William Warntz and the Legacy of Spatial Thinking at Harvard University

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Introduction

• Objectives:
  – Revisit the spatial research–teaching agenda of Harvard/Western Professor William Warntz
  – Examples of research interest

• Documentation:
  – *Harvard Papers in Theoretical Geography*
  – *Preliminary Statement Concerning the Establishment of a Geography Department within Harvard University* (4 June 1968)
  – Course content for honor students

• Should the Academy be interested?
William Warntz
Benchmarks and Career Influences

• Berwick, PA 1922
• Economics, Penn—is there a macrogeography? 1941
• World War II, 1943–1948, pressure patterns and flows
• John Q. Stewart, social physics
• Lester Klimm, population
• PhD *The Geography of Price* 1955
• Appointments at Penn, Hunter, Columbia, Princeton
• American Geographical Society, 1956–1966
• *Toward a Geography of Price* 1959
• Walter Isard, Regional Science
• President International Regional Science Assoc 1965
• Harvard 1966–1971
• Western Ontario, 1971–1988
• Cambridge University 1976
• Students and colleagues
Geographer Uses 3,100 Nails To Construct Map

A unique three-dimensional map showing an abstract measure of population distribution and indicating the economic importance of all the cities, towns, and rural areas in the United States has been patiently constructed out of 3,100 nails by an economist-geographer.

William Warnitz of 47 Park Place has built this "potential of population" map for a special exhibit of the American Geographical Society at the New York World's Fair. The varying heights of the nails represent the varying demographic "potentials" of population groupings based on formulas analogous to those in field quantum physics.

New York, the highest nail, clearly dominates the rest of the country in overall importance, as exhibited in movement of people, mail and monetary goods into the geographical Society in New York.

He is also a research associate in astro-physical sciences at Princeton University and lectures, on the graduate level, at both the University of Pennsylvania and Hunter College.

Mr. Warnitz is a consultant to such well known organizations as the National Science Foundation in Washington and the Educational Services Inc., in Cambridge, responsible for redesigning the social sciences curriculum in schools. He is a member of the advisory board of the Bureau of the Census and consultants for the Learning Center in Princeton.

Dedicated to revitalizing the subject of geography. Mr. Warnitz will have two books coming out within the next week. One, "Geography Now and Then," tells the role of
Population Potential and Macrogeography

**Macrogeography:**
- Refers to the level of abstraction (not geographic scale)
- Seen as a departure from traditional regional geography
- Each part of a system influences all other parts
- Self-regulating systems
- A framework for General Spatial Systems Theory

**Population Potential:**
- Index of sociological intensity
- Population at any point in space contributes to the population potential of all other points
- A measure of influence at a distance
- Aggregate accessibility to a population

**Income Potential:**
- Weighting population values at points by average income (social mass per capita)
FIGURE 6. Canada and United States population potential surface 1972. Units of \(10^9\) persons per mile.

FIGURE 7. Canada and United States income potential surface 1972. Units of \(10^6\) dollars per mile.

FIGURE 24. Ratio of income potentials to population potentials circa 1960. Dark lines are isolines of per capita accessibility to social mass; lighter lines are lines of force that connect high and low values across the gaps between the wealthy and the poor.
Newton, The Newtonians, and the Geographia Generalis Varenii*

William Warntz

Newton, The Newtonians, and the Geographia Generalis Varenii

William Warntz

ON OUR STAFF . . .

Dr. William Warntz, Associate Director of the Laboratory, joined our staff in the fall of 1966, at which time he was appointed to the faculty of the Graduate School of Design of Harvard University as Professor of Theoretical Geography and Regional Planning.
CONTEXT

a newsletter from the Laboratory for Computer Graphics about developments in systems for the analysis and graphic representation of spatial factors in man's physical and social environment.

February 1968

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GEOGRAPHY AND THE PROPERTIES OF SURFACES SERIES

- 46 papers 1967–1972:
- **William Warntz** (6)—spatial order, map projections, spatially continuous fields, contour mapping
- **Michael Woldenberg** (9)—central places & hexagonal networks, energy flow, spatial order in human & physical systems, hierarchical systems, structural taxonomies
- **C. Ernesto S. Lindgren** (18)—minimum paths, hexagonal hierarchies, space transformations, N-dimensional spatial analysis & graphical constructions, determination of geodesic lines, generating conceptual surfaces in 3-D, projective transformations, homological transformations in 4-D, movement across dimensional views
- **Thomas Poiker** (2)—optimal mapping & coding of surfaces, the law of travel
- Others (11), Harvard students & research associates affiliated with the Lab & the Graduate School of Design
GEOGRAPHY OF INCOME SERIES

I. Macroscopic Aspects of Metropolitan Evolution, GH Dutton, 1970
IV. A Description of the 1967–78 United States Income Potential Surface, D Kingsbury, 1971
VI. Allometric Growth in Social Systems, MJ Woldenberg, 1971

SPECIAL PAPERS SERIES

B. Sparking Potential, Personal Interaction and Social Distance, Directions for a Theory, GH Dutton, 1969
C. The Thinking Earth, D Sucher, 1970
D. Some General Ideas for Regional Planning Education with Special Application to Turkey, I Tekeli, 1970

F. Recorded as E. Allometry in Micro-environmental Morphology, R Bon, 1972
Preliminary Statement Concerning Possible Establishment of a Geography Department within Harvard University

4 June 1968

- Request by Franklin Ford, Dean of A&S, to form ad hoc committee
- Submission to Carnegie Corporation of NY (23 pages)
- Intellectual Rationale (excerpts follow):
  - “Geography as a science of spatial relations …” p 1
  - “…understanding of the causes and significances of the patterns of the location of phenomena …” p 2
  - “Every educated person should carry about in his mind’s eye an instantaneously available globe” … p 2 (similar to learning to read)
  - “any explanation of a location involves the notion of movement”…p 4
  - “patterns repeat themselves in surprising variety” p 4
  - “…a student can discover these patterns, these morphological laws, for himself so that his planet, Earth, fills his consciousness with its symmetry and ordered beauty” p 4
Geometry, Geography, Graphics

• Interrelated since 2\textsuperscript{nd} century A.D. (C Ptolemy)
• Re-emergence of all three, with geographers using (p 5):
  – tools of calculus, probability, symbolic logic, and the algebras
  – especially topology and the geometries that may be handled graphically
  – Taking the \textit{geo} in geometry literally for study of earth-related surfaces and paths . . . ,
    • Expanded in physical geography to include landforms, contour mapping, drainage patterns, temperatures, pressure, precipitation
    • Expanded for spatial patterns of social, economic, and cultural phenomena beyond measures of density—to field quantity potentials, probabilities, costs, times, etc.
• “These conceptual patterns may be regarded as overlying the surface of the real earth and the geometric and topological characteristics of these patterns, as transformed mathematically or graphically, thus describe aspects of the geography of the real world.” p 6
Three Levels of Geography
Descriptive, Classificatory, Theoretical-Predictive

• **Descriptive Geography:**
  – Characteristics of selected places
  – Uniqueness
  – Largely verbal
  – Generally the structures and processes described are non-spatial

• **Classificatory Geography:**
  – Necessary and at the heart of regional geography
  – Location and the concepts related to it (e.g., concentrated, dispersed, clustered, contiguous, etc.) is what makes regionalization geographic
  – Regionalizing is equivalent to the operations of set theory in mathematics
  – Unions, intersects, and subsets are valid ideas expressing “uniform” geographical regions.
  – “A geographer may well regard the earth’s surface as the ‘set of all sets.’”
  – In Venn diagrams, only topological properties are used, whereas on geographical maps, all geometrical properties (i.e., scale, direction, size, and shape) have precise meaning for the kind of map projection selected.
• Theoretical-Predictive Geography:
  – “T-P Geography emphasizes the common characteristics relating to the spatial structure (form) and spatial process (movement) found for a wide variety of phenomena in the physical and non-physical world.” p 9
  – That is, “morphological laws or spatial patterns repeat themselves regardless of the non-spatial dissimilarities present among the phenomena.” p 10
  – The geometrical and topological characteristics of conceptual surfaces (potentials, probabilities, costs) reveal much of importance concerning the geography of the real world (p 10). Examples include central place theory, diffusion of information, macrogeography of sociological intensity.
  – The projection of spatial properties and their transformations allow us to establish a measure of control for “experimental” testing of hypotheses. p 11
  – Special attention is given to the dynamics of the relationship of structure and process. Any geographic prediction involves movement (circulation, diffusion, interaction, orbits, flows). Predictive geography, the geography of explanation, is interested in both movements and patterns.
Cartography and Geography

• The map as an experimental tool. “It allows us to twist space into desired shape. What projection will yield the “uniform surface” we need so that we can meaningfully test geographic theory?” p 15

• “Needed spatial transformations [spearheaded by Tobler] are those which permit expansion, collapse, repetition, dislocation, inversion, elimination, interruption, superposition, straightening, and flattening of . . . geographical surfaces.” p 15

• Warntz expresses excitement with computers that enable cartographic goals previously thought to be unattainable.
The Core of a New Department of Geography
(Warntz 1968)

• Appointments, research, and courses to reflect the continued mathematization of the field

• A focus on theoretical-predictive geography will reinforce commerce among (and the unifying concepts of) geography, geometry, and graphics to consider (predict and control) geographical patterns in the real world

• This will diminishes the need to feature the traditional systematic divisions of the discipline

Franklin Ford stepped down as Dean before the proposal was put before the University’s Committee on Educational Policy. Intellectual and financial problems in the Graduate School of Design in the late 1960s–early 1970s precluded the possibility of a new initiative at that time for geography at Harvard.
Some concluding thoughts on the relevance of the 1950s–1980s thinking of Warntz to educational and societal needs in the early 21st Century?

• Computational and conceptual prowess
• The value (and diversity) of spatial reasoning across disciplines
• Trans-disciplinary communication and problem solving
• Educating students for critical spatial thinking
• Geographical intelligence and responsible citizenship
• What did Harvard and Western students learn from Warntz? from Warntz’s course syllabi . . . . . .
  . . . . . . How might the content differ today?
Lecture-seminars and Tutorials for Honors Students

I. On Knowing in General. On Knowing in Geography (about Earth’s Shape)
II. Domain and Range—Implications of “For Geography, the Earth’s Surface is the Set of All Sets of Places”
III. Three Levels of Geography—Descriptive, Classificatory, Predictive
IV. On Knowing Where You Are. On Going Somewhere Else
V. Spatial Partitioning. The Sandwich Theorem—Fundamental for Geography
VI. Geography and the Topological and Geometrical Properties of Surfaces
VII. Necessity for and Utility of Statistical Methodology for Areal Distributions
VIII. Cartographics is to Geographical Science as Graphics is to Science
IX. Existence Theorems in Mathematics—Geometrical Interpretations and Geographical Applications
X. A General Model of Spatial Competition
XI. Boundaries and their Properties
XII. Spatial Hierarchies and Dimensional Tensions
XIII. Macrogeography and Microgeography
XIV. Geography as General Spatial Systems Theory
XV. The Roles of Universities—The Knowledge Problem
Every educated person should carry about in his mind’s eye an instantaneously available globe. The globe should be in life colors and rotating slowly in the sunlight. On it the mind’s eye should see at least the continental outlines, major political divisions, vegetation and climatic belts, primal atmospheric and oceanic circulation, the earth’s outstanding cities and their economic flows, and ultimately the people themselves and the quality of life.

William Warntz, 1968
Initiatives in **spatial thinking**

- [http://teachspatial.org](http://teachspatial.org)

About **William Warntz**


About **Harvard Laboratory for Computer Graphics and Spatial Analysis**


4. Proposed Solution for the Minimum Path Problem, C Ernesto S Lindgren, 1967
5. The Identification of Mixed Hexagonal Central Place Hierarchies with Examples from Finland, Germany, Ghana, and Nigeria, M Woldenberg, 1967
8. Energy Flow and Spatial Order, with Special Reference to Mixed Hexagonal Central Place Hierarchies, M Woldenberg, 1968

14. A Nomographic Representation of Trajectories, W Messcher


17. Hyper-surfaces and Geodesic Lines in 4-D Euclidean Space, C Ernesto S Lindgren, 1968


24. The Descriptive Geometry (or Representative) of a Collection of Points Fixed by N Coordinate Numbers or of N-Dimensions, by Felippe dos Santos Reis, trans by C Ernesto S Lindgren, 1968

25. The Law of Travel; and Its Application to Rail Traffic, by Eduard Lill (1891), translating and forwarding by TK Peucker, 1969


27. Notes on the Methodology for Generation of the Representative of a Set, C Ernesto S Lindgren, 1969


31. Some Reflections on Concepts Based on Three-Dimensional Geometry, C Ernesto S Lindgren, 1969
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<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Author(s)</th>
<th>Year</th>
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<tbody>
<tr>
<td>32</td>
<td>Algorithms and Models Based on Projective Transformations in Spatial Location, Regional Planning, and Central Place Theory</td>
<td>C Ernesto S Lindgren</td>
<td>1969</td>
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<td>33</td>
<td>Graphical Representation of a Matrix with Applications in Spatial Location</td>
<td>C Ernesto S Lindgren, and C Steinitz</td>
<td>1969</td>
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<td>Some Thought on Optimal Mapping and Coding of Surfaces</td>
<td>TK Peucker</td>
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<td>Homological Transformations in Four-Dimensional Space</td>
<td>C Ernesto S Lindgren</td>
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<td>36</td>
<td>A Study of the Movement of a Point on a Plane and in Space</td>
<td>C Ernesto S Lindgren</td>
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<td>Set of Equal-Value Antipodal Points for Two Continuous Distributions</td>
<td>C Ernesto S Lindgren</td>
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<td>An Outline for the Theory of Man-Made Space—Essays in Urbanology</td>
<td>Number One, K Balkus</td>
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<td>39</td>
<td>A Structural Taxonomy of Spatial Hierarchies</td>
<td>MJ Woldenberg</td>
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<td>The Determination of Fixed-Points in Finite-Dimensional Spaces</td>
<td>C Ernesto S Lindgren</td>
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<td>41</td>
<td>Law and Order in the Human Lung</td>
<td>MJ Woldenberg, G Cumming, K Harding, K Horsfield, K Prowse, and S Singhal</td>
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<td>The Hexagon as a Spatial Average</td>
<td>MJ Woldenberg</td>
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<td>43</td>
<td>The Two Dimensional Spatial Organization of Clear Creek and Old Man Creek, Iowa</td>
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<td>44</td>
<td>The Sandwich Theorem—A Basic One for Geography</td>
<td>W Warntz, C Lindgren, K Kiernan, L Bonfiglioli, E Lozano</td>
<td>1971</td>
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<td>45</td>
<td>Relations between Horton’s Laws and Hydraulic Geometry as Applied to Tidal Networks</td>
<td>MJ Woldenberg</td>
<td>1972</td>
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<td>46</td>
<td>The Two Dimensional Spatial Organization of the Pecatonica River, Southwestern Wisconsin</td>
<td>MJ Woldenberg and L Onesti.</td>
<td>1972</td>
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