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Biogeography Synopsis 4: Isolation by Resistance, Principles of Electrical Circuitry
Applied to Genetic Modeling

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Scientists engaged in genetic research associated with wildlife habitat & migration typically have employed Isolation By Distance [IBD] to model resistance effects of genetic exchange between populations.[MacRae 2006] This approach uses either Euclidean distance or least-cost-path analysis of a landscape where raster cells are assigned arbitrary values based upon available data and resolution is limited to cell-size. Ecologist Brad MacRae identifies significant limitations of analyses based on IBD. Results are accurate only for 1-dimensional pathways between sample pairs and provide only rough or indeterminate approximation of actual landscapes which are nearly always heterogenous, many-pathed.

MacRae proposes to realign the problems of modeling microevolutionary processes between demes by treating landscapes as conductive surfaces, analogizing allele exchange to electrical network dynamics. This is powerful because instead of generalizing landscapes as is required in the raster-based IBD modeling, the Isolation By Resistance [IBR] method allows full consideration of the effects of landscape upon natural populations. By visualizing genes as electrons IBR fulfills the first requirement of effective modeling in that it simplifies without overgeneralization. [Polya 1945] The nuances of landscape change, where geographic barriers are the primary agent of resistance and therefore an important regulator of population dynamics. are preserved. Network topology is consistent with the investigation of genetic expression. Another strength of IBR is that it apparently yields convincing results using the typical depth & breadth of natural population data samples while IBD using least cost path analysis requires weighting by classification that is more qualitative rather than representing edges relative to numerical data as collected. MacRae's method is also readily testable since he and his team have produced shareware called "Circuitscape", freely distributed online. [MacRae, 2007]

I am impressed with this work because of its elegance and clear utility. As I recently worked through numerous results of researchers working on wildlife corridors in California I had the opportunity to compare their work products. Although my understanding of both network and genetic topology is incomplete IBR seems to yield the most solid results and the best maps. Beyond application to modeling genetic migration, IBR also serves as an appealing example of a heuristic approach to problem solving by analogy. [Polya 1945]

Sources

Polya,G. How To Solve It, 1945

MacRae, Brad. "Isolation By Resistance" *Evolution*, 60(8), 2006, pp. 1551–1561

MacRae, Brad. "Circuitscape";

<http://www.nceas.ucsb.edu/~mcrae/circuitscape.html>