

Recommended Indicators and Thresholds of Acoustic Resources Quality

NPS State of the Park Reports

Interim Guidance— December 2013



Natural Sounds & Night Skies Division

WASO-Natural Resource Stewardship & Science

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Introduction to Soundscapes and Acoustic Environments

Sounds, and the environment that transmits them, are the *acoustic resources* of a park. They play vital roles in ecological interactions and visitor experience. Park sounds include natural (wind, water, wildlife, vegetation), cultural (tribal ceremonies), and historic (battle reenactments) sounds. An acoustic environment relatively free from sound can be important in settings that seek to inspire a contemplative or respectful attitude in park visitors. The *acoustic environment* is the combination of all sounds and physical resources that affect sound propagation in a given area. The sound made by a falling tree is part of the acoustic environment whether or not a human is there to perceive it.

Soundscape refers to the totality of the perceived acoustical environment. Soundscape usually refers to human perception, but the term could also apply to other species. For example, bat soundscapes include a wealth of ultrasonic information that is not represented in human soundscapes. Park soundscapes, and park acoustical environments, will often include noise from sources inside and outside the park boundaries. *Noise* is defined as unwanted or extraneous sound (Dictionary of Acoustics), where extraneous refers to sound that serves no function.

Every unit in the national park system has a unique acoustic environment, and every unit should understand what its desired acoustic environment would be. The quality of the acoustic environment affects visitor experience and ecological function. Acoustic resource condition should be evaluated in relation to visitor enjoyment, wilderness character, ecosystem health, and wildlife interactions.

This interim guidance explains the three-tiered (red, amber, green) ratings suggested by the Natural Sounds and Night Skies Division (NSNSD) for the State of the Parks Program and offers the rationale for the indicators and thresholds that support these ratings. Soundscapes and acoustic environments are dynamic and multidimensional. The proposed State of the Parks acoustical assessment selectively distills a wealth of information into a simple indicator. Alternative indicators and thresholds are available, if the programmatic approach presented here seems inappropriate for a park unit. Parks are encouraged to contact the NSNSD to address unresolved issues or explore options for alternative analyses.

Two categories of impact criteria

The National Park System is comprised of a wide variety of park units, and each unit merits an analysis structured to address its unique attributes and establishing legislation. However, the State of the Parks process requires a rapid and simplified approach that will generate consistent, comparable information across all park units. For this purpose, two categories of analysis were developed based on the proximity of a park unit to urban areas. Urban Areas were taken from the US Census 2010 (U.S. Census Bureau 2010).

Parks that are distant from urban areas possess lower sound levels, and they exhibit less divergence between existing sound levels

and predicted natural sound levels. These quiet areas are more susceptible to subtle noise intrusions than urban areas. Visitors and wildlife have a greater expectation for noise-free environments. Accordingly, the thresholds for the amber and red condition ratings will be lower for these park units than for units near urban areas. Urban areas tend to have higher ambient sound levels than non-urban areas (U.S. EPA 1971, Schomer et al. 2011). Higher thresholds are used for parks in urban areas. However, acoustical environments are important in all parks: units in urban areas may seek to preserve or restore low ambient sound levels to offer respite for visitors.

The urban criteria are applied to park units that have at least 90% of the park property *within* an urban area. The non-urban criteria were applied to units that have at least 90% of the park property *outside* an Urban Area. Some parks fall in between these groups. For these parks, we offer analyses using both criteria.

Use and Limitations of this Guidance

These recommendations characterize the quality of the acoustic environment, which is a complex and multifaceted resource, using a single metric. For both urban and non-urban criteria, the acoustic analysis is based on the increase in median sound level that can be attributed to human activities by a geospatial sound model. The median sound level, or L_{50} , represents the level that is exceeded 50 percent of the time during a summer day. Sound levels were measured at 244 sites, with some sites sampled more than once, for a total of 353 data sets. A model was developed that predicts the median sound level using 109 explanatory variables such as location, climate, landcover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports. The resulting model can predict sound levels anywhere in the contiguous U. S., and it can also estimate how much lower these sound levels would be in the absence of human activities. The difference between the existing and predicted natural sound level was used to evaluate acoustic environmental condition.

Modeled results are currently available for the lower 48 states (not AK or HI), due to limitations in the availability of the predictive geospatial data layers. Furthermore, prediction of the acoustical condition is dependent on the quality of available geospatial data layers. For example, if a seasonally closed road is missing from the national scale road layer; the acoustic effect of the road will be missing from the prediction. Note that a layer describing air tour routes is currently not available.

Ambient sound pressure levels change with time, exhibiting cycles on daily, seasonal, and annual scales. A stable estimate of the seasonal L_{50} can be obtained by measuring over a 25 day monitoring period. Because this value is both a statistic and a long-term average, it is not necessarily in agreement with an individual's perception of a soundscape at any particular time. The L_{50} is the sound pressure level exceeded 50% of the hour and is relatively unaffected by transient events like sparse animal vocalizations and isolated military jet operations. Finally, because the expected condition is based on consistent trends, contemporary noise sources (e.g. road construction or a new flight route) cannot be predicted are not included in the estimate.

Parks are encouraged to consider modifying this framework, and discuss options with NSNSD. A far more comprehensive suite of indicators of the acoustic environment and soundscape is possible and may be warranted for a management plan or a more in-depth assessment. Examples of other parameters and metrics include percent time audible of anthropogenic sounds, noise free interval (time between noise intrusions), time above certain thresholds, reduction in listening area or alerting distance, masking, speech interference, sleep interruption, impacts to wildlife species of concern, and impacts to visitors.

Additional metrics or adjustments to thresholds may be desired by a park to adequately capture a range of management concerns and ensure adequate protection. Other relevant factors such as park enabling legislation, park significance, management objectives, desired future conditions, presence of sensitive resources and sensitive species, wilderness status, and visitor uses may dictate additional metrics and the modification of resource condition benchmarks should be considered when making decisions or taking management action related to the resource.

Condition Thresholds

Table 1 reports the L_{50} impact thresholds (green, amber, and red) for the two categories of impact criteria. The *listening area*, the area in which a sound can be perceived by an organism, will be reduced when background sound levels increase. The failure to perceive a sound because other sounds are present is called *masking*. Masking interferes with wildlife communication, reproductive and territorial advertisement, and acoustical location of prey or predators (Barber, Crooks, & Fristrup, 2010). The effects of masking are not limited to wildlife. Masking also inhibits human communication and visitor detection of wildlife sounds. In urban settings, masking can prevent people from hearing important sounds like approaching people or vehicles, and interfere with the way visitors experience cultural sounds or interpretive programs.

Seemingly small increases in sound level can have substantial effects, particularly when quantified in terms of loss of listening area (Payne & Webb, 1971; Barber et al., 2010). Each 3 dB increase in the background sound level will reduce a given listening area by half. The noise impact metric is reported as an L_{50} , meaning that half the time, noise impacts exceed this level. Impact is defined as the difference between existing sound levels and natural ambient sound levels in A-weighted decibels (dBA). The decibel (dB) scale is a measure of sound pressure level. The decibel scale is logarithmic, meaning that a 10 dB increase in sound pressure level represents a tenfold increase in sound energy. The A-weighted dB scale is a unit of measure commonly used to approximate the perceived loudness of an environment. It approximates our perception of how loud sounds are by discounting sounds that occur in low frequencies (below 1,000 Hz) and high frequencies (above 6,000 Hz).

Table 1. Condition thresholds for non-urban and urban parks

Indicator	Threshold for non-urban parks (dBA)	Threshold for urban parks (dBA)
Mean L ₅₀ impact (dBA)	Threshold ≤ 1.5 <i>Listening area reduced by ≤ 30%</i>	Threshold ≤ 6.0 <i>Listening area reduced by ≤ 75%</i>
Calculated as difference between existing ambient and natural ambient models	1.5 < Threshold ≤ 3.0 <i>Listening area reduced by 30 - 50%</i>	6.0 < Threshold ≤ 12 <i>Listening area reduced by 75 - 94%</i>
	3.0 < Threshold <i>Listening area reduced by > 50%</i>	12 < Threshold <i>Listening area reduced by > 94%</i>

The single parameter most useful for assessing a park's acoustic environment is the impact of anthropogenic sources, measured in A-weighted decibels (L₅₀ dBA), and calculated as the difference between existing and natural ambient sound levels. This metric indicates how much anthropogenic noise raises the existing sound pressure levels in a given location. Because acoustical conditions within a park boundary may vary widely along a gradient, mean L₅₀ impact level is used for this analysis, because it is a close representation of expected impact levels at a randomly chosen point in a park. Full-scale model outputs for existing, natural, and impact levels can be found in Figures 1, 2, and 3.

For non-urban parks, the threshold separating green and amber conditions is set at 1.5 dBA mean L₅₀ impact, which corresponds to a 30% reduction in listening area. For urban parks, the threshold separating green and amber conditions is set at 6 dBA, which corresponds to a 75% reduction in listening area.

For non-urban parks, the threshold separating amber and red conditions is set at 3 dBA. An impact of this magnitude suggests that anthropogenic noise is noticeable at least 50% of an hour or more (Mennitt, Fristrup, Sherrill, & Nelson, 2013), and corresponds to a 50% loss in listening area. For urban parks, the threshold separating amber and red conditions is set at 12 dBA, which corresponds to a 94% loss in listening area. However, it should be noted that many urban parks preserve a moment in time or a resource that existed in a historically urban area. Therefore, the sounds associated with densely urbanized areas may support the park's purpose and contribute to the cultural soundscape.

Park-specific impact maps

To better express the geospatial variation of impact across parks, each state of the parks report will also include a park-specific impact map, as shown in Figure 4. The maps were generated using 270 meter resolution, meaning that each pixel represents 270 meters. Each park-specific map is a subset of Figure 3, L₅₀ dBA impact sound pressure levels for the continental United States. An inset map is included in each park-specific map to provide a better sense of context, and major roads and highways are labeled for reference.

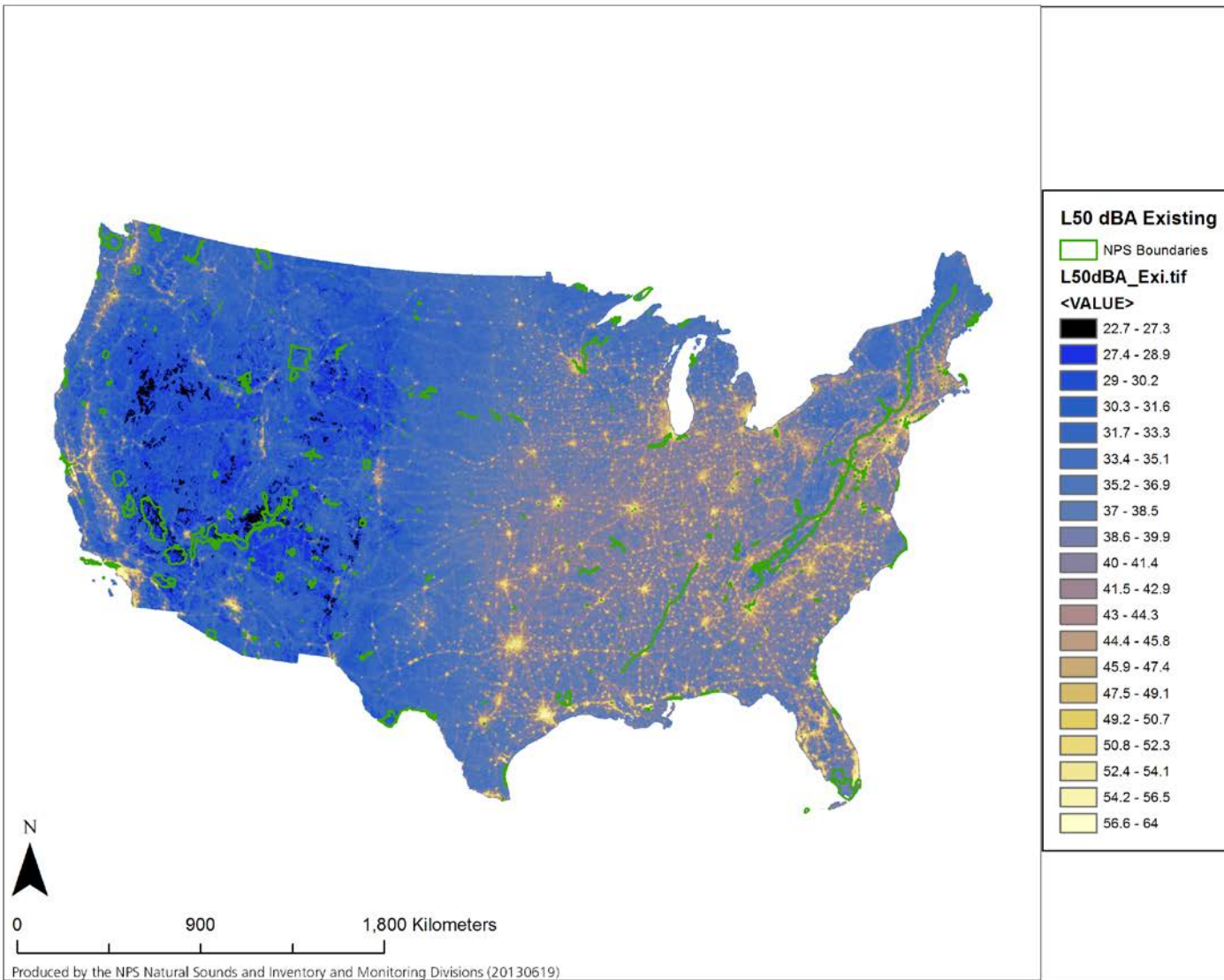


Figure 1. L₅₀ dBA existing sound pressure levels for the continental United States.

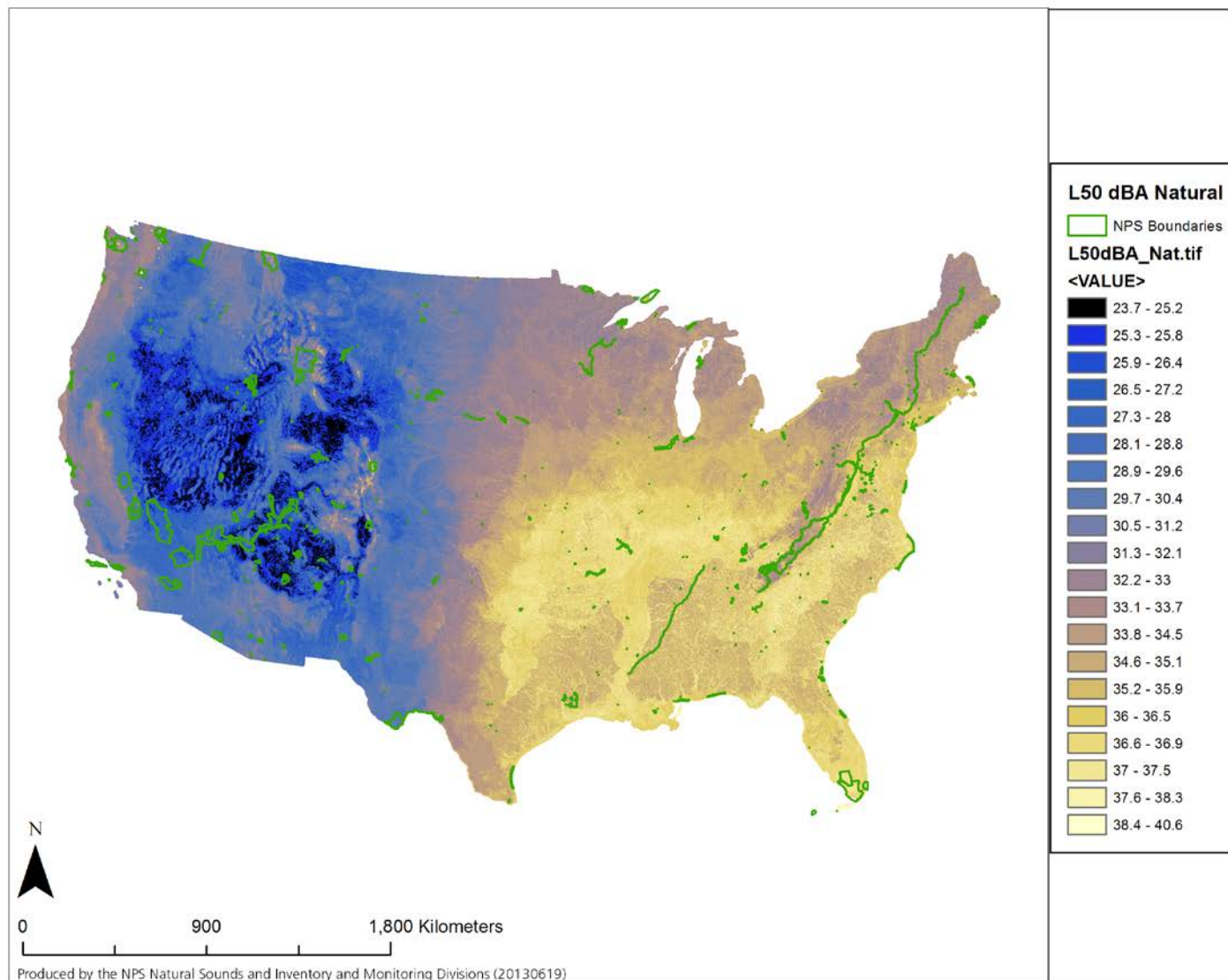


Figure 2. L₅₀ dBA natural sound pressure levels for the continental United States.

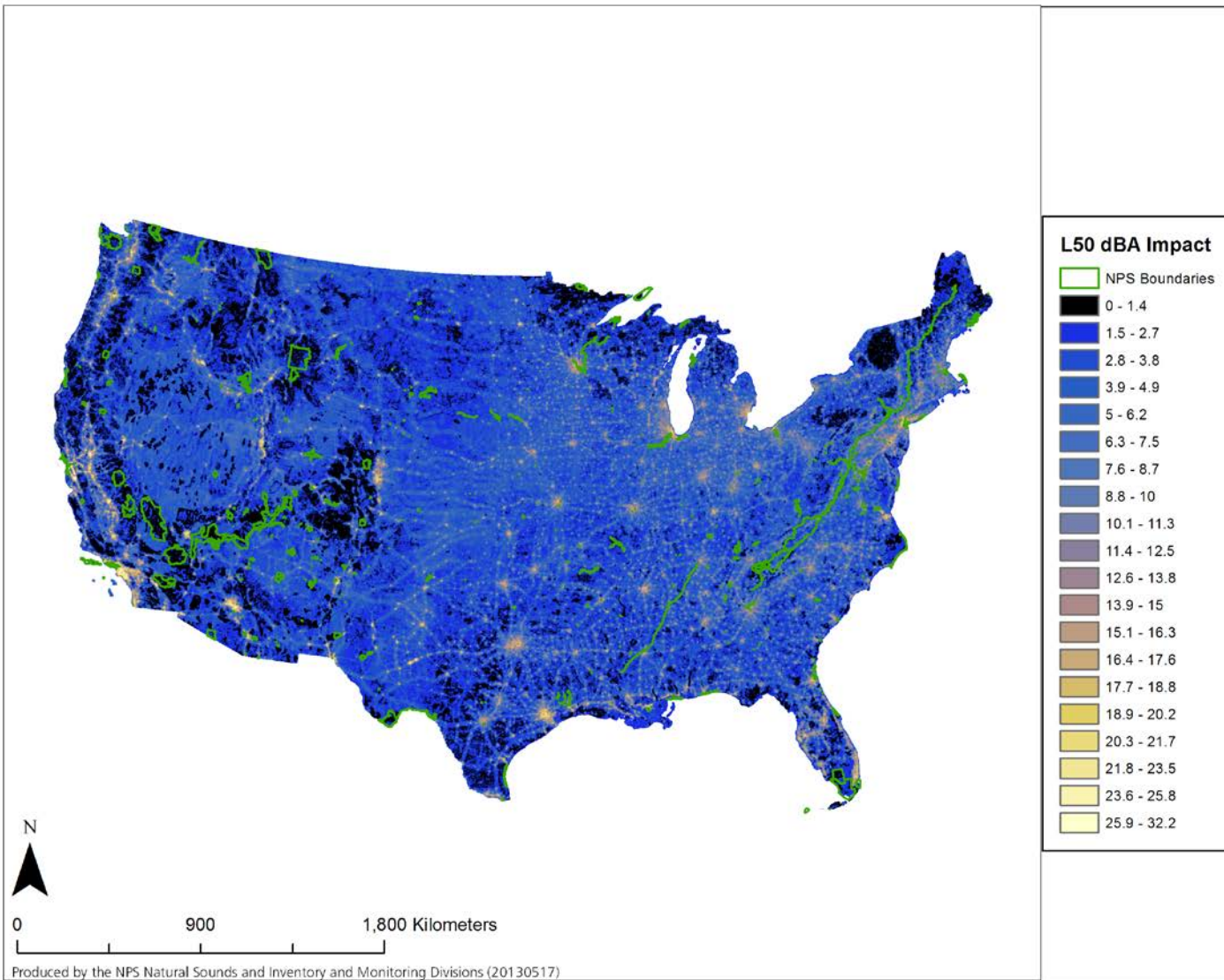


Figure 3. L₅₀ dBA impact sound pressure levels for the continental United States.

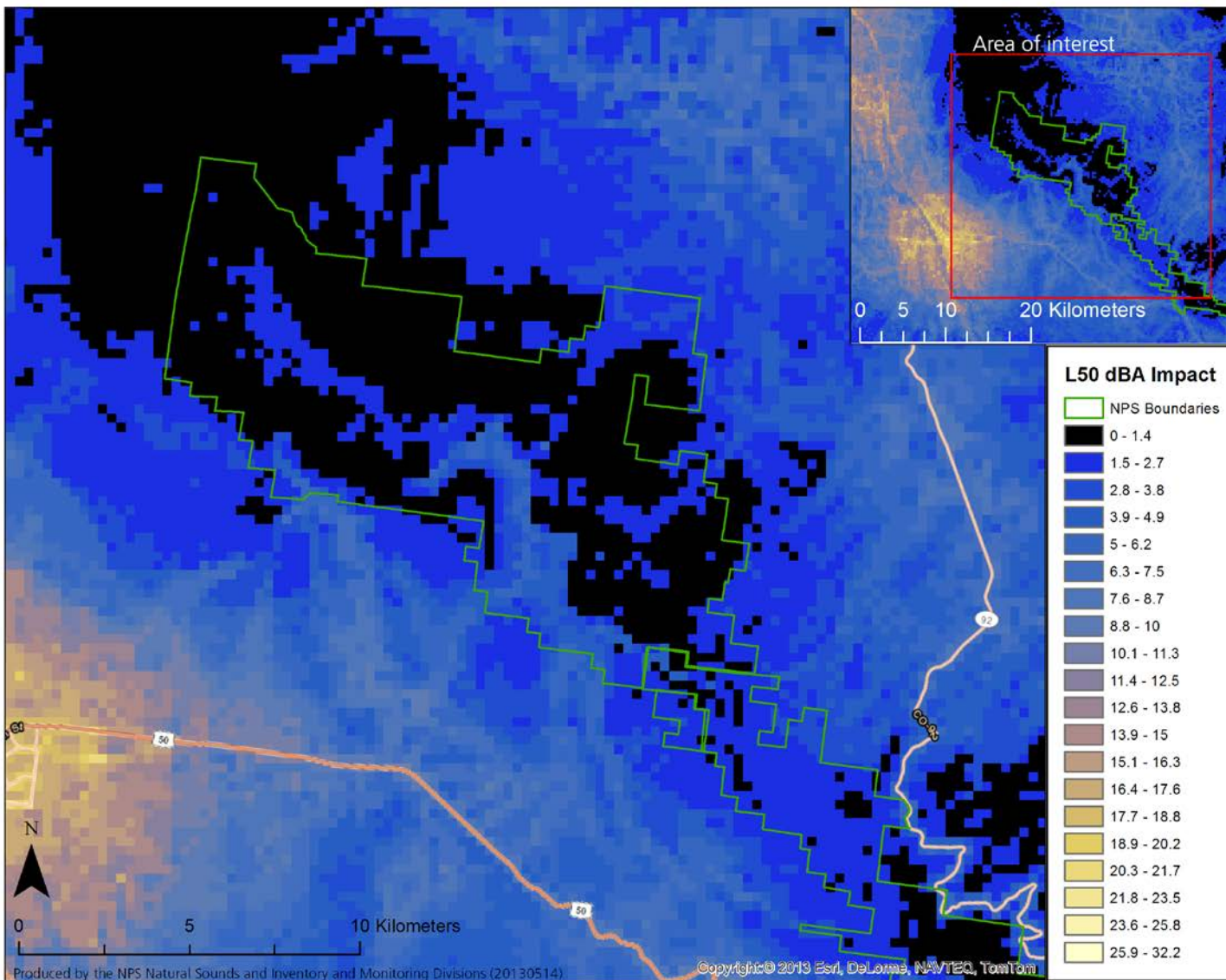


Figure 4. Park-specific impact map for Black Canyon of the Gunnison National Park.

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