

Bibliography

- Abercrombie, P. (1945) *Greater London Plan 1944*, HMSO, London.
- Ajo, R. (1944) *Tampereen Liikennealue*, Tutkimuksia XIII, Kansantaloudellisia, Helsinki, Finland.
- Alexander, C. (1964) *Notes on the Synthesis of Form*, Harvard University Press, Cambridge, MA.
- Alexander, C. (1965) A city is not a tree, *Architectural Forum*, **122** (1), 58–61 and (2), 58–62.
- Alexander, C. (1979) *The Timeless Way of Building*, Oxford University Press, New York.
- Alexander, C., Ishiwaka, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I. and Angel, S. (1977) *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, New York.
- Allen, P. M. (1982) Evolution, modelling and design in a complex world, *Environment and Planning B*, **9**, 95–111.
- Alonso, W. (1964) *Location and Land Use: Toward a General Theory Land Rent*, Harvard University Press, Cambridge, MA.
- Anas, A. (1981) The estimation of multinomial logit models of joint location and travel mode choice from aggregated data, *Journal of Regional Science*, **21**, 223–242.
- Anas, A. (1982) *Residential Location Markets and Urban Transportation: Economic Theory, Econometrics and Policy Analysis with Discrete Choice Models*, Academic Press, New York.
- Anas, A. (1983) Discrete choice theory, information theory and the multinomial logit and gravity models, *Transportation Research B*, **17**, 13–23.
- Angel, S. and Hyman, G. M. (1976) *Urban Fields: A Geometry of Movement for Regional Science*, Pion Press, London.
- Aono, M. and Kunii, T. L. (1984) Botanical tree image generation, *IEEE Computer Graphics and Applications*, **4**, 10–33.
- Arlinghaus, S. L. (1985) Fractals take a central place, *Geografiska Annaler*, **67B**, 83–88.
- Arlinghaus, S. L. and Nystuen, J. D. (1990) Geometry of boundary exchanges, *The Geographical Review*, **80**, 21–31.
- Arnheim, R. (1968) Gestalt psychology and artistic form, in L. L. Whyte (Editor) *Aspects of Form*, Lund Humphries, London, pp. 196–208.
- Bacon, E. N. (1967) *Design of Cities*, The Viking Press, New York.
- Ball, R. C. (1986) DLA in the real world, in H. E. Stanley and N. Ostrowsky (Editors) *On Growth and Form: Fractal and Non-Fractal Patterns in Physics*, Martinus-Nijhoff Publishers, Dordrecht, pp. 69–78.
- Barnsley, M. F. (1988a) *Fractals Everywhere*, Academic Press, San Diego, CA.
- Barnsley, M. F. (1988b) Fractal modelling of real world images, in H.-O. Peitgen and D. Saupe (Editors) *The Science of Fractal Images*, Springer-Verlag, New York, pp. 219–242.
- Barnsley, M. F. and Demko, S. G. (1985) Iterated function schemes and the global construction of fractals, *Proceedings of the Royal Society A*, **399**, 243–275.

- Barnsley, M. and Hurd, L. (1993) *Fractal Image Compression*, A. K. Peters, New York.
- Barnsley, M. F. and Sloan, A. D. (1988) A better way to compress images, *Byte*, **13**, 215–223.
- Batty, M. (1974) Spatial entropy, *Geographical Analysis*, **6**, 1–31.
- Batty, M. (1976) *Urban Modelling: Algorithms, Calibrations, Predictions*, Cambridge University Press, Cambridge, UK.
- Batty, M. (1991) Cities as fractals: simulating growth and form, in T. Crilly, R. A. Earnshaw and H. Jones (Editors) *Fractals and Chaos*, Springer-Verlag, New York, pp. 41–69.
- Batty, M. (1992) Physical phenomena, *Geographical Magazine*, **64** (7), 35–37.
- Batty, M. and Longley, P. A. (1987) Urban shapes as fractals, *Area*, **19**, 215–221.
- Batty, M. and March, L. (1976) The method of residues in urban modelling, *Environment and Planning A*, **8**, 189–214.
- Batty, M. and Sikdar, P. K. (1982) Spatial aggregation in gravity models: 2. One-dimensional population density models, *Environment and Planning A*, **14**, 525–553.
- Batty, M. and Xie, Y. (1994) Preliminary evidence for a theory of the fractal city, unpublished paper, National Center for Geographic Information and Analysis, State University of New York, Buffalo, NY.
- Beckmann, M. J. (1969) On the distribution of urban rent and residential density, *Journal of Economic Theory*, **1**, 60–67.
- Ben Akiva, M. and Lerman, S. R. (1985) *Discrete Choice Analysis: Applications to Travel Demand*, The MIT Press, Cambridge, MA.
- Benevolo, L. (1980) *The History of the City*, The MIT Press, Cambridge, MA.
- Benguigui, L. and Daoud, M. (1991) Is the suburban railway system a fractal? *Geographical Analysis*, **23**, 362–368.
- Berry, B. J. L. (1964) Cities as systems within systems of cities, in J. Freidmann and W. Alonso (Editors) *Regional Planning and Development: A Reader*, The MIT Press, Cambridge, MA, pp. 116–137.
- Berry, B. J. L. and Horton, F. E. (Editors) (1970) *Geographic Perspectives on Urban Systems*, Prentice-Hall, Englewood Cliffs, NJ.
- Berthon, S. and Robinson, A. (1991) *The Shape of the World: The Mapping and Discovery of the Earth*, Rand McNally, Chicago, IL.
- Best, R. H., Jones, A. R. and Rogers, A. W. (1974) The density-size rule, *Urban Studies*, **11**, 201–208.
- Bleicher, H. (1892) *Statistische Beschreibung der Stadt Frankfurt am Main und Ihrer Bevölkerung*, J. D. Sauerländer's Verlag, Frankfurt am Main.
- Blumenfeld, D. E. (1972) Effects of road system designs on congestion and journey times in cities, unpublished PhD Thesis, University College, London.
- Bracken, I. (1993) An extensive surface model database for population-related information: concept and application, *Environment and Planning B*, **20**, 13–27.
- Bracken, I., Holdstock, S. and Martin, D. (1987) Map manager: intelligent software for the display of spatial information, *Technical Reports in Geo-Information Systems, Computing and Cartography*, 3, Wales and South West Regional Research Laboratory, University of Wales, Cardiff.
- Bronowski, J. (1973) *The Ascent of Man*, BBC Publications, London.
- Buchanan, C. et al. (1963) *Traffic in Towns: A Study of the Long Term Problems of Traffic in Urban Areas*, HMSO, London.
- Bunde, A. and Havlin, S (Editors) (1991) *Fractals and Disordered Systems*, Springer-Verlag, New York.
- Burrough, P. A. (1981) Fractal dimensions of landscapes and other environmental data, *Nature*, **294**, 240–242.
- Burrough, P. A. (1984) The application of fractal ideas to geophysical phenomena, *The Institute of Mathematics and Its Applications*, **20**, 36–42.
- Bussiere, R. (1972a) Static and dynamic characteristics of the negative exponential

- model of urban population distributions, *London Papers in Regional Science*, **3**, 83–113.
- Bussiere, R. (Editor) (1972b) *Models Mathématiques de Repartition des Populations Urbaines*, Centre de Recherche et de Rencontres d'Urbanisme, Paris, France.
- Bussiere, R. and Snickars, F. (1970) Derivation of the negative exponential model by an entropy maximizing method, *Environment and Planning*, **2**, 295–301.
- Bussiere, R. and Stovall, T. (1981) *Systèmes Evolutifs Urbains et Régionaux à L'Etat D'Équilibre*, Centre de Recherche et de Rencontres D'Urbanisme, Paris, France.
- Buttenfield, B. P. (1985) Treatment of the cartographic line, *Cartographica*, **22**, 1–26.
- Carpenter, L. (1980) Computer rendering of fractal curves and surfaces, *Computer Graphics*, **10**, 90–97.
- Chapin, F. S. and Weiss, S. F. (Editors) (1962) *Urban Growth Dynamics: In a Regional Cluster of Cities*, John Wiley and Sons, New York.
- Chapin, F. S. and Weiss, S. F. (1968) A probabilistic model for residential growth, *Transportation Research*, **2**, 375–390.
- Christaller, W. (1933, 1966) *Central Places in Southern Germany*, Prentice Hall, Englewood Cliffs, NJ.
- Clark, C. (1951) Urban population densities, *Journal of the Royal Statistical Society (Series A)*, **114**, 490–496.
- Clark, C. (1967) *Population Growth and Land Use*, Macmillan at the St. Martin's Press, London.
- Clark, N. N. (1986) Three techniques for implementing digital fractal analysis of particle shape, *Powder Technology*, **46**, 45–52.
- Coleman, J. S. (1964) *Introduction to Mathematical Sociology*, The Free Press, New York.
- Couclelis, H. (1985) Cellular worlds: a framework for modeling micro-macro dynamics, *Environment and Planning A*, **17**, 585–596.
- Coyne, R. D., Rosenman, M. A., Radford, A. D., Balachandran, M. and Gero, J. S. (1990) *Knowledge-Based Design Systems*, Addison-Wesley Publishing Company, Reading, MA.
- Craig, J. and Haskey, J. (1978) The relationships between the population, area and density of urban areas, *Urban Studies*, **15**, 101–107.
- Crick, F. (1990) *What Mad Pursuit: A Personal View of Scientific Discovery*, Penguin Books, Harmondsworth.
- Curry, L. (1972) A spatial analysis of gravity flows, *Regional Studies*, **6**, 131–147.
- Dam, A. van (1984) Computer software for graphics, *Scientific American*, **251**, 102–113.
- Dantzig, G. B. and Saaty, T. L. (1973) *Compact City: A Plan for a Livable Urban Environment*, W. H. Freeman and Company, San Francisco, CA.
- Daunton, M. J. (1977) *Coal Metropolis: Cardiff 1870–1914*, Leicester University Press, Leicester.
- Davies, P. (Editor) (1989) *The New Physics*, Cambridge University Press, Cambridge, UK.
- Dawkins, R. (1986) *The Blind Watchmaker*, Longmans Scientific and Technical, London.
- Dearnley, R. (1985) Effects of resolution on the measurement of grain 'size', *Mineralogical Magazine*, **49**, 539–546.
- Dell'Orco, P. and Ghiron, M. (1983) Shape representations by rectangles preserving fractality, *Auto-Carto*, **6**, 299–308.
- Demko, S., Hodges, L. and Naylor, B. (1985) Construction of fractal objects with iterated function systems, *Computer Graphics*, **19**, 271–278.
- Devaney, R. L. (1990) *Chaos, Fractals and Dynamics: Computer Experiments in Mathematics*, Addison-Wesley Publishing Company, New York.
- Dewar, R. and Harris, C. K. (1986) Percolation on the DAP, in L. Pietronero and E.

- Tosatti (Editors) *Fractals in Physics*, North-Holland Publishing Company, Amsterdam, pp. 145–148.
- Dodge, C. and Bahn, C. R. (1986) Musical fractals, *Byte*, **11**, 185–196.
- DoE (1978) *Housing Survey Reports 10: English House Condition Survey 1976: Part 1: Report of the Physical Condition Survey*, Department of the Environment, HMSO, London.
- DoE (1979) *Housing Survey Reports 11: English House Condition Survey 1976: Part 2: Report of the Social Survey*, Department of the Environment, HMSO, London.
- Dorigo, G. and Tobler, W. (1983) Push-pull migration laws, *Annals of the Association of American Geographers*, **73**, 1–17.
- Doxiadis, C. A. (1968) *Ekistics: An Introduction to the Science of Human Settlements*, Hutchinson, London.
- Dutton, G. (1973) Criteria of growth in urban systems, *Ekistics*, **36**, 298–306.
- Dutton, G. H. (1981) Fractal enhancement of cartographic line detail, *American Cartographer*, **8**, 23–40.
- Edmonston, B. (1975) *Population Distribution in American Cities*, D. C. Heath and Company, Lexington, MA.
- Einstein, A. (1921) *Geometrie und Erfahrung*, J. Springer, Berlin.
- Elson, M. (1986) *Green Belts*, Heinemann, London.
- Evans, A.W. (1989) South East England in the eighties: explanations for a house price explosion, in M. Breheny and P. Congdon (Editors) *Growth and Change in a Core Region*, Pion Press, London.
- Falconer, K. (1990) *Fractal Geometry: Mathematical Foundations and Applications*, John Wiley and Sons, Chichester.
- Feder, J. (1988) *Fractals*, Plenum Press, New York.
- Feller, W. (1950) *An Introduction to Probability Theory and Its Applications: Volume 1*, John Wiley and Sons, New York.
- Feynman, R. (1965) *The Character of Physical Law*, The MIT Press, Cambridge, MA.
- Flook, A. G. (1978) The use of dilation logic on the quantimet to achieve fractal dimension characterisation of textured and structured profiles, *Powder Technology*, **21**, 295–298.
- Forrest, S. R. and Witten, T. A. (1979) Long-range correlations in smoke-particle aggregates, *Journal of Physics A*, **12**, 1109–1117.
- Fotheringham, A. S., Batty, M. and Longley, P. A. (1989) Diffusion-limited aggregation and the fractal nature of urban growth, *Papers of the Regional Science Association*, **67**, 55–69.
- Fournier, A., Fussell, D. and Carpenter, L. (1982) Computer rendering of stochastic models, *Communications of the ACM*, **25**, 371–384.
- Frankhauser, P. (1988) Fractal aspects of urban structures, *International Symposium des Sonderforschungsbereich 230: Naturliche Konstruktionen-Leichtbau in Architektur und Natur: Teil 1*, Universities of Stuttgart and Tübingen, West Germany.
- Frankhauser, P. (1990) Aspects fractals des structures urbaines, *L'Espace Géographique*, **19**, 45–69.
- Frankhauser, P. (1991) Fraktale Stadtwachstum, *Archiv und Zeitschrift für Architektur und Städtebau*, **109**, 84–89.
- Frankhauser, P. (1992) Fractal properties of settlement structures, paper presented at the First International Seminar on Structural Morphology, Montpellier, France, 7–11 September 1992.
- Frankhauser, P. (1994) *La Fractalité des Structures Urbaines*, Collection Villes, Anthropos, Paris, France.
- Frankhauser, P. and Sadler, G. (1991) Fractal analysis of agglomerations, *International Symposium des Sonderforschungsbereich 230: Naturliche Konstruktionen-Leichtbau in Architektur und Natur: Teil 2*, Universities of Stuttgart and Tübingen, West Germany.

- Gallion, A. B. and Eisner, S. (1950, 1975) *The Urban Pattern: City Planning and Design*, Van Nostrand Reinhold Company, New York.
- Garreau, J. (1991) *Edge City: Life on the New Frontier*, Doubleday, New York.
- Geddes, P. (1915, 1949) *Cities in Evolution*, Williams and Norgate, London.
- GLC (1985) *London: Facts and Figures*, Greater London Council Intelligence Unit, County Hall, London.
- Goodchild, M. F. (1980) Fractals and the accuracy of geographical measures, *Mathematical Geology*, **12**, 85–98.
- Goodchild, M. F. (1982) The fractional Brownian process as a terrain simulation model, *Modeling and Simulation*, **13**, 1133–1137.
- Goodchild, M. F. and Mark, D. M. (1987) The fractal nature of geographic phenomena, *Annals of the Association of American Geographers*, **77**, 265–278.
- Gottman, J. (1961) *Megalopolis: The Urbanized Northeastern Seaboard of the United States*, The Twentieth Century Fund, New York.
- Gould, S.J. (1966) Allometry and size in ontogeny and phylogeny, *Biological Review*, **41**, 587–640.
- Hagerstrand, T. (1952) The propagation of innovation waves, *Lund Studies in Geography: Series B: Human Geography*, **4**, 3–19.
- Hagerstrand, T. (1965) A Monte Carlo approach to diffusion, *European Journal of Sociology*, **6**, 43–67.
- Haggett, P., Cliff, A. D. and Frey, A. (1977) *Locational Analysis in Human Geography*, John Wiley and Sons, New York.
- Hall, P. (Editor) (1966) *Isolated State: An English Edition of Der Isolierte Staat*, by Johann Heinrich von Thunen, Pergamon Press, Oxford.
- Hall, P., Gracey, H., Drewett, R. and Thomas, R. (1973) *The Containment of Urban England*, Allen and Unwin, London.
- Hayashi, Y. and Isobe, T. (1985) Modelling the long term effects of transport policies on industrial location behaviour, paper presented at the International Conference on Transport Behaviour, 16–19 April, Noordwijk, The Netherlands.
- Hensher, D. A. and Johnson, L. W. (1981) *Applied Discrete-Choice Modelling*, Croom Helm, London.
- Hill, F. S. and Walker, S. E. (1982) On the use of fractals for efficient map generation, *Graphics Interface '82*, 17–21 May, Toronto, Ontario, pp. 283–289.
- Hillier, B. and Hanson, J. (1984) *The Social Logic of Space*, Cambridge University Press, Cambridge, UK.
- Howard, E. (1898, 1965) *To-Morrow: A Peaceful Path to Real Reform*, Swan Sonnenschein, London, republished (1965) *Garden Cities of To-Morrow*, The MIT Press, Cambridge, MA.
- Hutchinson, J. E. (1981) Fractals and self-similarity, *Indiana University Journal of Mathematics*, **30**, 713–747.
- Isard, W. (1956) *Location and Space-Economy*, The MIT Press, Cambridge, MA.
- Jacobs, J. (1961) *The Death and Life of Great American Cities*, Vintage Books, New York.
- Jenks, G. F. (1981) Lines, computers and human frailties, *Annals of the Association of American Geographers*, **71**, 1–10.
- Johnson, J. H. (1984) Hierarchical structure in design, in R. Langdon and P. Purcell (Editors) *Design Theory and Practice*, Design Council, London, pp. 51–59.
- Jones, A. R. (1975) Density-size rule, a further note, *Urban Studies*, **12**, 225–228.
- Jullien, R. and Botet, R. (1987) *Aggregation and Fractal Aggregates*, World Scientific Company, Singapore.
- Kadanoff, L. P. (1986) Fractals: where's the physics? *Physics Today*, **39**, 6–7.
- Kaproff, J. (1986) The geometry of coastlines: a study in fractals, in K. Hargittai (Editor) *Symmetry: Unifying Human Understanding*, Pergamon Press, Oxford, UK, pp. 655–671.
- Kaye, B. H. (1978) Specification of the ruggedness and/or texture of a fineparticle profile by its fractal dimension, *Powder Technology*, **21**, 1–16.

- Kaye, B. H. (1984) Multifractal description of a rugged fineparticle profile, *Particle Characterization*, **11**, 14–21.
- Kaye, B. H. (1989a) *A Random Walk Through Fractal Dimensions*, VCH Publishers, New York.
- Kaye, B. H. (1989b) Image analysis techniques for characterizing fractal structures, in D. Avnir (Editor), *The Fractal Approach to Heterogeneous Chemistry: Surfaces, Colloids, Polymers*, John Wiley and Sons, New York, pp. 55–66.
- Kaye, B. H. and Clark, G. G. (1985) Fractal description of extra terrestrial fineparticles, Department of Physics, Laurentian University, Sudbury, Ontario.
- Kaye, B. H., Leblanc, J. E. and Abbot, P. (1985) Fractal dimension of the structure of fresh and eroded aluminum shot fineparticles, *Particle Characterization*, **2**, 56–61.
- Keeble, L. (1959) *Principles and Practice of Town and Country Planning*, The Estates Gazette, London.
- Kent, C. and Wong, J. (1982) An index of littoral zone complexity and its measurement, *Canadian Journal of Fisheries and Aquatic Sciences*, **39**, 847–853.
- Kim, K. S. (1985) *Urban Form Measures and Their Application to the Seoul Metropolitan Area*, Sung Kyun Kwan University, Seoul, Korea (in Korean).
- Kondo, H., Matsushita, M. and Ohnishi, S. (1986) Diffusion-limited aggregation with a restriction of growth direction, in Y. Kato, R. Takaki and J. Toriwaki (Editors) *Science of Form*, KTK Scientific Publishers, Tokyo, pp. 33–38.
- Kostof, S. (1991) *The City Shaped: Urban Patterns and Meanings Throughout History*, Little, Brown and Company, Boston, MA.
- Lam, N. and Quattrochi, D. A. (1992) On issues of scale, resolution and fractal analysis in the mapping sciences, *The Professional Geographer*, **44**, 88–98.
- Lauwerier, H. (1991) *Fractals: Endlessly Repeated Geometrical Figures*, Princeton University Press, Princeton, NJ.
- Lerman, S. R. (1985) Random utility models of spatial choice, in B. G. Hutchinson, M. Batty and P. Nijkamp (Editors) *Optimization and Discrete Choice in Urban Systems*, Springer-Verlag, Berlin, pp. 200–217.
- Levy, S. (1992) *Artificial Life: The Quest for a New Creation*, Pantheon, New York.
- Lewin, R. (1992) *Complexity: Life at the Edge of Chaos*, Macmillan Publishing Company, New York.
- Longley, P. A. (1984) Comparing discrete choice models: some housing market examples, in D. E. Pitfield (Editor) *Discrete Choice Models in Regional Science*, Pion Press, London, pp. 163–180.
- Lovejoy, S. (1982) Area–perimeter relation for rain and cloud areas, *Science*, **216**, 185–187.
- Lovejoy, S., Schertzer, D. and Ladoy, P. (1986) Fractal characterization of inhomogeneous geophysical measuring networks, *Nature*, **319**, 43–44.
- MacDonald, N. (1983) *Trees and Networks in Biological Models*, John Wiley and Sons, Chichester, UK.
- Mandelbrot, B. B. (1967) How long is the coast of Britain? Statistical self-similarity and fractal dimension, *Science*, **155**, 636–638.
- Mandelbrot, B. B. (1975) Stochastic models for the earth's relief, the shape and fractal dimension of coastlines and the number-area rule for islands, *Proceedings of the National Academy of Sciences USA*, **72**, 3825–3828.
- Mandelbrot, B. B. (1982) Comment of computer rendering of fractal stochastic models, *Communications of the ACM*, **25**, 581–583.
- Mandelbrot, B. B. (1983) *The Fractal Geometry of Nature*, W. H. Freeman and Company, San Francisco, CA.
- Mandelbrot, B. B. (1984) On fractal geometry and a few of the mathematical questions it has raised, *Proceedings of the International Congress of Mathematicians*, 16–24 August, Warsaw, Poland, pp. 1661–1675.

- Mandelbrot, B. B. (1988) Appendix A: fractal landscapes without creases and with rivers, in H.-O. Peitgen and D. Saupe (Editors) *The Science of Fractal Images*, Springer-Verlag, New York, pp. 243–260.
- Mandelbrot, B. B. (1990) Fractals – a geometry of nature, *New Scientist*, **127**, 38–43.
- Mandelker, D. (1962) *Green Belts and Urban Growth*, University of Wisconsin Press, Madison, WI.
- March, L. (1971) Urban systems: a generalized distribution function, *London Papers in Regional Science*, **2**, 156–170.
- March, L. and Steadman, P. (1971) *The Geometry of Environment: An Introduction to Spatial Organization in Design*, RIBA Publications, London.
- March, L. and Stiny, G. (1985) Spatial systems in architecture and design: some history and logic, *Environment and Planning B*, **12**, 31–53.
- Mark, D. M. (1984) Fractal dimension of a coral reef at ecological scales: a discussion, *Marine Ecology Progress Series*, **14**, 293–294.
- Mark D. M. and Aronson, P. B. (1984) Scale-dependent fractal dimensions of topographic surfaces: an empirical investigation with applications in geomorphology and computer mapping, *Mathematical Geology*, **16**, 671–683.
- Mark, D.M. and Peucker, T.K. (1978) Regression analysis and geographic models, *Canadian Geographer*, **22**, 51–64.
- McFadden, D. (1979) Quantitative methods for analyzing travel behavior of individuals: some recent developments, in D. A. Hensher and P. R. Stopher (Editors) *Behavioural Travel Demand Modelling*, Croom Helm, London, pp. 279–318.
- McGuire, M. (1991) *An Eye For Fractals: A Graphic and Photographic Essay*, Addison-Wesley Publishing Company, New York.
- McMahon, T. A. (1975) The mechanical design of trees, *Scientific American*, **233**, 92–102.
- Meakin, P. (1983a) Diffusion-controlled cluster formation in two, three and four dimensions, *Physical Review A*, **27**, 604–607.
- Meakin, P. (1983b) Diffusion-controlled cluster formation in 2–6 dimensional space, *Physical Review A*, **27**, 1495–1507.
- Meakin, P. (1985) The structure of two-dimensional Witten–Sander aggregates, *Journal of Physics A*, **18**, L661–L666.
- Meakin, P. (1986a) Some recent advances in the simulation of diffusion-limited aggregation and related processes, in L. Pietronero and E. Tosatti (Editors) *Fractals in Physics*, North-Holland Publishing Company, Amsterdam, pp. 205–212.
- Meakin, P. (1986b) Computer simulation of growth and aggregation processes, in H. E. Stanley and N. Ostrowsky (Editors) *On Growth and Form: Fractal and Non-Fractal Patterns in Physics*, Martinus-Nijhoff Publishers, Dordrecht, pp. 111–135.
- Meakin, P. (1986c) Universality, non-universality and the effects of anisotropy on diffusion-limited aggregation, *Physical Review A*, **33**, 3371–3382.
- Meakin, P. (1986d) A new model for biological pattern formation, *Journal of Theoretical Biology*, **118**, 101–113.
- Meakin, P. and Tolman, S. (1989) Diffusion-limited aggregation: recent developments, in L. Pietronero (Editor) *Fractals' Physical Origins and Properties*, Plenum Press, New York, pp. 137–168.
- MHLG (Ministry of Housing and Local Government) (1955) *Green Belts*, Circular 42/55, HMSO, London.
- MHLG (Ministry of Housing and Local Government) (1957) *The Green Belts*, Circular 50/57, HMSO, London.
- Mills, E. S. (1970) Urban density functions, *Urban Studies*, **7**, 5–20.
- Mills, E. S. and Tan, J. P. (1980) A comparison of urban population density functions in developed and developing countries, *Urban Studies*, **17**, 313–321.
- Mogridge, M. J. H. (1984) Strategic population forecasting for a conurbation using

- the negative exponential density model, paper presented to the British Section of the Regional Science Association's Annual Meeting, September 1984, The Transport Studies Group, University College, London.
- Morris, A. E. J. (1979) *History of Urban Form: Before the Industrial Revolutions*, Longmans Scientific and Technical, London.
- Morse, D. R., Lawton, J. H., Dodson, M. M. and Williamson, M. H. (1985) Fractal dimension of vegetation and the distribution of arthropod body lengths, *Nature*, **314**, 731–733.
- Muller, J. C. (1986) Fractal dimension and inconsistencies in cartographic line representations, *The Cartographic Journal*, **23**, 123–130.
- Muller, J. C. (1987) Fractal and automated line generalisation, *The Cartographic Journal*, **24**, 27–34.
- Munton, R. (1983) *London's Green Belt: Containment in Practice*, Allen and Unwin, London.
- Musgrave, F. K., Kolb, C. E. and Mace, R. S. (1989) The synthesis and rendering of eroded fractal terrains, *Computer Graphics*, **23**, 41–50.
- Muth, R. (1969) *Cities and Housing: The Spatial Pattern of Urban Residential Land Use*, Chicago University Press, Chicago, IL.
- Muthukumar, M. (1983) Mean field theory for diffusion-limited cluster formation, *Physical Review Letters*, **50**, 839–842.
- Nakano, T. (1983) A 'fractal' study of some rias coastlines in Japan, *Annual Reports of the Institute of Geosciences, University of Tsukuba*, **9**, 75–80.
- Nakano, T. (1984) A systematics of 'transient fractals' of rias coastlines: an example of rias coast from Kamaishi to Shizugawa, North-Eastern Japan, *Annual Reports of the Institute of Geosciences, University of Tsukuba*, **10**, 66–68.
- Naroll, R. S. and Bertalanffy, L. von (1956) The principle of allometry in biology and the social sciences, *General Systems Yearbook*, **1**, 76–89.
- Nelson, T. R. and Manchester, D. K. (1988) Modeling of lung morphogenesis using fractal geometry, *IEEE Transactions on Medical Imaging*, **7**, 321–327.
- Newling, B. E. (1966) Urban growth and spatial structure: mathematical models and empirical evidence, *Geographical Review*, **56**, 213–225.
- Niemeyer, L., Pietronero, L. and Wiesmann, H. J. (1984) Fractal dimension of dielectric breakdown, *Physical Review Letters*, **52**, 1033–1036.
- Nittmann, J., Daccord, G. and Stanley, H. E. (1985) Fractal growth of viscous fingers: quantitative characterization of a fluid instability phenomenon, *Nature*, **314**, 141–144.
- Nittmann, J., Daccord, G. and Stanley, H. E. (1986) When viscous fingers are fractal, in L. Pietronero and E. Tosatti (Editors) *Fractals in Physics*, North-Holland Publishing Company, Amsterdam, pp. 193–202.
- Nittmann, J. and Stanley, H. E. (1986) Tip splitting without interfacial tension and dendritic growth patterns arising from molecular anisotropy, *Nature*, **321**, 663–668.
- Nordbeck, S. (1965) The law of allometric growth, *Discussion Paper No. 7*, Michigan Inter-University Community of Mathematical Geographers, University of Michigan, Ann Arbor, MI.
- Nordbeck, S. (1971) Urban allometric growth, *Geografiska Annaler*, **53B**, 54–67.
- Nystuen, J. (1966) Effects of boundary shape and the concept of local convexity, *Discussion Paper No. 10*, Michigan Inter-University Community of Mathematical Geographers, Department of Geography, University of Michigan, Ann Arbor, MI.
- OPCS (1984) *Key Statistics for Urban Areas*, Office of Population Census and Surveys, HMSO, London.
- Orbach, R. (1986) Dynamics of fractal networks, *Science*, **231**, 814–819.
- Orford, J. D. and Whalley, W. B. (1983) The use of the fractal dimension to quantify the morphology of irregular-shaped particles, *Sedimentology*, **30**, 655–668.

- Parr, J. B. (1985a) A population-density approach to regional spatial structure, *Urban Studies*, **22**, 289–303.
- Parr, J. B. (1985b) The form of the regional density function, *Regional Studies*, **19**, 535–546.
- Parr, J. B., O'Neill, G. J. and Baird, A. G. M. (1988) Metropolitan density functions: a further exploration, *Regional Science and Urban Economics*, **18**, 463–478.
- Parr, J. B. and O'Neill, G. J. (1989) Aspects of the lognormal function in the analysis of regional population distribution, *Environment and Planning A*, **21**, 961–973.
- Paterson, L. (1984) Diffusion-limited aggregation and two-fluid displacements in porous media, *Physical Review Letters*, **52**, 1621–1624.
- Peitgen, H.-O., Jürgens, H. and Saupe, D. (1990) The language of fractals, *Scientific American*, **263**, 40–47.
- Peitgen, H.-O., Jürgens, H. and Saupe, D. (1992) *Fractals for the Classroom: Part 1: Introduction to Fractals and Chaos*, Springer-Verlag, New York.
- Peitgen, H.-O. and Richter, P. H. (Editors) (1986) *The Beauty of Fractals: Images of Complex Dynamical Systems*, Springer-Verlag, New York.
- Penck, A. (1894) *Morphologie der Erdoberfläche*, Stuttgart, Germany, quoted in Perkal (1958a).
- Pentland, A. D. (1984) Fractal-based description of natural scenes, *IEEE Transactions of Pattern Analysis and Machine Intelligence*, **6**, 661–674.
- Perkal, J. (1958a) O Dlugosci Krzywych Empirycznych, *Zastosowania Matematyki*, **3**, 257–286; translated 1966 by W. Jackowski as 'On the length of empirical curves', in *Discussion Paper No. 10*, Michigan Inter-University Community of Mathematical Geographers, Ann Arbor, MI.
- Perkal, J. (1958b) Proba Obiektywnej Generalizacji, *Geodezja i Kartografia*, **7**, 130–142; translated 1966 by W. Jackowski as 'An attempt at objective generalization', in *Discussion Paper No. 10*, Michigan Inter-University Community of Mathematical Geographers, Ann Arbor, MI.
- Peucker, T. K. (1975) A theory of the cartographic line, *AutoCarto*, **2**, 508–518.
- Pietronero, L. (Editor) (1989) *Fractals' Physical Origin and Properties*, Plenum Press, New York.
- Pietronero, L., Evertsz, C. and Wiesmann, H. J. (1986) Scaling properties of growing zone and capacity of Laplacian fractals, in L. Pietronero and E. Tosatti (Editors) *Fractals in Physics*, North-Holland Publishing Company, Amsterdam, pp. 159–163.
- Porter, E. and Gleick, J. (1990) *Nature's Chaos*, Viking Penguin, New York.
- Prusinkiewicz, P. and Lindenmayer, A. (1990) *The Algorithmic Beauty of Plants*, Springer-Verlag, New York.
- Ravetz, A. (1980) *Remaking Cities*, Croom Helm, London.
- Reps, J. W. (1965) *The Making of Urban America: A History of City Planning in the United States*, Princeton University Press, Princeton, NJ.
- Richardson, L. F. (1961) The problem of contiguity: an appendix of 'Statistics of deadly quarrels', *General Systems Yearbook*, **6**, 139–187.
- Richter, P. H. and Peitgen, H. O. (1985) Morphology of complex boundaries, *Berichte der Bunsengesellschaft für Physikalische Chemie*, **89**, 571–588.
- Rickaby, P. (1987) An approach to the assessment of energy efficiency of urban built form, in D. Hawkes, J. Owers, P. Rickaby and P. Steadman (Editor) *Energy and Urban Built Form*, Butterworth, Sevenoaks, pp. 43–61.
- Rosenau, H. (1983) *The Ideal City: Its Architectural Evolution in Europe*, Routledge and Kegan Paul, London.
- Roy, J. R. (1983) Estimation of singly-constrained nested spatial interaction models, *Environment and Planning B*, **10**, 269–274.
- Ruelle, R. (1991) *Chance and Chaos*, Princeton University Press, Princeton, NJ.
- Saaty, T. L. (1980) *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, McGraw-Hill, New York.

- Sander, L. M. (1987) Fractal growth, *Scientific American*, **256**, 82–88.
- Satpathy, S. (1986) Dielectric breakdown in three dimensions, in L. Pietronero and E. Tosatti (Editors) *Fractals in Physics*, North-Holland Publishing Company, Amsterdam, pp. 173–176.
- Saupe, D. (1988) Algorithms for random fractals, in H.-O. Peitgen and D. Saupe (Editors) *The Science of Fractal Images*, Springer-Verlag, New York, pp. 71–136.
- Saupe, D. (1991) Random fractals in image synthesis, in A. J. Crilly, R. A. Earnshaw and H. Jones (Editors) *Fractals and Chaos*, Springer-Verlag, New York, pp. 89–118.
- Saviranta, J. (1973) Chorological matrices and gravity models in human geography, *Fennia*, **121**, 5–51.
- SERPLAN (Standing Conference on London and South East Regional Planning) (1976) *The Improvement of London's Green Belt*, SC620, HMSO, London.
- Shelberg, M. C., Moellering, H. and Lam, N. (1982) Measuring the fractal dimensions of empirical cartographic curves, *Auto Carto*, **5**, 481–490.
- Shepherd, J. and Congdon, P. (1990) *Small Town England: An Investigation into Population Change among Small and Medium-Sized Urban Areas*, Progress in Planning Series, Pergamon, Oxford.
- Sheppard, E. S. (1979) Geographic potentials, *Annals of the Association of American Geographers*, **69**, 438–447.
- Simon, H. A. (1969) *The Sciences of the Artificial*, The MIT Press, Cambridge, MA.
- Sitte, C. (1889, 1965) *City Planning, According to Artistic Principles*, Random House, New York.
- Smeed, R. J. (1961) The traffic problem in towns, *Manchester Statistical Society Papers*, Norbury Lockwood, Manchester.
- Smeed, R. J. (1963) Road development in urban areas, *Journal of the Institution of Highway Engineers*, **10**, 5–30.
- Smith, A. R. (1982) The genesis demo: instant evolution with computer graphics, *American Cinematographer*, **63**, 1038–1039 and 1048–1050.
- Smith, B. (1991) Morphological similarities: Taunton, England and Guatemala City, Guatemala, unpublished paper, Department of Geography, State University of New York, Buffalo, NY.
- Stanley, H. E. (1977) Cluster shapes at the percolation threshold: an effective cluster dimensionality and its connection with critical-point exponents, *Journal of Physics A*, **10**, L211–L219.
- Stanley, H. E. and Ostrowsky, N. (Editors) (1986) *On Growth and Form: Fractal and Non-Fractal Patterns in Physics*, Martinus-Nijhoff Publishers, Dordrecht.
- Steadman, P. (1979) *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts*, Cambridge University Press, Cambridge, UK.
- Steadman, P. (1983) *Architectural Morphology: An Introduction to the Geometry of Building Plans*, Pion Press, London.
- Steinhaus, H. (1954) Length, shape and area, *Colloquium Mathematicum*, **3**, 1–13.
- Steinhaus, H. (1960) *Mathematical Snapshots*, Oxford University Press, Oxford.
- Stevens, P. S. (1974) *Patterns in Nature*, Penguin Books, Harmondsworth.
- Stewart, J. Q. (1941) An inverse distance variation for certain social influences, *Science*, **93**, 89–90.
- Stewart, J. Q. (1947) Suggested principles of "Social Physics", *Science*, **106**, 179–180.
- Stewart, J. Q. (1950) The development of social physics, *American Journal of Physics*, **18**, 239–253.
- Stewart, J. Q. and Warntz, W. (1958) Physics of population distribution, *Journal of Regional Science*, **1**, 99–123.
- Suzuki, M. (1984) Finite size scaling for transient similarity and fractals, *Progress in Theoretical Physics*, **71**, 1397–1400.
- Takayasu, H. (1990) *Fractals in the Physical Sciences*, Manchester University Press, Manchester.

- Tanner, J. C. (1961) Factors affecting the amount of travel, *Road Research Laboratory Technical Paper No. 51*, HMSO (Department of Scientific and Industrial Research), London.
- Thibault, S. and Marchand, A. (1987) Reseaux et Topologie, Institut National Des Sciences Appliquees de Lyon, Villeurbanne, France.
- Thompson, D'A. W. (1917, 1961) *On Growth and Form*, Cambridge University Press, Cambridge, UK.
- Thomson, J. M. (1977) *Great Cities and Their Traffic*, Victor Gollancz, London.
- Tobler, W. (1979a) Smooth pycnophylactic interpolation for geographical regions, *Journal of the American Statistical Association*, **74**, 519–530.
- Tobler, W. R. (1979b) Cellular geography, in S. Gale and G. Olsson (Editors) *Philosophy in Geography*, D. Reidel, Dordrecht, pp. 279–386.
- Tobler, W. (1981) A model of geographical movement, *Geographical Analysis*, **13**, 1–20.
- Toffler, A. (1981) *The Third Wave*, Bantam Books, New York.
- Turcotte, D. L. (1992) *Fractals and Chaos in Geology and Geophysics*, Cambridge University Press, Cambridge, UK.
- Turkevitch, L. A. and Scher, H. (1985) Occupancy-probability scaling in diffusion-limited aggregation, *Physical Review Letters*, **55**, 1026–1029.
- Vance, J. E. (1990) *The Continuing City: Urban Morphology in Western Civilization*, The Johns Hopkins University Press, Baltimore, MD.
- Vaughan, R. (1987) *Urban Spatial Traffic Patterns*. Pion Press, London.
- Vicsek, T. (1989) *Fractal Growth Phenomena*, World Scientific Company, Singapore.
- Voss, R. F. (1984) Multi-particle fractal aggregation, *Journal of Statistical Physics*, **36**, 861–872.
- Voss, R. F. (1985) Random fractal forgeries, in R. A. Earnshaw (Editor) *Fundamental Algorithms for Computer Graphics*, Springer-Verlag, New York, pp. 805–835.
- Voss, R. F. (1988) Fractals in nature: from characterization to simulation, in H.-O. Peitgen and D. Saupe (Editors) *The Science of Fractal Images*, Springer-Verlag, New York, pp. 21–70.
- Waldrop, M. M. (1992) *Complexity: The Emerging Science at the Edge of Order and Chaos*, Simon and Schuster, New York.
- Weaver, W. (1967) *Science and Imagination: Selected Papers*, Basic Books, New York.
- Weiss, H. K. (1961) The distribution of urban population and an application to a servicing problem, *Operations Research*, **9**, 860–874.
- West, B. J. and Goldberger, A. L. (1987) Physiology in fractal dimensions, *American Scientist*, **75**, 354–365.
- Whyte, L. L. (1968) Introduction, in L. L. Whyte (Editor) *Aspects of Form*, Lund Humphries, London, pp. 1–7.
- Wiesmann, H. J. (1989) Realistic models of dielectric breakdown, in L. Pietronero (Editor) *Fractals' Physical Origins and Properties*, Plenum Press, New York, pp. 243–257.
- Williams, G. (1987) An introduction to relaxation methods, *Byte*, **12**, 111–123.
- Wilson, A. G. (1969) The use of analogies in geography, *Geographical Analysis*, **1**, 225–233.
- Wilson, A. G. (1970) *Entropy in Urban and Regional Modelling*, Pion Press, London.
- Witten, T. A. (1986) Scale-invariant diffusive growth, in H. E. Stanley and N. Ostrowsky (Editors) *On Growth and Form: Fractal and Non-Fractal Patterns in Physics*, Martinus-Nijhoff Publishers, Dordrecht, Holland, pp. 54–68.
- Witten, T. A. and Sander, L. M. (1981) Diffusion-limited aggregation: a kinetic critical phenomenon, *Physical Review Letters*, **47**, 1400–1403.
- Witten, T. A. and Sander, L. M. (1983) Diffusion-limited aggregation, *Physical Review B*, **27**, 5686–5697.
- Woldenberg, M. J. (1968) Hierarchical systems: cities, rivers, Alpine glaciers, bovine

- livers and trees, unpublished PhD thesis, Department of Geography, Columbia University, New York.
- Woldenberg, M. J. (1973) An allometric analysis of urban land use in the United States, *Ekistics*, **36**, 282–290.
- Woldenberg, M. J. and Berry, B. J. L. (1967) Rivers and central places: analogous systems? *Journal of Regional Science*, **7**, 129–139.
- Wong, D. W. S. and Fotheringham, A. S. (1990) Urban systems as examples of bounded chaos: exploring the relationship between fractal dimension, rank size and rural-to-urban migration, *Geografiska Annaler*, **72B**, 89–99.
- Woolley, B. (1988) In search of a postmodern maths, *The Guardian (London)*, Friday 10 June, p. 29.
- Woronow, A. (1981) Morphometric consistency with the Hausdorff–Besicovitch dimension, *Mathematical Geology*, **13**, 201–216.
- Wrigley, N. (1985) *Categorical Data Analysis for Geographers and Environmental Scientists*, Longmans Technical and Scientific, London.
- Wrigley, N. and Longley, P. A. (1984) Discrete choice modelling in urban analysis, in D. T. Herbert and R. J. Johnston (Editors) *Geography and the Urban Environment: Volume 6: Progress in Research and Applications*, John Wiley and Sons, Chichester, pp. 45–94.
- Wycherley, R. E. (1962) *How the Greeks Built Cities*, W. W. Norton and Company, New York.
- Zielinski, K. (1979) Experimental analysis of eleven models of population density, *Environment and Planning A*, **11**, 629–641.
- Zielinski, K. (1980) The modelling of urban population density: a survey, *Environment and Planning A*, **12**, 135–154.
- Zipf, G. K. (1949) *Human Behavior and the Principle of Least Effort*, Addison-Wesley Publishing Company, Cambridge, MA.

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