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Research Paper

Towards predicting wildness in the United Kingdom

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HIGHLIGHTS

- Bi-modal stimuli were used to assess how wild environments were perceived to be.
- Self-assessment Manikins were used to measure emotional responses to the stimuli.
- A unique dataset was used that enabled each stimulus to be presented in three experimental conditions.
- Objective measures allowed a Wildness Rating Prediction tool to be developed.
- The study showed wildness to be a more intellectual or cognitive construct than tranquillity.

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ABSTRACT

This paper reports the findings of a 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 or cognitive 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.

1. Introduction

The progressive decline of Britain's native woodlands over the last 3000 years and the establishment of successive layers of cultural landscapes have resulted in significant loss of biodiversity across all trophic levels. This is evidenced by the fact that at the end of the 14th Century apex predators such as the grey wolf and brown bear had vanished, 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). This high rate of attrition was acknowledged by Habron (1998), who when writing about the visual perceptions of Scottish landscapes, stated that "in bio-physical terms, there is very little, if any, wildland left in Scotland, as most of the landscape has been altered by human hand or grazing, and what does remain is now under pressure from recreational activities and the continued development of forestry".

This analysis applies equally to many of the UK's more remote areas where tourism in particular is bringing increasing numbers of visitors in search of 'natural environments'. In 2010 the Scottish Highlands attracted 2.1 million tourists who contributed over £500 million to the Scottish economy. Over half of these visitors (57%) reported the scenery and landscape as being the prime reasons for visiting the area ("2011 Scotland Visitor Survey: Regional results"). In the case of Dartmoor National Park, which is located approximately 600 miles south of the Scottish Highlands, 2.4 million tourists contributed over £110 million to the regional economy in 2012 ("National Parks: Facts and Figures"). These figures show that despite prolonged anthropocentric activity having reduced the British landscape to a simplified ecology, the desire of many to

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engage with what are considered to be unspoilt natural environments is strong.

The gradual change in our accepted norm of ecological and environmental conditions is often referred to as the Shifting Baseline Syndrome. This describes the incremental decline of standards that emerge as a result of each new generation lacking knowledge of the historical condition of their environment. The concept was first elucidated by Pauly (1995) and is useful when attempting to understand how and why various visual and acoustic attributes contribute to, or detract from, the perception of environmental qualities such as wildness or tranquillity. Both of these perceptive environmental characteristics 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 that the wording used within the literature 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 Statement 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 align with Habron's descriptors and use the term 'wildland', which they define as; "uninhabited and often relatively inaccessible countryside, where the influence of human activity on the character and quality of the environment has been minimal", and 'wildness' as the perceptive quality that such places are measured by. This descriptor is conceptually easier to handle than terms such as 'untrammelled', which underpins the definition of wilderness in the USA's 1964 Wilderness Act. The terms wildland and wildness have therefore been applied throughout this paper and for reference have been included along with other key concepts in the Glossary of terms Supplemental file.

Previous qualitative studies into how wild spaces are characterised, such as Australia's National Wilderness Inventory (2003), have focussed on a set of generally accepted attributes of wildness that relate to perceived levels of remoteness and naturalness (Lesslie, Taylor, & Maslen, 1993). The degree of naturalness of a scene is broadly associated with vegetation and water, plus the amount of human-induced change present (Ode, Tveit, & Fry, 2008). Vegetation quality is judged by the percentage of natural vegetation present within the visual scene and its shape, level of succession, and the extent to which it conforms with traditional land use of the environment being appraised. The visual scale and degree of disturbance to both the landscape and the vegetation also contributes to perceived naturalness. Scale provides the observer with information about size, shape, diversity, openness and availability of resources, all of which are components of Appleton's Prospect-Refuge-Theory (1975), whereas disturbance allows the unity (coherence) of the scene to be gauged. The spatial arrangement of water within the scene and some idea or imagined ideal of what a traditional landscape may have looked like are also deemed to be important elements in the naturalness construct. Remoteness is simply taken to mean the distance from places of permanent occupation or established access routes.

Naturalness and remoteness were used by Carver, Comber, McMorran, and Nutter (2012) on behalf of Scottish Natural Heritage (SNH), to underpin the development of a GIS model designed to map wildland contours across Scotland. As part of the project a uni-modal perception study was also carried out (SNH, 2012) to derive weighting factors for use within the model. This study employed photographs and a questionnaire to illicit responses from a large sample of volunteers. The results showed the presence of wildlife and noticeable geological and geographical features within the landscape (such as cliff faces and boulder fields) to be additional 'natural' elements that significantly contributed to the perception of wildness. Conversely built up areas, energy infrastructure (such as pylons, wind turbines and dams) and recreational infrastructure (such as four-wheel-drive tracks, hiking paths, ski lifts, and evidence of hunting), all influenced the visual perception of wildness in a negative way. These human artefacts introduce an element of visual discontinuity within the landscape that can result in a perceived lack of contextual coherence (i.e. the human artefacts can be perceived to be out of context). Elements within the landscape (and soundscape) that disturb the observer's affiliation with nature are also deemed to be out of context. This is especially the case if they conflict with the natural, cultural and historical richness of the environment or accepted stewardship practices.

Within this study contextual features have been defined as: man-made elements within the landscape (and soundscape) that do not disrupt the human affiliation with nature. When combined with the definition of naturalness provided in the Glossary of terms, the objective measure of 'natural and contextual features' (NCF) present within the visual scene can be determined.

From what has been said above it can be appreciated that visual scene perception involves utilising information from the global properties of the visual world, rather than simply from single objects located within it. Thus a wild land may for example consist of water, rocks and birds, 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 contextual template (schemata) against which to compare them to. Kaplan and Kaplan (1989) referred to this context as configurational coherence, and simplified the term by explaining that it related to "the degree to which a scene hangs together". However, this is only part of the process, as our senses evolved to compensate for the weaknesses of each other, thereby enabling us to characterise our environment on more than just a uni-modal sensory input. Therefore in situations where no schemata exist to account for contextual discontinuity, additional senses are brought on-line to try and resolve the ambiguity. In the first instance this tends to fluctuate between vision and audition, until context of the sensory information received enables an environment to be adequately described. Therefore what we hear (or expect to hear) is a fundamental part of landscape characterisation. This is defined here as; the process by which an individual uses sensory cues, their previous experiences, and their knowledge of biological, natural and man-made indicators, to make a judgement on how to describe a location.

Landscape character assessment methodologies within the UK, rarely incorporate objective acoustic measures within their appraisals (Countryside Agency, 2002) of what Gobster, Nassauer, Daniel, and Fry (2007) describe as the 'scenic aesthetic' (i.e. landscape scenery). This is despite a growing body of scientific evidence that supports the argument that the perceptive process of environmental characterisation is much more than a uni-modal sensory construct. 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 cognitive construction of tranquil space (Hunter et al., 2010).

The fact that wildness and tranquillity are frequently mentioned together within the management plans and marketing material of National Parks, and with policies related to the management

Table 1
Acoustic metrics used in the study.

Metric	Definition
LAeq	A-weighted equivalent sound level. This is the preferred method used by acousticians to describe sound levels that vary over time resulting in a single decibel value that takes into account the total sound energy over the period of interest
LAmax	A-weighted maximum sound level measured during the recording period
LAmin	A-weighted minimum sound level measured during the recording period
LA10	A-weighted noise level exceeded for 10% of the recording period
LA90	A-weighted noise level exceeded for 90% of the recording period
Lday	This is LAeq measured over a 12 h period (07:00–19:00)

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 a modified version of the Tranquillity Rating Prediction Tool (TRAPT) proposed by Pheasant, Horoshenkov, and Watts (2010), which uses the day time equivalent sound level (Lday, see Table 1) and the percentage of natural and contextual features visible within the landscape, could use bi-modal variables to accurately predict mean perceived wildness of an environment. Unless of course the perception of wildness is a less intuitive construct than tranquillity, or vice versa.

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 as they affect 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 measure the wildness of environments, rather than visual properties alone. The hypotheses being tested are that naturalness and remoteness would correlate well with wildness, but not so much with tranquillity; and that wildness is typically a more cognitive construct than tranquillity, naturalness and remoteness. 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 Metre (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 and natural environments, between the least wild (wholly urban) and most wild (wildland) end points. During filming the camcorder was swept from left to right over a 1 min recording period, 30 s of which settled on the central view. At the same time the associated soundscape was recorded as a WAV file on the SLM, which was calibrated in the field using a B&K 4231 94 dB (1 kHz) sound calibrator. The advantage of recording the soundscape on the sound level metre was that simultaneous objective acoustic measures for the metrics described in Table 1 were also taken. A-weighted filters have been used as they cover the audio range 20–20 kHz and have a response similar to that of the human ear.

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 audio file was imported and reconciled with its corresponding visual scene. The decision was then taken to either present each of the locations with just the 30 s central view or with the 120° 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 five environments that covered 120° and eleven that used only the central shot. In both cases the presented stimuli lasted for approximately 30 s (±2) as per the exposure time reported by Pheasant, Horoshenkov, Watts, and Barrett (2008).

The bi-modal stimuli used within the study consisted of fifteen locations presented in the following three different experimental conditions:

(1) As recorded in situ (referred to 'as is')
(2) With enhanced mechanical soundscape components added (referred to as 'enhanced mechanical')
(3) With enhanced biological or natural soundscape components added (referred to as 'enhanced biological or natural')

A recording of a congested main road in the Devonshire village of Modbury was also included. This was left un-edited and used as the control stimuli, as wildness and tranquillity ratings were expected to be close to zero.

When each location was edited to incorporate additional biological and mechanical sounds care was taken to ensure that the added components were in context with the environment in which they were being presented. The biological sounds 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 overlaid on 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 an emphasis on locational congruence rather than on standardised effect.

Fig. 1 shows the central view of the sixteen locations used in the study along with a description of the key soundscape components contained in each of the experimental conditions in the order: 'as is', 'enhanced mechanical' and 'enhanced biological or natural'.

Alongside each experimental condition is the LAeq of that particular stimuli and the amount (±dB) that it differs from the 'as is' condition. The supplemental links for Glen Etive, River Nevis, Hay Tor, Modbury, Great Mis Tor and Ovenden Moor, provide examples of the audio recordings used in the three experimental conditions. These six locations have been selected as they cover the broad spectrum of the wildland continuum presented within the study. Once the editing of the video tracks was complete, the resulting 46 stimuli (i.e. 15 environments × 3 experimental conditions + 1 control environment), were each placed in random order and then turned into a video stream that was copied onto a DVD. This whole process was repeated twice more to enable three uniquely ordered

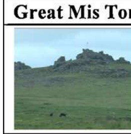
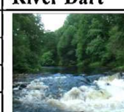
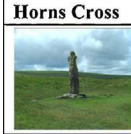
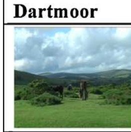
Location	Image	Soundscape	LAeq	+/- dB
Highland Railway		Very quiet	35.5	N/A
		Train Horn	72.8	+ 37.3
		Call of stag	44.5	+ 9.0
Corrour Estate		Wind	38.0	N/A
		Aircraft	40.7	+ 2.7
		Buzzard	38.5	+ 0.5
Glen Etive*		Stream	44.3	N/A
		Aircraft	57.1	+12.8
		Eagle	56.9	+12.6
Glen Nevis		Car park	48.5	N/A
		Fast jet	61.4	+12.9
		Birds	54.1	+5.5
River Nevis*		River	50.5	N/A
		Tractor	56.1	+5.6
		Birds	55.2	+4.7
Hangershell Tor		Birds	34.4	N/A
		Siren	44.6	+10.1
		Stream	40.8	+6.3
Great Mis Tor*		Wind	42.7	N/A
		Gun fire	63.5	+20.7
		Birds	52.0	+9.3
River Dart		River	71.0	N/A
		Aircraft	80.4	+9.4
		Birds	71.5	+0.5
Modbury (Control environment)*		Soundscape	LAeq	63.4dB
		Heavy traffic		
Hay Tor*		Traffic	44.7	N/A
		Aircraft	64.9	+20.1
		Insects	51.6	+6.9
Horns Cross		Wind	38.4	N/A
		Traffic	50.3	+11.9
		Birds	43.7	+5.3
Widecombe-in-the-Moor		Sheep	39.4	N/A
		Tractor	58.6	+19.2
		Birds	53.5	+14.1
Dartmoor		Insects	55.3	N/A
		Traffic	55.7	+0.5
		Birds	60.3	+5.0
Adjacent to main road (A38)		Traffic	62.1	N/A
		Chain saw	75.7	+13.5
		Birds	43.6	-18.5
Ovenden Moor*		Turbines	51.4	N/A
		Traffic	56.3	+5.0
		Stream	52.2	+0.8
Denholme		Traffic	51.8	N/A
		Bulldozer	59.4	+7.6
		Birds	53.0	+1.2

Fig. 1. Introduction to the locations used in the study and their soundscape attributes. Supplemental mp3 files have been included for those locations marked with an asterisk.

DVDs to be produced. An additional 'introduction and practice' DVD was also compiled that contained slides explaining the purpose of the experiment and the terminology and graphical representations used to describe the variables being measured. It also contained five video clips of contrasting stimuli that were not included in the main dataset.

2.3. Procedure

Twenty one subjects (10 female and 11 male) took part in the experiment. Their average age was 38 years (±15.7 years) and their ages ranged from 38 to 71 years. All of the subjects arrived as 'naïve' volunteers and each was rewarded with a £15 store voucher.

The experiment was conducted in a soundproof psychoacoustic suite with the volunteers sitting in pairs wearing ROLAND RH-300 stereo headphones. These had been calibrated using the 94 dB 1 kHz calibration tone recorded in the field, to ensure that the audio data was presented at the same level that it was recorded. For each location shown on the Pioneer (PDP-506XDE) plasma screen, which was attached to a Samsung R125-DVD player, the subjects awarded a score of 0–10, with 0 being least and 10 being most, for the following bi-modal environmental attributes: wildness; tranquillity; naturalness; and felt remoteness. They also used Self-assessment Manikins (SAM) to indicate their emotional reaction to the environment being shown in terms of: pleasantness; calmness; and control (Fig. 2).

The use of SAMs is a non-verbal pictorial assessment technique devised by Hades, Cook, and Lang (1985) that directly measures the pleasure, arousal, and dominance 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 & Lang, 1994). The advantage of using SAMs as opposed to Semantic Differential (SD) for example, is that the ranked pictures can be quickly interpreted with little error across a wide range of age groups and cultures. It therefore fitted well with the limited time that the subjects had to record their scores on the response sheets provided.

Prior to the experiment commencing the subjects viewed the introduction and practice DVD which contained a detailed explanation of the variables being measured and of the experimental procedure. Wildness was explained to relate to how free from human control or manipulation an area appears to be (Scottish Natural Heritage, 2003) and tranquillity was defined as "how peaceful and attractive a place is perceived to be, i.e. the extent to which it is considered to be a place to get away from everyday life" (Herzog & Barnes, 1999). In relation to naturalness the

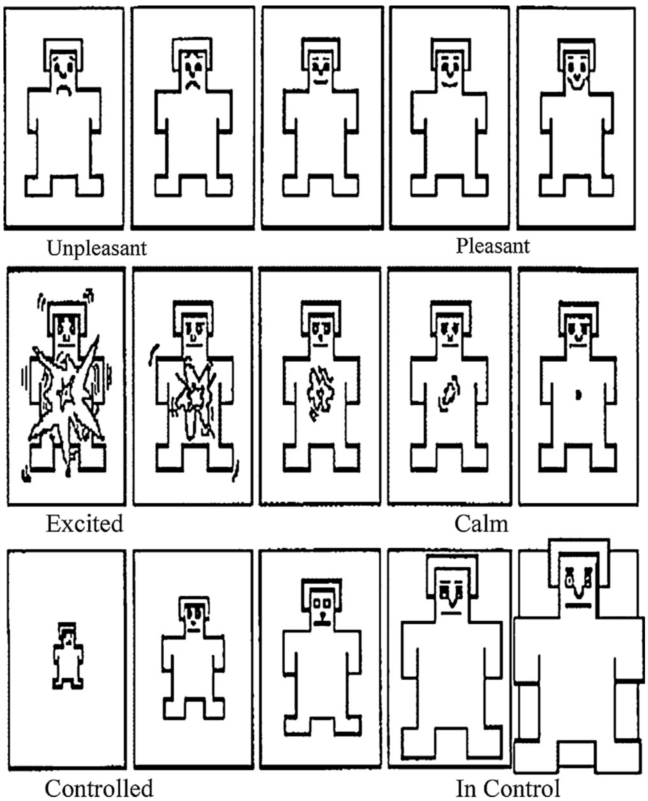


Fig. 2. The Self-assessment Manikins (SAM) used to illicit emotional responses.

subjects were instructed to consider the following key indicators: the naturalness of the vegetation; landscape patterns; visual scale; the degree of human-induced change present; and the overall unity of the scene. They were also encouraged to draw upon whatever other value judgements they considered appropriate.

In previous wildness perception studies (Scottish Natural Heritage, 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 arguably because these studies have used uni-modal stimuli, i.e. photographs to stimulate a response, rather than a more immersive auditory-visual dataset. In the introduction and practice DVD, the concept of 'felt remoteness' was introduced to the subjects. This is an adaptation of 'felt intensity', which is used to explain the intangible sensitivities to certain components of the urban environment (Massey, Allen, & Pile, 1999).

Due to the high probability that 'felt remoteness' would be an unfamiliar concept, the subjects were instructed that they should rate it based on how far from civilization the auditory and visual information made them feel for each location presented. They were also told that for the purpose of this experiment the term civilization should be taken to mean populated areas, or well used transportation routes, such as main roads and railway stations that service such areas.

It was acknowledged during the experimental design phase that there would be a degree of uncertainty in the validity and reliability of the ratings attributed to the felt remoteness variable. However, it was included in the experiment as there was an assumption that the additional information provided by an auditory input that was congruent to the visual scene, would provide key information in relation to distance and therefore remoteness. Distance being the noun that the adjective remoteness describes.

When introducing the SAMs to the subjects it was verbally explained that calmness was being used as a proxy for arousal, and that it referred to how various auditory and visual components within the presented stimuli raised levels of alertness and excitement. Pleasantness was considered to be an intuitive construct and the subjects were simply asked to score each environment on how pleasant or unpleasant they found it to be. No other guidance was provided to the subjects on rating calmness and pleasantness. Control, which was used as a proxy for dominance, was slightly more problematic to explain to the volunteers and to apply to environmental quality appraisal. This may well be because it is used to measure interaction-structured situations and stimuli, rather than passive activities, such as viewing and listening to landscapes. The participants were instructed to rate control on the extent to which they felt that they were either in control of the environment being assessed or controlled by it in some way. To illustrate this point they were asked to consider the extent to which a busy road or the presence of a dangerous animal within their immediate environment might influence how 'in control' or 'controlled' they felt.

Once these points had been covered and all questions answered, the subjects were asked to complete a practice exercise. This included five 30 s video tracks that showed a range of environments that differed to those being used in the actual experiment. During the first presentation of these environments the subjects were simply introduced to the stimuli and not required to make any quality evaluations. Whilst viewing the five environments for the second time, they were asked to score them on perceived wildness, tranquillity, naturalness and felt remoteness. Then during the third and final exposure to the stimuli they were required to include their emotional responses to calmness, pleasantness and control. The introduction and practice session lasted approximately 20 min and was followed by a 10 min break.

During the experiment the subjects were shown 3 DVDs that contained 15 locations in each of the 3 experimental conditions, plus the 1 control location in the 'as is' condition only. Each DVD therefore contained 46 video clips. DVD 1 included 15 s gaps between each location presented to allow subjects enough time to record their responses. The 2nd and 3rd DVDs had 10 s gaps between each video clip. All subjects were shown DVD 1 first and given the choice which of the remaining two DVDs they wanted to view next. Due to the length of this experiment, all subjects were given a second 10 min comfort break between the final two DVDs. Only results from the second and third presentations of each video set were used in the final analysis.

At the end of the experiment, after all 3 DVDs had been shown, subjects were asked to complete a questionnaire that queried which visual and auditory components of the stimuli most enhanced and detracted from their 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 & Bosely, 1992; Watts, Pheasant, & Horoshenkov, 2011). Fig. 3 summaries the process and timeline followed in this experiment.

2.4. Objective measures

The WAV files used to introduce 'enhanced mechanical' and 'enhanced biological or natural' soundscape components to each of the environments presented were analysed by a specially written Matlab code that enabled their A-weighted sound levels to be calculated. This was achieved by comparing them against the calibration tones that were recorded onto the sound level metre in the field. This process showed an acceptable maximum error of ±0.5 dB.

The interpretation of naturalness and context provided in the introduction was used to determine the percentage of natural and contextual features (NCF) within each of the visual scenes. These

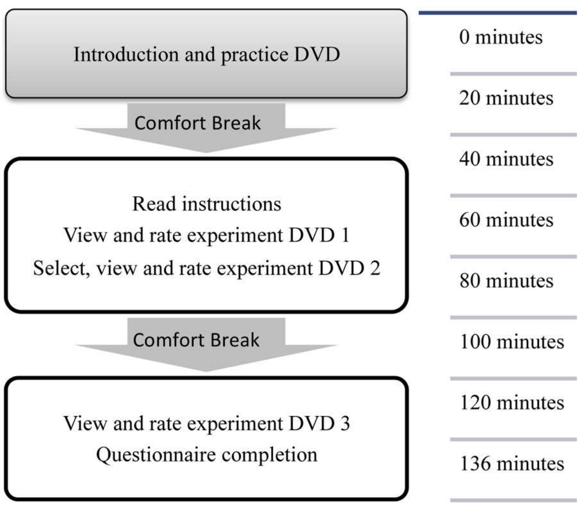


Fig. 3. Flow diagram of the experimental procedure produced in Word.

were derived using the methodology described in Pheasant et al. (2008) by pasting the landscape images into PowerPoint and overlaying a 10×10 grid. The areas covered by natural and contextual features 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 as slight changes in camera angle have the potential to bias the measurement. If N is the area with natural and contextual features and M the total area of man-made features then NCF is given by:

$$\mathrm{NCF} = \frac{100N}{N+M} \qquad (1)$$

For the purpose of calculating the percentage of wildland within the visual scene, elements of human-induced change such as plantations, or other overt acts of stewardship that disrupted the unity of the scene, were subtracted from N in Eq. (2), yielding the area of wildland W. Contextual features were not included within this calculation as the measure is applied to human artefacts within the landscape and does not fit with the notion of wildness. The percentage of wild land (%W) was therefore given by:

$$\%W = \frac{100W}{N+M} \qquad (2)$$

2.5. Analysis

Microsoft Excel 2010 was used to collate the ratings awarded to each of the experimental variables (wildness, tranquillity, naturalness, felt remoteness, calmness, pleasantness and control) for each of the 46 environments presented and to perform a repeated-measures Analysis of Variance (ANOVA). This was carried out in order to confirm that the values for the dependent variables (wildness and tranquillity) obtained in the three treatments were sufficiently different to each other. Excel was also used to carry out a Pearson correlation analysis between the mean ratings awarded by the subjects (for each of the landscape attributes and emotional responses listed above); and the objectively derived measures. These were the acoustic metrics listed in Table 1, the percentage of natural and contextual features present within the visual scene and the percentage of land calculated as being 'wild'.

IBM SPSS Statistics 20 was used to perform stepwise linear regression analysis to identify the combination of independent variables that provided the highest coefficient of determination (adjusted R^2) and the highest significance (P-value) for the dependent variables wildness and tranquillity. It was also used to perform simultaneous linear regression analysis to establish the relationship between the acoustic metric LAeq and the emotional responses for calmness, pleasantness and control, and to develop two theoretical models for predicting wildness that utilised objectively derived data.

3. Results

3.1. Analysis of Variance

The results of the repeated measures ANOVA contained in Table 2 show that the video clips presented in each of the three experimental conditions ('as is', enhanced mechanical sounds and enhanced biological or natural sounds) were significantly different to each other ($P < 0.00$), for both perceived wildness and perceived tranquillity. They also show that the results for perceived tranquillity contained a much higher degree of variance across all conditions than the results obtained for wildness, thereby suggesting that tranquillity and wildness are indeed separate perceptive constructs. The difference in variance may be explained by the fact that LAeq is known to be a strong factor within the construction of tranquil space and that the locations showing the greatest degree of variance (Great Mis Tor, Highland railway and the A38 trunk road), all contained relatively high levels of mechanical noise in the enhanced experimental condition that may have been interpreted by some of the subjects as being ambiguous, or out of context with the visual scene being presented. This was certainly the case for one individual who mistakenly interpreted the call of an unseen rutting stag, introduced as 'enhanced biological or natural sounds' to the scene of the highland railway, as the roar of a lion.

3.2. Pearson correlation analysis

The results of the Pearson correlation analysis which are contained in Table 3 identified that average perceived wildness is well correlated with perceived naturalness, felt remoteness and the emotional response pleasantness, but less so to calmness and control and to sound levels. It also showed that tranquillity is well related to naturalness and felt remoteness but much more so to the emotional reactions of pleasantness, calmness and control and to the acoustic indices LAeq, LA10 and LA90, explanations of which are provided in Table 1.

3.3. Stepwise linear regression analysis

When all of the results were analysed using stepwise linear regression analysis the independent variables that resulted in the highest observed coefficient of determination (adjusted R^2) and highest significance (P-values) for the dependent variable wildness were: perceived felt remoteness; perceived naturalness; and the percentage of wildland contained within the visual scene. In the case of tranquillity the emotional responses for calmness and perceived naturalness, and the measured LAeq were all shown to be significant factors. These results, which are contained in Table 4, indicate that visual information plays a stronger role in both constructs than auditory information and that wildness is potentially a more cognitive (i.e. more analytical) construct than tranquillity as it draws almost as much on perceived 'felt remoteness' as it does on perceived 'naturalness'. Care was taken within this statistical test to reduce bias by including as small a set of predictor variables as possible.

3.4. Simultaneous linear regression analysis

In order to understand the extent to which objectively derived auditory and visual measurements were able to predict wildness, simultaneous linear regression analysis was carried out using LAeq

Table 2
Results of the repeated measures ANOVA.

Wildness			Tranquillity		
Summary	Average	Variance	Summary	Average	Variance
Adjacent to main road (A38)	4.33	1.69	Adjacent to main road (A38)	3.33	10.19
Highland railway	6.09	0.55	Highland railway	5.50	11.91
Corrour Estate	8.32	0.01	Corrour Estate	8.67	0.12
Widecombe-in-the-Moor	5.06	0.45	Widecombe-in-the-Moor	6.20	6.22
Horns Cross	6.94	0.61	Horns Cross	6.94	5.75
Great Mis Tor	6.53	0.90	Great Mis Tor	5.22	13.38
Dartmoor	6.62	0.13	Dartmoor	5.94	0.77
Denholme	4.79	0.04	Denholme	4.05	1.69
Glen Etive	7.94	0.56	Glen Etive	7.19	8.27
Glen Nevis	5.63	0.37	Glen Nevis	4.44	2.79
Hangershell Tor	7.55	0.49	Hangershell Tor	7.36	6.90
Hay Tor	5.32	0.28	Hay Tor	3.86	1.70
River Nevis	7.40	0.19	River Nevis	7.66	2.85
Ovenden Moor	6.02	0.25	Ovenden Moor	4.58	5.47
River Dart	7.65	0.31	River Dart	4.21	2.86
Treatment			**Treatment**		
as is	6.59	1.63	as is	6.80	3.99
Enhanced mechanical sounds	5.75	1.75	Enhanced mechanical sounds	3.29	4.08
Enhanced biological or natural sounds	6.89	1.36	Enhanced biological or natural sounds	6.94	2.17

ANOVA				ANOVA			
Source of variation	*F*	*P*-value	F_{crit}	Source of variation	*F*	*P*-value	F_{crit}
Rows	38.87	1E−14	2.06	Rows	6.51	1.4E−05	2.06
Columns	45.17	2E−09	3.34	Columns	53.13	2.9E−10	3.34

Each of the tests contained 44 degrees of freedom (df).

Table 3
Results of the Pearson correlation analysis.

	WI	TQ	N	FR	P	CA	CO	EQ	10	90	NC	W
Wildness (WI)	1											
Tranquillity (TQ)	0.76	1										
Naturalness (N)	0.96	0.86	1									
Felt Remoteness (FR)	0.94	0.86	0.94	1								
Pleasantness (P)	0.73	0.97	0.85	0.81	1							
Calmness (CA)	0.63	0.97	0.76	0.73	0.97	1						
Control (CO)	0.65	0.78	0.78	0.75	0.98	0.99	1					
LAeq (EQ)	−0.40	−0.74	−0.47	−0.53	−0.69	−0.79	−0.75	1				
LA10 (10)	−0.41	−0.77	−0.49	−0.55	−0.71	−0.81	0.78	0.99	1			
LA90 (90)	−0.40	−0.62	−0.41	−0.51	−0.56	−0.63	0.59	0.91	0.86	1		
% NCF (NC)	0.52	0.31	0.51	0.38	0.30	0.28	0.29	−0.13	0.13	−0.12	1	
% Wild (W)	0.71	0.32	0.58	0.59	0.33	0.22	0.24	−0.12	−0.13	−0.19	0.44	1

The abbreviations shown in parenthesis in column 1 denote the variable titles used in row 1.

Table 4
Results of the stepwise linear regression analysis.

Wildness versus Felt remoteness, % Wildland and Naturalness

Adjusted $R^2 = 0.92$, $F(2,43) = 176.91$, $P < 0.000$, S.E. 0.43, $n = 46$

	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	1.52	0.228	6.685	<0.000	1.06	1.98
Felt remoteness	0.333	0.085	3.889	<0.000	0.16	0.50
% Wild	0.008	0.002	4.076	<0.000	0.00	0.01
Naturalness	0.340	0.089	3.797	<0.000	0.15	0.52

Tranquillity versus Calmness, Naturalness and LAeq

Adjusted $R^2 = 0.94$, $F(2,43) = 243.3$, $P < 0.000$, S.E. 0.61, $n = 46$

	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	−1.850	1.206	−1.534	0.132	−4.283	0.583
Calmness	0.544	0.071	7.645	<0.000	0.400	0.688
Naturalness	1.462	0.195	7.508	<0.000	1.069	1.855
LAeq	−0.030	0.013	−2.276	<0.05	−0.057	−0.003

Table 5
The extent to which objective measures was able to predict wildness and tranquillity.

Wildness versus %Wild and LAeq						
Adjusted R^2 = 0.52, $F(2,43)$ = 25.90, P < 0.000, S.E. 1.07, n = 46						
	Coefficient	S.E.	t-Stat	P-value	Lower 95%	Upper 95%
Intercept	6.625	0.875	7.571	<0.000	4.861	8.390
%Wild	0.025	0.004	6.270	<0.000	0.017	0.033
LAeq	–.040	0.015	–2.718	<0.01	–0.069	–0.010
Tranquillity versus LAeq and NCF						
Adjusted R^2 = 0.56, $F(2,43)$ = 30.60, P < 0.000, S.E. 1.68, n = 46						
	Coefficient	S.E.	t-Stat	P-value	Lower 95%	Upper 95%
Intercept	11.667	1.79	6.50	<0.000	8.05	15.29
LAeq	–0.164	0.023	–7.167	<0.000	–0.210	–0.118
NCF	0.028	0.013	2.228	<0.05	0.003	0.054

and the percentage of wild land contained within the visual scene as independent variables. The same test was also conducted to assess whether LAeq and the percentage of natural and contextual (man-made) features present agreed with the equation used within the Tranquillity Rating Prediction Tool (TRAPT). The results are contained in Table 5.

From Table 5 it can be seen that that the percentage of wild land contained within the visual scene and the A-weighted equivalent sound level (LAeq) are both significant factors in predicting wildness at the 95% confidence level. The mid-range adjusted R^2 value of 0.52 may be attributable to a missing variable, such as the distance from the nearest conurbation or access route, or it may be a function of the relatively small sample size used within the study.

In the case of tranquillity the relationship between LAeq and NCF was shown to be similar to the values used in the Tranquillity Rating Prediction Tool, where the Tranquillity Rating equaled 9.86 + 0.041 NCF – 0.146 LAeq. The mid-range adjusted R^2 for this measure is likely to be a result of the landscape types being assessed and the relatively low degree of soft fascination contained within the scenery. This is known to be an essential component of the tranquillity construct and is a lower state of arousal than directed attention. Within this study directed attention within the perception of tranquillity is most likely to have been elevated by several of the edited mechanical and biological soundscape components.

3.5. Effects of enhanced soundscapes

The addition of mechanical noise resulted in an average decreased wildness rating of 0.9 of a point within the 0 (least wild)–10 (most wild) range. The greatest effect however, was observed on the perception of tranquillity, where ratings were reduced by up to −3.5 points within the 0–10 scale. The addition of biological and natural sounds made a small but significant increase in wildness ratings of 0.3 of a wildness point, but had no significant effect on perceived tranquillity. These findings are supported by the results of the ANOVA reported in Section 3.1.

Interestingly, the greatest influence of enhanced mechanical noise on all the subjective ratings did not relate to the environment that had the highest LAeq (80.5 dB), which emanated from a low flying aircraft, but from two short bursts of automatic weapon fire. These came from a military firing range within the Dartmoor National Park (Great Mis Tor) and at 63.5 dB(A) were 17.0 dB(A) lower than the aircraft mentioned above. 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. Thereby adding strength to the theory that perceived environmental characterisation relies on multi-modal, rather than uni-modal information. It also relies on cognitive categories of noise, rather than just objective measures of such. 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. This location is also situated within the Dartmoor National Park and lies approximately 2 miles from the nearest road. The introduction of the siren, which although low at 44.6 dB(A) was still 10 dB(A) higher than the original ('as is') sound level, degraded the feeling of isolation by 3.3 points on the 0–10 point scale.

When the 'as is' 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 or natural sounds have been added. However, the amount of improvement in overall perceived environmental quality is limited, perhaps because each of these qualities is already rated very highly. The recording of Glen Etive in the Scottish Highlands enhanced with biological or natural sounds (birdsong) (see Fig. 1) was the environment rated as being 'most wild'. Subjects rated it as 8.3 (mean) in the 'as is' condition, but this rose to a mean of 8.7 once enhanced biological or natural sounds had been added, which was an increase in perceived wildness of (+0.4). This 'as is' location was also assessed as being the most: tranquil (9.1), natural (9.1), pleasant (4.7) and calm (4.8), of all the locations and experimental conditions presented in the data set. Note that the SAM rating methodology uses a 5 point scale, as opposed to the 11 point scale used for the assessment of wildness, tranquillity, naturalness and felt remoteness.

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 on the 'as is' assessment, it reflects how transitory noises are continually processed within auditory scene analysis, to enable the brain to perceptually construct as much environmental context as possible. The biological sound added to this location was the distant mewing of an unseen buzzard which lasted for no more than 2 s.

3.6. LAeq versus the emotional responses

When the emotional responses calmness, pleasantness and control were regressed against LAeq (Table 6), the sound level was shown to be a significantly negative factor in all three emotional measures. When the emotional responses were tested together against the dependent variables, wildness and tranquillity, only calmness and pleasantness were highly significant factors (P < 0.001). For both wildness and tranquillity, control fell a long

Table 6
Results of regression analysis of the emotional response versus LAeq.

Calmness versus LAeq.						
Adjusted $R^2 = 0.61$, $F(1,44) = 73.68$, $P < 0.000$, S.E. 0.62, $n = 46$						
	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	7.341	0.453	16.214	<0.000	6.428	8.253
LAeq	−0.067	0.008	−7.975	<0.000	−0.084	−0.050
Pleasantness versus LAeq						
Adjusted $R^2 = 0.34$, $F(1,44) = 24.60$, $P < 0.000$, S.E. 0.84, $n = 46$						
	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	6.518	0.621	10.492	<0.000	5.266	7.770
LAeq	−0.057	0.011	−4.960	<0.000	−0.080	−0.034
Control versus LAeq						
Adjusted $R^2 = 0.45$, $F(1,44) = 39.08$, $P < 0.000$, S.E. 0.58, $n = 46$						
	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	6.378	0.427	14.924	<0.000	5.516	7.239
LAeq	−0.049	0.008	−6.251	<0.000	−0.065	−0.033

way short of the 95% confidence level. This may well be because control is an ambiguous concept to apply to passively viewed scenes and it is potentially not considered to be relevant, or perhaps it was not well understood by the subjects.

3.7. Questionnaire analysis

Further insight into how the subjects rated the environments can be obtained from a review of the questionnaire results. These showed that the two visual components that contributed most to the perception of wildness were: the lack of man-made influence (24%) and the presence of wide open spaces with distant views (24%). The two soundscape components that contributed the most to the perception of wildness were biological noises and running water. The visual detractors of wildness were traffic (39%) and energy infrastructure (pylons and wind turbines) (26%), whereas transportation noise (65%) and gunfire (15%) accounted for the least favourable 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 visual factors. Nearly half of the respondents (43%) reported that silence or “extreme quiet” enhanced the feeling of remoteness the most and 22% stated that low levels of biological noise had the greatest influence.

3.8. Developing a Wildness Rating Prediction Tool

The negative impact of noise upon the perception of both wildness and tranquillity has been a recurring theme throughout the analysis of the results from this study. The hypothesis that it is the LAeq of ‘man-made’ noise rather than naturally occurring sounds, and the percentage of wildland visually present within the scene that informs the wildness construct, is confirmed. It is therefore possible to propose a Wildness Rating Prediction Tool (WRAPT). This follows the approach taken by Pheasant et al. (2010) in the development of TRAPT. Within the application of the proposed WRAPT, it is anticipated that levels of man-made noise will be negatively correlated to the wildness rating and that the percentage of wildland in the landscape would be positively related. Therefore, in order to mathematically account for the negative impacts of mechanical noise, 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

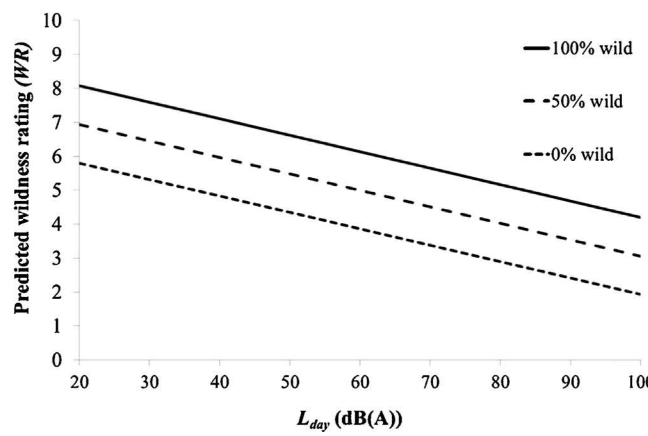


Fig. 4. Predicted wildness versus Lday.

used. The default value chosen was based on a very low level of 26 dB(A) recorded on the Corrour Estate over a 90 s period during the field study. This recording was not used within the video clips presented to the subjects as it contained no perceptible environmental information. The findings of this pilot study suggest that the 26 dB(A) default value can be applied to natural environments, such as raging rivers that have a very high LAeq, as these environments were rated highly by subjects for wildness, regardless of the sound level presented within the video clip. This is evidenced by the River Dart, which in the ‘as is’ experimental condition had a mean wildness rating of 7.7 despite the 71.7 dB LAeq recorded at this location.

By regressing wildness with the percentage of the landscape measured as wild (%W) and LAeq values that included the 26 dB default for wholly natural soundscapes, the regression equation contained in Table 7 was obtained.

Fig. 4 shows how the predicted wildness rating changes as a function of the average noise level for various percentages of wildland within the landscape. It can be observed that higher noise levels decrease wildness ratings, whereas the greater the percentage of wild land presents the higher the rating. The form of the WRAPT equation being proposed is similar to that of TRAPT, which links tranquillity ratings with noise levels and the percentage of natural and contextual features present (see Eq. (1)). Note that for practical purposes it is recommended that Lday, which is

Table 7
Results of the WRAPT regression analysis.

WRAPT						
Adjusted $R^2 = 0.72$, $F(2,43) = 60.74$, $P < 0.000$, S.E. 0.81, $n = 46$						
	Coefficient	S.E.	*t*-Stat	*P*-value	Lower 95%	Upper 95%
Intercept	6.875	0.444	15.496	<0.000	5.981	7.770
%Wild	0.021	0.003	6.859	<0.000	0.015	0.027
LAeq (26 dB(A) default)	−0.049	0.007	−6.665	<0.000	−0.064	−0.034

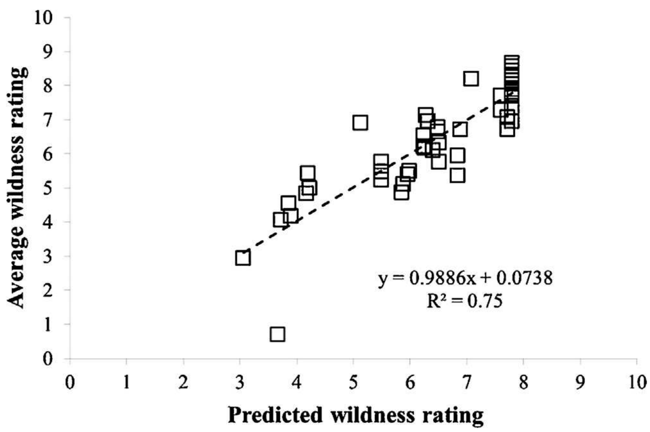


Fig. 5. Predicted wildness rating versus actual wildness rating.

the average noise level (LAeq) over an average day (7am–7pm), is used in both WRAPT and TRAPT.

The strength of the relationship between the average wildness ratings obtained during this study, and those predicted by the WRAPT model is shown in Fig. 5. It can be seen that the simple regression line has a slope close to 1 and when this is extrapolated it passes close to the origin.

4. Discussion

4.1. Interpretation of results

As expected the correlational analysis revealed that the average subjective wildness rating is very closely associated with both 'naturalness' and 'felt remoteness' but much less to noise levels than the tranquillity rating. On the other hand wildness is less well correlated to the emotional responses of pleasantness and calmness than tranquillity. It is therefore suggested that wildness is a more intellectual or cognitive construct than the more affective tranquillity concept. Wildness is less related to rated emotional affects and has a reduced, though important component related to 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 and this may well have been due to the high wildness or tranquillity values already attributed to 'as is' conditions, leaving little room for improvement. It is also likely that those participants that lacked sufficient knowledge to identify some of the natural sounds, such as the distant call of a rutting deer or the hammering of a woodpecker, may have 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 call of unseen 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 broadly support 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. The findings of this study also support the importance of energy infrastructure, i.e. pylons, wind turbines and radio masts, in depressing the perception of wildness.

4.2. Limitations

This study utilised 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 experimental data did not provide the subjects with sufficient context to the environment being assessed or that it failed to fit with their existing perceptual 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 relate to the fact that soundscapes dominated by affective qualities such as gunfire and emergency sirens, which showed a significant reduction in all of the variables rated, requires a different measure to LAeq, as it takes no regard of the context of the sound that it is measuring. A limitation of WRAPT therefore is that the model is insensitive to the context of mechanical sounds, in particular affectively discordant ones. It is therefore suggested that the model is applied in environments that are dominated by noise emitted from transportation, including aircraft, and transportation infrastructure related activities such as construction and maintenance. Sounds emitting from energy infrastructure, such as wind turbines can also be included because of their 'mechanicalness'. An alternative interpretation as to why WRAPT fails to reach its maximum possible score 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 a deeper and more robust quality of wildness. Specifically this quality might relate to the 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, and that is because such environments do not exist within the United Kingdom. What they did do however, was present a sample of British landscapes that spanned the limited wildland continuum available. This enabled the first Wildness Rating Prediction 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.

Although the relatively small sample size used is also acknowledged as a limitation of this study, there are a reasonable amount of studies published within the psychology and brain research literature that utilise a small number of subjects to produce reliable results from audio-visual stimuli. This is often the case where lower levels of cognitive processing of the stimuli is required, as was the case in this study, whereas experiments requiring a greater degree of cognitive effort tend to draw on larger samples to attain reliable results. Wada, Kitagowa, and Naguschi (2003) and Andersen, Tiippana, and Sams (2004) are two examples of laboratory studies that used small sample sizes, 12 and 19 respectively, to produce acceptable results. This provides confidence as to the reliability of the results presented here.

5. Conclusions

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. By 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. Future research into quantifying wildness would benefit from using data recorded in the field for each of the three experimental conditions rather than relying on the use of edited stimuli and by using a larger sample of respondents. Calibrating the model with the wild land contours developed by Carver et al. and used by Scottish Natural Heritage could potentially help revise and thereby strengthen the model. Understanding the importance of monetary trade-offs within the provision and protection of wild land within the UK is also an area that has yet to be adequately investigated. For full landscape assessments it is suggested that both the WRAPT and TRAPT models are used, in order to obtain an overall assessment of these particular landscape qualities.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landurbplan.2014.09.009.

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