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 undesirable areas of the park. 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.

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.

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

GABE JOSEPH

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.

Backcountry Management Plan
Sets standards for the amount and intensity of noise permissible in different areas of the park.

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

Flight Distance from Ground
The closer planes are to the ground, the louder engine noise will sound. Following topographic lows is one of the best ways to reduce noise impact.

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.

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