

Introduction to the Special Issue on Location Modeling

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The year 2009 marked the centennial of Alfred Weber's (1909) *Theory of the Location of Industries*, which more than any other single publication launched the field of Location Science. In the ensuing 100 years, the field has changed dramatically. The hand-drawn concentric circles and mechanical devices of the early 20th century were rendered obsolete by the invention of linear programming, digital computers, branch-and-bound, and GIS. On the computational side, simple but efficient greedy, substitution, and Lagrangean-relaxation heuristics have been augmented by newer developments in simulated annealing, genetic algorithms, ant colony optimization, Tabu search, heuristic concentration, as well as other approaches. Models for industrial factories and warehouses now occupy a small space in the field, having been joined by public sector facility location, emergency vehicle posting, special concerns for undesirable and obnoxious facilities, and countless other point, line, and areal facility problems. Researchers have explored different solution spaces (planar, network, discrete, spherical, and hybrid), numerous objectives (single vs. multiple), temporal aspects (static vs. dynamic), the nature of demand (point, planar, path flows), and other problem dimensions.

Location researchers approach these issues from a variety of backgrounds: economics, engineering, geography, mathematics and operations research from both academic and business points of view. To bring these varied specialists together, Jonathan Halpern and Michael Goodchild, launched the International Symposium on Locational Decisions (ISOLDE) in 1978, which was held in Banff, Alberta. This symposium has been held every three years since 1978 for an intensive week focused solely on location decision-making. The papers in this special issue of *Networks and Spatial Economics* are expanded and refined treatments of topics identified at ISOLDE XI, held in Santa Barbara CA in 2008, as central to current scholarly inquiry into locational decisions. However, in no sense are

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they proceedings of that symposium, for the papers comprising this special issue explore details and reach conclusions not previously aired in other forums. Moreover, all papers in this special issue have been rigorously reviewed.

This collection of papers makes clear that location modelers today have an impressive set of tools and concepts that they can use and combine to address the problem at hand as realistically as possible. These papers readily integrate GIS with mathematical programming and heuristics. Several of these papers incorporate gravity model concepts to more realistically model consumer behavior and accessibility, or employ origin-destination paths and network routing to model transportation more realistically. Stochastic and dynamic elements are integrated as well.

The first paper in this issue is a good example of the impressive toolkit available to location modelers today to realistically model complex spatial decisions. Bozkaya, Yanik, and Balcisoy tackle the problem of locating supermarkets in a competitive urban environment. Competitive location models have been of interest since Hotelling (1929) first discussed how vendors of artesian water optimized market share by pricing, as well as considering the possibility of location to grab market share. Optimization models for competitive location began appearing in the 1980s. In their paper, "A GIS-Based Optimization Framework for Competitive Multi-Facility Location-Routing Problem," Bozkaya et al. maximize the profit for a supermarket chain. Their revenue depends on the customers attracted to their stores given the locations of competitors' stores and realistic consumer behavior whereby the probability of patronizing a store is proportional to store attractiveness and inversely proportional to the distance from the consumer. The chain's costs include the cost of delivering goods to the stores from a central warehouse. Usually, location-routing models have been applied to choosing the best location for the warehouse and to routing trucks from the warehouse to a fixed set of customers, but in this paper it is applied to locating the destinations (the stores) and designing the route from a fixed central supply point.

The second paper, "Planning for Agricultural Forage Harvesters and Trucks: Model, Heuristics, and Case Study," also contributes to the routing literature, though in a very different way. Blanco, Carpena, Hinojosa, and Puerto study the problem of jointly planning the routes and schedules for two kinds of vehicles whose activities must be coordinated. The model was developed for an agricultural cooperative, which creates additional complexities. The cooperative consists of multiple landowners who share equipment. Each landowner may have multiple smallholdings of land, all of which need to be harvested and transported to the silos in the same time window, which makes the problem a type of clustered traveling salesman problem with time windows and nested routing decisions. Blanco et al. use GIS for input data processing and a Tabu search algorithm for solving the model.

One of the recent themes in the location literature in the last 10–20 years has been the robustness of location systems and networks. Such research initially focused on how to locate facilities and develop networks to better withstand and continue functioning after attacks or failures. These concerns led naturally to models that optimize how to restore systems *after* disruptions. In our third paper, Matisziw, Murray, and Grubestic add to this literature with their paper on "Strategic Network Restoration." Their approach is multiobjective, dynamic, and path-based. A particular strength of their approach is that it does not need to specify *a priori* the importance of nodes; instead, the importance is determined by the network structure

and path flows. Their model addresses the connectivity, flow, and cost of the system over multiple time periods simultaneously.

The fourth paper moves away from the dynamic approach of the first three papers, but continues with the theme of researchers integrating numerous tools from the location analyst's toolkit. Johnson, Turcotte, and Sullivan address a very timely question: "What Foreclosed Homes Should a Municipality Purchase to Stabilize Vulnerable Neighborhoods?" Previous operations research models of the housing sector are few, and most have focused on land acquisition. This paper, motivated by working with community-based organizations in economically depressed areas, focuses on a new application: housing rehabilitation. Their model for this problem is a type of multi-objective, nonlinear knapsack problem. The three objectives are to maximize the social benefit to the residents (via gravity-model-based accessibility to amenities), maximize equity across neighborhoods (via a minimax objective related to the p -dispersion problem), and maximize efficiency (by clustering the acquired housing units as much as possible).

The fifth paper in this special issue, "Stochastic Location-Assignment on an Interval with Sequential Arrivals," deals with the placement of servers along a line to serve stochastic demands. The demands arrive sequentially, and upon arrival, each is assigned to one of the servers, with that server unavailable for future demands. The problem is concerned with minimizing the expected sum of costs of serving the demands. In this paper Viswanath and Ward deal with both server placement and server-to-demand assignment decisions. They prove that there is a necessary condition for optimality of server locations, and test the model by developing optimal solutions for up to 10 servers.

Our last paper brings us back, 100 years later, to Alfred Weber and the problem of locating a factory on a planar landscape. Drezner and Scott's paper on "Optimizing the Location of a Production Firm" not only locates a firm on a 2-dimensional continuous surface to serve a geographically dispersed set of customers, but also determines the product price and transportation rate per mile charged to customers. Given elastic demand curves for customers, the problem is to find the location, price, and transport rate—all of which can vary continuously—to maximize the firm's profit. Our guess is that solving for these three decisions simultaneously is something Weber and Palander could never have figured out how to do with weights, pulleys, and concentric circles. Clearly, as these six papers attest, the field of location science has come a long way in 100 years.

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