Geovisualizing Indicators of Sustainability:
Three New-Media Traverses from Global to Neighborhood Scales

J. Kevin Byrne
St. Mary's University of Minnesota
correspondence: 2155 Draper Avenue, Roseville, MN 55113 e: jkbyrn07@smumn.edu

1. GOAL

This is a study presented in five parts that describes why and how a research theme of sustainable development might be better portrayed via a current method of technology-enhanced geovisualization. Media assets were created that fit into a framework of sustainability indicators, geographic scale, and new media. An argument is tendered that these frames interact well as principal criteria to advance a key United Nations goal and dramatically deliver sustainability as scalable messages to more stakeholders and larger general audiences.

2. HISTORY AND BACKGROUND OF METHOD AND THEME

Geovisualization (aka "Geographic Visualization") is an interdisciplinary method conducted with tools and techniques that support geospatial data analysis through interactive visualization. (Wikipedia, 2008) The history of geographic visualization goes back 50 years to the publication of *Cosmic View* by Kees Boeke and continues to the present, see table 1 and figure 1. *Cosmic View's* subtitle was "The Universe in 40 Jumps." Some jumps were maps. It seeded a later, more famous presentation of the same concept in a film titled *Powers of Ten.*

TABLE 1: Highlights of Geovisualization's various anniversaries (2007).

anniv.	*event/s*
50th	*Cosmic View* by Kees Boeke published
45	Geographic Information Systems (GIS) arrives
41	*Harvard Computer Graphics and Spatial Analysis Lab* opens
38	ESRI incorporates
30	Film *Powers of Ten* by Charles and Ray Eames is released
16	World Wide Web is invented
15	*Green Map System* is published
14	Web browsers arrive
9	Google incorporates
6	Keyhole incorporates
3	Google buys Keyhole and launches *Google Earth*
2	*Google Maps* API is published

Ten years after *Cosmic View* was published geographers Chorley and Haggett fashioned a synoptic and innovative view of the relationship between the variables of "map scale" and "presentation complexity," table 2. Cells offer dozens of tangible map examples as phrases. Authors characterized the upper left as a zone of where maps emphasized "reality" in contrast to the lower right where maps communicate with more "abstraction." The matrix seemed very useful for years as "analog" cartography theory and research developed. That said, it does not fully accommodate "new media" so intrinsic to today's geovisualization efforts.

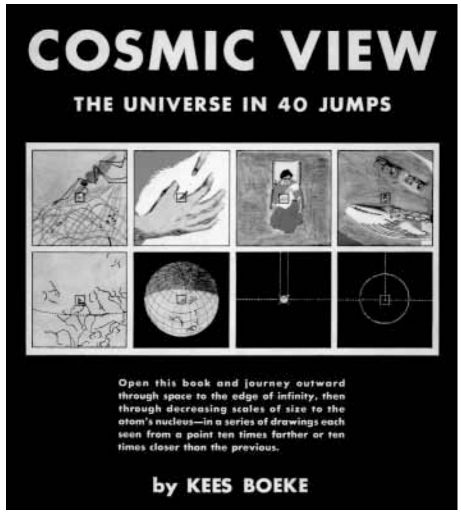


FIGURE 1: Boeke's innovative book from 1957 displays uniform scale change through maps and drawings.

TABLE 2: Analog map media (circa 1967).

Dimensional scale>	1:10 – 1:999	1:1,000 – 1:9,999	1:10,000 – 1:49,999	1:50,000 – 1:99,999	1:100,000 – 1:999,999	1:1 mil. and below
Complexity (high to low):	*model*	*plan*	*medium plot*	*large topo*	*small topo*	*atlas*
Photographic	Detailed plan of factory floor	Air photo of city streets for car or pedestrian count	Orthophotomap	Air photo annotated with geological info	---	Remote-sensed surfaces with places identified
Ordered	Plan of floor of doll's house	City street and building plan	Topographic map with details of rights of way	Topo map overprinted with soil series	Land use overprinted with int'l map	Topo map in atlas featuring places
Simplified	Layout of simple street for playground	Motorists' map of city center of one-way streets and parking	Street atlas of city with street names and landmarks only	Motorists' map of though routes in a conurbation	Hydrographic charts for sea navigation	General aeronautical chart
Topical	Track layout for model railway	3D model of land values in a city	Map of bus system in a city	Map of single railway system	Map of inter-connecting railway systems	Maps of air corridors for navigation

From Chorley, Richard J. and Peter Haggett, eds., *Models in Geography,* London: Methuen and Co., 1967. *Fig. 16.17, p. 705, simplified.*

Sustainable development as a phrase arrived rather quietly two decades ago under a mandate to help United Nations stakeholders think holistically about systems (environmental and intellectual capital must flow in circles) and ensure that they respect our childrens' future (do not "mortgage" our childrens' future). (Report of the World Commission, 1987) Described another way, sustainability "wraps economics, ecology, social and personal well-being together in one package. It ties the package up with system dynamics and mails the whole thing decades or even centuries into the future." (AtKisson, 1999) It could be argued that the history of sustainable development probably goes back 45 years to the publication of Rachel Carson's *Silent Spring* and continues to the present, see table 3.

TABLE 3: Highlights of Sustainable Development's various anniversaries (2007).

anniv.	*event/s*
45^{th}	Rachel Carson's *Silent Spring* published
40	Environmental Defense Fund launches its opposition to DDT
37	First Earth Day held, Joni Mitchell's *Big Yellow Taxi* released
35	U.S. Clean Water Act enacted
28	Three Mile Island nuclear accident occurs
25	United Nations World Charter published
22	Sinking of Rainbow Warrior in Auckland, New Zealand
20	U.N. "Brundtland" Report of the World Commission released
15	U.N. Earth Summit held in Rio, term *ecological footprint* coined
10	Kyoto Protocol signed
5	U.N. Sustainability Summit held in Johannesburg

When one types the phrase "sustainable development" into a web search browser today over 20 million hits are displayed. It is thus a central theme and concern of many people in many places. Sustainability theory, together with geovisualization methods, became compelling centerpieces to this study.

3. METHOD AND THEME JOINING WITHIN AN INDICATORS FRAMEWORK

A systematic and useful method for studying sustainable development is *indicator development and analysis*. Indicators are bits of information that reflect the status of complex systems and make conditions visible so we can track through to better decisions. Three popular indicators used today to study sustainable development are *water footprints, ecological footprints,* and *curbside recycling*. Their popularity and relevance today might also be judged by results as each phrase was entered into a search engine, see table 4, first row. In general table 4 serves as a conspectus at the core of this study. It functions as a matrix of indicators broken out by attributes, with two key variables shown as boldface rows. Footprint indicators that I used are described in the words of their respective inventors…

> The water footprint of a country is…the volume of water needed for the production of the goods and services consumed by the inhabitants of the country…Factors determining the water footprint of a country are: volume of consumption, consumption pattern, climate, and agricultural practice. (Hoekstra and Chapagain, 2004). An ecological footprint is the 'area of productive land and water ecosystems require to produce resources that a population consumes and to assimilate the wastes that population produces, wherever on Earth that land and water may be located.' (McDonald and Paterson, 2003; Wakernagel, 2001) Recycling researchers have developed a meta-indicator known as the REAP index. 'The REAP (recycling education, awareness, and participation) index is a one-figure summary statistic that is applied to [a community district] indicating the relative priority for developing strategies to increase recycling awareness and participation.' (Clarke and Maantay, 2005)

TABLE 4: Research Conspectus.

Footprint indicators > *Attributes…*	**Water**	**Ecological**	**Curbside recycling**
Number of Google hits on the phrase (2008)	560,000 hits	540,000 hits	386,000 hits
Unit of measurement	In cubic meters, per capita per year	In acres, per capita per year	As mobile bins count, per household per month
Scale	**Global**	**National-regional**	**Neighborhood**
Locations	12 countries sampled from North America, Europe, Asia, and Africa	New Zealand and its regions	One neighborhood in the Twin Cities (USA)
Media assets created for this study	**Google Earth Pro Movie (proprietary software used to create movie file then playable via non-proprietary software)**	**Google Earth KMZ file (digital file is created viewable in non-proprietary software)**	**ESRI ArcMap file (static digital file is created using proprietary software and is exportable for non-proprietary software viewing)**
Figures shown in this paper	Figure 4	Figure 3	Figure 2
Academic references	Hoekstra and Chapagain, 2004	Wakernagel, 2001; McDonald and Paterson, 2003	Clarke and Maantay, 2005

Google Earth is one of many dynamic new-media software tools that permits one to drape features and data atop a "virtual globe". (Nuernberger, 2006) It was released in 2003 by Google (table 1). Its globe can be navigated as if the user is in an aircraft. Digital features are point, line, shape, or numerical data that reside within layers and/or overlays. Such layers and overlays can be toggled on or off , offering a viewer control of levels of complexity as connoted in table 2. Animation is possible using a "tour" menu selection. Using Google Earth "Pro", tours can be captured as movies, then stored, exchanged, and played back.

A long-lived, proprietary tool for geovisualization on the ArcGIS platform is *ArcMap;* it is sold and maintained by ESRI, a GIS software powerhouse that incorporated in 1969 (see table 1). Files created in ESRI's ArcMap are intrinsically static but can be imported into other non-proprietary "virtual globe" software to enable dynamic display.

4. A "REMATRIXING" OBJECTIVE: ACCOMMODATING NEW MEDIA COMPLEXITY

An effort to bring table 2 into the new millennium of virtual geovisualization was undertaken and is shown in table 5 in model form. New-media maps at three scales were created by this author with the objective being to illustrate some new ways of helping research communities and academic audiences understand today's mainstream sustainability indicators. See table 5, "media assets" row, fig. 2-4. I simplified table 2's upper row labels and replaced old "presentation complexity" subcriteria with "digital media" subcriteria pertaining to layers and overlays. ESRI and Google Earth software today is dominated by the interactive toggling of these levels such that users are permitted to vary complexity according to their cognitive skills and instructional/research objectives.

TABLE 5: Rematrixing of table 2 using scale aside *media complexity* (*i.e.,* toggling of layers or overlays on or off); three media examples created for this study are labeled within cells.

Dimensional scale> **Media complexity** (toggle status):	**1:10 – 1:999 very large >**	**1:1,000 – 1:9,999**	**1:10,000 – 1:49,999**	**1:50,000 – 1:99,999**	**1:100,000 – 1:999,999**	**1:1 million and smaller < very small**
Minimal digital layers or overlays are turned on						
Some layers or overlays are on		curbside recycling see fig. 2.		ecofootprints see fig. 3.	ecofootprints	ecofootprints
Many layers or overlays on					water footprints see fig. 4.	water footprints

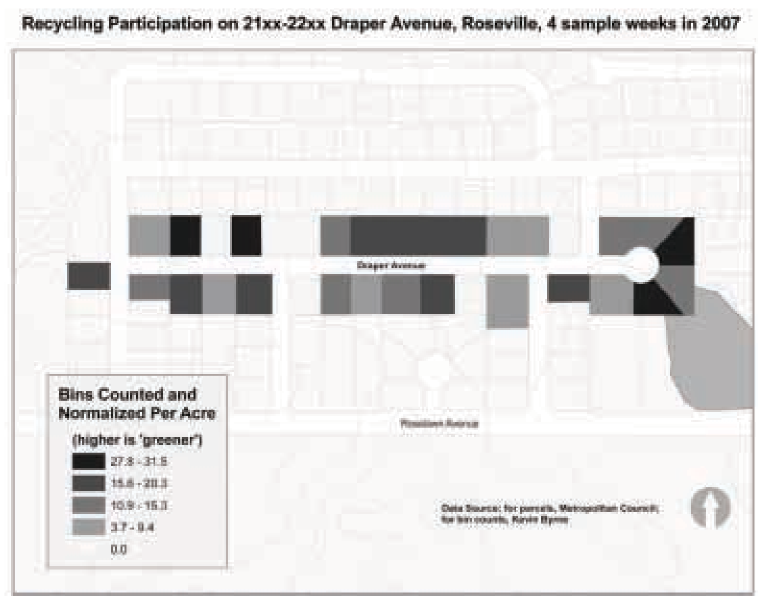


FIGURE 2: Curbside recycling rates in a Twin Cities neighborhood, large scale, 2007. Clarke and Maantay proposed in 2005 that a measure of "square footage per person" be used to normalize REAP. I pursued a much simpler indicator but did normalize bins count per acre per household to achieve a kind of "recycling footprint." *(Software: ESRI ArcMap v9.2.)*

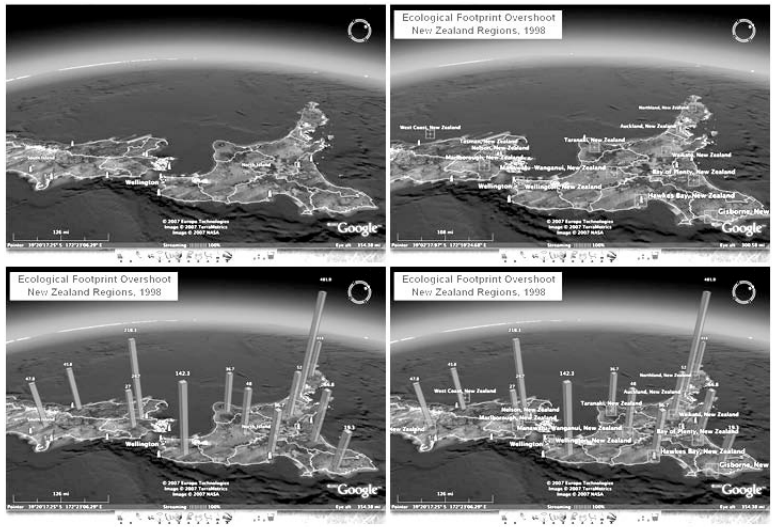


FIGURE 3: Four screen shots of Google Earth frames from a KMZ “digital tour” of New Zealand. Ecological footprint “overshoots” were calculated in acres for each of New Zealand regions, 1998. Scale is medium. Layers and overlays are varied by toggling them on and off. Data is intentionally *not* normalized in order to dramatize the role densely-populated Aukland plays in Kiwi “eco-overshoot.” (Software: *GEGraph 2.2.1, Google Earth v4.)*

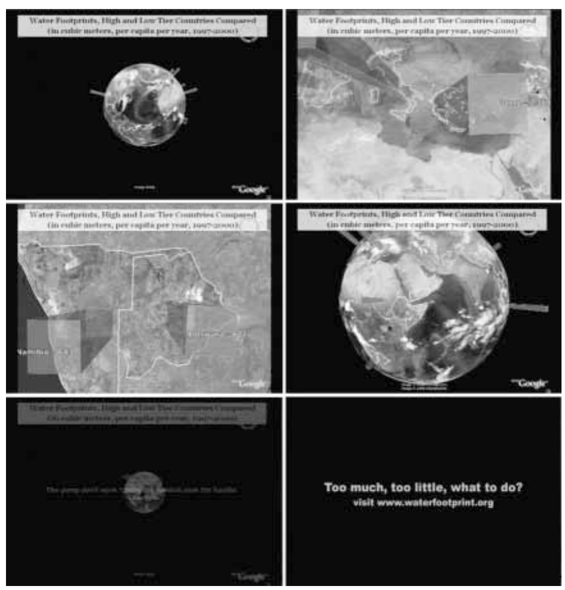
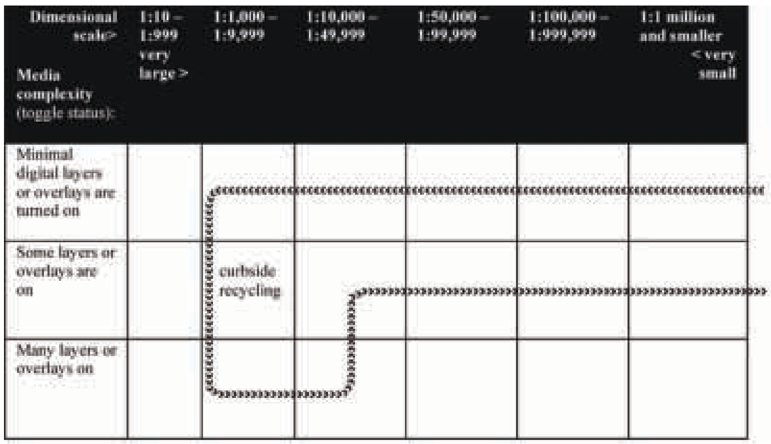


FIGURE 4: Six screen shots of Google Earth frames from a global tour displaying 12 nations’ water footprints, 1997-2000. Scale varies from small to medium. Playback format is Quicktime or AVI. Movie duration is 50 seconds. Frame 5 features a transition between a tour frame and some text matter. A quote and credits frame were added to the end to simulate a public-service-style announcement. (Software: *GEGraph 2.2.1, Google Earth Pro v4, iMovie HD v6.03.)*

5. REFLECTION AND PROSPECT

Geographic scale and new media combine well as symbiotic criteria for advancing the U.N.'s goal of sustainable development. Google Earth and other media are very flexible and "mashable"; they thus can act as dramatic and scalable channels that help reach larger and larger audiences. Some arguments for the future promise and challenges afforded by new media geovisualization are both lofty and trenchant. This excerpt is from Google Earth's own guru: "Our mission is to organize the world's information. It turns out that some of that information is hard to understand on a Web page, but it's easy to understand on a map. World travelers…have a broader view on the world than people who stay home. With Google Earth, we have a chance to let the world in on the secret." (Jones, 2007) Other members of the various research and technology communities offer a mix of different constellations, arguments, or media pathways. (Neurenberger, 2006; Henderson at al., 2006; Brown, 2006)



Dimensional scale> Media complexity (toggle status):	1:10 – 1:999 very large >	1:1,000 – 1:9,999	1:10,000 – 1:49,999	1:50,000 – 1:99,999	1:100,000 – 1:999,999	1:1 million and smaller < very small
Minimal digital layers or overlays are turned on						
Some layers or overlays are on		curbside recycling				
Many layers or overlays on						

FIGURE 5: Turning table 5 into a "storyboard traverse" – the now-static *curbside recycling map* from figure 2 can become an animated tour that changes by both scale and complexity.

Having started this study with new media exemplification from "top-down," *i.e.,* at a global scale (figure 4), I close this paper with the prospect that stakeholders for sustainable development benefit most fully by engaging geovisualizing indicators across all scales (figures 2-4). Figure 5 thus models how the static map data of fig. 2 might be "storyboarded," i.e. planned for eventual import into Google Earth then animated across scale and layers. The effect would appear to start as a zoom-in from outer space (dotted-arrows coming in from upper right) that flies a viewer down to street level, with details then being enhanced during block-data fly-by (center left); lastly, some layers are toggled off and it the animation is concluded by a zoom-back to planetary scale (dotted-arrows exit at middle right).

I have a one year plan to extend new media examples reported here so that they can traverse across more columns and rows of Table 5. Participation of college students will be invited; we will post digital results to YouTube. TeacherTube, or blogs for feedback. Please stay tuned:

"If we encourage the majority of [residents] to start saving their neighbourhoods we probably will end up saving the planet."

– Peter Neilson, Executive Officer, New Zealand's Business Council for Sustainable Development

REFERENCES

AtKisson, Alan. 1999. *Believing Cassandra: an Optimist Looks at a Pessimist's World*. White River Junction, VT: Chelsea Green.

Boeke, Kees. 1957. *Cosmic View: The Universe in 40 Jumps*. New York, NY: John Day.

Brown, Martin. 2006. *Hacking GoogleMaps and GoogleEarth*. New York, NY: ExtremeTech.

Clarke, Marjorie and Juliana Maantay. 2005. Optimizing recycling in all of New York City's neighborhoods: Using GIS to develop the REAP index for improved recycling education, awareness, and participation. *Resources Conservation Recycling* 46(2): 128-148.

Henderson, Colin and Selena Patton, Reporters, Plenary presentation titled "New Technologies – Disruptive or Enabling?" at the *Cambridge Conference,* July 17, 2007. www.cambridgeconference.com/2007_conference_information/Conference%20proceedings/rp3_jones.pdf *Last accessed May 19, 2008.*

Hoekstra, Arjen, and Ashok Chapagain. 2004. *Water Footprints of Nations, Volume 1: Main Report.* Delft, Netherlands: UNESCO-IHE.

Jones, Michael. "Our Geospatial Future." Plenary presentation at the *Cambridge Conference,* July 17, 2007. http://www.cambridgeconference.com/2007_conference_information/Podcasts/ *Last accessed May 19, 2008.*

McDonald, Garry and Murray Paterson. 2003. *Ecological Footprints of New Zealand and Its Regions.* Wellington, NZ: Ministry for the Environment.

Nuernberger, Andrea, "Virtual Globes in the Classroom." 2006. Santa Barbara, CA: UCSB SPACE. http://csiss.org/SPACE/resources/virtual-globes.php#GISdata *Last accessed May 19, 2008.*

"Report of the World Commission on Environment and Development: Our Common Future." 1987. United Nations Documents Cooperation Circles. http://habitat.igc.org/open-gates/wced-ocf.htm *Last accessed May 19, 2008.*

Wackernagel, Mathis. "Advancing Sustainable Resource Management: Using Ecological Footprint Analysis for Problem Formulation, Policy Development, and Communication." February 21, 2001, Oakland, CA: Redefining Progress.

Wikipedia: "Geovisualization." http://en.wikipedia.org/wiki/Geovisualization *Last accessed May 19, 2008*