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U.S. Constructed Area Approaches the Size of Ohio

PAGE 233

The construction and maintenance of impervious surfaces—buildings, roads, parking lots, roofs, etc.—constitute a major human alteration of the land surface, changing the local hydrology, climate, and carbon cycling. Three types of national coverage data were used to model the spatial distribution and density of the impervious surface area (ISA) for the conterminous United States. The results (Figure 1) indicate that total ISA of the 48 states and Washington, D.C. is 112,610 km² (± 12,725 km²), which is slightly smaller than the state of Ohio (116,534 km²) and slightly larger than the area of herbaceous wetlands (98,460 km²) of the conterminous United States [*Vogelmann et al.*, 2001].

The same characteristics that make impervious surfaces ideal for use in construction produce a series of effects on the environment. Impervious surfaces alter sensible and latent heat fluxes, causing urban heat islands [*Changnon*, 1992]. In heavily vegetated areas, the proliferation of ISA reduces the sequestration of carbon from the atmosphere [*Milesi et al.*, 2003]. ISA alters the character of watersheds by increasing the frequency and magnitude of surface runoff pulses [*Booth*, 1991]. Watershed effects of ISA begin to be detectable once 10% of the surface is covered by impervious surfaces, altering the shape of stream channels, raising water temperatures, and sweeping urban debris and pollutants into aquatic environments [*Beach*, 2002]. Consequences of ISA include reduced numbers and diversity of species in fish and aquatic insects, and degradation of wetlands and riparian zones.

Despite the recognition of the environmental impacts of impervious surface area (ISA), few areas have ISA maps due, in part, to the technical challenges and cost constraints of using high spatial resolution (~1 m) data for direct mapping of constructed surfaces [*Yang et al.*, 2003]. As an alternative, we have used existing national coverage data sources to model the percent cover of ISA on a 1-km grid for the conterminous United States. The data sources included satellite observed nighttime lights [*Elvidge et al.*, 1999], three classes of Landsat-derived urban land cover [*Vogelmann et al.*, 2001], and U.S. Census Bureau road vectors. The three national coverage data sets were resampled to a 1-km equal area reference grid.

Ground truth calibration data were derived from 80 high-resolution (15-cm) color aerial photographs selected along urban-to-rural development gradients from 13 major urban centers. The aerial photographs were from the year 2000 (± 1 yr). Square-km tiles were extracted from the aerial photography, matching the coverage of specific cells in the reference grid. Gridded point counts were made on each photo tile to estimate the percentage of ISA (see Figure 2).

The nighttime lights radiance, road density, and Landsat-derived urban land cover values were paired to the percentage of ISA values from the aerial photography. Linear regression was used to develop an empirical model for estimating percentage of ISA from the lights, roads, and the three National Land Coverage Data urban classes (Figure 3).

The results (Figure 1) provide the first national map and inventory of ISA. The data will be useful to several science, conservation, and resource management communities, including water resource managers concerned with the impacts of ISA on water quality, and the impacts of enhanced surface runoff on riparian and wetland vegetation; the science and conservation communities concerned with human impacts on biodiversity, habitat loss, and habitat fragmentation; and regional- to continental-scale modelers of the hydrologic and climatic consequences associated with the continuing buildup of ISA.

The United States is adding ISA at a rapid pace. Population is increasing at a rate of 3 million people per year. Public and private

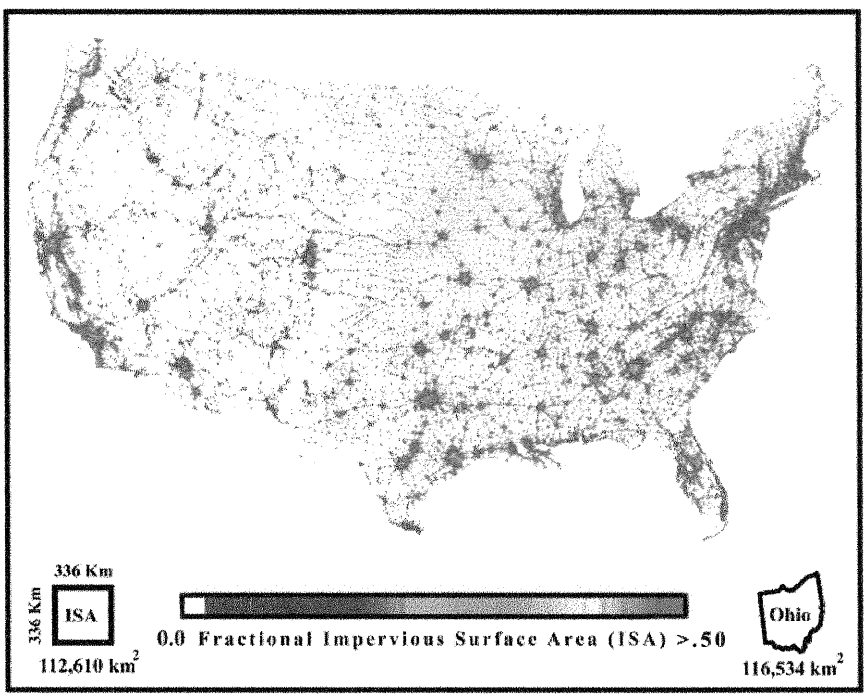

Fig. 1. The spatial distribution and density of ISA for the conterminous United States. The aggregated area of ISA is nearly the size of the state of Ohio.

BY CHRISTOPHER D. ELVIDGE, CRISTINA MILESI, JOHN B. DIETZ, BENJAMIN T. TUTTLE, PAUL C. SUTTON, RAMAKRISHNA NEMANI, AND JAMES E. VOGELMANN

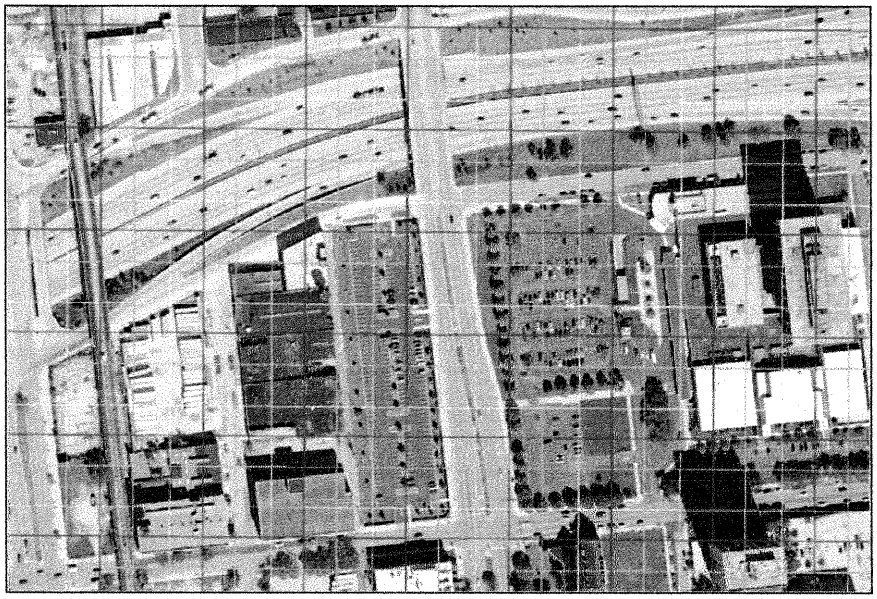

Fig. 2. Gridded ISA point counts were made of 80 1-km tiles of high-resolution aerial photography to provide calibration data for the ISA model.

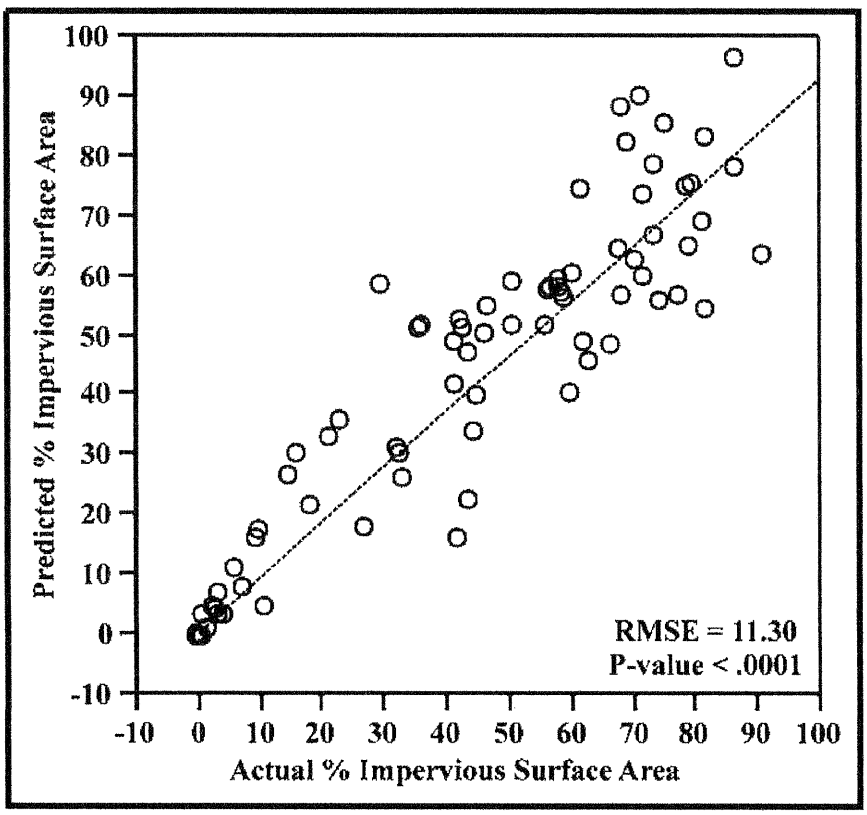

Fig. 3. Linear regression was used to generate a model for estimating the spatial distribution and density of ISA. The parameter estimates for the regression model were: Percentage of ISA = .140 (Radiance DN) + .0012(Roads Density) + .0045(Landsat-derived Land Cover Class 22) + .0029 (Landsat-derived Land Cover Class 21).

sector construction spending tops $480 billion per year. This includes more than one million new single-family homes and in excess of 10,000 miles of new roads per year.

Given these trends, ISA is likely to become a more prominent environmental and growth management issue in the coming years.

Acknowledgments

This project was funded in part by NASA's Land Cover Land Use Change research program.

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Changnon, S. A. (1992), Inadvertent weather modification in urban areas: Lessons for global climate change, *Bull. Am. Meteorol. Soc.*, *73*, 619–627.

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Milesi, C., C. D. Elvidge, R. R. Nemani, and S. W. Running (2003), Assessing the impact of urban land development on net primary productivity in the Southeastern United States, *Rem. Sens. Environ.*, *86*, 401–410.

Vogelmann, J. E., S. M. Howard, L. Yang, C. R. Larson, B. K. Wylie, and N. Van Driel (2001), Completion of the 1990s National Land Cover Data set for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources, *Photogramm. Eng. Rem. Sens.*, *67*, 650–662.

Yang, L., C. Huang, C. G. Homer, B. K. Wylie, and M. J. Coan (2003), An approach for mapping large-area impervious surfaces: synergistic use of Landsat-7 ETM+ and high spatial resolution imagery, *Can. J. Rem. Sens.*, *29*, 230–240.

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Paul C. Sutton

From: John Dietz [John.Dietz@noaa.gov]
t: Saturday, August 07, 2004 10:08 AM
o: Paul C. Sutton
Subject: Re: isa press release

Attachments: ISA_EOS_1.pdf

ISA_EOS_1.pdf
(354 KB)

Hi Paul,

here's the PDF that was in EOS. I can try to get the "official" one from EOS next week.

All I know about the press it got was this from something that Chris E.
put in
the NGDC weekly report.

****

Impervious Surface Area Study Generates Press activity. The recent article, U.S. constructed area approaches the size of Ohio, published in EOS Transactions, (American Geophysical Union) by NGDC's Chris Elvidge, has generated many media contacts. AGU has reported to NGDC that it has sent full copies of the article to many media organizations. T' se include the New York Times, Boston Globe, Saint Louis Post-Dispatch, The Weather .nel, Le Figaro (France) and National Public Radio. Also, a number of webs sites have summarized article. These include:
http://earthobservatory.nasa.gov/Newsroom/MediaAlerts/2004/2004061417187.html
http://news.bbc.co.uk/2/hi/science/nature/3808765.stm
http://www.sustainable.doe.gov/management/geninfo.shtml (scroll down)
Citation: Elvidge, C.D., Milesi, C., Dietz, J.B., Tuttle, B.T., Sutton, P.C., Nemani, R., Vogelmann, J.E., 2004, U.S. constructed area approaches the size of Ohio. EOS Transactions, American Geophysical Union, v. 85, p. 233.

Paul C. Sutton wrote:

>Hi John,
>
>Could you send me a Xeroxed copy of
>The EOS article on impervious surface?
>Also a list of any press it got.
>
>Paul Sutton
>
>_____
>
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>Department of Geography
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>Denver, Colorado 80208
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* John.Dietz@noaa.gov
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U.S. Constructed Area Approaches the Size of Ohio

The construction and maintenance of impervious surfaces (buildings, roads, parking lots, roofs, etc.) constitutes a major human alteration of the land surface, changing the local hydrology, climate, and carbon cycling. We have used three types of national coverage data to model the spatial distribution and density of impervious surface area (ISA) for the conterminous USA. Our results (Figure 1) indicate that total ISA of the 48 states (and D.C.) is 112,610 (+/- 12,725) square kilometres, which is slightly smaller than the State of Ohio (116,534 km^2) and slightly larger than the area of herbaceous wetlands (98,460 km^2) of the conterminous USA [*Vogelmann et al.*, 2001].

The same characteristics that make impervious surfaces ideal for use in construction produce a series of effects on the environment. Impervious surfaces alter sensible and latent heat fluxes, causing urban heat islands [*Changnon*, 1992]. In heavily vegetated areas the proliferation of ISA reduces the sequestration of carbon from the atmosphere [*Milesi et al.*, 2003]. ISA alters the character of watersheds by increasing the frequency and magnitude of surface runoff pulses [*Booth*, 1991]. Watershed effects of ISA begin to be detectable once 10% of the surface is covered by impervious surfaces, altering the shape of stream channels, raising water temperatures, and sweeping urban pollutants into aquatic environments [*Beach*, 2002]. Consequences of ISA include reduced numbers and diversity of species in fish and aquatic insects and degradation of wetlands and riparian zones.

Despite the recognition of the environmental impacts of impervious surface area (ISA), few areas have ISA maps due in part to the technical challenges and cost constraints of using high spatial resolution (~ one meter) data for direct mapping of constructed surfaces[5]. As an alternative, we have used existing national coverage data sources to model the percent cover of ISA on a one kilometre grid for the conterminous USA. The data sources included satellite observed nighttime lights [*Elvidge et al.*, 1999], Landsat derived land cover [*Vogelmann et al.*, 2001], and U.S. Census Bureau road vectors. The ISA model was calibrated using eighty aerial photographs selected on urban-to-rural transects from thirteen cities in the USA.

Ground truth calibration data was derived from 80 high resolution (10 cm) color aerial photographs selected along development gradients from fourteen major urban centers. The aerial photographs were from year 2000 (+/- one year). Square kilometre tiles were extracted from the aerial photography, matching the coverage of specific cells in the reference grid. Gridded point counts were made on each photo tile to estimate the % ISA (see Figure 2).

The nighttime lights radiance, road density, and NLCD land cover values were paired to the % ISA values from the aerial photography. Linear regression was used to develop an empirical model for estimating % ISA from the lights, roads, and the three NCLD urban classes (Figure 3).

Our results (Figure 1) provide the first national map and inventory of ISA. The data will be useful to several science, conservation and resource management communities, including: 1) Water resource managers concerned with the impacts of ISA on water quality and the impacts of enhanced surface runoff on riparian and wetland vegetation. 2) The science and conservation communities concerned with human impacts on biodiversity, habitat loss, and habitat fragmentation, and 3) Regional to continental scale modellers of the hydrologic and climatic consequences associated with the continuing build up of ISA.

The USA is adding ISA at a rapid pace. Population is increasing at a rate of 3 million people per year. Public and private sector construction spending in the USA tops 480 billion dollars per year. This includes more than a million new single family homes and in excess of 10,000 miles of new roads per year. Given these trends, ISA is likely to become a more prominent environmental and growth management issue in the coming years.

Acknowledgments

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Yang, L., Huang, C., Homer, C.G., Wylie, B.K., Coan, M.J., An approach for mapping large-area impervious surfaces: synergistic use of Landsat-7 ETM+ and high spatial resolution imagery, *Canadian Journal of Remote Sensing*, 29, 230-240, 2003.

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For additional information contact Christopher D. Elvidge , NOAA National Geophysical Data Center, 325 Broadway, Boulder, Colorado 80303, USA. Email chris.elvidge@noaa.gov).

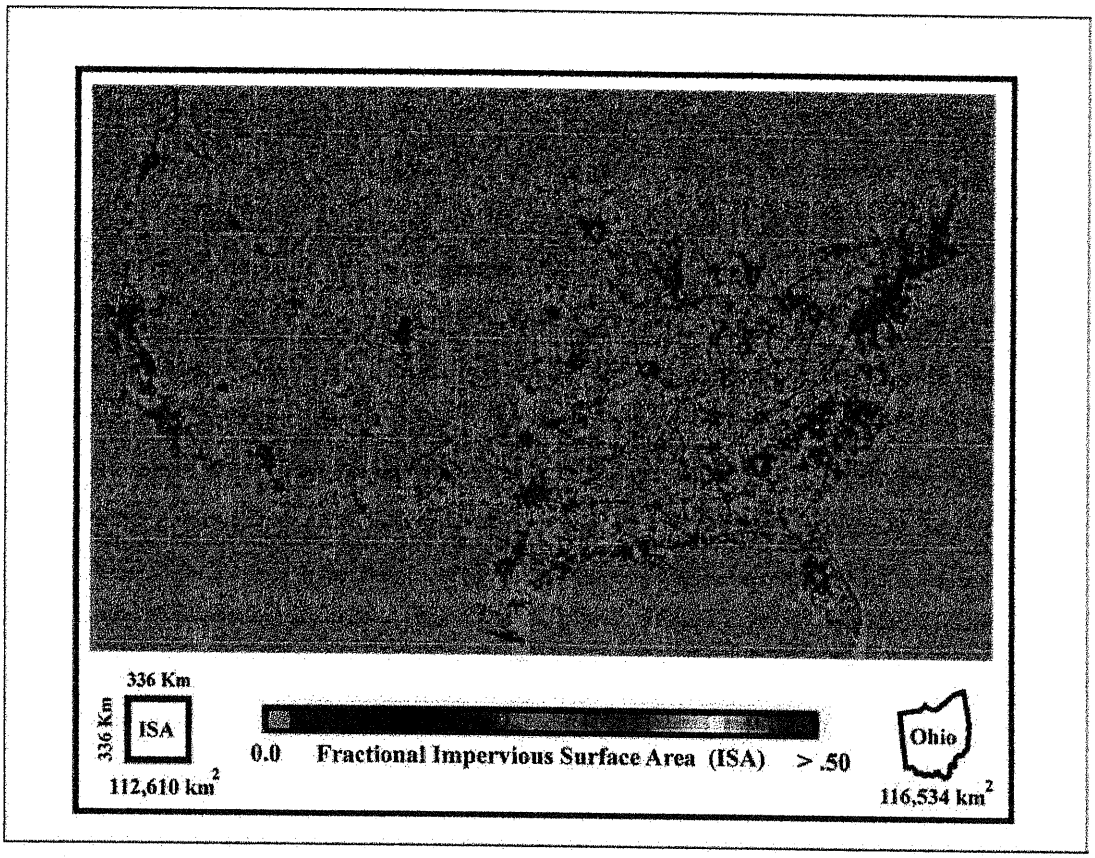

Figure 1. Spatial distribution and density of ISA for the conterminous United States. The aggregated area of ISA is nearly the size of the State of Ohio.

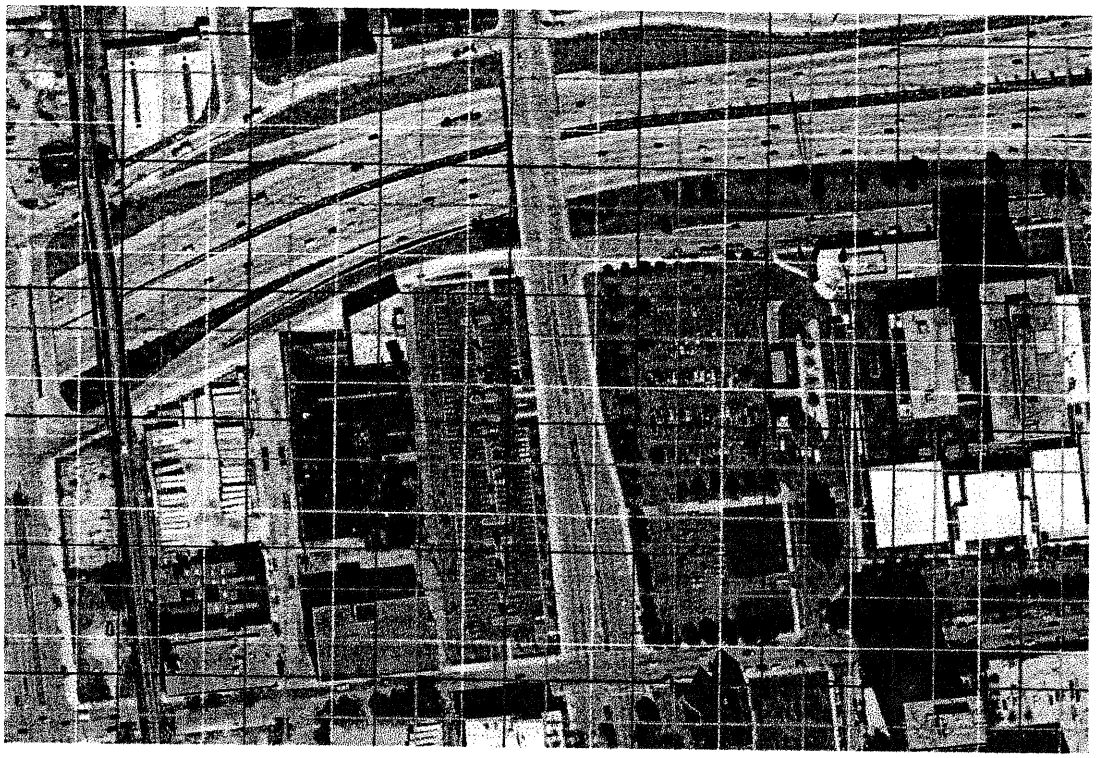

Figure 2. Gridded ISA point counts were made of 80 one-kilometer tiles of high-resolution aerial photography to provide calibration data for the ISA model.

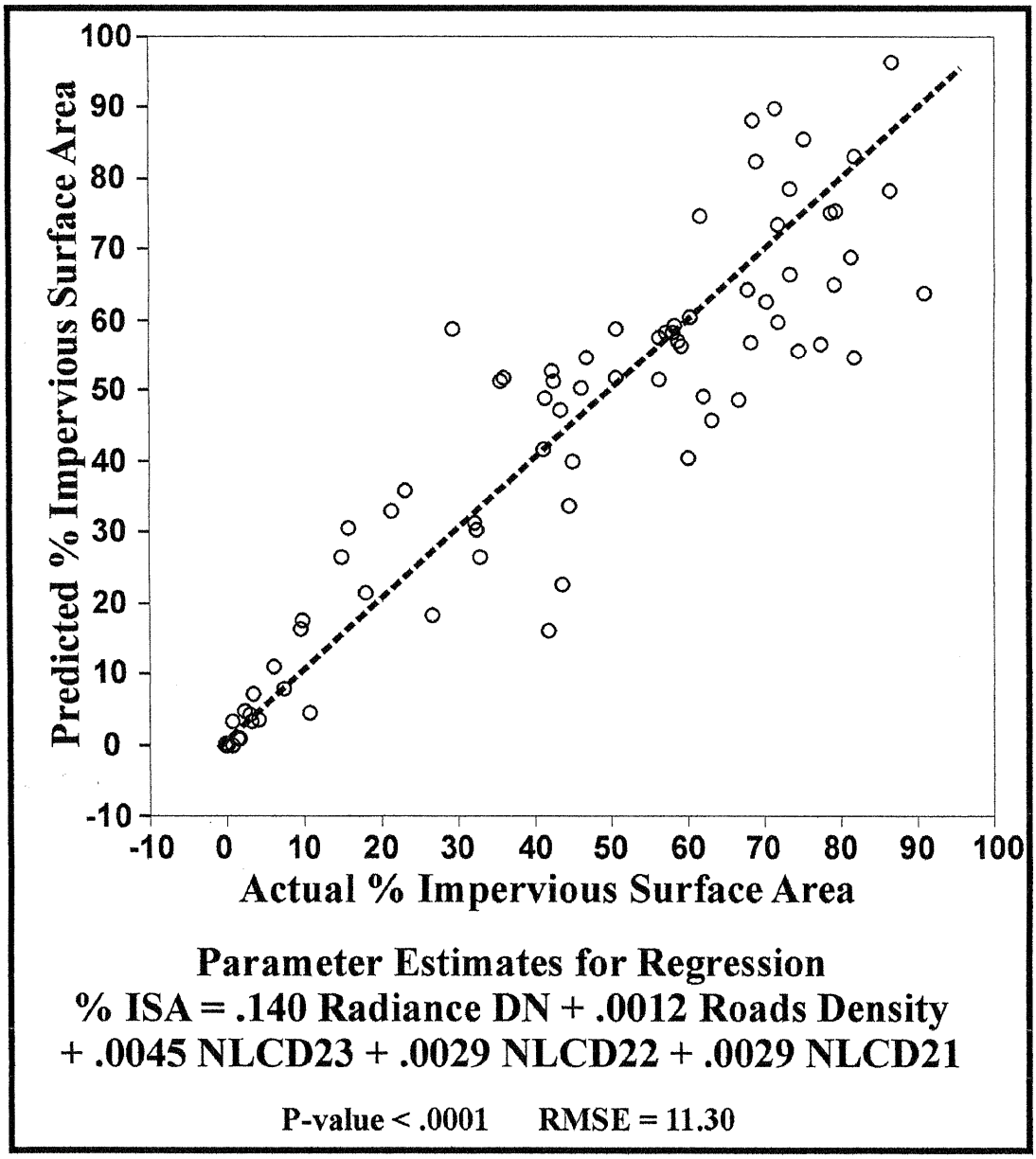

Figure 3. Linear regression used to generate a model for estimating the spatial distribution and density of ISA.

MEDIA ALERTS ARCHIVE

June 14, 2004

USA's Built-Up Surfaces Equal Ohio in Area

If all the highways, streets, buildings, parking lots and other solid structures in the 48 contiguous United States were pieced together like a giant jigsaw puzzle, they would almost cover the state of Ohio. That is the result of a study by Christopher Elvidge of the National Oceanic and Atmospheric Administration's National Geophysical Data Center in Boulder, Colorado, who along with colleagues from several universities and agencies produced the first national map and inventory of impervious surface areas (ISA) in the United States.

As calculated by the researchers, the total impervious surface area of the 48 states and District of Columbia is approximately 112,610 square kilometers (43,480 square miles), and, for comparison, the total area of the state of Ohio is 116,534 square kilometers (44,994 square miles).

The new map is important, because impervious surface areas affect the environment. The qualities of impervious materials that make them ideal for construction also create urban heat islands, by reducing heat transfer from Earth's surface to the atmosphere. The replacement of heavily vegetated areas by ISA reduces sequestration of carbon, which plants absorb from the atmosphere, Elvidge says in the 15 June issue of Eos, published by the American Geophysical Union. Both of these effects can play a role in climate change.

In watersheds, impervious surface areas alter the shape of stream channels, raise the water temperature, and sweep urban debris and pollutants into aquatic environments. These effects are measurable once ten percent of a watershed's surface area is covered by ISA, Elvidge writes. The consequences of increased ISA include fewer fish and fewer species of fish and aquatic insects, as well as a general degradation of wetlands and river valleys. The impervious surface area of the contiguous United States is already slightly larger than that of its wetlands, which is 98,460 square kilometers (38,020 square miles).

Elvidge notes that few areas have ISA maps, because they are difficult and expensive to create. He used a variety of data sources to produce the map accompanying his article, including nighttime lights observed by satellite, Landsat images, and data on roads from the U.S. Census Bureau, along with aerial photography. He anticipates that this map will be useful to scientists and planners managing conservation and resource allocation, as well as those working on issues of water quality, biodiversity, habitat loss and fragmentation, and climate change.

The population of the United States is increasing by three million persons annually, Elvidge writes. New impervious surface areas are rapidly covering vegetated surfaces, including one million new single family homes and 20,000 kilometers (10,000 miles) of new roads per year. Given these trends, he says, ISA will likely become a more prominent issue in coming years.

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Back to: News

Last Updated: Tuesday, 15 June, 2004, 12:30 GMT 13:30 UK

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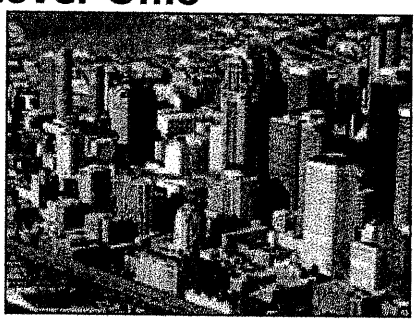
US concrete 'would cover Ohio'

If all the concrete structures in America's 48 contiguous states were added up, they would cover a space almost as big as Ohio, researchers say.



Excessive concrete cover is not good for the environment

Workers from several universities and agencies have put together the first ever map of the US, which shows "impervious surface areas" (ISA).

It is important to tot up concrete cover because of its harmful effect on the environment, the researchers claim.

The work was led by the National Oceanic and Atmospheric Administration.

Giant Jigsaw

If you made a giant jigsaw out of all the highways, streets, buildings, parking lots and other solid structures in the contiguous states, it would cover 112,610 sq km (43,480 sq miles). That is an area nearly the size of Ohio, which is 116,534 sq km (44,994 sq miles).

This is far more than a Christmas cracker statistic, the researchers claim, because concrete cover - or ISA - is not good for the environment.

The replacement of heavily vegetated areas by ISA reduces the depletion of carbon dioxide, which plants absorb from the atmosphere. This can speed up global warming.

ISAs can also alter the water cycle and disrupt aquatic ecosystems. They do this by changing the shape of stream channels, raising water temperatures and washing pollutants into aquatic environments.

Population growth

The ISA of the contiguous states is already slightly larger than that of its wetlands, which cover 98,460 sq km (38,020

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sq miles).

The population of the US is increasing by three million a year. Concrete cover is spreading to match.

Every year, one million new family homes are built and 20,000 km (10,000 miles) of roads are laid.

Given these trends, it is likely a lot more will be made of impervious surface areas in the future.

The research was part funded by the US space agency (Nasa).

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