Best Focal Length to Represent a Landscape View Using a Single-Frame Photograph

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Abstract: The focal length which best represents the relevant context and character of the landscape in a particular view is investigated through an independent validation study. The study was conducted in Co. Wicklow, Ireland, where seven photographs were taken with FX-equivalent focal lengths between 30 mm and 90 mm at each of three viewpoints. Participants were asked to evaluate how well each photograph represents the visible landscape in terms of its context. The results indicate that a focal length slightly longer than 50 mm is thought to best capture the scope of a landscape view. These results generally support the use of a "normal" focal length lens, and contradict HUNTER'S (2012) recommendations.

Keywords: Visual impact assessment photography, photosimulation standards, landscape perception

1 Introduction

The conduct of visual impact assessments (VIAs) has increased as the public expresses greater concern over visual changes to the landscape. These concerns have become more contentious with the accelerating growth of large renewable energy developments in the countryside (APOSTOL et al. 2016). A fundamental purpose of VIAs is to represent the future visual condition of the landscape with the project, and to evaluate the effects of the change. It has become standard practice in VIAs to represent the existing and proposed visual conditions with visual simulations. There are several visual simulation technologies available, including animated video, computer virtual reality (VR) and augmented reality (AR). However, the standard visual simulation uses a rendered computer image of the proposed project montaged with a single-frame photograph that is then digitally edited to represent the future visual condition. One reason for its wide use and acceptance is that it is compatible with the paper reports that are required when filing for government permits; it is a media with which the bureaucracy is comfortable.

While the technical details of how to construct photorealistic simulations have been applied in practice for decades, there are still a number of fundamental questions that have not been settled. One of these is the choice of the lens focal length to best represent the visual change to both professionals and the public. In 2006, Scottish Natural Heritage published Visual Representation of Windfarms: Good Practice Guidance, which recommended and justified the use of a 50 mm lens on a 35 mm format camera (HORNER + MACLENNAN & ENVISION 2006). While the use of a 50 mm lens has been accepted as the closest representation to what we see, photographers continue to have lively discussions about this issue (e. g., ASK METAFILTER 2009).

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The discussion of what focal length best represents what people see when looking at wind turbines became a serious topic in Scotland. In 2010 The Highland Council published Visualization Standards for Wind Energy Development, requiring:

> *a 70mm focal length lens on a 35 mm SLR is required for distances up to 1.5 kilometers from the viewpoint to the nearest turbine and a 75 mm focal length lens for distances exceeding 1.5 kilometers. We may require additional focal lengths for long distance views. (THC 2010, p. 4)*

In 2011, HUNTER (2012) conducted a study to verify The Highland Council's new standards. He interviewed over 500 people at 6 viewpoints. The views represented Scottish landscapes – a lake with mountains in the background, fields with hedgerows, castle ruins with a lake and hills in the midground; wind energy projects were not represented. Each person was asked to consider 7 images represented focal lengths ranging from 50 mm to 110 mm, in 10mm increments. They were:

> *asked to specify which of the images, in their opinion, provided the most realistic representation of the scale and distance to a specific focal point (or area) located centrally in the landscape in all photographs. (HUNTER 2012, p. 2)*

The results were that:

> *The distribution of focal length preferences was slightly skewed towards the longer focal lengths considered in the study. Hence, the mean focal length calculated from the participants' responses was 79.3 mm (±1.5 mm) for all responses obtained. This ranged between 75.3 mm (±4.96 mm) and 89.5 mm (±3.88 mm) for individual landscape views. The median of all participant responses was 80 mm, but this ranged between 70 mm and 90mm depending on the view under consideration.*
>
> *The participants' choice of focal length did not demonstrate a clear and systematic relationship with the distance to the focal point under consideration in the landscape but this warrants further investigation. (HUNTER 2012, p. 2)*

The choice of which focal length best represents a landscape view is an important one for VIA professionals, and the shift from 50 mm to 80mm would be significant. It therefore seemed appropriate to conduct an independent validation study of what focal length best represents the relevant context and character of the landscape in a particular view.

2 Methods

In preparation for the exercise, photographs were taken of three views in Kilmacanogue (Co. Wicklow, Ireland) on 16th August 2016: northwest across a purple heather to mountains, northeast toward Sugar Loaf Mountain, and east across fields separated by hedges. The photographs were taken with a Nikon D7100 at a resolution of 6,000-by-4,000 pixels and equipped with an AF-S DX Nikkor 18-105 mm f/3.5-5.6G ED VR zoom lens. The camera was mounted on a tripod and centered on the primary landscape element in the view. The zoom lens was set to approximate the focal length of 90 mm on a full-frame or FX format camera and the photograph was recorded. The focal length was then reduced by approximately 10mm and the photograph recorded. This process was repeated through the target focal length of 30mm, a safe lower limit where barrel distortion would not be noticed. Because a zoom lens was used, the actual focal lengths were approximations of the target value, as shown in Table 1. Figure 1 shows the extent of view for each focal length at the heather viewpoint.

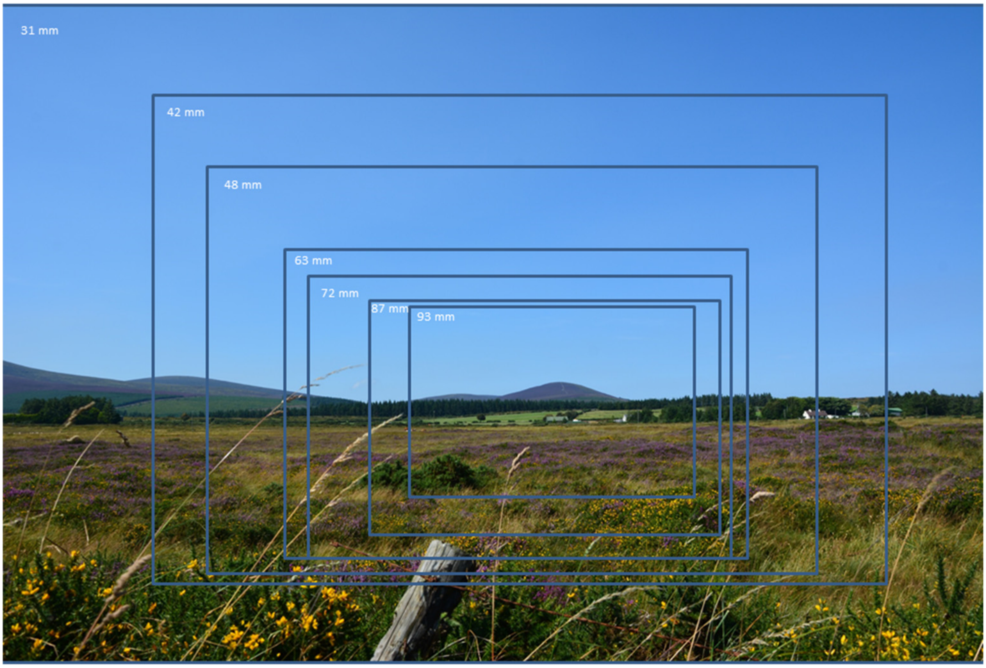

Fig. 1: The extent of view for each focal length at the heather viewpoint in Kilmacanogue (Co. Wicklow, Ireland)

Table 1: Target and Actual FX Equivalent Focal Lengths for Evaluation Photographs

Target Focal Length	Target Horizontal Angle of View	FX Equivalent Focal Length		
		Northwest	Northeast	East
30	61.9	32.2	32.2	32.2
40	48.5	42.9	42.9	42.9
50	39.6	49.1	49.1	49.1
60	33.4	64.4	61.4	61.4
70	28.8	73.6	73.6	69.0
80	25.4	89.0	79.8	89.0
90	22.6	95.1	95.1	95.1

The study conducted on 23th August 2016 in Kilmacanogue, Ireland. The participants were part of a 2016 training school for COST Action TU 1401 Renewable Energy and Landscape

Quality hosted by Dublin Institute of Technology and Dublin City University. The issue of the "best" focal length for visual simulations was not discussed with the participants prior to the field study.

At each view, each participant evaluated the seven photographs based on the following instructions:

> *For this exercise, we are going to evaluate how well a photograph represents the scope of the visible landscape. Scope means the extent of the view that is necessary to capture the relevant context and character of the landscape.*
>
> *Does the extent of the photograph show exactly enough of the relevant surroundings to understand the view in its landscape context, or is there too little context or a too much context, or way too little or way too much context in the photo than is necessary to represent the actual view.*

The rating scale ranged from 1 for "way too little," through 5 for "way too much," and 3 for "exactly the same".

3 Results

A total of 26 participants rated all three sets of photographs for a total of 546 judgements. The median and mean ratings for each photograph at each site and for all three sites combined are reporting in Table 2 through Table 5. At each location, the 50mm focal length was judged to most closely represent the relevant surroundings in order to understand the view in its landscape surroundings.

A rating of 3 indicates that the photograph represents "exactly the same" visual scope as the viewer experienced at the viewpoint; in all 167 photographs were given this rating. The median of these photographs' actual (not target) focal length is 49.1, and the mean is 55.2 mm, with a standard deviation of 16.1 and standard error of 1.2.

Table 2: Ratings of Target Focal Lengths at Kilmacanogue Looking Northwest

Target Focal Length	Median	Mean	Std. Dev.	Std. Error
30	4	3.692	1.192	0.234
40	4	3.269	0.874	0.171
50	3	3.038	0.824	0.162
60	3	2.769	0.710	0.139
70	3	2.577	0.578	0.113
80	2	2.115	0.864	0.169
90	2	2.000	1.058	0.2076

Table 3: Ratings of Target Focal Lengths at Kilmacanogue Looking Northeast

Target Focal Length	Median	Mean	Std. Dev.	Std. Error
30	4	3.846	1.190	0.233
40	3	3.308	0.838	0.164
50	3	3.038	0.599	0.117
60	3	2.615	0.637	0.125
70	2.5	2.538	0.706	0.138
80	2	1.962	0.662	0.130
90	1	1.462	0.582	0.114

Table 4: Ratings of Target Focal Lengths at Kilmacanogue Looking East

Target Focal Length	Median	Mean	Std. Dev.	Std. Error
30	4	3.73	1.002	0.197
40	3	3.077	0.688	0.135
50	3	2.923	0.688	0.135
60	2	2.308	0.679	0.133
70	2	2.077	0.796	0.156
80	2	1.731	0.827	0.162
90	1	1.462	0.706	0.138

Table 5: Ratings of Target Focal Lengths for Three Kilmacanogue Views

Target Focal Length	Median	Mean	Std. Dev.	Std. Error
30	4	3.756	1.119	0.127
40	3	3.218	0.800	0.091
50	3	3.000	0.703	0.080
60	2	2.564	0.695	0.079
70	2	2.397	0.727	0.082
80	2	1.936	0.795	0.090
90	1	1.641	0.837	0.095

4 Discussion

Two technical criticisms of the current study come to mind. First, HUNTER'S (2012) procedure was not followed exactly. For instance, he used a photograph taken with a 50 mm lens and cropped it to represent lenses with focal lengths of 60 mm to 110 mm, in 10 mm increments. While producing images that correspond exactly to the target focal lengths, this procedure results in a significant loss of image resolution. There is no obvious advantage to this – Hunter does not provide justification – since the analysis is based on the actual focal length of each photograph and the loss of resolution in visual simulation of distant objects clearly presents a real flaw in the procedure. Resolution becomes a critical factor in preparing visual simulations, since research by SULLIVAN et al. (2012) has found that wind turbines are clearly visible at distances that were commonly assumed beyond the limits of visibility. Hunter also specifies that it is necessary to use a full-frame or FX digital camera. Again, no justification is given. Under good lighting, there should be no particular advantage to using an FX camera rather than a high-quality DX format camera.

Second, neither study includes wind turbines, or other renewable energy project. This is odd, since Hunter states that "the purpose of this [i. e., his] study was to independently field test and verify The Highland Council's visualization standards" for wind energy development visualizations (HUNTER 2012, p. 2).

Hunter's explanation for this research design decision is:

> *A decision was made in early course to exclude landscape views containing existing wind energy developments from consideration in the study. This decision was based on a concern that the presence of a wind energy development might bias the responses of participants with predetermined and strongly held views about the visual impact of wind energy developments on the Scottish landscape. (HUNTER 2012, p. 9)*

It seems probable that judgement of size and distance to proposed features, such as wind turbines, communications towers, or large solar energy projects may differ from similar judgements of views without specific features, such as a view toward hills or of fields with hedgerows. In any case, one could ask participants about their renewable energy attitudes, and test Hunter's hypotheses statistically. In the end, neither of these criticisms seem likely to have an important influence on the results.

Perhaps a more interesting discussion is whether single-frame photographs are the most appropriate way to represent visual experience of the landscape. A number of researchers have found that multi-frame panoramic images represent the landscape better than single-frame images. YUHAN et al. (2015) demonstrate that a 180° panoramic photograph of an urban site provides useful information to help respondents understand and respond to the landscape during an interview. According to SEVENANT and ANTROP (2011) the choice between normal single-framed and panoramic pictures depends on the particular landscape character and context, echoing the findings of PALMER & HOFFMAN (2001). Whereas panoramic pictures give an experience closer to human angle of view, a single-frame photograph provides greater visible detail that may be important to understanding and evaluating a scenic (SULLIVAN and MEYER 2014). The findings of these and other researchers are in contradiction to HUNTER'S (2012) suggestion that a telephoto image provides a better representation.

In addition, there are a number of new digital technologies that are being used to represent existing and future landscapes. Virtual reality (VR) methods are being explored that provide an immersive visual experience in a digitally simulated landscape (WISSEN HAYEK et al. 2016). However, VR methods are based on computer generated images that may be geometrically accurate, but lack photorealism. Augmented reality (AR) is proposed as an approach that helps address this problem. WIKIPEDIA (2016) describes AR as:

> *A live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.*

AR is the basis for a new generation of video games, some of which require sophisticated equipment, but other approaches are based on smart-phones, such as Pokémon Go. VENTUSAR

(2016) uses this technology to simulate renewable energy projects on an iPad while viewers are in the field.

Finally, our study is primarily concerned with determining the appropriate focal length to represent a landscape view in a VIA that will be submitted as part of a permitting application to the appropriate government authority. It is to be expected that single-frame photographs will continue to be the standard format for photosimulations, since they are more easily included in legal documents, such VIAs, which must often be in printed form to made part of the public record. If future research determines that a single-frame photograph's angle of view excludes important landscape context, it may become best professional practice to "panelize" simulations to better represent the visible experience.

5 Conclusions

The results of this study indicate that a focal length slightly longer than the traditional "normal" 50 mm is thought to best capture the scope of a landscape view. However, this is substantially less than the 79 mm obtained by HUNTER (2012) and there was also considerable support for a focal length with a wider angle of view than the "normal" lens.

These results indicate that further study to determine focal length guidelines for simulating renewable energy projects is warranted. Future studies should incorporate wind turbines, or other development features that are the normal subject of photosimulations and visual impact assessments. In addition to evaluating how well the image captures the scope of the view captures the relevant context and character of the landscape, it would be appropriate to evaluate:

> **Distance**. Does the simulated feature in the photograph looks like it is exactly the same distance away from you as it actually appears, or does it look a little further or a little closer, or a lot further or a lot closer in the photo than it actually appears?
>
> **Scale**. Does the simulated feature in the photograph have the same visual magnitude or relative size as it actually appears, or does it look a little smaller or a little larger, or a lot smaller or a lot larger in the photo than it actually appears?

The nature of this topic lends itself to investigation through numerous small studies. However, the efficacy of this distributed approach would be strengthened by establishing a common protocol. It is hoped that such a framework could be developed through COST Action TU 1401 Renewable Energy and Landscape Quality.

References

APOSTOL, D., PALMER, J., PASQUALETTI, M., SMARDON, R. & SULLIVAN, R. (2016), The Renewable Energy Landscape. Routledge, New York.

ASK METAFILTER (2009), How can you see what I saw? http://ask.metafilter.com/137009/How-can-you-see-what-I-saw.

HORNER + MACLENNAN & ENVISION (2006), Visual Representation of Windfarms: Good Practice Guidance. Inverness, Scotland: Scottish Natural Heritage.

HUNTER, P. (2012), The Effect of Focal Length on Perception of Scale and Depth in Landscape Photographs: Implications for Visualisation Standards for Wind Energy Developments. University of Sterling, Sterling, UK. Summary available at: http://www.highland.gov.uk/download/downloads/id/1024/university_of_stirling_ study_of_visualisation_standards.pdf.

PALMER, J. & HOFFMAN, R. (2001), Rating reliability and representation validity in scenic landscape assessments. Landscape and Urban Planning, 54 (1-4), 149-161.

SCOTTISH NATURAL HERITAGE (2014), Visual Representation of Wind Farms. Version 2.1. Scottish Natural Heritage, Inverness, Scotland.

SEVENANT, M. & ANTROP, M. (2011), Landscape representation validity: A comparison between on-site observations and photographs with different angles of view. Landscape Research, 36 (3), 363-385. doi:10.1080/01426397.2011.564858.

SULLIVAN, R., KIRCHLER, L., ROCHÉ, S., BECKMAN, K. & RICHMOND, P. (2012), Wind Turbine visibility and visual impact threshold distances in Western landscapes. In: Proceedings, National Association of Environmental Professionals, 37th Annual Conference, May 21-24, 2012, Portland, Oregon.

SULLIVAN, R. & MEYER, M. (2014), Guide to Evaluating Visual Impact Assessments for Renewable Energy Projects. National Park Service, Denver, Colorado.

THE HIGHLAND COUNCIL (2010), Visualization Standards for Wind Energy Development. The Highland Council, Inverness, Scotland.

VENTRUSAR (2016), Ventrus AR Digital Visualization for Planning. http://ventusar.com/.

WIKIPEDIA (2016), Augmented reality. https://en.wikipedia.org/wiki/Augmented_reality.

WISSEN HAYEK, U., WALTISBERG, D., PHILIPP, N. & GRÊT-REGAMEY, A. (2016), Exploring issues of immersive virtual landscapes for the support of participatory spatial planning support. Journal of Digital Landscape Architecture, 1-2016, 100-108.

YUHAN, S., LANGE, E. & THWAITES, K. (2015), Improving photographic representation of human vision for landscape assessment. In: BUHMANN, E. et al. (Eds.), Peer Reviewed Proceedings of Digital Landscape Architecture 2015 at Anhalt University of Applied Sciences. Wichmann, Berlin/Offenbach, 90-100.