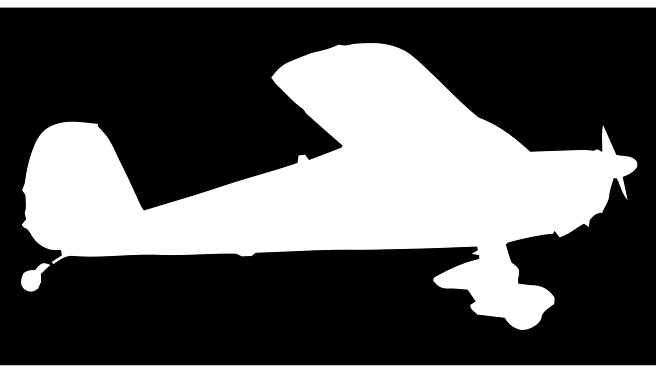
# BUZZKILL



# MINIMIZING AIRCRAFT NOISE OVER DENALI NATIONAL PARK

## BACKGROUND

A primary role the 1962 Wilderness Act sets for the National Park Service is to preserve "outstanding opportunities for solitude". Yet in Denali National Park in Alaska, this solitude is increasingly interrupted by small, low-flying aircraft, which carry flightseers and climbers between surrounding airports and the peaks at the heart of the park. Solitude-seeking hikers are outspokenly disturbed, and studies indicate noise pollution's effect on animal behavior can change ecosystems in yet-unknown ways.

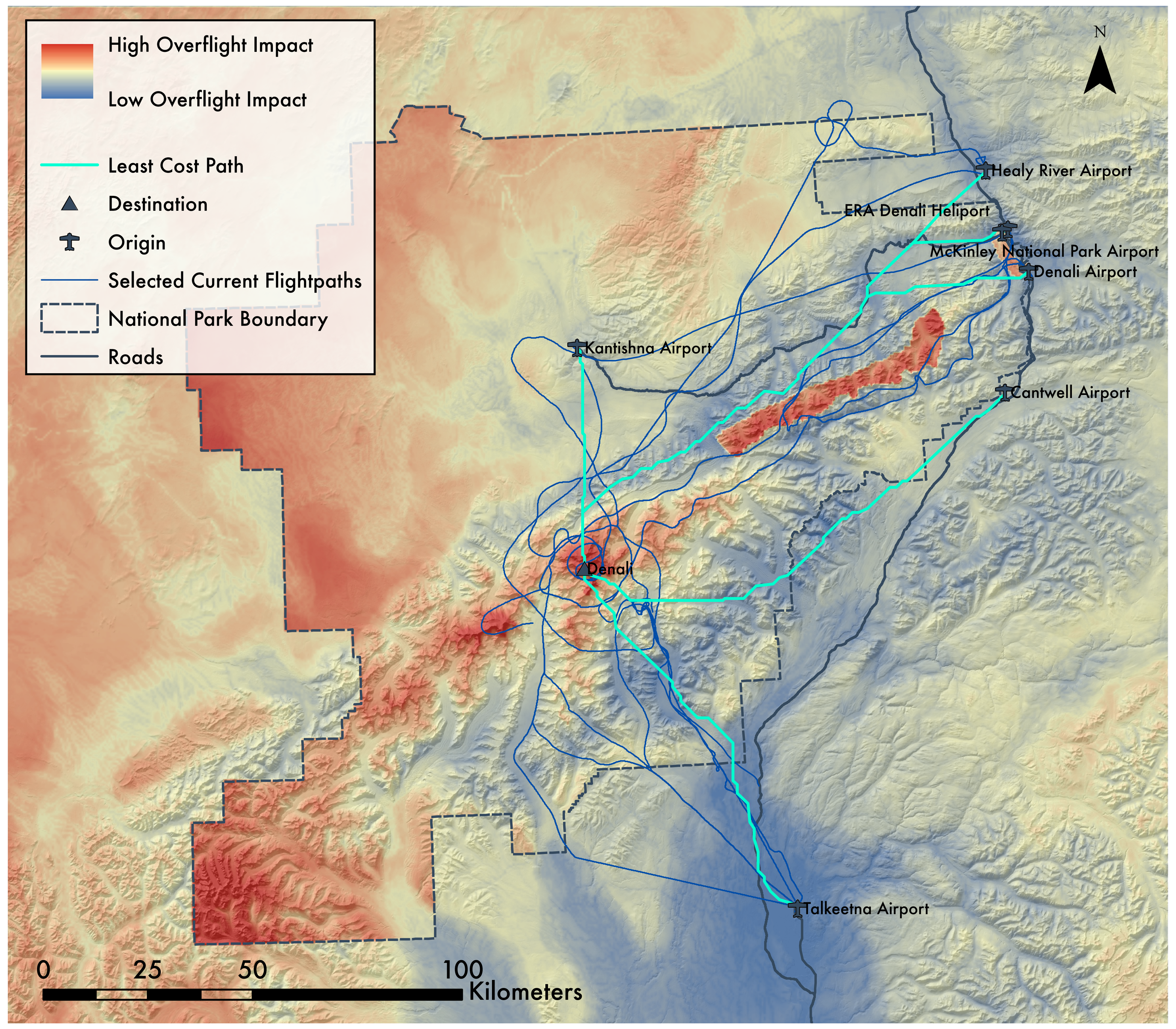
Pilots, scientists, and park officials have met to change common flight routes, trying to move them away from sound-sensitive areas while keeping them safe and practical. However, there are an overwhelming number of subjective factors involved in sound sensitivity and flight practicality, and many conflicting opinions about them. To help make this compromise, NPS would like a model for the optimal flight paths given all these considerations—one where stakeholders can interactively change the parameters to understand the problem and reach a compromise.

To build this model, I collaborated closely with scientists and GIS specialists in Denali National Park, where I am continuing this work over the summer.

## METHODS

We considered this as a Least Cost Path problem, where given start points (airports), an end point (the Denali massif), and a "cost raster" of the undesirability of flying over each 500m cell, we found the paths with the least sum cost of cells traversed. NPS Denali created cost rasters for various sensitivity factors (see below)—we wanted to see how different weighted combinations of these would produce different optimal routes. Each component cost raster was normalized, multiplied by a weight (0, 2, or 8), then all summed to produce an overall cost raster. The weights of the compenent rasters acted as the parameters for the model.

For users to explore these parameters interactively, we needed to pre-compute all of their 2,187 unique combinations. I wrote a Python geoprocessing script to parallelize the tasks—a weighted sum and the ArcGIS Least Cost Path tools—between 10 networked computers over 20 hours. I then made a webpage to show and compare the resulting routes for any combinations of these weights.




*Compared to current routes, optimal flight paths (cyan) avoid areas with greatest noise sensitivity (red), preferring regions with a higher natural ambient noise level (to mask aircraft noise), highest distance from the ground, and least existing opportunities for solitude. This is just one set of paths of the 2,187 possibilities computed by combining the routing factors below in different weighted sums.*

## RESULTS

There is no single best new route that comes from this project; that is for stakeholders to decide as they explore the possibilities it has generated. However, many of the optimal routes resemble changes that have already been proposed, such as avoiding popular backpacking areas south of the road in the northeast of the park. Politically, seeing this result lends those proposals more credibility, which may help drive their adoption. Other weight combinations suggest drastic but feasible changes, such as directing east-west flights along the southeastern park border, well away from popular hiking areas.

The model also uncovered flaws in the ArcGIS Least Cost Path algorithm. When run on a raster where every cell has cost 1, the paths it chooses are indirect and longer than straight lines—in other words, not optimal. Because it considers cost between cell centers, diagonal travel is penalized. But planes fly at any heading, not just the cardinal directions, so all 8 neighboring cells should be considered equidistant. Modifying this algorithm for my summer work should eliminate these "taxicab distance" paths and produce more valid results.

## SOURCES


Aircraft Overflights Advisory Council. "2012 Factsheet." Healey, Alaska: 2012.

Denali National Park and Preserve. Backcountry Management Plan. National Park Service. Denali Park, Alaska: January 2006.

Wilderness Act of 1964, 16 U.S. C. 1131-1136.



Many thanks to Davyd Betchkal, Britta Schroeder, and Regan Sarwas of Denali National Park and Preserve for producing the cost rasters (cited below), and for the enthusiasm, support, and time they have given to this project.


This is a joint project for Earth & Ocean Sciences (GIS) and Computer Science (Visual Analytics).

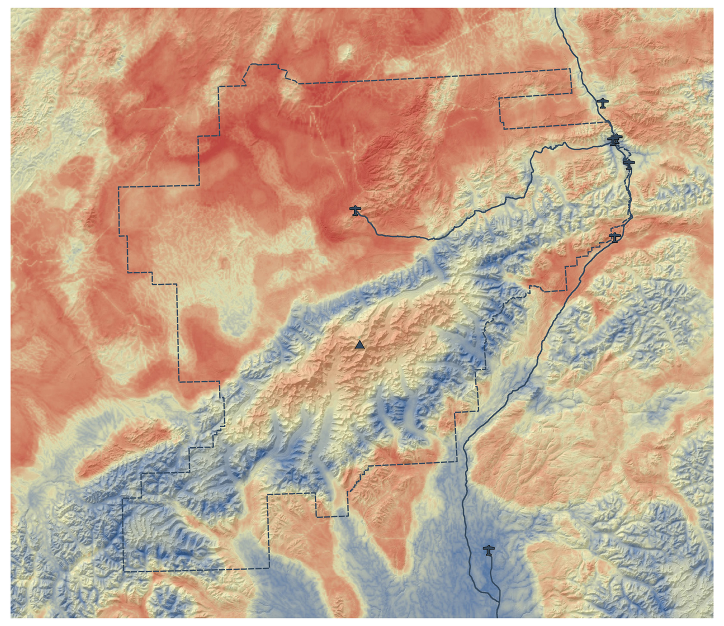

**GABE JOSEPH**

THE NATIONAL PARK SERVICE

TUFTS EARTH & OCEAN SCIENCES

TUFTS COMPUTER SCIENCE

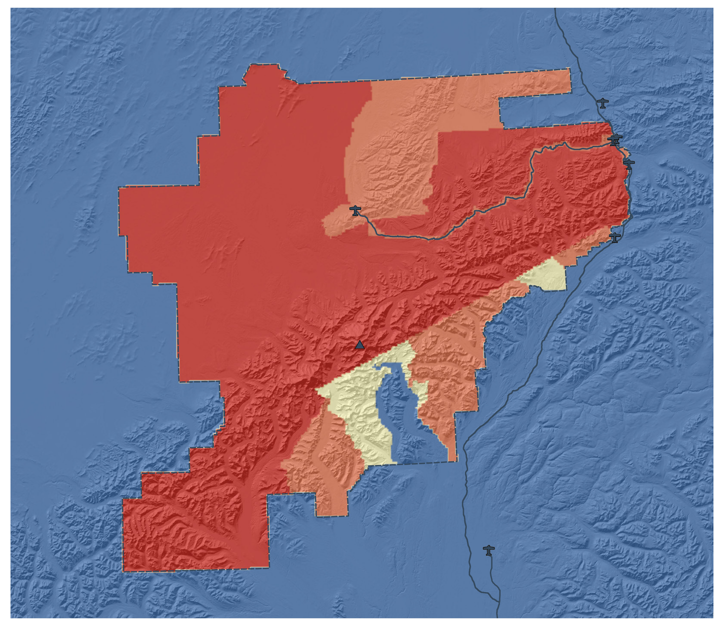

## ROUTING FACTORS



**Natural Ambient Sound Level**

*Prefer flying over naturally louder areas, like streams, where noise is less intrusive than, say, a quiet, open field. Based on modeling of median sound pressure level across the entire state.*

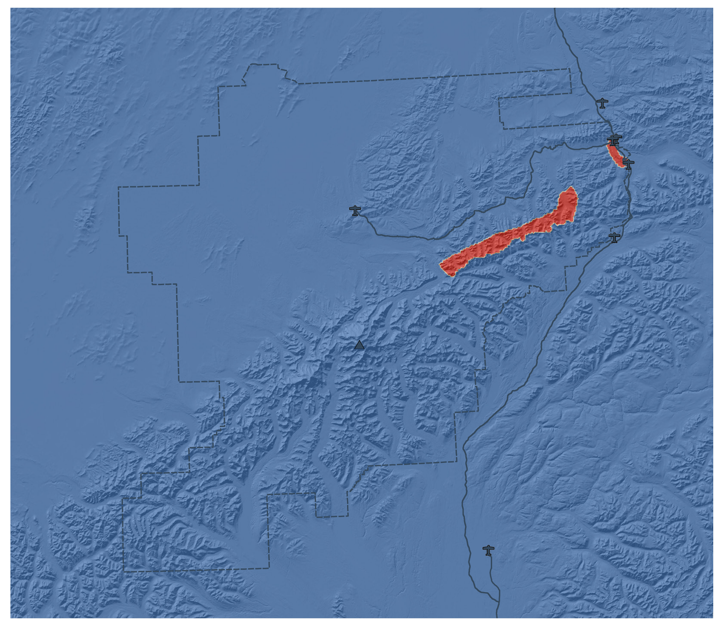
A geospatial model of ambient sound pressure levels in the contiguous United States. Mennitt, Daniel and Sherrill, Kirk and Fristrup, Kurt, The Journal of the Acoustical Society of America, 135, 2746-2764 (2014)



**Backcountry Management Plan**

*Sets standards for the amount and intensity of noise permissible in different areas of the park.*

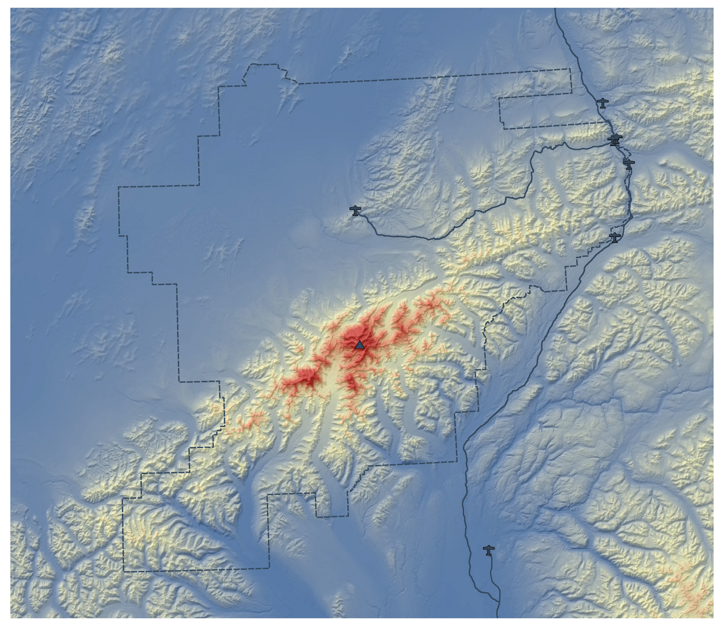
National Park Service. 2006. Denali National Park and Preserve Final Backcountry Management Plan, Environmental Impact Statement. National Park Service, Denali Park, Alaska.



**Aircraft Overflights Advisory Council Best Practices**

*In 2012, the Overflights Advisory Council recommended avoiding these areas where backpackers have been most disturbed.*

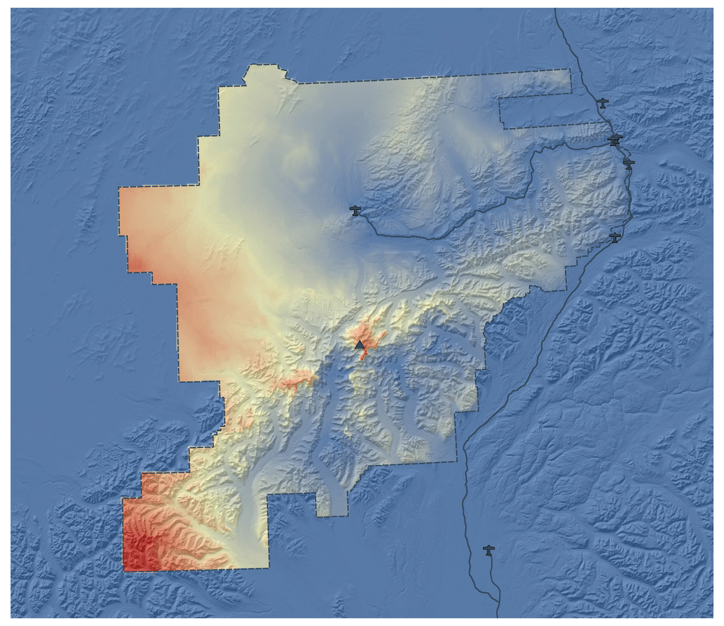
Denali Aircraft Overflights Advisory Council. "Sound Sensitive Areas." 2009. Digitized 2015.



**Flight Distance from Ground**

*The closer planes are to the ground at their 8,000ft above-sea-level cruising altitude, the louder engine noise will sound. Following topographic lows is one of the best ways to reduce noise impact.*

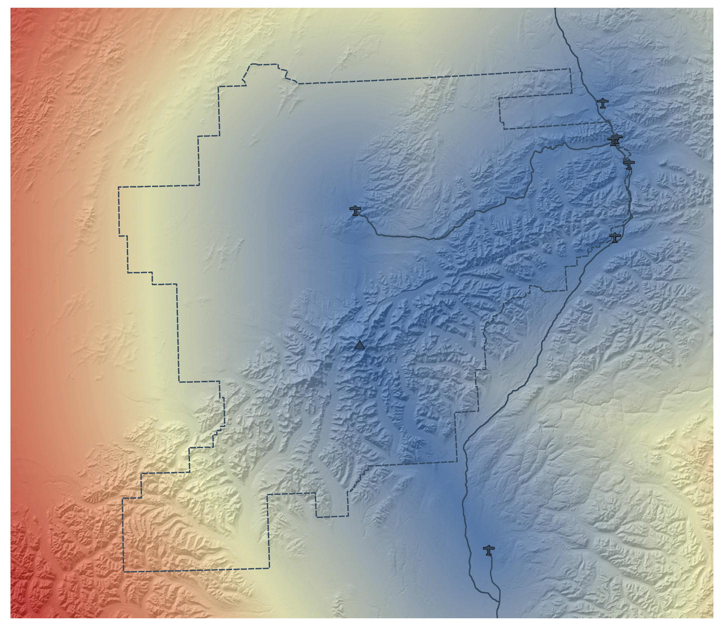
USGS. NED Alaska 2 arc-second. 2013.



**Hiking Accessibility**

*People who take the time to travel to hard-to-reach areas value their quietude significantly more. Encourage planes towards the road and other places where solitude is less important.*

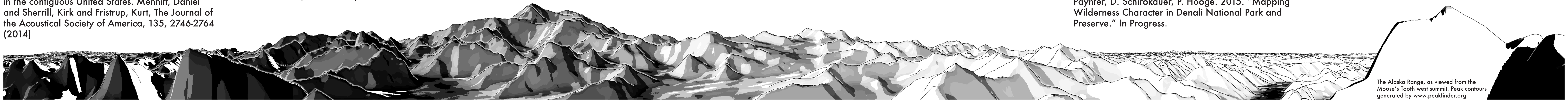
Burrows, R, D. Abbe, J. Tricker, P. Landres, J. Paynter, D. Schirokauer, P. Hooge. 2015. "Mapping Wilderness Character in Denali National Park and Preserve." In Progress.



**Flight Directness**

*Prefer straighter lines from each airport to the Denali massif. Without this, ArcGIS Least Cost Paths are often wandering and impractically indirect.*

Computed from data provided by the National Park Service.



The Alaska Range, as viewed from the Moose's Tooth west summit. Peak contours generated by www.peakfinder.org