ancient way-mark (Horn's Cross) in the Dartmoor National Park that had been enhanced with native birdsong, was the environment that the subjects felt they were most in control of, although it was only assessed as being marginally higher (0.1) than the unedited state.

3.3 Multiple regression and questionnaire analysis

When both the subjectively derived and objectively measured independent variables were regressed against wildness, in order to establish a perceptive measure of the construct, naturalness ($p<0.001$), felt remoteness ($p<0.05$) and LAeq ($p<0.05$), were all shown to be significant factors at the 95% confidence level ($R^2=0.93$, $F(3,42) = 215.77$, $p<0.001$, S.E. 0.40, n=46). Interestingly the average continuous sound pressure level (LAeq) was the weakest of the independent variables despite the level of mechanical noise and the overall quality and richness of the soundscape being a continuous theme within the post experiment questionnaire. In the case of tranquillity felt remoteness ($p<0.001$) and calmness ($p<0.001$) were the independent variables that were most significant ($R^2=0.98$, $F(2,43) = 1311.22$, $p<0.001$, S.E. 0.33, n=46). The high importance of felt remoteness within how tranquil the stimuli were perceived to be fits well with Kaplan's 'sense of being way' (1989), which is a key component of Attention Restoration Theory (ART).

Further insight into how the subjects rated the environments can be obtained from a review of the questionnaire results, which showed that the two visual components of the stimuli presented that most contributed to the perception of wildness were: the lack of man-made influence (24%) and wide open spaces with distant views (24%). The two soundscape components contributing the most to the perception of wildness were biological noises and running water. Not surprisingly the visual detractors of wildness were traffic (39%) and energy infrastructure (pylons and wind turbines) (26%). Mechanical noise (65%) and gunfire (15%) accounted for the least favorable soundscape components. When assessing 'felt remoteness' the subjects stated that wide open spaces with distant views (24%) and a total lack of man-made features (22%) were the most important contributory factors and that silence or 'extreme quiet' (43%) and the presence of low levels of biological noise (22%) enhanced the feeling of remoteness the most.

When the independent variables obtained using the 5 point SAM scale, i.e. calmness, pleasantness and control, were tested against the dependent variable 'wildness' ($R^2 = 0.63$, $F(3,42) = 23.61$, $p<0.001$, S.E. 1.01, n=46) only pleasantness was significant ($p<0.001$). When the same test was carried out using tranquillity as the dependent variable ($R^2 = 0.95$, $F(3,42) = 449.30$, $p<0.01$, S.E. 0.55, n=46), both calmness and pleasantness were identified as being highly significant ($p<0.01$ and $p<0.001$ respectively). When tested against LAeq only calmness and pleasantness were highly significant, $p<0.001$ and $p<0.01$ respectively. At no point during the study was the SAM "control" rating seen to be a significant factor.

3.4 Developing a practical Wildness Rating Prediction Tool

In order to develop a practical model for measuring the wildness of an area multiple regression analysis was also carried out to establish the strength of the relationships between the dependent variables wildness and tranquillity, and the objectively measured independent variables included within the correlation analysis. Objective measures were used as these can be gathered in the field and quantified within a model. The results showed that wildness is contingent ($R^2=0.60$, $F(2,43) = 31.93$, $p<0.001$, S.E. 1.03, n=46) upon the percentage of un-managed land within the visual scene, i.e. % wild ($p<0.001$) and to a lesser degree LAeq ($p<0.01$). In the case of tranquillity both the auditory and visual components were significant factors ($R^2=0.60$, $F(2,43) = 32.16$, $p<0.001$, S.E. 1.64, n=46), with the ambient soundscape (LAeq) being the most dominant ($p<0.001$) and %NCF slightly less important

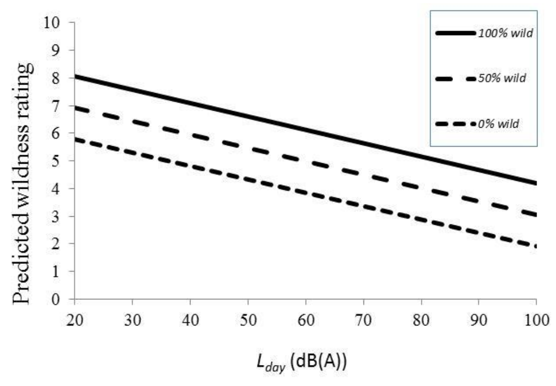
(p<0.05). In all cases of regression analysis the only significance scores included within this paper are those that were supported by appropriate confidence intervals.

Throughout the analysis of the results the negative impact of noise upon the perception of both wildness and tranquillity has been a recurring theme. By following the successful approach taken in developing TRAPT, the hypothesis that it is the equivalent continuous sound pressure level (LAeq) of 'man-made' noise (rather than naturally occurring sounds), and the percentage of wildland present in the scene that are the key variables required to develop a Wildness Rating Prediction Tool (WRAPT), was adopted. Both independent variables can be obtained from site surveys. Within this model it was anticipated that levels of man-made noise would be negatively correlated to the wildness rating and that the percentage of wild land in the landscape would be positively related. Therefore in order to account for the negative impacts of mechanical noise within the model a default value for all environments where only natural sounds are perceptible was determined. For all other environments, i.e. those where man-made noise predominates, LAeq is used. The default value employed was based on a very low level of 26 dB(A), which produces a predicted Tranquillity Rating of 10 (i.e. the highest possible level with 100% NCF present), using TRAPT (Pheasant et al, 2010). It also relates closely to the lowest LAeq observed during the field studies when no mechanical sounds were perceived and wind speeds were <5m/s.

By using the average noise level of man-made noise (LAeq) and the percentage of ground in the landscape that was considered wild (%W) a regression equation was derived relating these independent variables to the average wildness rating (WR) on a 0 to 10 scale. The results (R^2=0.75, $F(2,43) = 62.20$, p<0.001, S.E. 0.81, n=46) show that both variables are highly statistically significant (p<0.001). The form of the equation is given by:

$$WR = 6.77 + 0.023\ \%W - 0.049\ LAeq \quad (2)$$

Figure 4 shows how the wildness rating varies with average noise level at various percentages of wild land within the landscape. It can be observed that higher noise levels decrease wildness ratings, while the greater the percentage of wild land present the higher the rating, which is in the expected direction. The form of the equation is similar to that of TRAPT which links tranquillity ratings with noise levels and the percentage of natural and contextual features present (see equation (1). Note that for practical purposes it is recommended that Lday, which is the average noise level over an average day (7am to 7pm), is used. The strength of the relationship between the actual wildness ratings obtained during this pilot study and those predicted by the model is shown in the scatterplot in Figure 5. On this graph it can be seen that the regression line has a slope close to 1 and when extrapolated passes close to the origin.



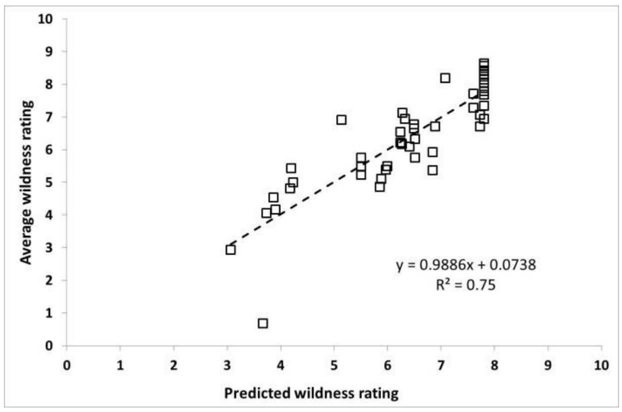


Figure 4 – Predicted wildness versus Lday

Figure 5 – Predicted WR versus Actual WR

4. Discussion

4.1 Interpretation of the results

As expected the correlational analysis revealed that the average subjective wildness rating is very closely associated with both 'naturalness' and 'remoteness' but much less so to noise levels (LAeq) than the tranquillity rating. On the other hand wildness is less well correlated to the emotional responses of pleasantness and calmness than tranquility. It is therefore suggested that wildness is a more intellectual construct than tranquillity as it is less related to emotional measures and has a reduced, though important, emphasis, on auditory inputs.

Rated wildness and tranquillity were negatively affected by man-made noise but positively influenced by the addition of natural sounds. However, the level of improvement was relatively low (overall mean for wildness +0.2) and this may well have been down to the high values already attributed to the 'as is' condition, which left little room for improvement. It is also likely that those participants that lacked sufficient knowledge to identify some of the natural sounds presented, such as the distant call of a rutting deer or the hammering of a woodpecker, found them disturbing or ambiguous. From the debriefs conducted at the end of each experiment it was clear that some of the subjects found insect sounds threatening, especially the buzzing of bees and that others were left unsettled by the unseen call of raptors such as the buzzard and eagle. However, the questionnaire did identify that these sounds along with extreme quiet, were the auditory factors that most enhanced 'felt remoteness'.

The findings of this research support in part those found during the 2012 wildness perception study commission by Scottish Natural Heritage (SNH). In particular they agree with the four main wildness attributes put forward i.e. naturalness of land cover, the presence (or not) of man-made structures or features and the degree of remoteness. However, on the latter point the metric used within this study was 'felt remoteness', rather than a physical measure, such as distance to the nearest road or railway station. Interestingly SNH reported that older built structures within the landscape that provided configurational coherence appeared to enhance the feeling of wildness. This interpretation was not supported by this study, where the ancient granite cross on Dartmoor was rated higher for tranquillity, naturalness and remoteness than it was for wildness in the 'as is' condition, suggesting that it was a visual detractor of wildness rather than a feature that enhanced it. However, it is acknowledged that this was the only ancient artifact presented during the study and also that the assessments were being made in response to bi-modal rather than uni-modal stimuli. The findings of the study also support the importance of energy infrastructure, i.e. pylons, wind turbines and radio masts, in depressing the perception of wildness. In fact it also showed that environments that contained pylons were rated much lower than the one that contained wind turbines in all experimental conditions. This was most likely due to the fact that the wind farm was on a relatively large expanse of Pennine moorland, whereas the pylons were much closer to roads and man-made features, the context of which was provided by the auditory input.

The model proposed to predict the wildness rating could incorporate estimated levels of man-made noise such as the Calculation of Road Traffic Noise for UK Road Traffic (Department for Transport and Welsh Office, 1988), or the UK Aircraft Noise Contour Model (ACON) (Civil Aviation Authority, 1999) where applicable, and the percentage of wild land can be estimated from maps or photographic surveys. It is suggested that the following categories be applied to rate the level of wildness as per the approach suggested for tranquillity mapping (Watts et al., 2013), which uses a rating of 7.0 - 7.9 as "good" and ≥8.0 as "excellent". When applying the same approach to wildness it can be seen from Figure 4 that a landscape with 100% wild land would require the average man-made noise level over the day (7am to 7pm) to be ≤42 dB(A) to obtain a "good" rating. To obtain an excellent rating the noise level would need to be ≤22dB(A), which in practice would indicate no perceptible noise at all. For smaller percentages of wildland it is predicted that lower levels of noise would need to exist to reach these suggested levels of rated wildness. However below a percentage of 50% wildland it can be seen from Figure 4 that it would not be possible to reach good or excellent levels of wildness.

4.2 Limitations

This study utilized three experimental conditions, two of which contained enhanced acoustic information, in order to determine the key factors that influenced the perception of wildness and tranquillity. It is likely that for some environments this edited data did not provide sufficient context to the environment being assessed or that it failed to fit with an existing schemata. The use of edited stimuli may also partly explain why the wildness prediction model, in its current form, fails to reach the maximum achievable score of 10, despite the input parameters being at the optimum level. This may however simply be related to the fact that the model is derived from a regression analysis and that 25% of the variance is unexplained by the subjective assessments, thereby introducing an element of inaccuracy into the model.

However, an alternative interpretation is that there is a variable missing from the model and the strongest indication is that it most likely relates to an objective measure of the 'quality of wildness'. Specifically to that feeling of remoteness, size, vulnerability and unending naturalness that comes from being in the type of pristine environments that compelled SNH (2003) to remove the word wilderness from their wildland literature. None of the videos used within this research presented data that was collected in anything approaching true wilderness environments. Consider for example the vast and pristine expanse of the Sahara Dessert, the Australian Outback, Oregon or Alaska, for example, where ratings approaching 10 would be fully expected. What it did do however, was present a sample of British landscapes that spanned the limited wildland continuum available and enabled the first wildness rating tool (WRAPT) for use in the UK to be developed. Note a similar approach could be used in other countries in order to calibrate the model for local conditions

5. Conclusions – Richness of the dataset

This research extends beyond the literature by drawing on a rich dataset to demonstrate that unlike tranquillity, wildness appears to be a more intellectual construct. However, it relates well to remoteness and naturalness and is reduced by the presence of mechanical noise and man-made structures such as energy infrastructure. Using the successful approach previously employed for the development of a prediction model for tranquillity (TRAPT), it has been demonstrated that a very similar approach works well for wildness. WRAPT is the first attempt to predict wildness from physical variables, the values of which can be readily obtained from field surveys supplemented by detailed maps where large areas require assessment. The approach adopted here could also be extended to include additional monetary trade-offs. For full landscape assessment it is suggested that both WRAPT and TRAPT models are used in order to obtain an overall impression of the landscape quality.

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