CLOSE UP AT A DISTANCE

CLOSE UP AT A DISTANCE

MAPPING, TECHNOLOGY, AND POLITICS

Laura Kurgan

ZONE BOOKS • NEW YORK • 2013

001-232 80423 3 12-12-04 2:42 PM

© 2013 Laura Kurgan
ZONE BOOKS
1226 Prospect Avenue
Brooklyn, NY 11218

All rights reserved.

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, including electronic, mechanical, photocopying, microfilming, recording, or otherwise (except for that copying permitted by Sections 107 and 108 of the U.S. Copyright Law and except by reviewers for the public press), without written permission from the Publisher.

Printed in Canada.

Distributed by The MIT Press,
Cambridge, Massachusetts, and London, England

Library of Congress Cataloging-in-Publication Data

Kurgan, Laura.
Close up at a distance : mapping, technology, and politics / Laura Kurgan.
p. cm.
ISBN 978-1-935408-28-4 (alk. paper)
1. Satellite image maps. 2. Remote-sensing images—Political aspects. 3. Global positioning system—Social aspects. 4. Aerial photography. I. Title.

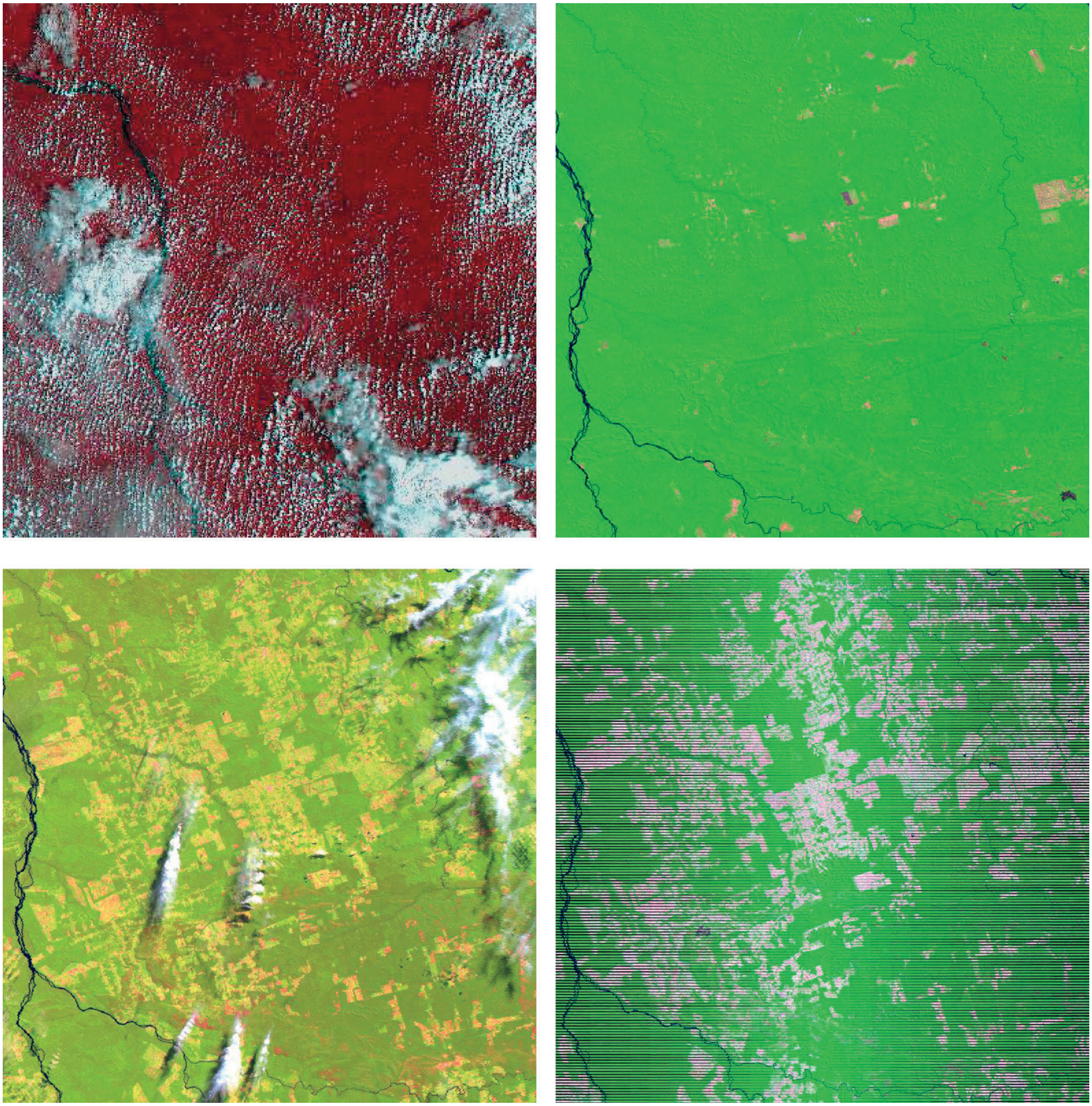
G70.4.K87 2013
526—dc23

2012040173

Contents

001-232 80423 5 12-12-04 2:42 PM

LEXICON



Landsat's forty-year archive gives researchers the ability to investigate changes at the same location over time. These images, acquired by Landsat 1, 4, 5, and 7, show an area near Nova Monte Verde, a municipality in the Brazilian state of Mato Grosso, just south of the Amazon, where rain forest is being replaced by ranching and monocropping. Top left: November 30, 1972; top right: August 5, 1986; bottom left: May 5, 2006; bottom right: August 4, 2012. The striping in the last image is due to failure of Landsat 7's scan line corrector.

From Military Surveillance to the Public Sphere

The discussions of the projects in this book refer to a number of technologies used in the process of mapping—GPS, remote-sensing satellites, and GIS. The projects make use of them in order to create new images or repurpose existing ones. But the history and politics of these technologies are at once obscure and important for understanding what's at stake in working with them. The following lexicon attempts to sketch the stories of the development of these technologies, their technical language, and their political and historical contexts. This chapter, which largely eschews explicit theoretical reflection, is designed both to document the increasing public access to these technologies and to lay the groundwork for the discussions of how they have been put to use in the chapters that follow. The list is not a complete one, but touches on most of the technologies with which I have engaged.

GLOBAL POSITIONING SYSTEM (GPS)

The GPS is a network of twenty-four satellites and five ground stations designed to provide to anyone carrying a portable receiver a highly specific determination of his or her location, anywhere, anytime, and in any weather.[1] The satellites, launched and operated by the U.S. military, are arranged in six circular orbits at an altitude of 11,000 miles, which makes it possible for at least four of them to be "seen" at one time by a receiver anywhere on Earth, and they constantly emit signals specifying their time and their own positions. A GPS receiver measures the time that the different signals take to reach it, and by comparing that with what it learns about where the satellite is, the receiver can calculate its own position. GPS location and time signals are freely available to anyone with a GPS receiver, including those embedded in other devices, such as mobile phones and cameras.

001-232 80423 39 12-12-04 2:43 PM

The research and launch period for the Global Positioning System began in 1973 and ended in 1991, when the program became operational just in time for the first Gulf War. The first experimental satellite was launched in 1978, the first satellite in the system was launched in 1989, and the full constellation of twenty-four satellites, also known as NAVSTAR by the Department of Defense, was completed in 1993.[2] GPS is now not only a household word, but a ubiquitous technology—what the official GPS website calls a "U.S.-owned utility"—used for everything from directing missiles to their target, to tracking elephants, to locating mobile phones and their users, to everyday navigating on land and sea, to hiking in the mountains, to recording the precise time of a financial transaction, to playing urban games using geotagging devices, and beyond.

Originally designed to provide accurate measurements of positions to within 100 meters, GPS is now capable of locating a position within 5 meters of accuracy. Not everyone, however, has always been permitted to make use of this degree of accuracy. When the system was launched by the U.S. military, it was designated a "dual-use technology," which meant that its features were also available for civilian use—but in an intentionally downgraded way. Originally it was governed by a policy known as "Selective Availability," which intentionally scrambled the highly accurate signals so as to reduce accuracy readings to 100 meters for civilian users. It was possible for civilians to improve the accuracy using a technique called "differential correction," which involved gathering additional readings from base stations at known locations within roughly three hundred miles (the area covered by one group of four satellites) and correcting the errors by measuring against the location of the base stations. This allowed, even in the early days of the system, position readings between 2 and 5 meters of accuracy.

Over time, the accuracy and availability of the GPS system has been affected less by the limitations or capacities of the technology than by a series of U.S. government policy decisions.[4] The first was the decision to activate the system in a two-tier manner, with different quality readings available to military and civilian users.

Only five years later, in 1996, President Clinton committed the United States to the continued maintenance and upgrade of the system and announced that it was his "intention to discontinue the use of GPS Selective Availability (SA) within a decade, in a manner that allows adequate time and resources for our military forces to prepare fully for operations without SA."[5] In May 2000, the SA program was abandoned, and fully accurate GPS readings are now publicly and freely available.

Today, according to the U.S. government's online GPS information page:

001-232 80423 40 12-12-04 2:43 PM

> The GPS signal in space will provide a "worst case" pseudorange accuracy of 7.8 meters at a 95% confidence level. The actual accuracy users attain depends on factors outside the government's control, including atmospheric effects and receiver quality. Real-world data collected by the FAA show that some high-quality GPS SPS receivers currently provide better than 3 meter horizontal accuracy. [FAA data from early 2011 shows GPS SPS was often accurate to ~1 meter.] Higher accuracy is available today by using GPS in combination with augmentation systems. These enable real-time positioning to within a few centimeters, and post-mission measurements at the millimeter level.... The accuracy of the GPS signal in space is actually the same for both the civilian GPS service (SPS) and the military GPS service (PPS). However, SPS broadcasts on only one frequency, while PPS uses two. This means military users can perform *ionospheric correction*, a technique that reduces radio degradation caused by the Earth's atmosphere. With less degradation, PPS provides better accuracy than the basic SPS. Many users enhance the basic SPS with local or regional augmentations. Such systems boost civilian GPS accuracy beyond that of PPS.[3]

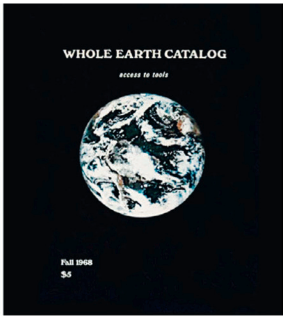
In 2004, President Bush created the National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) and adopted a new national policy committed to modernization, sustainability, and maintenance of GPS as a free worldwide utility.

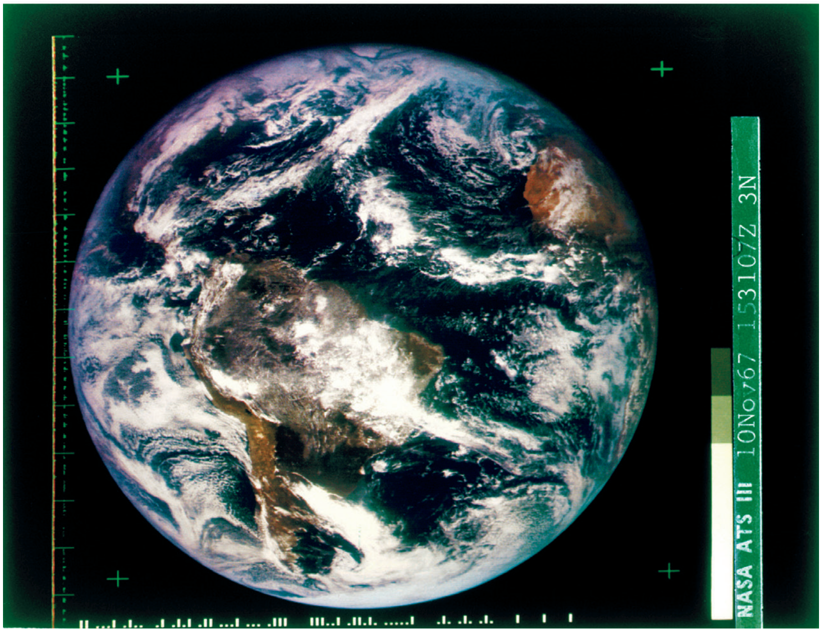
> Over the past decade, the Global Positioning System has grown into a global utility whose multi-use services are integral to U.S. national security, economic growth, transportation safety, and homeland security, and are an essential element of the worldwide economic infrastructure. In the year 2000, the United States recognized the increasing importance of the Global Positioning System to civil and commercial users by discontinuing the deliberate degradation of accuracy for non-military signals, known as Selective Availability.[6]

The policy acknowledges the development of European-based PNT systems and supports standards of interoperability and compatibility so that they might rely on each other's infrastructure. The policy also endorses a more accurate version of the system for military use, but without SA. In 2010, President Obama reaffirmed these policies.

Other nations have begun putting their own PNT systems into place. In Russia, the system is called GLONASS and has been in operation since 1995. Galileo is a system being developed by the European Union and other partner countries and is planned to be operational by 2014. There are other regional systems being planned by China, India, and Japan.

001-232 80423 41 12-12-04 2:43 PM





In 1966, Stewart Brand printed and sold buttons which asked the question, "Why haven't we seen a photograph of the whole Earth yet?" As his colleague Robert Horvitz wrote later, "Stewart wanted NASA to release a photo of the whole Earth because he believed it would have significant psychological impact: it would be visual proof of our unity and specialness, as our luminous blue ball-of-a-home contrasted dramatically with the dead black emptiness of space. Differences in skin color, religion, nationality and wealth, which can seem so important down here on Earth, shrink to nothing when viewed from afar." No spy satellite images were declassified. But a year later, NASA and a team of weather scientists at the universities of Wisconsin and Chicago released a film made of images taken by the newly launched ATS-III satellite in November 1967, titled "The First Color Movie of the Planet Earth: Viewed from 22,300 Miles over Brazil." And in the fall of 1968, the first issue of Brand's *Whole Earth Catalog* told readers how to buy a 16mm print of the film, and featured another image, also from the ATS-III spin-scan camera, taken over Brazil on November 10, 1967, on its cover. SATELLITE IMAGE: NASA

REMOTE-SENSING SATELLITES

The *Oxford English Dictionary* defines "remote sensing" as the sensing "of something not immediately adjacent to the sensor; *spec*. the automatic acquisition of information about the surface of the earth or another planet from a distance, as carried out from satellites and high-flying aircraft." Remote sensing implies the collection of knowledge from an array of distances and methods, from human sight and sound to seeing and hearing from hundreds of miles in the sky or deep down in the ocean from the water's surface. What follows, however, focuses only on remote-sensing satellites and the technologies that allow us to see very closely from a distance.

Remote-sensing satellites have been launched since the 1960s, generally to an altitude of between 400 and 900 kilometers (249 and 559 miles) above the Earth, first by the United States and the Soviet Union (later Russia) and then by other states, including France, Israel, and India.[7] Remotely sensed images are generated either by the telescopic lenses of cameras or by sensors on the satellites. Older satellites captured what they sensed as analog images on physical storage surfaces, such as film, while later satellites have transmitted their data as digital information that is converted to images by ground stations. With either method, what remote-sensing satellites sense and record is reflected radiation: the ordinary visible light spectrum that allows us to see colors, and, since the 1970s, the nonvisible infrared spectrum that allows, for example, for types of vegetation to be differentiated from each other by more than color.

This is all that each remote sensing satellite has in common. What follows outlines a series of satellites used for remote sensing from 1960 until 2010. It is by no means a complete list, but can serve as an introduction to the satellites used here. The orbiting platforms range from spy satellites launched by the U.S. military and intelligence agencies (for instance, Corona), to those launched with public funds to monitor the Earth's resources (Landsat and SPOT), to privately launched satellites that today make very high-resolution imagery publicly available (for instance, Ikonos and GeoEye). This sequence tells the story of the technopolitical transformation of access to remote-sensing imagery, a progression in both access and resolution that today makes very detailed images of the Earth from outer spac;e almost commonplace. The history is one of a tension between secrets and spying, on the one hand, and access and commerce, on the other, finally enabling nonprofessionals and civilians to make use of these powerful information resources.[8]

In my work, the satellites I have made use of are mostly those launched by the United States and operated by a combination of private corporations and U.S. government agencies. This is not an accident. Aside from the French SPOT

001-232 80423 43 12-12-04 2:44 PM

satellites, launched in 1986, the United States has always had the highest-resolution imagery available and has maintained a set of policies designed to guarantee its global dominance in the field of satellite imagery.[9] This may change in the future. As with GPS satellites, other countries have launched high-resolution Earth-imaging satellites, including India, China, Japan, and Israel, and this list will expand to include Turkey, South Africa, and the Gulf Cooperation Council in the next decade.[10]

CORONA (UNITED STATES, 1959–1972)

Begun under the Eisenhower administration in reaction to the Soviet Union's Sputnik project, the Corona program focused primarily on photographing the Soviet Union and the People's Republic of China. The series of six classified satellites—dubbed KH-1 through KH-4B in a series of secret documents titled *Talent Keyhole*—produced high-resolution images for intelligence, reconnaissance, and mapping purposes. Today, Corona negatives and accompanying documents are available in the public sphere, prominently featuring the crossed-out words "TOP SECRET."

Over time, the ground resolution of Corona imagery improved from 40 feet to 5 feet.[11] Individual Corona images are film negatives, each recording 10 miles by 120 miles of ground space. The imagery was exposed on a newly designed physical polyester film, now known as Mylar. It was collected onboard the satellite in rolls and ejected or "de-orbited" in canisters inside a capsule with small parachutes, to be picked up in midair by aircraft at a location near Hawaii. "The capsules were designed to float, so that if the plane missed, Navy boats could retrieve them. In case the boats missed, the capsules were fitted with salt plugs that would dissolve after two days in the ocean, causing the capsule to sink beneath the waves, so the film could never fall into enemy hands."[12]

Rather than orbiting the earth for long periods of time, Corona satellites were "tasked" on missions to specific sites and territories. Corona was alternately used to spy on and to map certain locations. On its first successful one-day mission, August 18, 1960, KH-1 orbited the Earth only three times, taking pictures of 1.65 million square miles of the Soviet Union and Eastern Bloc countries on three thousand feet of film. Later missions lasted up to nineteen days, and the KH-4 satellites were equipped with two cameras—for both intelligence and mapping purposes. The last imagery was acquired by the KH-4B satellite on May 31, 1972. According to historian Keith Clarke, "The systems worked so well that in short order the CIA was using Corona to map the world, remap the U.S., and to evaluate all 1:24,000 topographic maps for revision."[13]

The archive of over eight hundred thousand Corona images—2.1 million feet

001-232 80423 44 12-12-04 2:44 PM

of film in thirty-nine thousand canisters[14]—was declassified on February 22, 1995 with President Clinton's Executive Order 12951. The archive became available to the public three months later.[15]

LANDSAT (UNITED STATES, 1972–)

Appearing concurrently with the nascent environmental movement of the 1970s and dubbed the ERTS-1 (Earth Resources Technology Satellite), Landsat names a series of seven satellites launched by the National Aeronautics and Space Administration (NASA). The first was launched in July 1972. Together, they comprise the first publicly accessible remote-sensing program. Of these seven satellites, only Landsat 5 and Landsat 7 are currently functioning. A further satellite, known as the Landsat Data Continuity Mission, is scheduled for launch in 2013.[16]

Over time, ground resolution of the Landsat images has increased from 80 meters to 15 meters, which is officially described as "moderate." Each Landsat scene measures 170 by 185 kilometers (106 by 115 miles) of ground space. At its highest resolution, Landsat can picture large buildings and airstrips. According to a NASA presentation on Landsat, "this is an important spatial resolution because it is coarse enough for global coverage, yet detailed enough to characterize human-scale processes such as urban growth."[17] Landsat satellites orbit the Earth on predictable paths. The same coordinates are imaged at nearly the same time of day, every fourteen to eighteen days.

Because Landsat imagery is inexpensive and readily available, it is used frequently by researchers to investigate and highlight large-scale patterns related to climate change, natural resource management, land development, or disaster recovery. However, Landsat was not always so accessible. In the early 1980s, the program was privatized, and the National Oceanic and Atmospheric Administration (NOAA) selected the Earth Observation Satellite Company (EOSAT), later known as Space Imaging, to archive, collect, and distribute Landsat data as well as to build, launch, and operate the next two Landsat satellites (with government subsidies). As NASA tells the story today, "commercialization proved troublesome, with NOAA and EOSAT raising the cost of images by 600%, effectively "pric[ing] out many data users." Faced with competition from the newly launched French SPOT satellite and with coverage collapsing because EOSAT acquired imagery only when there were customers to buy it, Landsat images nearly disappeared by the end of the decade. "By 1989," reports the NASA Landsat history, the program was in such shambles that "NOAA directed EOSAT to turn off the satellites (no government agency was willing to commit augmentation funding for continued satellite operations, and data users were unwilling to make the hefty investments in computer processing hardware if future data collection was uncertain)."[18]

001-232 80423 45 12-12-04 2:44 PM

Over the course of the 1990s, control of Landsat's satellites and its imagery output was gradually returned to the U.S. government.[19] The pivotal role of Landsat imagery in the planning and implementation of the Gulf War,coupled with competition from the newer and cheaper SPOT, led to the Land Remote Sensing Policy Act, signed into law by President Clinton on October 28, 1992. It bolstered the Landsat program, stating that "continuous collection and utilization of land remote sensing data from space are of major benefit in studying and understanding human impacts on the global environment, in managing the Earth's resources, in carrying out national security functions, and in planning and conducting many other activities of scientific, economic and social importance."[20] The latest satellite, Landsat 7, was launched in 1999, and on July 1, 2001, operational control of the entire system and its archive was officially returned to the federal government, with EOSAT/Space Imaging giving up their commercial right to Landsat data. The program appears to be set to continue with the Landsat Data Continuity Program. Landsat images can be obtained from http://landsat.gsfc.nasa.gov.

SPOT (FRANCE, 1986–)

SPOT, an acronym for Système Probatoire d'Observation de la Terre, is a series of five satellites launched between 1986 and 2002 by the French national space agency, the Centre National d'Études Spatiales (CNES), in collaboration with Swedish and Belgian scientific agencies. At the time of its initial launch, SPOT 1 posed a serious challenge to the U.S. and Soviet monopoly on satellite imagery by offering 20-meter and 10-meter spatial resolution, significantly better than Landsat. Of the five satellites, SPOT 4 and SPOT 5 are currently functioning, and Astrium GEO Information Services (the private owners of the system) planned to launch two new satellites in 2012 and 2013 (SPOT 6 and 7) with ground resolution as high as 1.5 meters, as well as a successor pair of satellites called Pléiades, offering half-meter resolution (the first was launched in September 2012).[21]

Over time, SPOT image data has improved from 20 meters to 2.5 meters ground resolution at an altitude of 832 kilometers (517 miles). This resolution is able to capture small buildings, but not their details. SPOT orbits around the polar axis, capable of returning to the same place on Earth every twenty-six days.

In June 2010, the company announced a data-purchase agreement with the U.S. government allowing access to all image data collected by SPOT 4 and SPOT 5 over the United States. As with Landsat imagery (in partnership with NASA), the U.S. Geological Survey can distribute these images for free.[22] SPOT announced that its image data will therefore be the "most widely used medium resolution commercial sources of Earth observation data in the U.S. government."[23] This purchase may be the U.S. government's response to the pending danger in the Landsat data

001-232 80423 46 12-12-04 2:44 PM

gap should a new Landsat satellite not be launched. Archival and recent can be purchased online through the SPOT catalogue at Astrium.[24]

IKONOS (UNITED STATES, 1999–)

Launched by the private company Space Imaging (the transformed EOSAT, now known as GeoEye) in September 1999, Ikonos-2 was the first satellite to make high-resolution satellite imagery available to civilian users, leading the *New York Times* to describe it some weeks later as "the world's first private spy camera."[25]

John Pike, then in charge of space policy at the Federation of American Scientists, told the *Times* that high-resolution imagery "was revolutionary when it was available to the nuclear powers, and one expects it to have similar potential now that it is commercial."[26] Robert Wright, writing in the *New York Times Magazine*, called it "a geopolitical milestone. Able to discern objects only a few feet wide—to see at 'one-meter resolution'—it will give presidents, generals and assorted political actors around the globe a kind of power once confined to elite nations."[27]

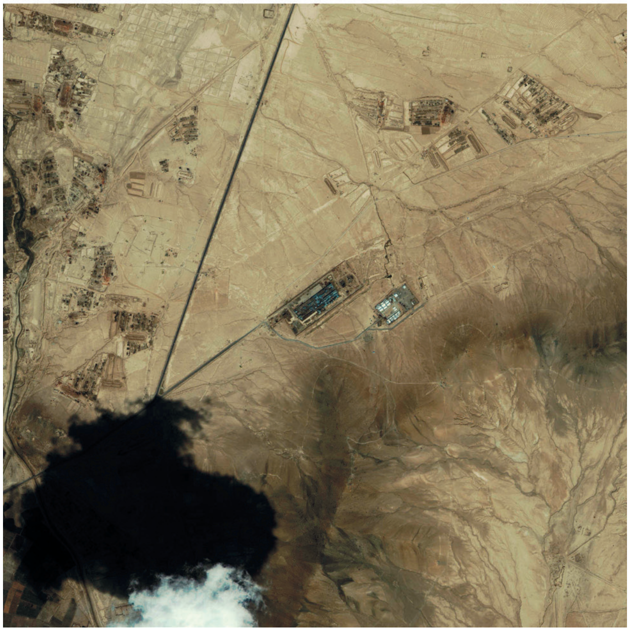
Ikonos was launched with the capability of providing image data with 1-meter ground resolution in a swath 11.3 kilometers (7 miles) wide from an altitude of 681 kilometers (423 miles). It functions by combining 82-centimeter (32.28-inch) resolution black-and-white ("panchromatic") images with 4-meter (13.12-foot) resolution multispectral images to create 1-meter (3.28-foot) color imagery (pan-sharpened).[28] At 1-meter resolution, Ikonos can distinguish a tank from a truck. Every point on Earth can be revisited by Ikonos every three to five days. Although its lifespan was a proposed seven years, Ikonos is still functioning.

Ikonos does not collect a steady stream of images. Its sensors are turned on only to record image data when tasked. Once the satellite is assigned an objective and the image data is received by a purchaser, it becomes available for repurchase and can be ordered and received through a website that includes the image data's longitude, latitude, and date stamp, but not the identity of the tasking agency or individual. Between its launch in 1999 and mid-2011, Ikonos had imaged more than 280 million square kilometers (over 100 million square miles) of the Earth's surface.[29]

The simultaneous provision of high-resolution image data to civilians, the U.S. military, and other governments globally was made possible by President Clinton's March 10, 1994, Presidential Decision Directive, which "among other things, loosened restrictions on the sale of high resolution imagery to foreign entities."[30]

According to the European Space Agency, "the spacecraft operations of Ikonos-2 are unique among the current commercial imaging satellites in that they allow each international affiliate to operate its own ground station(s). These ground stations are assigned blocks of time on the satellite during which they can directly task

001-232 80423 47 12-12-04 2:44 PM



On the front page of the *Washington Post* on March 3, 2005, Dana Priest revealed the existence of a secret CIA prison, code-named the Salt Pit, near Kabul, Afghanistan. Eight months later, she reported that the Salt Pit had been an early part of a "hidden global internment network," a series of so-called "black sites," in which the CIA housed and interrogated terror suspects. Her first article had offered enough detail to send GlobalSecurity.org looking for earlier satellite images of the Salt Pit, and so the second article included a high-resolution Ikonos satellite image of the building.

Top: Salt Pit, as seen by Ikonos satellite, January 25, 2001. COURTESY GEOEYE

Bottom: Salt Pit, as seen by Ikonos satellite, July 17, 2003. COURTESY SPACE IMAGING MIDDLE EAST

Ikonos, and immediately receive the downlinked imagery for which they tasked."[31]

The launch of Ikonos allowed the United States to retain its position as the primary provider of highest-resolution image data globally, but in so doing, it introduced sensitive issues of "shutter control," which, in the words of former Space Imaging vice president Mark Brender, "provides a lever by which the U.S. government can interrupt service when there is a 'threat to national security or foreign policy concern.'"[32] Rather than exercising shutter control, however, the U.S. government has deployed other means of controlling imagery during sensitive times: for example, purchasing the rights to all Ikonos image data over Afghanistan and Pakistan for the two months directly following the September 11, 2001 attacks on the United States. Images from the Ikonos archive, as well as new (tasked) acquisitions, are available for purchase worldwide through GeoEye.

QUICKBIRD-2 (UNITED STATES, 2001–)

QuickBird-2 was launched in October 2001, less than a year after the loss at launch of its predecessor, QuickBird-1. It is a high-resolution Earth-observation satellite owned by DigitalGlobe. It operates in a polar orbit, 482 kilometers (299.5 miles) above the Earth, with a swath width of 18 kilometers (11 miles). It is capable of sub-1-meter resolution, as high as 65 centimeters (25.6 inches).[33] Like Ikonos, QuickBird does not collect image data unless tasked to do so. It can revisit some sites beneath its orbit as frequently as every two and a half days, others within no more than six days. QuickBird-2 is also subject to shutter control, although the U.S. government has never implemented it.

QuickBird-2 and the other satellites in what DigitalGlobe calls its "constellation of sub-meter spacecraft" have emerged as major providers of overhead image data to the U.S. government. In a 2002 memo to the director of the National Imagery and Mapping Agency (NIMA), then–CIA Director George Tenet specified that "it is the policy of the Intelligence Community to use U.S. commercial space imagery to the greatest extent possible" and that the U.S. government should use commercial satellites unless military ones provide better resolution with classified image data.[34] DigitalGlobe has since been awarded two contracts by the U.S. government: $500 million from the NextView program in September 2004 and $3.5 billion over ten years from an EnhancedView contract in August 2010.[35]

The "sub-meter constellation" also does nongovernmental work. DigitalGlobe has agreements with humanitarian and human rights initiatives, among them the Satellite Sentinel Project at Harvard University, to provide QuickBird-2 and other images of zones of conflict in nearly real time. In March 2011, for instance, a DigitalGlobe vice president announced, on the company's blog, the release of satellite images of burned and destroyed villages in the Abyei region of Sudan. He

001-232 80423 49 12-12-04 2:44 PM

wrote: "We've collected, processed, analyzed and delivered imagery and information in record time, given the urgency of the situation and the need to demonstrate to both sides that the world is watching." He added, for context, that this was simply part of the satellite business:

> we do keep a constant eye on the planet, to gain early insights into the business, market, environmental and political changes that impact people around the world. That's why we are keeping such a close eye on Sudan. It may be hard to watch, to look at an image and know someone's home is gone, a livelihood destroyed, that many lives have been lost. All involved are seeking the truth in pictures, and delivering valuable information and insight to both sides of the country. We certainly hope that one day, peace will come to this nation.[36]

QuickBird-2 image data can be purchased at digitalglobe.com, along with that of its fellow DigitalGlobe satellites WorldView-1 (50-centimeter/19.7-inch resolution) and WorldView-2 (46-centimeter/18.1-inch resolution).

GeoEye-1 (United States, 2008–)

The revolution in the privatization of high-resolution imagery from outer space that is exemplified by the generation of satellites from Ikonos on stems both from the declassification efforts of the 1990s and a series of U.S. government decisions to "support the continued development of the commercial satellite imagery industry by sharing the costs for the engineering, construction and launch of the next generation of commercial imagery satellites."[37] One result was the September 2008 launch of GeoEye-1, a private satellite owned by GeoEye with resolution below a half meter (41 centimeters, 16.41 inches). Its swath width is just over 15 kilometers (9 miles), and from its sun-synchronous polar orbit 681 kilometers high (423 miles), it can revisit anywhere on Earth once every three days, passing overhead, like other imaging satellites, at 10:30 a.m., local time. Like Ikonos, also owned by GeoEye, and QuickBird-2, it is subject to shutter control and does not collect imagery unless tasked to do so.

According to GeoEye, "While the satellite collects imagery at 0.41-meters, GeoEye's operating license from the U.S. Government requires re-sampling the imagery to 0.5-meter for all customers not explicitly granted a waiver by the U.S. Government."[38] Nevertheless, at this reduced 50-centimeter resolution, the home plate of a baseball diamond is visible from space.

GeoEye's CEO wrote in January 2010:

> The defense and intelligence communities have developed a huge appetite for unclassified, high-resolution, map-accurate satellite imagery. One leading reason is that our government can freely share unclassified images with allies, coalition

001-232 80423 50 12-12-04 2:44 PM

partners and disaster relief workers, thus speeding collaboration and time-critical decision-making. Another reason is that commercial imagery is highly cost-effective because we can resell excess capacity and imagery to commercial customers.

As a result, the use of satellite imagery by analysts and mapmakers at military headquarters is the norm.[39]

After the U.S. government, GeoEye's second major customer is Google. Since mid-2009, a lot of GeoEye-1 imagery has been freely available to Google Earth users. Although the Google logo was prominently displayed on the launch rocket—such that *Wired* magazine could title an article "Google's Super Satellite Captures First Image"[40]—Google does not own the satellite. Instead, through its Google Earth interface, it distributes and makes accessible imagery produced and tasked by others. (There is of course a possibility that Google has commissioned GeoEye imagery collection for its own purposes, but if so, it's a closely held secret.) It is unclear whether Google displays the GeoEye imagery at its full resolution, and since one cannot download images from Google Earth in the same way as one can from GeoEye itself—where each pixel has a size of one square meter and a longitude, latitude, and spectral signature—it's rather difficult to find out. For its full resolution and data, GeoEye-1 image data can be purchased at www.GeoEye.com.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

The Global Positioning System and remote-sensing satellites simply generate data. GIS is the generic name for software that allows users to locate data spatially. Any line on a spreadsheet, item on a list, or field in a database that records a physical address has the potential, once linked to its geographic coordinates, to become a point on a digital map. Once that point is recorded, it can be linked to or labeled with any other sort of data: the address can be connected to the name of a road, a dollar amount, a color or a shade, something a person said, a crime committed or thwarted, an encounter with an animal or a deity, or almost anything else that can be stored in a database—and that includes nonquantitative data.

Environmental Systems Research Institute (ESRI) is the Microsoft Word of GIS software and has the generic Web domain name www.GIS.com. GIS is described by ESRI as a system that "integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information."[41]

The most popular textbook on GIS, *Geographic Information Systems and Science*, describes the "field of GIS as concerned with the description, explanation, and

001-232 80423 51 12-12-04 2:44 PM

prediction of patterns and processes at geographic scales. GIS is a science, a technology, a discipline and an applied problem solving methodology."[42] The textbook description says nothing about hardware and software, and rightly so, because it focuses on how GIS has radicalized and transformed the methodologies and processes of cartography, geography, urban planning, urban design, data management, archeology, sociology, and public health, among many other fields and practices. Although these are very different disciplines, they all have a stake in using maps as a basis for research and analysis.

Over the course of its short history, GIS has been commonly talked about as having transformed cartography into spatial data management. GIS has become a metaphor for the role that data now play in the drawing of new maps of the world, especially its cities and its resources. Often, the data is newly created for the map. What GIS does well is to layer diverse sets of information onto a single digital file or map.

Both these things—data displayed on maps and a layering of data onto maps—have long histories. Depending on where one starts the historical trajectory, one will end up with a very different interpretation of the meaning and uses of GIS. For example, some urbanists and public health researchers put the origin of GIS in John Snow's 1854 map of cholera in London. For them, the social data and statistical methods embedded in GIS are critical to the ways in which they define it.[43] These methods, which were developed later by Charles Booth in his poverty maps of London in 1898–99 and then by the Chicago School of sociological research in the first half of the twentieth century, constitute in effect the history of the modern city and define the modern history of cartography.[44]

But there are other genealogies. Some cite Ian McHarg's 1969 *Design with Nature* as the origin of GIS.[45] McHarg famously produced manually layered topographical maps with multiple sources of information in order to suggest ecologically smarter layouts for highways.[46] Slope, surface drainage, scenic value, residential values, forests, institutions, erosion, and so on were layered together into what McHarg called a "composite," an image in which one could see the effects of the layers on one another. The overlays bore titles such as "Composite: All Social Values" or "Composite: Physiographic Obstructions." McHarg's maps featured proposals such as "Recommended Minimum-Social-Cost Alignment" for a highway construction project. McHargian users of GIS have an expanded and design-oriented view of the built environment, one that incorporates ecological, landscape, and urban patterns, as well as the social forces that might affect those patterns.

The dominant history of GIS traces only the hardware and software that make up the GIS we know today on our computer desktops. The history section

001-232 80423 52 12-12-04 2:44 PM

of *Geographic Information Systems and Science* begins in the mid-1960s in Canada, where the first "real GIS" was a "computerized map measuring system."[47] It was produced to create the Canada Land Inventory System, a project—classically cartographic—to identify resources and their potential uses.[48] A second phase of rapid development, they write, came from the U.S. Census Bureau, which, planning for the 1970 census, created the DIME (Dual Independent Map Encoding) program, allowing the creation of digital records of every street in the United States such that the population could be referred and aggregated to specific geographies. From the perspective of emerging GIS software development, these two programs responded to the "same basic needs in many different application areas, from resource management to the census."[49]

These narratives and genealogies are important as examples (and this is not the full scope of genealogical narratives of GIS) because neither data collection nor software are neutral in the uses of GIS. Sociologists, urban planners, advocacy groups, and other users of GIS software often tend to downplay the art of mapping and can unknowingly, or knowingly, as Mark Monmonier has argued, "lie with maps."[50] GIS software, which hides from the viewer or user of the map the statistical operations that the maker of the map utilizes, can make this traditional possibility a great deal easier. A more polite term for this, which acknowledges the explicitly aesthetic operations of some GIS users and recognizes the deployment of maps for persuasive purposes, as well as for the management of people and things, would be that of Dennis Wood, "the power of maps."[51]

Obviously, the design of the data and the reasons for its collection have an effect on the biases of the map. Now that many specialists other than cartographers can make maps, it is especially important to understand the sources of data they rely on, the products of which are maps and images that are having an effect on policy, cities, landscapes, privacy, and beyond.

Remote sensing had an enormous influence on the data and imagery in GIS. Aerial exploration of the Earth's surface not only generated the image bases for all sorts of maps, but also allowed interpreters to discover new things about everything from land use to population density to changes in landscapes and landforms. The Corona program was already using satellite imagery to map large parts of the United States and elsewhere by coordinating its measurable images with mapping reference grids (longitude and latitude). And as the 1990s dawned, GPS emerged as an unprecedented and inexhaustible source of new data points.

However, no one, really, would be using GIS were it not for the emergence of desktop and then portable computers and the World Wide Web, which dramatically democratized the availability of data-processing power in the late 1980s and early 1990s and effectively put GIS–like data and software into mass circulation.

001-232 80423 53 12-12-04 2:44 PM

With the ubiquity of personal computers and the increased availability of GIS software and geospatial data—whether from GPS, remote-sensing satellites, or public and private libraries and archives—the ability to access, interpret, and put to use digital images of events occurring anywhere in the world, on any scale, from the local to the global, is no longer the sole property of governments, militaries, and large corporations. What the dissemination of these technologies has enabled is the democratization of what I have called "para-empirical" investigations. What follows here are nine such investigations, together with reflections on the ways in which they can help us understand better how the images generated by this hardware and software are used, how the rest of us can explore their unintended consequences and unexpected byproducts—and how sometimes we can make such images ourselves.

001-232 80423 54 12-12-04 2:44 PM

001-232 80423 216 12-12-04 2:59 PM

Notes

INTRODUCTION

1. Denis Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2001), p. 257.
2. Quoted by Cosgrove, *Apollo's Eye*, p. 258.
3. Martin Heidegger, "'Only a God Can Save Us': The *Spiegel* Interview (1966)," trans. William J. Richardson, S.J., in Thomas Sheehan (ed.), *Heidegger: The Man and the Thinker* (Chicago: Precedent Publishing, 1981), p. 56.
4. Cosgrove, *Apollo's Eye*, p. 257.
5. NASA Earth Observatory, "History of the Blue Marble," undated, http://earthobservatory.nasa.gov/Features/BlueMarble/BlueMarble_history.php.
6. NASA Goddard Space Flight Center, "VIIRS Eastern Hemisphere Image—Behind the Scenes," February 2, 2012, http://www.nasa.gov/topics/earth/features/viirs-globe-east.html.
7. *The Blue Marble* has been an object of fascination for many. Al Gore proposed in 1998 to position a satellite at one of the Earth's Lagrangian points, where the satellite would always capture a sun-lit view of the Earth. Gore wanted to make this image continuously available in real time on the Internet. "As White House aides tell it, Mr. Gore's idea came to him almost in a dream. He awoke at 3 a.m. one day in February 1998, and thought about a global view of Earth, they say, perhaps inspired by the famous 'Blue Marble' photograph of the planet taken in December 1972 by the returning crew of Apollo 17, the last moon mission. A copy of the picture hangs in Mr. Gore's office." The fantastical idea was never realized. See Warren E. Leary, "Politics Keeps a Satellite Earthbound," *New York Times*, June 1, 1999, p. F1.
8. See Jeff Richardson, "Blue Marble," *iPhone J.D.*, March 10, 2010, http://www.iphonejd.com/iphone_jd/2010/03/blue-marble.html, and NASA Earth Observatory, "History of the Blue Marble."
9. In this sense, I take some distance, so to speak, from the work of Lisa Parks, whose *Cultures in Orbit: Satellites and the Televisual* (Durham: Duke University Press, 2005) is an excellent study of the culture of satellite images in politics, the news, and our imagination. Her interpretations, however, stop at the ways in which these images are presented to us, which is to say that she reads only what has already been interpreted. The same can be said for other

001-232 80423 217 12-12-04 2:59 PM

influential theorists of satellite space, such as Paul Virilio, and sky-friendly geographers such as Denis Cosgrove and J.B. Harley. Although I have learned much from all them, the driving force behind the work in this book is somewhat different: not simply to talk about these images, but to work with them, do things with them, help create them, actively shape, produce, and modify them.

10. Peter Galison, *Einstein's Clocks, Poincaré's Maps* (New York: W. W. Norton, 2003), p. 285.
11. *Ibid.*, p. 287.
12. *Ibid.*, pp. 288–89.
13. *Ibid.*, pp. 292–93.
14. Rosalyn Deutsche, "Boys Town," *Environments and Planning D, Society and Space* 9.1 (March 1991), p. 21.
15. Philip Morrison and Phyllis Morrison and the Office of Charles and Ray Eames, *Powers of Ten: About the Relative Size of Things in the Universe* (New York: Scientific American Library, 1982).
16. *Ibid.*, pp. iv–v.
17. *Ibid*., p. 145.
18. See "Satellite Images Offer Detailed Views from Space," transcript, Neal Conan interview with John Pike of GlobalSecurity.org, *Talk of the Nation*, National Public Radio, July 10, 2007, http://www.npr.org/templates/transcript/transcript.php?storyId=11850958. Pike says: "Google is not independently acquiring the imagery. They're getting it from these commercial companies—two in the United States, one in Israel, one in France. The American companies are operating under government license. And so there are some restrictions on what they can acquire imagery of and how they can release it. So the Defense Department has already signed off on the public release of this imagery before Google is able to acquire it."
19. Barbara Crossette, "U.S. Seeks to Prove Mass Killings," *New York Times*, August 11, 1995, p. A3. The withholding of the images, especially the ones acquired by satellites, from the general public was challenged in a Freedom of Information Act lawsuit by Students Against Genocide. See the remarkable decision by the Court of Appeals for the District of Columbia Circuit in *Students Against Genocide v. Department of State*: http://www.cadc.uscourts.gov/internet/opinions.nsf/A26612A99D23C92B85256F7A0064436F/$file/99-5316a.txt.
20. See, on declassification, Kevin C. Ruffner, "CORONA and the Intelligence Community: Declassification's Great Leap Forward," April 14, 2007, Central Intelligence Agency, https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/csi-studies/studies/96unclass/corona.htm. Of course, although as John Pike says, "the satellite genie seems now irreversibly out of the bottle," the same cannot be said for American reconnaissance and surveillance programs in general, as the policies of the Bush Administration were to demonstrate quite dramatically. Pike, in "Satellite Images Offer Detailed Views from Space," *Talk of the Nation*, National Public Radio, July 10, 2007.
21. "The World: Campaign Poster; Grozny, Dec. 16, 1999 / Grozny, March 16, 2000," *New York Times*, March 26, 2000, section 4, p. 1, http://www.nytimes.com/2000/03/26/weekinreview/the-world-campaign-poster-grozny-dec-16-1999-grozny-march-16-2000.html.
22. Lara J. Nettelfield, "Terror in Chechnya: Russia and the Tragedy of Civilians in War" (review), *Human Rights Quarterly* 33. 3 (August 2011), p. 886.
23. Robert Mackey, "Satellite Image Shows North Korean Rocket Launch," *New York Times*, *The Lede* blog, April 8, 2009, http://thelede.blogs.nytimes.com/2009/04/08/satellite-image-shows-north-korean-rocket-launch.

001-232 80423 218 12-12-04 2:59 PM

24. Ian Sample, "North Korean Rocket Launch Caught on Film," *Guardian*, April 8, 2009, p. 21, http://www.guardian.co.uk/world/2009/apr/08/north-korea-rocket-launch-image.
25. Google Earth imagery is not entirely free: it is paid for by spatially motivated advertising. For a fuller argument on this, see Chris Perkins and Martin Dodge, "Satellite Imagery and the Spectacle of Secret Spaces," *Geoforum* 40 (2009), pp. 546–60, http://personalpages.manchester.ac.uk/staff/m.dodge/cv_files/spectacle_of_secret_spaces.pdf.
26. See the study from the RAND Corporation and the American Society of Photogrammetry and Remote Sensing, John Baker, Kevin N. O'Connell, and Ray A. Williamson (eds.), *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (Santa Monica: Rand Publishing, 2001), p. vii.
27. William J. Broad, "Giant Leap for Private Industry: Spies in Space," *New York Times*, October 13, 1999, p. A14, http://www.nytimes.com/1999/10/13/us/giant-leap-for-private-industry-spies-in-space.html.
28. Quoted in William J. Broad, "Private Spy in Space to Rival Military's," *New York Times*, April 27, 1999, p. F1, http://www.nytimes.com/1999/04/27/science/private-spy-in-space-to-rival-military-s.html.
29. Ann M. Florini and Yahya A. Dehqanzada, "Secrets For Sale: How Commercial Satellite Imagery Will Change the World," Washington, D.C.: Carnegie Endowment for International Peace, 2000, http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=160.
30. Secretary Colin L. Powell, "Remarks to the United Nations Security Council," New York City, February 5, 2003 (including slide show), http://www.globalsecurity.org/wmd/library/news/iraq/2003/iraq-030205-powell-un-17300pf.htm. The transcript is also available at "Threats and Responses. Powell's Address, Presenting 'Deeply Troubling' Evidence on Iraq," *New York Times*, February 6, 2003, p. A18, http://www.nytimes.com/2003/02/06/world/threats-responses-powell-s-address-presenting-deeply-troubling-evidence-iraq.html.
31. Open Source Center, "Iraqi Insurgency Group Utilizes 'Google Earth' for Attack Planning," July 19, 2006, http://www.fas.org/irp/dni/osc/osc071906.pdf; see also Peter Eisler, "Google Earth Helps Yet Worries Government, *USA Today*, November 7, 2008; and Open Source Center, "The Google Controversy—Two Years Later," July 30, 2008, http://www.fas.org/irp/dni/osc/google.pdf.
32. Satellite Sentinel Project: Monitoring the Crisis in Sudan, "Documenting the Crisis," http://satsentinel.org/documenting-the-crisis.
33. *Ibid*.
34. Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham: Duke University Press, 2005), pp. 79, 77.
35. *Ibid*., p. 81. She offers what are in effect revisionist accounts of the massacre ("Islamic fundamentalists provoked the massacre as an act of martyrdom and then killed themselves," etc.), which she prophylactically qualifies under the headings of "each political interest puts its own spin on the event" and "the impossibility of knowing exactly what happened at Srebrenica in July 1995," but which nonetheless seem to suggest that she has her doubts about the standard accounts—accounts that, I should add, have been confirmed at the International Criminal Tribunal for the Former Yugoslavia in The Hague and accepted even by most critics of U.S. policy during and after the war.
36. *Ibid*., pp. 84, 90.
37. *Ibid*., pp. 90–91.

001-232 80423 219 12-12-04 2:59 PM

38. *Ibid.*, p. 101.
39. *Ibid.*, pp. 106–107.
40. *Ibid.*, p. 101.
41. Pike, in "Satellite Images Offer Detailed Views from Space," National Public Radio, July 10, 2007.
42. J. B. Harley, "Deconstructing the Map," in *The New Nature of Maps: Essays in the History of Cartography*, ed. Paul Laxton (Baltimore; Johns Hopkins University Press, 2001), pp. 151–52.
43. *Ibid.*, pp. 165, 166, 157. See also the discussion of the Peters projection versus the Mercator projection in Mark Monmonier, *Drawing the Line: Tales of Maps and Cartocontroversy* (New York: Henry Holt, 1995), pp. 9–25.
44. Svetlana Alpers, "The Mapping Impulse in Dutch Art," in *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983), p. 138; Thomas Nagel, *The View from Nowhere* (New York: Oxford University Press, 1986).
45. *Ibid.*
46. Harley, "Deconstructing the Map," p. 166. The formalization and abstraction of the view from nowhere can allow us to ignore the politics underlying the development of technology, mathematics, and science that have enabled its production.
47. Yve-Alain Bois, "Metamorphosis of Axonometry," *Daidalos* 1.15 (September 1981), pp. 40–58.
48. *Ibid.*, pp. 56–57.
49. *Ibid.*, p. 57.
50. Cosgrove, *Apollo's Eye*, pp. 239 and 242. Paul Virilio, in *War and Cinema: The Logistics of Perception* (London: Verso, 1989), also explores the "logistics of military perception." Also essential in recounting this history is Beaumont Newhall, *Airborne Camera: The World from the Air and Outer Space* (New York: Hastings House, 1969).
51. In an essay titled "'The View from Nowhere'?: Spatial Politics and the Cultural Significance of High-Resolution Satellite Imagery," introducing an issue of *Geoforum*, Martin Dodge and Chris Perkins talk about the view from nowhere as an objective view. They say: "The papers in this collection question what can be seen in high-resolution satellite imagery and what this might mean. This work can perhaps be best introduced by considering the seductively objective view of the world that they claim to represent—what one might term, following Thomas Nagel (1986), the 'view from nowhere'. The key question is how this view is manufactured and mediated." All the papers in that collection address the point of view of high-resolution satellites. *Geoforum* 40.4 (2009), http://personalpages.manchester.ac.uk/staff/m.dodge/cv_files/view_from_nowhere_intro.pdf, p. 2.
52. Bruno Latour, "From Realpolitik to Dingpolitik, or How to Make Things Public," in Bruno Latour and Peter Weibel (eds.), *Making Things Public: Atmospheres of Democracy*, trans. Robert Bryce et al. (Cambridge, MA: The MIT Press, 2005), p. 26.

001-232 80423 220 12-12-04 2:59 PM

LEXICON

1. GPS.gov: Official U.S. Government Information about the Global Positioning System (GPS) and Related Topics, http://www.GPS.gov.
2. Garmin, "What is GPS?," http://www8.garmin.com/aboutGPS; United States Naval Observatory, "USNO NAVSTAR Global Positioning System," http://tycho.usno.navy.mil/gpsinfo.html.
3. GPS.gov, "GPS Accuracy," http://www.gps.gov/systems/gps/performance/accuracy.
4. For complete list of policy decisions, see National Executive Committee for Space-Based Positioning, Navigation, and Timing, "U.S. Space-Based PNT Policy," http://pnt.gov/policy.
5. The White House Office of Science and Technology Policy National Security Council, "Fact Sheet, U.S. Global Positioning System Policy," March 29, 1996, http://www.navcen.uscg.gov/pdf/1996_GPS_Policy.pdf.
6. National Executive Committee for Space-Based Positioning, Navigation, and Timing, "U.S. Space-Based Positioning, Navigation, and Timing Policy," December 15, 2004, http://www.pnt.gov/policy/2004-policy.shtml.
7. For a complete inventory of currently orbiting remote sensing satellites by country as of 2010, see Federation of American Scientists, Intelligence Resource Program, *The Remote Sensing Tutorial: What You Can Learn From Sensors on Spacecraft That Look Inward at the Earth and Outward at the Planets, the Galaxies and, Going Back in Time, The Cosmos*, http://www.fas.org/irp/imint/docs/rst/Front/overview2.html, and Socioeconomic Data and Applications Center, "An Annotated Guide to Earth Remote Sensing Data and Information Resources for Social Science Applications, Section 2.0: Selected Listings of Earth Remote Sensing Data and Information Resources, http://sedac.ciesin.columbia.edu/remote/app2.html.
8. Chris Perkins and Martin Dodge, "Satellite Imagery and the Spectacle of Secret Spaces," *Geoforum* 40.4 (2009), pp. 546–60, http://personalpages.manchester.ac.uk/staff/m.dodge/cv_files/spectacle_of_secret_spaces.pdf.
9. For the best analysis of these issues see Ann M. Florini and Yahya A. Dehquanzada, "No More Secrets?: Policy Implications of Commercial Remote Sensing Satellites," Carnegie Paper 1 (July 1999), http://carnegieendowment.org/1999/07/01/no-more-secrets-policy-implications-of-commercial-remote-sensing-satellites/3lh9.
10. Federation of American Scientists, Intelligence Resource Program, *The Remote Sensing Tutorial*, http://www.fas.org/irp/imint/docs/rst/Front/overview2.html.
11. According to Keith C. Clarke, KH-1 could see a runway, while the improved resolution of KH-4 could see missile silos or cars in a parking lot of the Kremlin. Keith C. Clarke, "America's First Satellite Surveillance," in *The Corona Story*, Project Corona: Clandestine Roots of Modern Earth Science, http://www.geog.ucsb.edu/~kclarke/Corona/story2.htm.
12. *Ibid*.
13. Clarke, "Beyond Surveillance," in *The Corona Story*, http://www.geog.ucsb.edu/~kclarke/Corona/story3.htm#row2.
14. National Reconnaissance Office, "Corona Fact Sheet," http://www.nro.gov/history/csnr/corona/factsheet.html.
15. Details can be found online at http://www.usgs.gov/#/Guides/disp1.
16. NASA, Godard Space Flight Center, "Landsat Data Continuity Mission," updated September 4, 2012, http://landsat.gsfc.nasa.gov/about/ldcm.html.

001-232 80423 221 12-12-04 2:59 PM

17. National Aeronautics and Space Administration, “Landsat Then and Now,” http://landsat.gsfc.nasa.gov/about/index.html.
18. National Aeronautics and Space Administration, “Landsat 5,” http://landsat.gsfc.nasa.gov/about/landsat5.html.
19. Details of the privatization of Landsat are well documented in Florini and Dehquanzada, “No More Secrets?” and in National Aeronautics and Space Administration, “Landsat 5.”
20. Florini and Dehquanzada, “No More Secrets?,” p. 7 and p. 7 n.20, citing the Land Remote Sensing Policy Act of 1992, section 2(1), Washington, D.C., October 28, 1992.
21. Astrium Geoinformation Services, “Technical Information About the SPOT Satellites,” 2012, http://www.astrium-geo.com/na/1240-spot-technical-information; “Pléiades, Very High Resolution Satellite Imagery,” 2012, http://www.astrium-geo.com/na/1032-pleiades-very-high-resolution-satellite-imagery ; see also Charlotte Gabriel-Robez, “Seeking Submeter Success,” *Earth Imaging Journal* (March-April 2012), http://eijournal.com/2012/seeking-submeter-success.
22. U.S. Geological Survey, “Technical Announcement: SPOT Comes to USGS Archive of Earth Observation Imagery,” November 13, 2009, http://www.usgs.gov/newsroom/article.asp?ID=2346.
23. Astrium, SPOTCatalog, http://catalog.spotimage.com/PageSearch.aspx?AspxAutoDetectCookieSupport=1. Prices start at between 1,300 Euros and 8,700 euros per scene.
24. See Astrium, “SPOT Satellite Imagery,” http://www.astrium-geo.com/sg/3214-spot-satellite-imagery.
25. William J. Broad, “Giant Leap for Private Industry: Spies in Space,” *New York Times*, October 13, 1999, p. A14, http://www.nytimes.com/1999/10/13/us/giant-leap-for-private-industry-spies-in-space.html. There was an Ikonos-1 satellite, but its launch earlier in 1999 failed, and a second satellite, originally named Ikonos-2, was renamed simply Ikonos.
26. *Ibid*.
27. Robert Wright, “Private Eyes,” *New York Times Magazine*, September 5, 1999, http://www.nytimes.com/1999/09/05/magazine/private-eyes.html.
28. GeoEye, “Ikonos: Setting the Standard,” http://www.geoeye.com/CorpSite/products-and-services/imagery-sources/Default.aspx.
29. GeoEye Commercial Imagery Archive Holdings, http://geofuse.geoeye.com/static/catalogholdings/GeoEye_CatalogHoldings.pdf.
30. Florini and Dehquanzada, “No More Secrets?,” p. 10 n.29, citing “Statement by Press Secretary,” The White House Office of the Press Secretary, Washington, D.C., March 10, 1994, p. 1.
31. European Space Agency, Earthnet Online, “Ikonos-2,” http://earth.esa.int/object/index.cfm?fobjectid=5097.
32. Jennifer LaFleur, “Government, Media Focus on Commercial Satellite Images,” *The News Media and the Law* (Summer 2003), p. 37, http://www.rcfp.org/browse-media-law-resources/news-media-law/news-media-and-law-summer-2003/government-media-focus-comm.
33. EOPortal.org, “Quickbird-2,” http://www.eoportal.org/directory/pres_QuickBird2.html; DigitalGlobe, Inc., “Products,” http://www.digitalglobe.com/products; and Space and Tech, “EarthWatch Granted ‘Half-Meter Resolution’ License,” http://www.spaceandtech.com/digest/sd2001-01/sd2001-01-013.shtml.
34. LaFleur, “Government, Media focus on Commercial Satellite Images,” p. 37.
35. Warren Ferster, “NGA Awards Big Satellite Imagery Contracts,” *Space News*, August 6, 2010,

001-232 80423 222 12-12-04 2:59 PM

http://www.spacenews.com/earth_observation/100806-NGA-awards-imagery-contracts.html.

36. Stephen Wood, "Our Eyes Can't Blink, *The DigitalGlobe Blog*, March 9, 2011, http://www.digitalglobeblog.com/2011/03/09/our-eyes-can%E2%80%99t-blink.
37. GISuser.com, "GeoEye-1—Visualize Home Plate on a Baseball Diamond from Space!," September 8, 2008, http://www.gisuser.com/content/view/15540/28.
38. GeoEye, "About GeoEye-1," http://launch.geoeye.com/LaunchSite/about/Default.aspx. When I purchased imagery for the *Shades of Green* project, the link above sent me to information about GeoEye-1 which explained that although the imagery is collected at 41 centimeters per pixel, I could purchase it only at 50 centimeters per pixel. Now, in August 2012, the same link leads to information about GeoEye-2, which will be launched in 2013, and the update is this: "GeoEye-2 will have the highest resolution of any commercial imaging system. It will collect images with a ground resolution of 34cm (13.4 inch) in the panchromatic or black-and-white mode. It will collect multispectral or color imagery at 1.36-meter (54 inch) resolution. This advanced resolution will offer our customers unprecedented, precise views for mapping, change detection and image analysis. Although the U.S. government will require GeoEye-2 imagery to be re-sampled from 34cm collection to 50cm products, this will result in better, clearer, sharper 50cm satellite imagery than previously available." In effect this means that the U.S. military will be able to use the imagery at 34 centimeters, or 13.4 inches, while civilians will still only be able to purchase the imagery at 50 centimeters per pixel.
39. Matt O'Connell, "A Leap Forward in Intelligence Gathering: New Developments in Commercial Geospatial Technology Promise Big Payoff," *Defense Systems*, January 20, 2010, http://defensesystems.com/articles/2010/01/27/industry-perspective-geoeye.aspx.
40. Brian X. Chen, "Google's Super Satellite Captures First Image," *Wired*, October 8, 2008, http://www.wired.com/wiredscience/2008/10/geoeye-1-super.
41. ERI, "Overview: What is GIS?," http://www.esri.com/what-is-gis/overview.html#overview_panel.
42. Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind, *Geographic Information Systems and Science: Principles, Techniques, Management, and Applications* (Hoboken, NJ: Wiley, 2005).
43. Steven Johnson, *The Ghost Map: The Story of London's Most Terrifying Epidemic—and How it Changed Science, Cities, and the Modern World* (New York: Riverhead Books, 2006).
44. Robert E. Park and Ernest W. Burgess, *The City: Suggestions for Investigation of Human Behavior in the Urban Environment* (1925; Chicago: University of Chicago Press, 1984).
45. See, for instance, the "GIS Hall of Fame," at the website of the Urban and Regional Information Systems Association (URISA), "the association for GIS professionals," into which McHarg was inducted in the first year (2005): "Arguably, Ian McHarg's 1969 landmark book *Design With Nature* has had a greater influence on the development and application of Geographic Information Systems than any other single event in GIS history." http://www.urisa.org/node/394.
46. Ian L. McHarg, *Design with Nature* (Garden City, NY: The Natural History Press, for the American Museum of Natural History, 1969).
47. Longley et al., *Geographic Information Systems and Science*, p. 16.
48. *Ibid*.
49. *Ibid*., p. 17.
50. Mark Monmonier, *How to Lie with Maps* (Chicago: University of Chicago Press, 1991).
51. Denis Wood, *The Power of Maps* (New York: Guilford Press, 1992).

001-232 80423 223 12-12-04 2:59 PM

PROJECTS

1. Jeff Hurn, for Trimble Navigation, *GPS: A Guide to the Next Utility* (Sunnyvale: Trimble Navigation, 1989), pp. 9–10.
2. Paul Virilio, *Desert Screen: War at the Speed of Light*, trans. Michael Degener (London: Athlone, 2002), p. 121.
3. Richard Meier, "Designing the Barcelona Museum of Contemporary Art," in *Richard Meier, Barcelona Museum of Contemporary Art* (New York: Monacelli Press, 1997), p. 16.
4. Claudia Gould, "Interview with Vito Acconci and Steven Holl," in *Vito Acconci and Steven Holl: A Collaborative Building Project, November–December 1993*, reprinted in Joseph Grima et al. (eds.), *Storefront Newsprints 1982–2009* (New York: Storefront Books, 2009), p. 399.
5. GeoLink, "GeoLink Moves Mapping into a Whole New Field—*Yours*" (Billings: GeoResearch Inc., 1993), n.p.
6. Yumiko Ono, "In Japan, They May Never Ask for Directions Again," *Wall Street Journal*, January 7, 1994, p. B1.
7. Hurn, *GPS: A Guide to the Next Utility*, p. 24. Today, the U.S. government refers to GPS as "the world's only global utility." See, for example, the website of the Second Space Operations Squadron at Schriever Air Force Base, Colorado, which operates the GPS system: http://www.schriever.af.mil/GPS.
8. *The Truth*, brochure describing "a field portable remote sensing system" (Arlington: PCI Remote Sensing Corp., 1993), n.p.
9. Fredric Jameson, "The Cultural Logic of Late Capitalism," in *Postmodernism, or The Cultural Logic of Late Capitalism* (Durham: Duke University Press, 1991), p. 54.
10. Intergraph, "Kuwait: Rebuilding a Nation," Intergraph Corp., Huntsville, Alabama, 1991, p. 10.
11. Jean Baudrillard, *The Gulf War Did Not Take Place*, trans. Paul Patton (Bloomington: Indiana University Press, 1995).
12. Virilio, *Desert Screen*, p. 43.
13. Neil Smith, "History and Philosophy of Geography: Real Wars, Theory Wars," *Progress in Human Geography* 16.12 (June 1992), p. 257. Smith, to be fair, was worrying here about the future of geography as a discipline. He was concerned by "the dangerous and self-defeating renunciation of an intellectual (as opposed to technical) agenda that too often accompan[ies] the programmatic advocacy of GIS." "Technology does not *cause* war," he writes, "but the traditional liberal argument that techniques are separate and separable from their uses is equally simplistic." He charges that "liberal advocates" of GIS are "embarrassed into silence by the integration of GIS with military agendas." No silence here, and while the causes of war are beyond the scope of this book, I do advocate the critical uses of these technologies, particularly uses that highlight the qualitative biases inevitably built into them.
14. "Intergraph: Your Partner in Rebuilding Kuwait," advertisement, 1991.
15. "Kuwait City: Image Mapping…the Integration of Remote Sensing, GIS and Digital Cartography," poster DDWA0027A, Intergraph Corp., Huntsville, Alabama, 1991.
16. "How Many Trees Were in Kuwait City?," *Armed Forces Journal International,* June 1991, p. 26.
17. "Kuwait City: Image Mapping…the Integration of Remote Sensing, GIS and Digital Cartography."
18. "A World of Solutions," interview with William E. Salter, *Intervue* (Fall 1991), p. 4.
19. Caryle Murphy, "U.N. Map Makers Draw Kuwaiti-Iraqi Border: Old Documents, New Technology Used," *Washington Post*, May 5, 1992, p. A19.

001-232 80423 224 12-12-04 2:59 PM

20. Jeffrey T. Richelson, "U.S. Reconnaissance Satellites Aren't All-Seeing, So Don't Expect Miracles," *Los Angeles Times*, February 17, 1991, p. M5, http://articles.latimes.com/1991-02-17/opinion/op-2094_1_reconnaissance-satellites.
21. "Spacecraft Played Vital Role in Gulf War Victory," *Aviation Week and Space Technology*, April 22, 1991, p. 91.
22. John G. Roos, "SPOT Images Helped Allies Hit Targets in Downtown Baghdad," *Armed Forces Journal International*, May 1991, p. 54; see also Roos, "SPOT's 'Open Skies' Policy Was Early Casualty of Mideast Conflict," *Armed Forces Journal International*, April 1991, p. 32.
23. U.S. News & World Report, *Triumph without Victory: The Unreported History of the Persian Gulf War* (New York: Times Books, 1992).
24. General H. Norman Schwarzkopf, with Peter Petre, *It Doesn't Take a Hero* (New York: Bantam Books, 1992), p. 468.
25. *Armed Forces Journal International*, April 1991, p. 32.
26. Executive Order 12951 of February 22, 1995: Release of Imagery Acquired by Space-Based National Intelligence Reconnaissance Systems, *Federal Register* 60.39 (February 28, 1995), pp. 10789–90, http://www.gpo.gov/fdsys/pkg/FR-1995-02-28/pdf/95-5050.pdf.
27. Oliver Morton, "Private Spy," *Wired* 5.8 (August 1997), pp. 114–99 and 149–52; http://www.wired.com/wired/archive/5.08/spy.html.
28. Keith C. Clarke, "Beyond Surveillance," in *The Corona Story*, Project Corona: Clandestine Roots of Modern Earth Science, http://www.geog.ucsb.edu/~kclarke/Corona/story3.htm.
29. Jim Graham, Lockheed-Martin Space Corp., "Corona Program Profile," May 1995; distributed in *Space News Digest* 1.298 (June 16, 1995), http://www.islandone.org/SpaceDigest/SpaceDigestArchive/SortingInProgress/SpaceNewsDigest.v01/v1n0298.
30. Kevin Ruffner (ed.), *Corona: America's First Satellite Program* (Washington, D.C.: Central Intelligence Agency, Center for the Study of Intelligence, 1995).
31. See Gillian Cook, "Khayelitsha: New Settlement forms in the Cape Peninsula," in David M. Smith (ed.), *The Apartheid City and Beyond* (London: Routledge, 1992), pp. 125–35. The South African Census of 2001 counts the population at 329,000, http://www.capetown.gov.za/en/stats/2001census/Documents/Khayelitsha.htm. But this number is famously underestimated. The Western Cape Population Unit's "Population Register Update: Khayelitsha 2005," published in 2006, explains the undercounting in the 2001 census and corrects it with results from a 2004 aerial survey. The report can be found at http://www.westerncape.gov.za/other/2007/10/kprufinal_2005_october_2007_publish_date.pdf.
32. See Denis Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2001), pp. 257–62, for a discussion of the new ways of seeing the Earth as catalyzed by the Apollo 8 and Apollo 17 photographs.
33. "Flashbacks," *Life Magazine*, October 1999, p. 66.
34. "All these pictures go on the Web site, so this will appear on the Web site," said the Pentagon spokesman. Office of the Assistant Secretary of Defense (Public Affairs), News Transcript, "DoD News Briefing, Wednesday, June 9, 1999—2:20 p.m.," http://www.defense.gov/transcripts/transcript.aspx?transcriptid=483.
35. Charles Lane and Thom Shanker, "Bosnia: What the CIA Didn't Tell Us," *New York Review of Books*, May 9, 1996, p. 10, http://www.nybooks.com/articles/archives/1996/may/09/bosnia-what-the-cia-didnt-tell-us.
36. Office of the Assistant Secretary of Defense (Public Affairs), News Transcript, "DoD News

001-232 80423 225 12-12-04 2:59 PM

Briefing, Saturday, April 10, 1999—2:05 p.m.," http://www.defense.gov/transcripts/transcript.aspx?transcriptid=583.

37. "On the way to the bus station…a police officer said to me: 'The war started in Drenica, and we are going to end it here.'" Glogovac resident, quoted by Human Rights Watch, "'Ethnic Cleansing' in the Glogovac Municipality," July 1999, http://www.hrw.org/legacy/reports/1999/glogovac.

38. SPOT has since been acquired by Astrium. The SPOT catalogue is online at: http://catalog.spotimage.com/PageSearch.aspx?AspxAutoDetectCookieSupport=1.

39. Thanks to Branden Joseph for pointing out image 05.20.99/083-264 when I presented this work as part of a lecture called "Random Access Memory" at a conference at Princeton University in 2000. He asked me to return to what he called the "white on white" image in my slides. His comment got me thinking about a future project titled *Monochrome Landscapes*.

40. Cloud cover preoccupied NATO and the Pentagon during the Kosovo campaign in terms of both the bombing campaign and the effectiveness of overhead imaging systems, which is also to say the public presentation of the battle. See Paul Watson, "Dispatch from Kosovo: Break in Clouds Can Give Allies Clear View of Targets," *Los Angeles Times*, April 3, 1999, p. A9. Later, in an interview, Kenneth Bacon, the Pentagon spokesman, said that "heavy cloud cover over Yugoslavia meant little aerial photography was available to show in the first weeks." Bradley Graham, "Pentagon's News Filter May Obscure Air War Effect," *Washington Post*, May 24, 1999, p. A20. After the war, Bacon suggested that one of the war's lessons was the need for "drones, particularly ones that can somehow penetrate through foliage and through bad cloud cover. So we all were hampered somewhat by the bad weather and by the intense forestation, or foliage, in Kosovo and Yugoslavia. So we're looking for ways that we can penetrate that more effectively in the future." Office of the Assistant Secretary of Defense (Public Affairs), News Transcript, "USIA Foreign Press Center Briefing—Kenneth H. Bacon," October 21, 1999, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=336.

41. Cable News Network, "America Strikes Back: Pakistan Warns Northern Alliance; Second Wave of Attacks Under Way," transcript, CNN Live Event/Special 14:20, Monday October 8, 2001, Transcript #100823CN.V54 (Lexis/Nexis).

42. Gilles Peress et al., *Here Is New York: A Democracy of Photographs* (New York: Scalo Publishers, 2002).

43. Ed Vulliamy, "A Mass Grave or Prime Real Estate?," *Guardian*, March 9, 2002, http://www.guardian.co.uk/world/2002/mar/10/terrorism.september113.

44. A Lexis/Nexis search indicates that the image was published on September 14 by newspapers as diverse as the *South China Morning Post* in Hong Kong and London's *Daily Mail*. See also Barnaby J. Feder, "Bird's-Eye Views, Made to Order," *New York Times*, October 11, 2001, http://www.nytimes.com/2001/10/11/technology/bird-s-eye-views-made-to-order.html: "Among the indelible images from the terrorist attacks last month were commercial satellite photographs showing smoke and dust of volcanic proportions stretching for miles from the ruins of the World Trade Center."

45. Miroslav Prstojevic et al., *Survival Guide Sarajevo* (Sarajevo: FAMA; New York: Workman Publishing, 1993); Nihad Kresevljakovic et al., *Survival Map 1992–1996* (Sarajevo: FAMA, 1996). FAMA's innovative and intelligent work during the war and the siege, including both these documents, is now online at http://www.famacollection.org/eng/fama-collection/fama-original-projects/index.html.

001-232 80423 226 12-12-04 2:59 PM

46. We used some sentences from Christy Ferer, widow of Port Authority executive director Neil Levin, who was killed on September 11, as a sort of epigraph on the map. She drew a distinction between "gawkers" and "tourists," on the one hand, and those who "have come to ground zero to pay respects and to deal with the psychic blow of what happened here." We weren't sure that distinction was always so clear, and so we quoted the last words of her *New York Times* op-ed. "It is a burial ground. It is a cemetery, where the men and women we loved are buried. Where they rest is now hallowed ground." Christy Ferer, "Unforgotten Soldiers," *New York Times*, October 25, 2001, p. A21, http://www.nytimes.com/2001/10/25/opinion/unforgotten-soldiers.html.
47. On the International Criminal Tribunal for the former Yugoslavia, see Laura Kurgan, "Residues," in *Alphabet City 7: Social Insecurity* (September 2000), pp. 112–30.
48. Ellsworth Kelly, *Four Panels* (1970–71). Screenprint on Special Arjomari paper, 36-3/4 x 62 inches (93.3 x 157.5 cm). There are many Ellsworth Kelly monochrome paintings and prints, but this is the one I had in mind.
49. This coincidence was noted by David Firestone, "Drilling in Alaska, a Priority for Bush, Fails in the Senate," *New York Times*, March 20, 2003, p. A1, http://www.nytimes.com/2003/03/20/us/drilling-in-alaska-a-priority-for-bush-fails-in-the-senate.html; Bob Herbert, "Ready for the Peace?," *New York Times*, March 20, 2003, p. A31, http://www.nytimes.com/2003/03/20/opinion/ready-for-the-peace.html.
50. U.S. Geological Survey, Fact Sheet 0028-01, "Arctic National Wildlife Refuge, 1002 Area, Petroleum Assessment, 1998, Including Economic Analysis," http://pubs.usgs.gov/fs/fs-0028-01/fs-0028-01.htm.
51. "International Meridian Conference," in *Annual Report of the Board of Regents of the Smithsonian Institution, Showing the Operation, Expenditures, and Condition of the Institution for the Year 1884* (Washington, D.C.: Government Printing Office, 1885), p. 186. See Peter Galison's account of the conference and the "struggle for symbolic centrality" in *Einstein's Clocks, Poincaré's Maps* (New York: W. W. Norton, 2003), pp. 144–55.
52. See Mark Monmonier, *Drawing the Line: Tales of Maps and Cartocontroversy* (New York: Henry Holt, 1995), ch. 1.
53. Natural Earth is a collaborative effort by volunteers to release map data for free. See "Natural Earth Version 1.3 Release Notes," http://www.naturalearthdata.com/blog/natural-earth-version-1-3-release-notes. I first learned about this warning on http://roomthily.tumblr.com/post/3041306314/null-island.
54. I was inspired to imagine the possibility of doing civilian satellite investigations by the before-and-after images of Grozny in the *New York Times* in March 2000.
55. "The 1994 Forest Code calls for all commercial logging to be regulated under designated forest concessions. Before they can be legally logged, areas slated for timber production are allocated to timber operators under a defined selection process." Benoit Mertens et al., *Interactive Forestry Atlas of Cameroon, Verion 2.0* (2007), p. 3, a Global Forest/World Resources Institute watch report, http://www.wri.org/publication/interactive-forestry-atlas-cameroon-version-2-0.
56. *Ibid*., p. 5.
57. "Each forest concession with a MINFOF–approved management plan is divided into 30 logging parcels (i.e., AACs), which are integral to the 30-year logging rotation that is at the heart of the sustainable forest management process." *Ibid*., p. 9.

001-232 80423 227 12-12-04 2:59 PM

58. See *ibid*.
59. I wrote about this in "Trying Not to Avoid Propositions Altogether," *Assemblage* 41 (April 2000), p. 37.
60. Gary Wolf, "Exploring the Unmaterial World," *Wired* 8.6, (June 2000), pp. 302–19, http://www.wired.com/wired/archive/8.06/koolhaas_pr.html.
61. Rem Koolhaas, "Earning Trust," lecture at a conference on Superhumanism in London in 2001, quoted in Doerte Kuhlmann, "Big Bright Green Pleasure Machine," in Karin Jaschke and Silke Ötsch (eds.). *Stripping Las Vegas: A Contextual Review of Casino Resort Architecture* (Weimar: University of Weimar Press, 2003), p. 180. A decade later, Koolhaas expressed some doubts about this, telling an interviewer from London's *Independent*: "We're very glad that what I call the 'YES' regime—which means the Yen, the Euro and the US dollar—which began in the 1980s and that dictated every value in every country, has finally come to an end. And I think it's a very good thing that the state is becoming responsible again after a long time of deregulation." Susie Rushton, "The shape of things to come: Rem Koolhaas's striking designs," *The Independent*, June 21, 2010. http://www.independent.co.uk/arts-entertainment/architecture/the-shape-of-things-to-come-rem-koolhaass-striking-designs-2005994.html.
62. Francis X. Clines, "Ex-Inmates Urge Return To Areas of Crime to Help," *New York Times*, December 23, 1992, p. A1, http://www.nytimes.com/1992/12/23/nyregion/ex-inmates-urge-return-to-areas-of-crime-to-help.html.
63. Lola Odubekun, *Vera Institute Atlas of Crime and Criminal Justice in New York City* (New York: Vera Institute of Justice, 1993), pp. 42 and 38.
64. *Ibid*., p. 43.
65. Jennifer Gonnerman, "Million-Dollar Blocks: The Neighborhood Costs of America's Prison Boom," *Village Voice*, November 9, 2004, pp. 17–23, http://www.villagevoice.com/2004-11-09/news/million-dollar-blocks.
66. Jeremy Travis, *But They All Come Back; Facing the Challenges of Prisoner Reentry* (Washington, D.C.: The Urban Institute Press, 2005), p. 5.
67. James Austin et al., *Unlocking America: Why and How to Reduce America's Prison Population* (Washington, D.C.: The JFA Institute, November 2007), p. 1, http://www.jfa-associates.com/publications/srs/UnlockingAmerica.pdf.
68. National Institute of Justice, *What is Crime Mapping?: Briefing Book* (2005), p. 1, http://www.cops.usdoj.gov/html/cd_rom/tech_docs/pubs/WhatIsCrimeMappingBriefingBook.pdf.
69. *Ibid*., pp. 1 and 4.
70. The Bureau of Justice Statistics updates its prison statistics each year. Go to http://bjs.ojp.usdoj.gov and click on "Corrections." You will find a link to "Total Correctional Population."

001-232 80423 228 12-12-04 2:59 PM

001-232 80423 229 12-12-04 2:59 PM

Design, typesetting, and production by Julie Fry
Printed and bound by Friesens, Altona, Manitoba

001-232 80423 231 12-12-04 2:59 PM

001-232 80423 232 12-12-04 2:59 PM