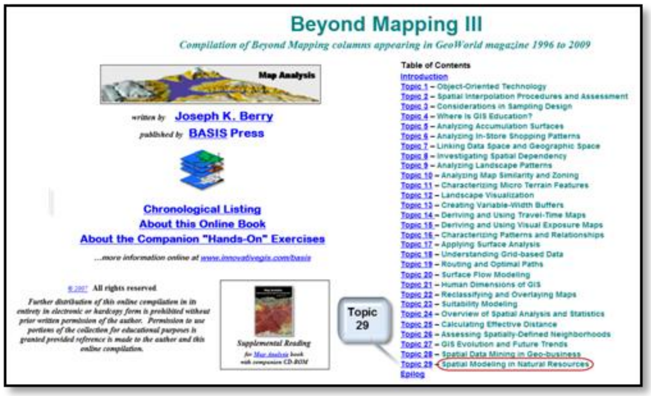
E911 for the Backcountry



www.innovativegis.com/basis/MapAnalysis/

Optimal Path Density is not all that Dense (Conceptually)

(GeoWorld, January 2013)

Several previous Beyond Mapping columns have addressed "Backcountry 911" that considers both on- and off-road travel for emergency response (GeoWorld, July to September, 2010; see Author's Note). Recall that the approach uses a stepped-accumulation cost surface to estimate travel-time by truck, then all-terrain vehicle (ATV) and finally hiking into areas too steep for ATVs.

The result is a map surface (formally termed an ***Accumulation Surface***) that identifies the minimum travel-time to reach all accessible locations within a project area. It is created by employing the "splash algorithm" to simulate movement in an analogous manner to the concentric wave pattern propagating out from a pebble tossed into a still pond. If the conditions are the same, the effect is directly comparable to the uniform set of ripples.

However as the wavefront encounters varying barriers to movement, the concentric rings are distorted as they bend and wiggle around the barriers to locate the shortest effective path. The conditions at each grid location are evaluated to determine whether movement is totally restricted (absolute barriers) or, if not, the relative difficulty of the movement (relative barrier). The end result is a map surface identifying the "shortest but not necessarily straight line" distance from the starting location to all other locations in a project area.

The emergency response surface shown in figure 1 identifies the minimum travel-time via a combination of truck, ATV and hiking from headquarters (HQ) to all other locations. Travel-time increases with each wavefront step as a function of the relative difficulty of movement that ultimately creates a warped bowl-like surface with the starting location at the bottom (HQ= 0.0 minutes away). The blue tones identify locations of very slow hiking conditions that result in the “mountain” of increasing travel-time to the farthest away location (Emergency Location #1= 96.0 minutes away).

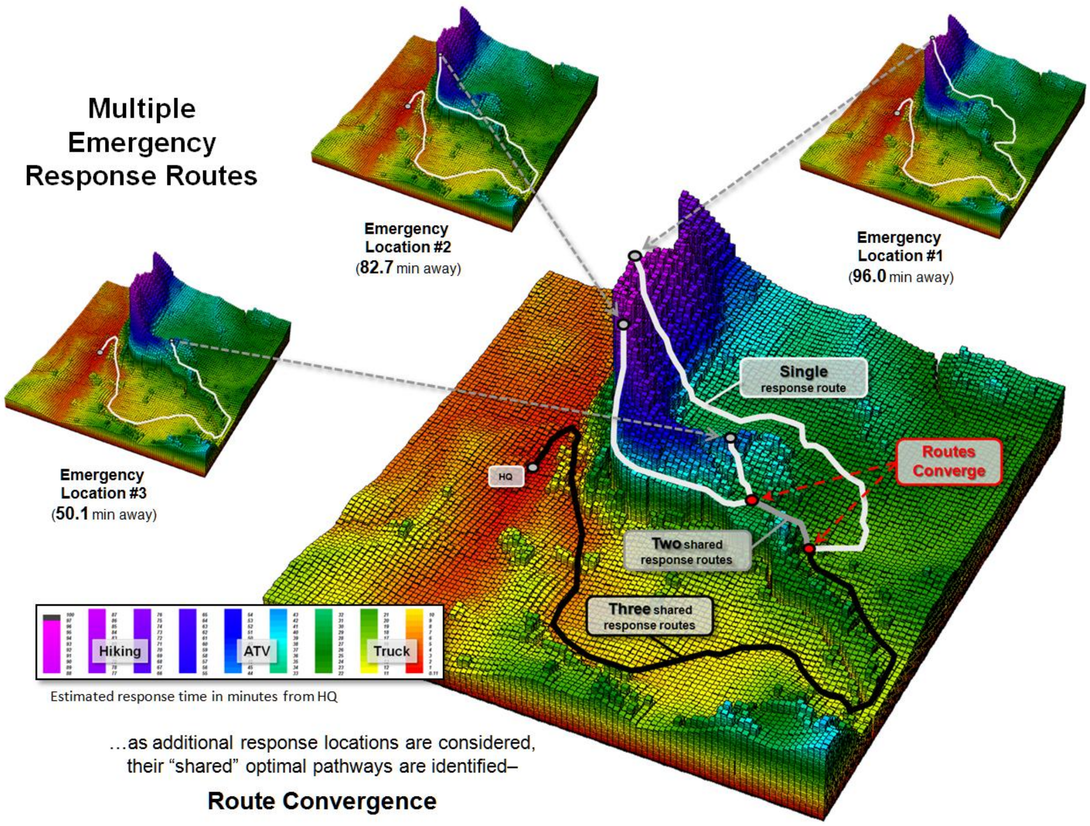


Figure 1. Multiple optimal paths tend to converge to take advantage of “common access” routes over the travel-time surface.

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The quickest route is rarely a straight line a crow might fly, but bends and turns depending on the intervening conditions and how they affect travel. The ***Optimal Path*** (minimum accumulated travel-time route) from any location is identified as “*the steepest downhill path over the accumulated travel-time surface*.” This pathway retraces the route that the wavefront took as it moved away from the starting location while minimizing travel-time at each step.

The small plots in the outer portion of Figure 1 identify the individual optimal paths from three emergency locations. The larger center plot combines the three routes to identify their convergence to shared pathways— grey= two paths and black= all three paths.

The left side of figure 2 simulates responding to all accessible locations in the project area. The result is an "***Optimal Path Density***" surface that "*counts the number of optimal paths passing through each map location.*" This surface identifies major confluence areas analogous to water running off a landscape and channeling into gullies of easiest flow. The light-colored areas represent travel-time "ridges" that contain no or very few optimal paths. The emergency response "gullies" shown as darker tones represent off-road response corridors that service large portions of the backcountry.

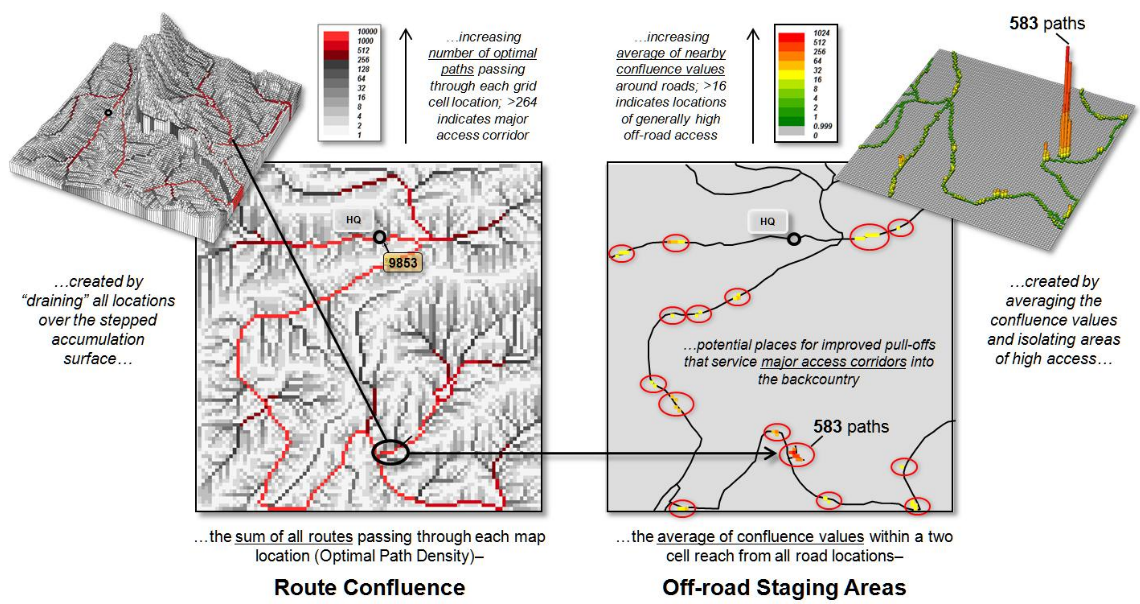

Figure 2. The sum of all optimal paths passing through a location indicates its relative rating as a "corridor of common access" for emergency response.

These "*corridors of common access*" are depicted as increasingly darker tones that switch to red for locations servicing more than 256 potential emergency response locations. Note that 9,853 locations of the 10,000 locations in the project area "drain" into the headquarters location (the difference is the non-accessible flowing water locations).

This is powerful strategic planning information, as well as tactical response routing for individual emergencies (backcountry 911 routing). For example, knowing where the major access corridors intersect the road network can be used to identify candidate locations for staging areas. The right side of figure 2 identifies fifteen areas with high off-road access that exceeds an average of sixteen optimal routes within a 1-cell reach from the road. These "jumping off" points to the major response corridors might be upgraded to include signage for volunteer staging areas and improved roadside grading for emergency vehicle parking.

In many ways, GIS technology is "more different, than it is similar" to traditional mapping and geo-query. It moves mapping beyond descriptions of the precise placement of physical features to prescriptions of new possibilities and perspectives of our geographic surroundings— an Optimal Path Density surface is but one of many innovative procedures in the new map analysis toolbox.

Author's Note: *for detailed discussions characterizing "Backcountry Emergency Response" using a stepped-accumulation cost surface to estimate travel-time by truck, then ATV and then hiking as off-road travel conditions change, see Topic 29, Spatial Modeling in Natural Resources, sections4 through 6, in the online book Beyond Mapping III posted at www.innovativegis.com/basis/MapAnalysis/; also a free-use poster and short paper are posted at www.innovativegis.com/basis/Papers/Other/BackcountryER_poster/.*