A Landscape Assessment Framework for Visual Impact Assessment in the USA

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Abstract: While widely prepared for EISs, there is no widely accepted geospatial approach to VIA in the USA. A landscape assessment framework for VIA is introduced that may be adapted to a project's particular context, such as the availability of spatial data and local sensitivities. The Northern Pass Transmission Project is used as a case study to show how it can be applied.

Keywords: Geodesign, visual impact indicators, transmission line

1 Introduction

While there are earlier examples, it is fair to say that visual impact assessment (VIA) became a mainstream administrative procedure with the implementation in the US of the National Environmental Policy Act of 1969 (NEPA), which required environmental impact statements (EIS) for major federal actions. Management of federal lands qualifies as a major action, and the two largest land management agencies, the Bureau of Land Management (BLM) and Forest Service (FS) developed systematic landscape assessment procedures for visual resource management (VRM) (USDI BLM 1984, USDA FS 1974 and 1995). These procedures assign visual quality objectives (VQO) to all managed lands. Simply put, visual impacts are insignificant when they are in compliance with the objectives, and become significant impacts when they are not in compliance.

However, BLM and FS manage less than 20 % of the US; the scenic resources on the other 80% of public and private lands typically lack VRM and VQOs. No generalized framework exists to conduct landscape assessments for VIA on these lands.

This paper presents such a framework developed to assess the visual impacts of the proposed Northern Pass Transmission Project (NPTP) and its alternatives (T. J. Boyle Associates 2015). The NPTP is a 300 km transmission line that brings 1,200 MW of hydro-electricity from Canada to southern New Hampshire, in the US. Of this length, 23 km of the preferred alternative would pass through the White Mountain National Forest (WMNF). The VIA must be a single comprehensive assessment, and while the WMNF has VQOs, none exist for the rest of New Hampshire. The framework presented here generalizes the FS and BLM approach to VRM to create a pragmatic approach to VIA that includes standard visual impact indicators to facilitate comparison of alternatives.

2 Landscape Assessment Framework

2.1 The General Model

Landscape assessment is an approach to evaluating the suitability for or potential effects of a proposal. It employs specialized computer software, in this case ArcMap, and digital data.

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It is particularly suitable for comparing alternatives that extend over large areas, such as is the case with the NPTP (WILLIAMS et al. 1983). The landscape assessment model generally follows the VRM approach used by the FS (USDA FS 1995). The landscape assessment model and the type of data required are shown in Fig. 1.

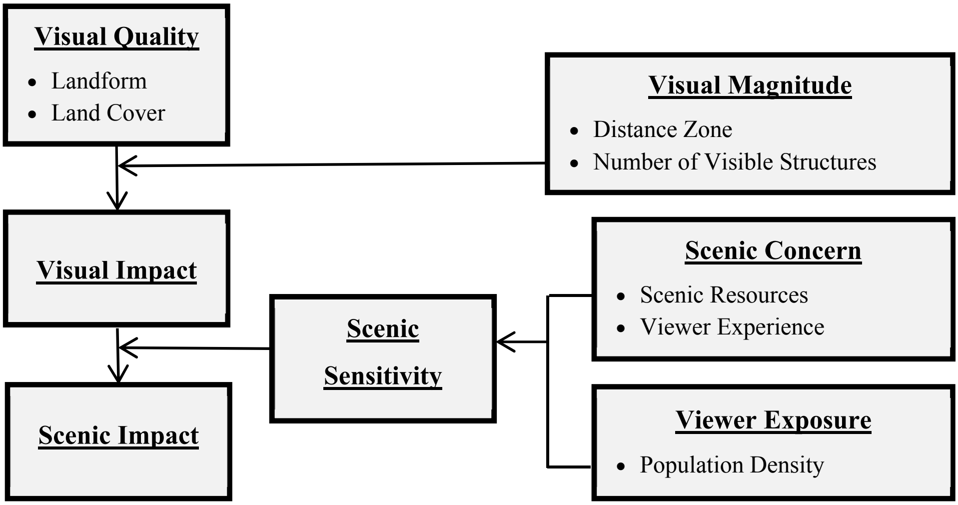

Fig. 1: Diagram of the landscape assessment framework for visual impact assessment

The data are reinterpreted into a rating scale of 0 to 5, though some data types do not have a value of "none" or 0. A cross-classification table is used to obtain a single combined rating for two attributes. Table 1 shows a typical example, where Attribute A ranges from 1 to 5 and Attribute B from 0 to 5. The remainder of this section will describe how the NPTP VIA was conducted.

Table 1: A typical cross-classification table to obtain a single rating for two attributes

	Attribute B					
Attribute A	**5. Very High**	**4. High**	**3. Moderate**	**2. Low**	**1. Very Low**	**0. None**
5. Very High	5	5	4	3	2	0
4. High	5	4	3	2	1	0
3. Medium	4	3	2	1	1	0
2. Low	3	2	1	1	1	0
1. Very Low	2	1	1	1	1	0

2.2 Visual Quality

In this analysis, Visual Quality is conceived as the intrinsic potential beauty of the landscape, independent of human perception. It is a synthesis of other, more basic intrinsic attributes; the two most important being landform and land cover (LINTON 1968). The general principle is that landscapes with greater relief and landscapes with more natural land cover have higher visual quality. The rating thresholds for landform and land cover are discussed below; the cross-classification table (i. e., Table 1) is used to combine them into a single rating.

2.2.1 Landform

HAMMOND (1954) developed an approach to landform classification that considers slope, relief, and profile type. MORGAN and LESH (2005) clearly describe how to implement Hammond's procedure, as well as two more recent adaptations. Ten-meter resolution National Elevation Data (NED) were used, with a 30 cell radius search to perform the landform classification. The results are: 1. Low relief (< 30 m), 2. Low hills (30-90 m), 3. Moderate hills (90-150 m), 4. High hills (150-300 m), and 5. Mountains (300-900 m).

2.2.2 Land Cover

The 2011 National Land Cover Data (NLCD) classification has been condensed to six classes with the following ratings: 0. High intensity development, 1. Low & Medium intensity development, 2. Developed open space, 3. Cultivated/Pasture/Grassland & Herbaceous wetland, 4. Forest/Shrub & Woody wetland, and 5. Water.

2.3 Visual Magnitude

This is a measure of the sense of visual prominence. It could be measured as square arc minutes on simulations. A GIS approach evaluates the number of visible structures within distance zones. The rating thresholds are discussed below; the cross-classification table is used to combine them into a single rating.

2.3.1 Distance Zone

Two field studies have evaluated the visual presence of transmission structures (DRISCOLL et al. 1976, SULLIVAN 2014). Both studies were conducted in the Western US, where the air is drier and clearer and the vegetation is frequently sparse, with less opportunity for screening from dense forest cover than in the Eastern US. Both studies found structures somewhat comparable to those proposed by NPTP had the potential to be detected past 10 miles (16 km) – by which they meant visible to someone with a critical eye who was looking for them. However, 10 miles seems to be a more reasonable threshold for a casual observer with an interest in scenery. The following distance zones were established based the literature and field observation for the NPTP VIA: Immediate (< 15 m), Foreground (15-400 m), Near Midground (0.4-2.4 km), Far Midground (2.4-4.8 km), Near Background (4.8-8.0 km), Far Background (8.0-16.1 km), and Distant (> 16.1 km).

In the Immediate distance, a single structure could dominate the view. The lattice elements may be still apparent in the Far Midground or Near Background. Conductors also become difficult to distinguish at this distance, though in direct sunlight they can be apparent at much further distances because of glare or reflected sunlight.

2.3.2 Number of Visible Structures

Visibility analysis was conducted to identify the number of structures visible within each distance zone. For the area within 2.4 km of the NPTP, digital terrain (DTM) and surface (DSM) model data with a resolution of 5 m were used for the ground elevation and land cover screen height (INTERMAP 2013). For areas from 2.4 to 16.1 km from the NPTP, the

NED 10 m resolution elevation data is used and NLCD forest cover is assigned a nominal 12 m height for the visual screen.

2.3.3 Visual Magnitude

Visual magnitude is in part a function of the proportion of the visual field a structure occupies at a particular distance. However, a transmission line is made up of many structures connected by conductors. Therefore, visual magnitude is also a function of the proportion of the visual field occupied by a line of the visual structures, as well as the cleared corridor in which they are located.

In a photograph it is a relatively easy matter to measure the visual magnitude; however, it is more difficult in a GIS analysis. Table 2 presents visual magnitude ratings based on the literature and NPTP VIA fieldwork. The visual magnitude for a particular viewpoint (i. e., raster cell) is the highest value among the six distance zones.

Table 2: The number of structures visible at each distance zone (in body of the table) d termines the Visual Magnitude rating

Distance Zone	**Visual Magnitude Ratings**					
	Very High	**High**	**Moderate**	**Low**	**Very Low**	**None**
Immediate	1 or more	—	—	—	—	—
Foreground	6 or more	3 – 5	2	1	—	—
Near Midground	32 or more	16 – 31	6 – 15	4 – 5	2 – 3	1
Far Midground	64 or more	32 – 63	10 – 31	7 – 9	4 – 6	3 or less
Near Background	96 or more	48 – 95	14 – 47	10 – 13	6 – 9	5 or less
Far Background	—	—	—	60 or more	30 to 59	29 or less
Distant	—	—	—	—	—	—

These thresholds were checked against and found to largely agree with the angular thresholds employed for landscape and visual impact assessment by HAACK et al. (2013). They present a rationale for measuring the visual magnitude of a proposed project reasoning that a project's potential visual prominence is "Insignificant" (i. e., unlikely to be noticeable by a casual observer) if the horizontal angle of view is 5° or less: "The development will not be highly visible in the view, unless it contrasts strongly with the background." The potential visual prominence is "Potentially Noticeable" if the horizontal angle of view is between 5° and 30°, which they describe as: "The development may be noticeable. The degree that it intrudes on the view will be dependent on how well it integrates with the landscape setting." Visual prominence is "Potentially Dominant" where the horizontal angle of view is 30° or greater and "the development will be highly noticeable."

2.4 Visual Impact

Visual Impact is an indication of the intrinsic impact, irrespective of the relative sensitivity of people or sites affected. Research has found that a given visual magnitude will have a greater visual impact to a landscape with higher visual quality than one with lower visual quality (BETAKOVA et al. 2015). Visual Impact is determined from the interaction of Visual Quality and Visual Magnitude using the cross-classification table, which embodies this principle.

2.5 Scenic Concern

Viewer concern with scenery varies based on the importance of scenery to their primary activity. In addition, the public can manifest its interest in scenic places through public designation. The Level of Designation and Viewer Experience are discussed below; a cross-classification table is used to combine them into a single rating.

2.5.1 Level of Designation

One way the public expresses its concern for scenic landscape quality is by establishing parks, trails, scenic byways, scenic rivers and lakes, historic sites, and other recreation resources. A higher concern is associated with designation by a higher level of government. Nationally designated recreation resources have a very high value (i. e., rated 5), state scenic resources have a high value (4), and recreation resources designated by local governments or non-governmental organizations have a medium value (3). Other areas in the recreation resource database have a very low value for designation (1). Fortunately, the New Hampshire GIS Clearinghouse (GRANIT) maintains a database for most of these resources.

2.5.2 Viewer Experience

There is the assumption that certain activities depend on scenic value for a high quality experience, others can benefit from the presence of scenic value, while scenic value is largely irrelevant for others. The ratings for the role of scenery in various activates is guided by the criteria in Table 3. Scenery is thought to have some importance for activities at all identified recreation resources (i. e., the rating is at least 1). The GRANIT recreation database includes a Primary Use attribute that was rated according to these criteria.

Table 3: Criteria for viewer experience weights

Importance	Rating	Criteria
Very High	5	Scenery is the primary part of a high quality experience
High	4	Scenery is an important part of a high quality experience
Moderate	3	Scenery may complement but is not essential to a high quality experience
Low	2	Scenery is irrelevant to a high quality experience
Very Low	1	Scenery plays no role in the experience (i. e., there is no view)

2.6 Viewer Exposure

Maybe a viewpoint is not particularly sensitive to visual impacts, but there are so many viewers that the total aggregate of their impacts is a concern. Viewer exposure is an attempt to account for the extent and duration of people to the visual impact. This might be measured using visitor counts at recreation sites or traffic data for all roads within a project viewshed. However, these data are relatively scarce in New Hampshire, therefore an estimate of viewer exposure at residences was developed for the NPTP VIA.

2.6.1 Number of Potential Viewers

To be useful, the estimate of potential residential viewers needs to be at a resolution that is similar to the visibility analysis. The finest level population data available from the 2010 US Census is at the block-level. In urbanized areas, blocks are mostly bounded by streets, while in rural areas other features may also be used. Each Census block was converted to a raster that matched the resolution of the visibility analysis, and the Census block population was evenly distributed among the raster cells. The ratings for potential visual exposure are based on the population density per square kilometre: Very high (5,000-700,000), High (1,000-5,000), Moderate (500-1,000), Low (10-500), Very low (above 0-10) and None (0).

2.7 Scenic Sensitivity

The sensitivity of the view from any particular place to scenic impacts is the maximum value of the scenic concern or viewer exposure analyses. However, within the WMNF the established scenic integrity objectives (SIO) are used to indicate scenic sensitivity. SIOs are VQOs established as part of the WMNF Forest Plan following Scenery Management System (SMS) procedures (USFS 1995) that serve as the model for the landscape assessment used in this VIA.

2.8 Scenic Impact

If Visual Impact is an intrinsic measure, Scenic Impact attempts to incorporate extrinsic social values and concerns. Scenic Impact is based on the relation between Visual Impact and Scenic Sensitivity. The Scenic Impact ratings are obtained by applying the cross-classification table; where there is no Visual Impact, there will be no Scenic Impact.

3 Indicators of Visual Impact

Each of the stages in the landscape assessment model presented above can be mapped, providing a holistic view of how the landscape could be impacted. While such visualizations are helpful for understanding the impact of a proposed project, they do not provide a simple systematic way to compare alternatives. In the US, NEPA has directed the federal government to “identify and develop methods and procedures … which will insure that presently unquantified environmental amenities and values may be given appropriate consideration.” Courts have generally interpreted this as a mandate to provide quantitative measurements or indicators of visual impacts (CHURCHWARD et al. 2013).

Many VIAs include a map of potential visibility, and report the area of the calculated viewshed. However, the landscape assessment framework for VIA lends itself to a variety of quantitative indicators. Most obviously the average value for Visual Impact, and Scenic Impact can be calculated for either the viewshed or the study area, which would include areas without visibility. A more nuanced understanding is achievable through viewing the component maps and indicators. For instance, considering the Scenic Sensitivity, Viewer Exposure and Scenic Concern maps and indices might help identify areas where the NPTP might appropriately be buried – a very expensive proposition, but one that may make the project politically acceptable. An investigation of Visual Magnitude for each of the six distance zones might help inform the selection of mitigation methods – monopole structures are generally less offensive in the foreground, while lattice structures tend to be better further away. For the NPTP, indicators were developed for the total length of the project, but also for four subregions, and they could have been done for individual towns.

Additional indicators were also developed around the potential visual impacts as seen from roads. The total length of sections with potential visibility was calculated for five classes of roads: expressways, arterial, collector, local, and non-public. The average value for Visual Impact, and Scenic Impact, as well as the component indicators was also calculated. Where traffic counts were available, it was possible to use the posted speed limit to estimate the total time of potential viewer exposure.

4 Discussion and Conclusion

The most common approach to VIA relies primarily on the evaluation of photographic simulations of the proposed project prepared for selected key observation points (KOPs). Various procedures can be used to evaluate the significance of the simulated visual change (e. g., USDI BLM 1986). While the evaluation of KOP simulations can be rich in detail, and is easily understood by the public, it is a very selective analysis without any pretence of comprehensive representation. For instance, how does a decision maker place a foreground photosimulation of a lattice transmission structure into context when it is known that visibility of the transmission line is from only a small proportion of the area close enough to be significantly impacted? Photosimulations can be informative, even evocative, but it is difficult to obtain an accurate overall understanding from them.

In contrast, it is probably inappropriate to use the landscape assessment model of visual impacts described here to understand the visual impact to a few selected viewpoints. Rather it provides a comprehensive evaluation across the landscape that can be visualized when mapped and also can be summarized through indicators. While it is particularly appropriate for comparing alternatives, thresholds to determine when a particular alternative's visual impacts are unreasonable have yet to be developed and validated. For instance, the NPTP VIA suggested that for areas where scenic impact is high or very high, the visual effect is possibly unacceptable even after using best practices design criteria and vegetation management. Areas with moderate and perhaps low scenic impact may also represent a visual impact, but are more likely to have the opportunity to become acceptable through the use of best practices design criteria and vegetation management.

An additional advantage of the landscape assessment approach is that it offers an opportunity to consider cumulative impacts. For instance, the NPTP preferred alternative was located in an existing transmission line corridor for all but the northern most 65 km. The existing transmission lines have an existing visual impact for which the NPTP cannot be held responsible. For the VIA the framework was used to calculate the total impact from all of the transmission structures, and then the impact of just the existing structures. The visual impact of the NPTP is the difference between the cumulative and existing visual impact. A similar approach could have been employed to evaluate the cumulative effect of other projects proposed near the transmission corridor, for instance the several wind power projects.

The landscape assessment framework for VIA is presented as a generalized model with the expectation that its implementation will be tailored to local circumstances and data. The NPTP is presented as an illustrative case study, but should not be taken as the authoritative application. It is hoped that others will employ this approach, alongside the more traditional evaluation of KOP simulations.

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