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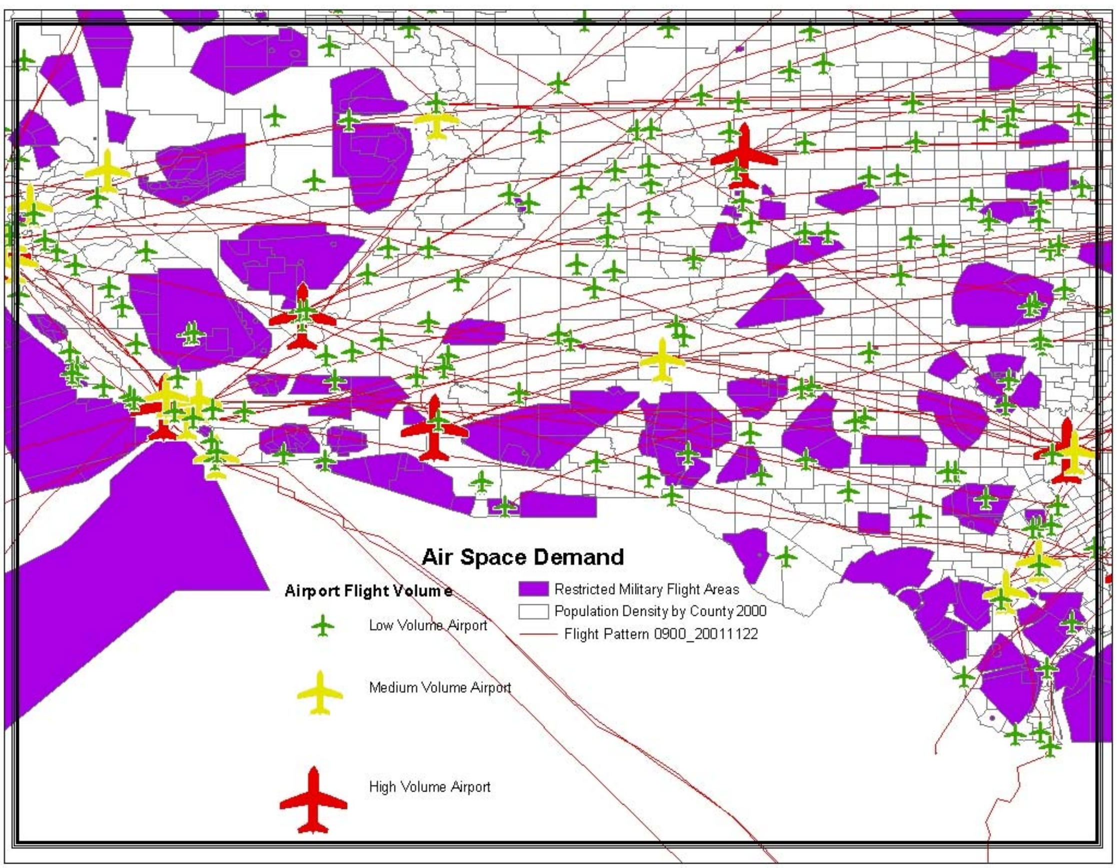
US Army Corps of Engineers®
Engineer Research and Development Center

The Sustainable Installation Regional Resource Assessment (SIRRA) Capability

Version 1

Elisabeth M. Jenicek, Donald F. Fournier, William D. Goran, Natalie R. Downs, and Adam Sagert

July 2004



Construction Engineering Research Laboratory

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Final Report

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ABSTRACT: Historically, many military installations had been isolated from urban development, thus creating protected havens for unique natural and cultural resources. That has changed over the last several decades. Population growth and urban development around military installations have left installations in the midst of large urbanized areas. A combination of "encroachment" factors create significant pressure to alter land use practices on military installations. The Department of Defense (DOD) must reconcile training and stationing issues with requirements to address multi-faceted encroachment issues, to comply with environmental regulations, and with its desire to act as a good steward of natural resources.

The U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) has initiated the Sustainability, Encroachment, and Room to Maneuver (SERM) program, which is developing new tools and approaches to help maintain the traditional and future operations planned for installations. These tools, data, and analyses support decisionmaking at national, regional, and local scales. The Sustainable Installations Regional Resource Assessment (SIRRA) methodology is one such tool. SIRRA begins initial assessment to define the salient issues that may impact installations now and in the future, thereby allowing decisionmaking within a broader and more informed context.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

Système International d'Unités ("International System of Measurement"), commonly known as the "metric system."

Preface

This study was conducted for the Office of the Chief of Engineers (OCE), Headquarters, U.S. Army Corps of Engineers (HQUSACE) under RDTE project T233FF, "FF Training Range sustainability"; Work Unit L74711, "FF Environmental Stewardship." The technical monitors were Michael Case and William Goran, Director of Special Projects, Construction Engineering Research Laboratory (CERL).

The concept of developing a regional resource assessment format that could be used to inform installation sustainability evolved from the Sustainability, Encroachment, and Room to Maneuver (SERM) Program at CERL. Mr. William Goran was instrumental in developing this program and providing funding necessary to complete the associated research. CERL investigators who contributed to this effort by developing and researching appropriate indicators were Heidi Howard, William Brown, Elisabeth Jenicek, Adam Sagert, Natalie Downs, Adam Hall, Mark Ginsburg, and Tomas Smith. Other contributors were George Xian of the U.S. Geological Survey and Donald Fournier of the University of Illinois.

The work was performed by the Energy Branch (CF-E) of the Facilities Division (CF) and the CF-N Branch of the CF Division, Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Elisabeth M. Jenicek. Thomas J. Hartranft is Chief, CF-E, Donald K. Hicks is Chief, CF-N, and L. Michael Golish is Chief, CF. The associated Technical Directors are Michael Case and William Goran. Part of this work was done by Donald Fournier of the University of Illinois at Urbana-Champaign under contract number DACA88-99-D-002, Delivery Order 0031. The technical editor was William J. Wolfe, Information Technology Laboratory. Donald Hicks is Chief, CEERD-CF-N, and Michael Golish is Chief, CEERD-CF. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN and the Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

The U.S. Department of Defense (DOD) is undergoing fundamental changes in capabilities to better support joint war fighting and operational objectives and to fulfill its obligations under the National Military Strategy (NMS). These changes in capabilities require stationing newly developed units and redefining the missions of existing ones. DOD installations—where we house our service members and their families, project and sustain the force, train and develop leaders, and acquire and maintain materiel to equip our forces and organizations—are necessarily part of the process. The units, their installation, and the locality must be a good "fit" for one another. Selecting the appropriate installation to station a unit is a complex decision that may carry unintended consequences. As the DOD transforms and modernizes to meet today's requirements, coincident changes have been occurring "outside the gate." It is not a static world. Societal changes, demographic shifts, and increasingly stringent environmental laws all affect the DOD's ability to effectively use its training lands and installations.

Historically, many military installations had been isolated from development, thus creating protected havens for unique natural and cultural resources. In essence, DOD land management practices and activities have served to protect and enhance the regional environment (Angello 2001). These isolated and remote installations had little residential or commercial development nearby and the public had little awareness of training activities. That has changed over the last several decades. The population and the amount of developed land around most U.S. cities (and consequently around military installations as well) have grown significantly.

Meanwhile, the DOD's ranges and training lands have remained undeveloped and insulated from the urban sprawl and development that has covered much of the landscape. This development has led to habitat destruction, leaving undeveloped ranges and training lands to become "islands of biodiversity." Their value as habitat and a natural resource base has steadily increased over time. Over time, population centers have expanded up to or near installation boundaries and, residential development has occurred in more remote areas and previously rural settings. Therefore, citizens have became more aware of training and range activities. Economic expansion, some of it probably driven by the installation's economic impact in the local area, has resulted in new suburban communities developing near military installations. The resulting effect is that military installations are now often in the midst of large urbanized or urbanizing areas. Military training activities produce noise (e.g., from the expenditure of munitions) and dust, (e.g., from air and ground activities), which can be perceived as a nuisance and annoyance to those who now live nearby. Training activities may also prevent access to land that is now the most pristine in the region.

The combination of factors—new environmental laws and nearby urban development—is now creating significant pressure to alter land use practices on military installations. These pressures are termed "encroachment," which is a general descriptor for the many pressures that limit the military use of land, air-, and sea-space (Van Antwerp 2001). DoD Senior Readiness Oversight Council (SROC) has identified eight categories of encroachment. While other valid encroachment concerns exist, the issue areas most likely to negatively affect readiness and the ability to station forces in the immediate future are:

- endangered species and critical habitat
- unexploded ordnance and munitions
- frequency encroachment
- maritime sustainability
- airspace restrictions
- air quality
- airborne noise
- urban growth.

Each encroachment issue becomes a threat to installation sustainability and/or a threat to stationing or mission sustainment. Most prominent among these are urban sprawl, threatened and endangered species (TES), and restrictions that impact use of munitions or other combat-related techniques such as obscurants. Military stationing and training land usage may also be affected by restrictions due to air quality standards, erosion control requirements, water quality standards, and restrictions on wetland impacts. The DOD has implemented programs to ensure compliance with environmental statutes and regulations, and that address these issues. Most major training installations have ranges designed and constructed specifically to meet the requirements of the forces assigned to that installation. Compliance actions have led to training capability curtailments at some installations. Management of endangered species causes restrictions on timing and location of training events. Large portions of some military ranges are unavailable during much of the year for such training activities as bombing, digging fighting positions, dismounted maneuver, occupying positions for combat, combat service support functions, and use of camouflage. As the number of listed plants and animals increases, the amount of land available for unmodified training activities may decrease further (Ellis 2001).

These restrictions reduce the military's flexibility to use its present land while the requirement for more maneuver space to exercise emerging weapons systems is growing. The DOD is limited in its ability to acquire new land. The costs and the general public's concerns about urbanization's effects on remaining natural and agricultural lands make acquisition problematic. Residential and commercial development on installation boundaries restricts land available for acquisition, causes competition for resources, and adds to the difficulty in providing undeveloped buffers around ranges and training areas.

The DOD must now reconcile its training and stationing issues with its requirement to address multi-faceted encroachment issues while complying with environmental regulations and fulfilling its desire to act as good stewards of the natural resources. Installation sustainability and mission sustainment are complementary where one relies on the other to make a complete whole. To enable this process, the U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) initiated the Sustainability, Encroachment, and Room to Maneuver (SERM) program. This program is developing new tools and approaches to help maintain the traditional and future operations planned for installations. These tools, data, and analyses support decisionmaking at national, regional, and local scales. Figure 1 illustrates the SERM analysis cycle.

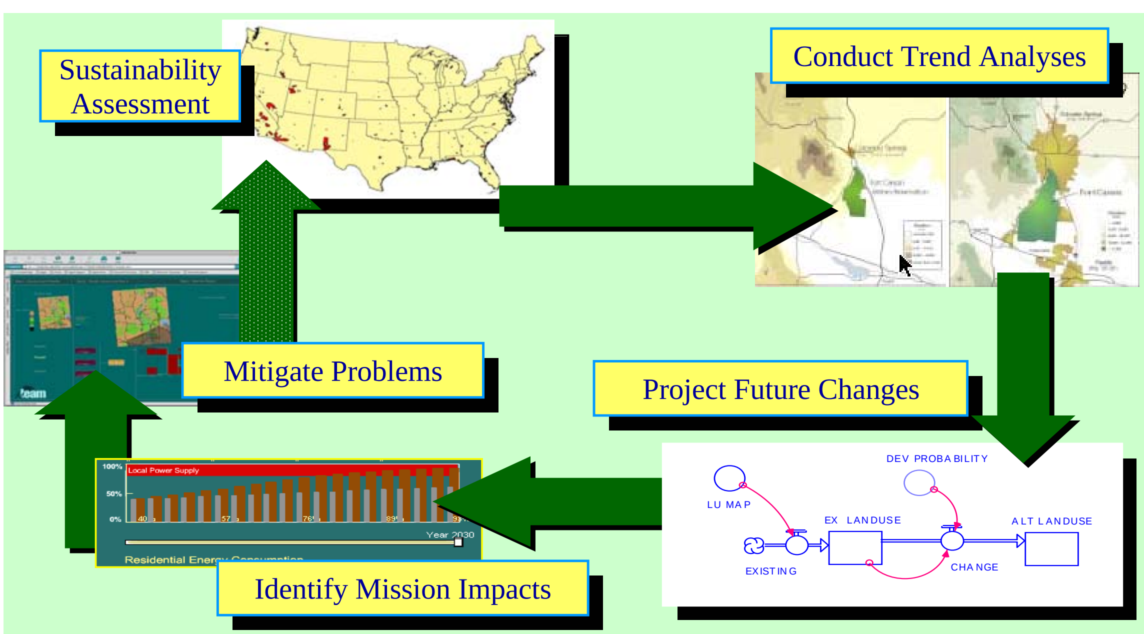

Figure 1. SERM analysis cycle.

The Sustainable Installations Regional Resource Assessment (SIRRA) methodology is the beginning of the cycle where an initial assessment is done to define the salient issues that may impact installations now and in the future. This allows decisionmaking within a broader and more informed context. This is especially true when considering the changes required under stationing and installation realignment actions. While installations may view encroachment issues as external threats, information on the extent of the regional threats can form the basis for opportunities to make informed decisions that develop and implement regional solutions that avoid considerable problems in the future.

Objective

The objective of this work was to review the issue of installation sustainability in the context of regional resource issues that may complicate the stationing of forces or the continued viable operation of military installations, and to formulate a SIRRA methodology that would include an initial assessment to define salient issues that impact installations now and in the future.

Approach

This research initiative is based on previous work at CERL in the area of encroachment and sustainability indicator development, under the Sustainability, Encroachment, and Room-to-Maneuver (SERM) which is part of the Fort Future initiative. As such, this work is a natural outgrowth of the SERM program; it represents an application of analysis techniques—developed in the SERM initiative—to stationing and installation realignment.

Stationing is a multi-faceted and complex issue requiring a careful and thoughtful approach that considers, not only installation assets and resources, but how that installation and mission fit into the surrounding region with its own demands and requirements for resources. How the region is developing and how resource requirements in the region are changing may impact an installation's capability to sustain the current and proposed missions. The methodology and framework used here are intended to respond to the issues changing urban dynamics in an integrated manner as part of an overall installation sustainability concept.

Mode of Technical Transfer

The information in this report is intended to be one of the many possible inputs into military decisionmaking for installation realignment, stationing, and management over the next few years. In addition, the information has relevance as baseline data for installation sustainability initiatives for any installation located within the United States. The data sets are nationwide in nature. The information described in this report is available on the internet at CERL's Fort Future web site.

2 Regional Resource Assessment

Planners for Department of Defense (DOD) installations face increasingly complex challenges, due to rapid land use changes, stakeholder involvement in planning processes, and rapidly changing Defense forces, technologies, and global circumstances. In response to these issues, the U.S. Army Corps of Engineers Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) in Champaign, IL initiated several projects that are included in a project grouping entitled Sustainability, Encroachment, and Room to Maneuver (SERM). These research efforts are all designed to provide tools, data, expertise and processes that help the DOD sustain and evolve mission operations, both military and civil works. The concept for SERM emerged from exploratory research initiated at CERL during the 1997-1998 timeframe. The purpose of SERM is to provide Defense planners with greater flexibility, greater ability to evaluate complex issues, and “the right information at the right time” to enhance their planning outcomes, while addressing current and future planning problems. The Sustainable Installations Regional Resource Assessment (SIRRA) is one of the projects under the SERM umbrella.

Regional resource assessment provides the opportunity to incorporate the broader perspective of regional issues into the concept of installation sustainability and its implications to mission sustainment. SIRRA is a process of characterizing installations based on a set of indicators grouped into several themes. SIRRA uses uniform assessments with a broad set of indicators covering the range of issues that may affect military installations and the locality in which they are located. The determined indicator(s) may be used to express the relative rating of installations based on single measures (or groups of measures) that define a theme. This standardized approach enables the use of national level data to evaluate the regional aspects of the installation setting. This provides a heightened awareness of long-term issues that could threaten mission sustainment. This methodology was first developed and presented in ERDC/CERL Technical Report (TR-02-27), *An Assessment of Encroachment Mitigation techniques for Army Lands* (Deal et al. 2002) and further developed in ERDC/CERL Special Report (SR-02-12) *Sustainable Installation Risk Assessment and Stationing Implications* (Fournier et al. 2002)

Regional Resource Assessment Framework and Metrics

Assessing installation sustainability is complex and requires the evaluation of a combination of indicators that are related to both exogenous and endogenous factors. These factors may not really lend themselves to prioritization, but present an indication of issues that may need to be addressed in installation planning and management. The effects of demographic change, community growth and sprawl, and regional economic vitality present levels of exogenous vulnerability that may be a threat to continued installation operation and mission sustainment. Issues associated with installation mission, management, and cultural and natural histories define endogenous risk. The framework developed here looks outside the installation and is based on exogenous indicators that could be determined with data sets available nationwide. Some indicators were deemed so critical that they were retained despite the lack of a national data set. Assessing levels of regional resource and environmental stress or demands entails developing a set of indicators or indices that can provide reliable information about the level and type of a given resource. The resource can vary from availability of clean water to the amount of air traffic congestion in the region, the latter being an indicator of air space resource availability.

Overview of Indicator Development

An "indicator" is a piece of information that reflects what is happening in a larger system. It allows observers to see the big picture by looking at a smaller part of it. Indicators are often quantitative measures such as physical or economic data. For example, traditional indicators such as inflation and unemployment rates are used for making economic decisions. Indicators are widely used as a tool for monitoring progress and to simplify, quantify, and communicate complex issues. Multiple indicators are sometimes aggregated into an index, usually for comparison across locations or to show change over time. Indicators are often used as the feedback mechanism to inform policy changes intended to improve the situation being measured. Their intent in the SERM analysis cycle is to provide the baseline information about the region in which the installation resides and to illuminate key issues that may be a current or future threat to mission sustainment or mission realignments. These provide the starting point for regional planning and impact amelioration. Because the process of measuring focuses attention on the impact, it makes a great deal of difference what is measured and how it relates to what we wish to measure. Developing indicators is a six-step process (Maclaren 1996):

1. Define and conceptualize the goals for which indicators are needed.
2. Identify the target audience, the associated purpose for which indicators will be used, and the relative number of indicators needed.

3. Choose an appropriate indicator framework.
4. Define indicator selection criteria.
5. Identify a set of potential indicators and evaluate them against the selection criteria.
6. Choose a final set of indicators and test their effectiveness.

As noted above, the goal of the indicators is to define and highlight regional issues that may define current or future encroachment and resource issues. The encroachment and mission sustainment issue areas have been defined by the SROC above. The target audience for the indicators and the regional resource assessment are decisionmakers and planners who need broadly based information to inform their processes of determining future stationing, base realignments, and installation sustainability actions.

A framework for developing a set of indicators is necessary for every indicator effort. Maclaren's recommended frameworks are goal-based, domain-based, issue-based, sectoral, and causal. They may also be combinations of two frameworks. A goal-based framework is predicated on the development of goals. Indicators or indices are then created to measure progress for each goal. A benefit of this framework is that there are fewer indicators. A weakness is that it doesn't capture linkages among the dimensions of the issue. A domain-based framework is based on the key dimensions or themes of the issue like environment, economy, and society. Indicators are identified for each theme. This framework is effective at ensuring that the key dimensions or themes of the issue are covered. A weakness of this framework is that indicators are not linked to goals. An issue-based framework is based on definable issues such as sprawl, crime, industrial pollution, solid waste management, or encroachment. Sectoral-based indicators are defined by different sectors in the economy. Causal-based indicators are developed within a framework of conditions, stresses, and responses using composite indicators for each condition based on a set of stressors. Relief of the stresses points to the solution for the stress or risk.

The difficulty in selecting indicators is not a lack of measures, but rather the overwhelming number of potentially useful indicators. The International Institute for Sustainable Development (2000) selected the following criteria based on indicator literature and practical experience with performance measurement:

- *Relevance*. Can the indicator be associated with one or several issues around which key policies are formulated? The indicator must be linked to critical decisions and policies.
- *Simplicity*. Can the information be presented in an easily understandable, appealing way to the target audience? Complex issues and calculations should yield clearly presentable and understandable information.

- *Validity*. Is the indicator a true reflection of the facts? Was the data collected using scientifically defensible measurement techniques? Is the indicator verifiable and reproducible? Methodological rigor is needed to make the data credible.
- *Temporality*. Is time-series data available, reflecting the trend of the indicator over time? Several data points are needed to visualize the direction the community or region may be going in the near future.
- *Measurability*. Is the data quantifiable—something that can be measured directly or can be counted? Data must be based on tangible information.
- *Availability and Affordability of Data*. Is good quality data available at a reasonable cost or is it feasible to initiate a monitoring process that will make it available in the future?
- *Expansiveness.* Is the indicator about a narrow or broad issue? Indicators that aggregate information on broader issues are preferred. For example, forest canopy temperature is a useful indicator of forest health and is preferable to measuring other indicators to come to the same conclusion.
- *Sensitivity*. Can the indicator detect a small change in the system? Determine whether small or large changes are relevant for monitoring.
- *Reliability*. Will you arrive at the same result if you make two or more measurements of the same indicator? Others should reach the same conclusions based on the indicator.

Sustainable Installations Regional Resource Assessment Framework

CERL developed a SIRRA framework that addresses many aspects of installation sustainability from a regional perspective. The regional resource assessment framework of sustainability issues and indicators is shown in Figure 1 (p 3). Each indicator measures a different dimension of potential vulnerability or stress. Comparison among installations of values for an individual indicator can give a measure of relative stress along one dimension. Each issue has several indicators and sometimes a combination of several indicators, or indices.

In addition to CERL indicator development, the U.S. Army Environmental Center (USAEC) developed the Environmental Regulatory Climate Model (ERCM). The ERCM is an indicator-based model used to assess demographic and environmental conditions.

Issue		
	Indicator	Data
	Indicator	Data
	Indicator	Data
Issue		
	Indicator	Data
	Indicator	Data
	Indicator	Data
	Indicator	Data

Figure 2. Regional resource assessment framework.

The model supports the Office of the Deputy Chief of Staff for Operations and Plans, (DAMO-TR), Headquarters, Department of the Army, in that office's task to analyze the relative training value of a variety of Army installations. That effort is known as the Installation Training Capacity (ITC) and is used to determine the relative capability of installations' to support live training by Active and Reserve Component units stationed at, or habitually training on, those installations, as well as live training requirements of Service Schools on those installations. ITC focuses on land, ranges, training facilities, and demographic/ environmental factors affecting training. The study does not consider other installation capabilities such as cantonment area facilities, infrastructure, housing, etc. The ERCM is a process to identify and evaluate:

- environmental issues that impact training
- encroachment issues that impact training
- impact of costs to maintain land for training
- environmental ability of the land to support and sustain training
- capability of the installation to expand or reconfigure to support training.

The ERCM Methodology is more fully described on the USAEC website at URL:

http://aec.army.mil/usaec/range/sustainment02.html

The ERCM Methodology is a coordinated effort with USAEC, major Army commands, and the Installation Management Agency. USAEC refines the methodology annually to ensure accuracy of information and pertinence of the criteria. ERCM has been combined with CERL's exogenous indicator framework to develop a list of environmental factors to consider prior to stationing of forces (Tomich 2002). ITC and SERM complement one another and provide independent approaches to similar issues.

The SIRRA research team developed a set of regional resource sustainability indicators based on the process, framework, and criteria considerations described above. To help determine installation sustainability, the indicators are a combination of issue-based and domain-based, which are called "themes." Using a combination framework has the advantage of being able to draw on the strengths of the two frameworks while downplaying their weaknesses (Maclaren 1996). This framework enables a relatively easy assessment of the potential resource issues in a region and highlights the issues within that region that an installation may be experiencing. The indicators show where the issues lie and highlight potential long-term sustainability implications.

Installation Sustainability Themes

The selected themes are based on regional resource concerns outside the installation boundaries. The associated indicators are determined using primarily national data sources. Community growth increases the contiguity between outside development and the installation. This contiguity increases the likelihood of incompatibility of land use between military activities and nearby urban development that results in conflicts. Given sufficient community size and proximity, the installation becomes an unintended growth limiter for the community. Water and energy resources are impacted by regional growth and related consumption and contamination. Regional types of energy use and their sources affect energy security and availability.

Based on the criteria and issues, the research team developed a set of 10 themes with a total of 48 indicators. The sustainability themes are: air, energy, urban development, threatened and endangered species (TES), location, water, economics, quality of life, infrastructure, and security.

SIRRA Indicators

Potential indicators for measuring regional resources within the 10 themes were selected based on the following data requirements:

- available at a uniform scale nationwide to ensure consistency in comparisons.
- recorded for multiple time periods to enable the evaluation of change.
- prepared by a reputable source, such as a government agency or professional data vendor, and accompanied by metadata for quality assurance.
- provided in a digital format, to accelerate data gathering and preparation for analysis.
- able to be converted to GIS format.

The 10 themes with their corresponding indicators represent a broad spectrum of issues related to resource availability and development. The 48 indicators provide a wide variety of information about population issues, economics, land development and usage, watershed quality and quantity, health, natural disasters, infrastructure, air pollution, regional energy, and regional quality of life. Indicators come from a variety of sources such as the U.S. Geological Survey for water resource information, the U.S. Environmental Protection Agency (EPA) for air pollution data and water supply characterization, the U.S. Census Bureau for population statistics, and the U.S. Department of Energy for energy related data. The SIRRA framework provides for a multiplicity of views or aggregations of the data collected. The national data sets are provided at the lowest practicable geographic resolution and can be parsed and aggregated into varying categorical constructs to provide a more coherent understanding of the issues related to a specified set of policies or decisions at a given installation or set of installations in one or more regions of the nation. This enables a more focused view of the implications associated with specific objective questions. Appendix A gives the details for each indicator and provides the logic for each indicator, along with data sources, method of calculation, and assessment criteria.

Since most of these are national data sets and were chosen due to the availability of national data, mapping provides a ready pictorial view of the sustainability issues. Table 1 lists the SIRRA indicators broken out by theme. Also shown are the data source and the data level.

Regional Resource Assessment Indicators Not Used

Several indicators were evaluated but not used in the final SIRRA format. It was decided that they did not lend themselves to national data set, that they were not of the type that varied regionally, or that data was not readily available. The first of these is Frequency Encroachment. Other indicators that were evaluated and not used were greenhouse gases, surface or ground water usage, sole-source aquifer, proximity to 100-year flood plain, and stakeholders.

Frequency Encroachment

Overview

Frequency encroachment can viewed from one of two perspectives: national and local. The national view is that the DOD spectrum has been, and will continue to be eroded by commercial demand. Major spectrum reallocations were conducted in 1994 and 1997 and more are under study. The local view focuses on individual field sites where demand for realistic training, test-range telemetry, and force-on-force training can exhaust spectrum allocation. Especially at test and training ranges, it is now common practice for the military to periodically borrow RF spectrum allocation from various neighbors. These neighbors may be Federal, state, local, or private entities.

Table 1. List of SIRRA indicators.

Theme		Indicator	Data Source	Data Level
Air Sustainability				
	A1	Criteria Pollutant Non-Attainment	EPA/EIA	county
	A2	Noise Complaints	ISR - annual	installation
Energy Sustainability				
	EN1	Electrical Source (Grid generation)	EPA E-GRID	State
	EN2	NAG Price Variability	EIA: state pages	State
	EN3	Petroleum Price Variability	EIA	State
	EN4	State Natural Gas Imports	EIA	State
	EN5	State Petroleum Imports	EIA	State
	EN6	Electrical Price Structure (Dereg)	EIA	State
Urban Development				
	UD1	Regional Population Density	USCB - 10 yrs	County
	UD2	Incr. Regional Growth Rate	USCB - 10 yrs	County
	UD3	Regional Population Growth	USCB - 10 yrs	County
	UD4	Regional Land Urbanization	NLCD - 5 yrs	County
	UD5	State Smart Growth Plans	APA web site	State
	UD6	Joint Land Use Study (JLUS)	DOD	Installation
TES Sustainability				
	TE1	TES Species Listed	USAEC - annual	Installation
	TE2	Ecological Resiliency	CEMML	Installation
	TE3	Critical Habitat	USAEC - annual	Installation
	TE4	# TES on Inst/# in Ecoregion	USAEC - annual	Installation
Locational Sustainability				
	L1	Federally Declared Floods	FEMA database	County
	L2	Seismicity	USGS maps	Zone
	L3	Weather-related Damage	NWS/NOAA - annual	State
	L4	Federally Declared Disasters	FEMA database	County
Water Sustainability				
	W1	Level of Development	JAWRA	Watershed
	W2	Ground Water Depletion	JAWRA	Watershed
	W3	Flood Risk	JAWRA	Watershed
	W4	Low Flow Sensitivity	JAWRA	Watershed
	W5	Watershed Species at Risk	JAWRA	Watershed
	W6	Water Quality	EPA IWI	Watershed
Economic Sustainability				
	EC1	DoD Local Employment	www.bea.gov (REIS)	County
	EC2	Job Availability/Unemployment	USCB & BLS - 10 yrs	County
	EC3	Housing Affordability	USCB - 10 yrs	County
	EC4	Poverty Rate	USCB - 10 yrs	County
QOL Sustainability				
	QL1	Crime Rate	Natl Arch of Criminal Justice Data	County
	QL2	Housing Availability	USCB - 10 yrs	County
	QL3	Rental Availability	USCB - 10 yrs	County
	QL4	Healthcare Availability	Bureau of Primary Healthcare	County
	QL5	Educational Attainment	USCB - 10 yrs	County
	QL6	Commute Times	USCB - 10 yrs	county
Infrastructure Sustainability				
	TA1	Capacity of Commercial Airports	TAF System	State
	TA2	Airport Suitability-C5	FAA	Installation
	TA3	Airport Suitability-C141	FAA	Installation
	TRR1	Railroad Capacity	FRA	County
	TR1	Proximity to Interstate	IRRIS	Installation
	TR2	Roadway Congestion	2002 Urban Mobility & FHWA	MSA
	TR3	Traffic Volume	TTI & FHWA	State
Security				
	AS1	Air Space Demand	FAA	Installation
	ES1	Net Metering	Green Power network	State
	LS1	Proximity to MSA	GIS	County

Like the problem itself, any index measuring frequency encroachment at a particular installation should have national and local components. Frequency-allocation is carried out on a nationwide basis and applies to all installations. Many installations are located near metropolitan statistical areas (MSAs). This proximity greatly increases the probability that an installation may need to borrow band privileges from a neighbor. Therefore, the risk to mission sustainability from RF encroachment is roughly proportional to an installation's proximity to MSA (as shown in indicator SP1 under the Security Theme). On the other hand, local information is considered classified because it implicitly reveals detailed information on testing and training operations. Consequently local frequency encroachment data are unavailable for the purposes of this report.

Therefore, for the purposes of this report, frequency-encroachment is considered to be largely redundant with SP1—Proximity to MSA. If more local information becomes available, this could change.

The National View

Consumer demand for new technology requiring wireless networks is growing rapidly. Applications include: wireless internet access, wireless private networks, and wireless telephones. This demand has already precipitated two different rounds of spectrum reallocation in 1994 and in 1997 (Hunt et al. 1995), (Edward et al. 1998). Additional reallocations are under study (NTIA 2003).

Moreover, consumer demand for spectrum will not stop growing anytime soon. Recent mathematical analysis of the scaling laws governing the capacity of wireless networks indicates that the demand for network access can easily exhaust the capacity of the RF spectrum (Gupta and Kumar 2000).

Meanwhile, the military's demand for spectrum is also increasing. Various modernization plans, including the Army's "Objective Force," plan using RF spectrum to: decrease the logistical footprint, decrease tactical decision cycle times, implement indirect fire control, and augment current intelligence gathering systems with large arrays of autonomous sensors (Latham 2000).

Although it is relatively easy to model RF spectrum allocation, the current methods used by the FCC (and others) are formulated on a nationwide basis. Hence, overlaying this data on top of an existing GIS system is, for the moment, impractical since all of DOD's allocation is nationwide, the data does not vary by geographic position. The concept of allocations varying from point to point geographically is still in its infancy. A more detailed explanation of RF spectrum allocation is contained in the "Report of the Army Science Board on DOD Spectrum Issues" (ASB 2000).

The Local View

Still, there is no spatial variability in the Army's spectrum demand. Mission requirements vary from location to location. Indeed three principle circumstances in which the Army uses frequencies not allocated to it are: test range telemetry, force-on-force training, and training with foreign-made RF equipment.

Test range telemetry

Here, Congress has made the Army's mission increasingly difficult, if only temporarily. Frequencies in the 2300 kHz satellite band have been sold to the commercial sector. A portion of the proceeds from the sale was supposed to be earmarked for modifying or updating the Army's equipment to use other frequencies. The Army continues to use these bands on a non-interference basis, but the money for equipment upgrade has not yet been allocated (ARSIC 2003).

Force-on-force training

Bandwidth crowding becomes particularly acute during force-on-force training, where spectrum demand suddenly becomes twice what it normally is. In selected instances, the military has used "family band radio" equipment to augment its own capabilities during training exercises.

Training with foreign-made RF equipment

Anti-aircraft devices developed by foreign governments may use frequencies not allocated to the U.S. government domestically. However, in the run-up to an actual conflict, there is a legitimate requirement to keep training as realistic as possible. Training against such foreign-made equipment requires the local installation to borrow time from a neighbor (which may be Federal, state, local, amateur, etc.) that holds primary band privileges. This can be done either through direct coordination, or by placing simulant equipment in areas that do not cause interference for the primary user.

Band coordination has been accomplished using two principal mechanisms. First, to eliminate interference from range to range, the DOD has a computer server for "Inter Area Spectrum Coordination." This allows all DOD band managers to coordinate frequency use with one another. Second, all coordination with users of other bands (Federal, state, local, civilian and scientific) has been accomplished via telephone and e-mail on a case-by-case basis. More formal methods of coordination have been difficult to implement because of DOD's sensitivity to implicitly giving out schedule information.

Capturing this data in GIS format

Because the data that can be captured in a GIS format is classified, the most reasonable alternative is to use proximity to MSA as a surrogate. For a local spectrum manager, this number should correlate with the number of neighbors contending for RF resources.

Other Indicators Not Used

Other indicators that were evaluated and not used were greenhouse gases, surface vs. ground water usage, proximity to 100-year flood plain, use of sole-source aquifer, and stakeholders. It was decided not to use greenhouse gas emissions on a state-by-state basis because this is a national issue and individual areas or regions are not currently being penalized or restricted due to these types of emissions. We chose not use ground and surface water consumption data because the issues associated with water resources and vulnerability are well covered by the indicators that were included in the assessment framework. Also the data does not lend itself to GIS format and is better suited for a narrower look at regional resources. The data on the 100-year flood plain is in the process of being updated; approximately 30 percent of the revised maps are available digitally. This indicator will be added when all maps are updated. Sole-source aquifer data was not used because of difficulties in obtaining the data. Efforts to obtain and map this data will continue because of the importance of this indicator.

3 Results and Implications for Sample Indicators

SIRRA data sets were obtained at differing geographic resolutions. The associated geographic units are based on the level that data was collected or compiled by the source. Some indicators are at the state level, some at the county level, and some are unique to the indicator. A few indicators contain data on the installation basis when national data sets were not available. National maps of each indicator were created using Arc GIS. The maps depict sustainability ratings of red, amber, or green. These ratings were based on regulatory values, statistical analysis, or assigning of ratings after review of relevant literature. The rationale for these values is explained in Appendix A, which includes the information on each indicator. Examples follow.

Electrical Price Structure (EN6)

The price structure for electricity demand and delivery indicates whether the commodity has been deregulated and is thus more susceptible to market distortion such as price instability and availability fluctuations. This indicator will affect the availability and price of electricity to a military installation, and is thus highly sought after as an energy sustainability indicator. Figure 3 shows a national map for electrical price structure showing regional variations. The default sustainability ratings are:

- *Red* = no deregulation
- *Amber* = delayed/suspended
- *Green* = active.

Educational Attainment (QL5)

Educational attainment is a county level indicator showing the high school graduation rates. It is assumed that the percentage of the population with a high school diploma or higher is an indicator of societal support for education (including the parental and community support). With strong support, it is then assumed the educational system will be strong and have a large amount of resources put into it.

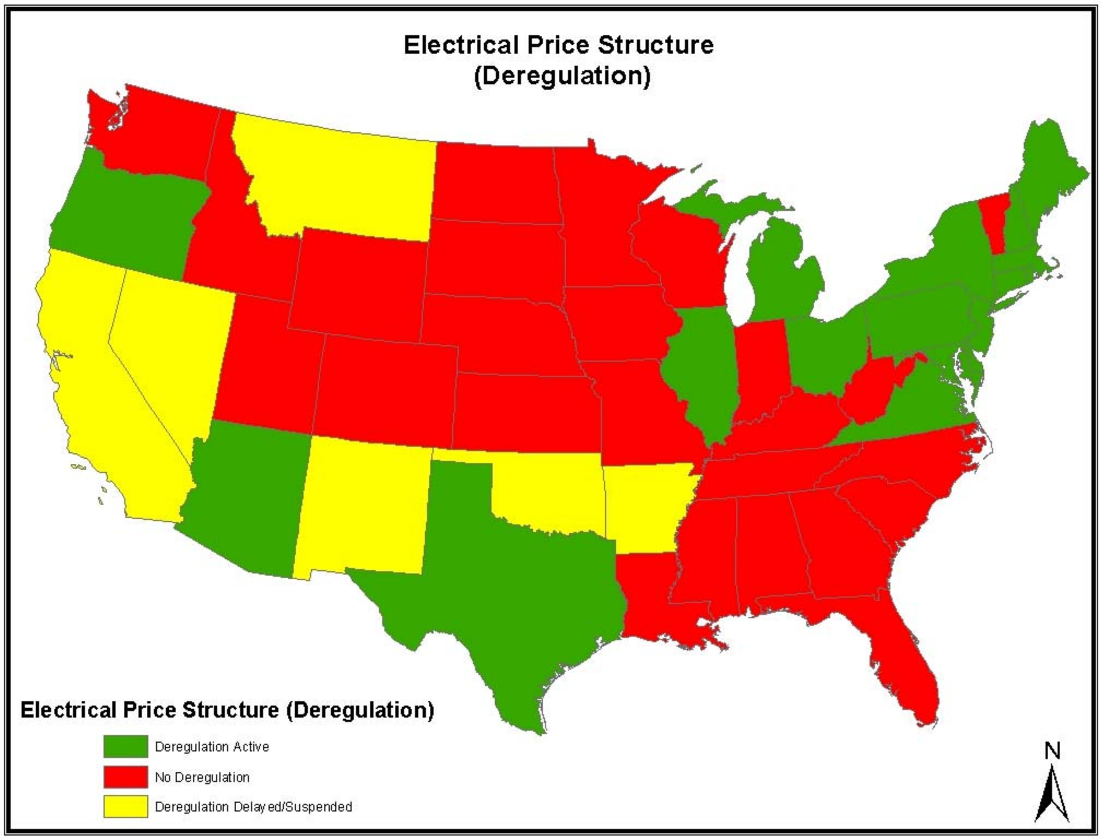

Figure 3. Electrical price deregulation map.

The sample is assumed to be relatively normal. Therefore, the national average of 76.1 percent was used to figure class breaks. Figure 4 shows the national map for educational attainment. Note the regional variations. The breaks for assessment levels are defined as follows:

- *Red* = less than 76.1 percent (national average or lower)
- *Amber* = 76.2 – 82.7 percent (within 0.5 standard deviation above the national average)
- *Green* = 82.8 – 100 percent (greater than 0.5 standard deviation above the national average).

Ground Water Depletion (W2)

The indicator for ground water depletion is a watershed level indicator showing the level of groundwater withdrawal in the large watersheds of the continental United States. Groundwater depletion characterizes the extent to which rates of groundwater withdrawals exceed long-run average recharge rates, resulting in overdraft and a condition referred to as “groundwater mining.”

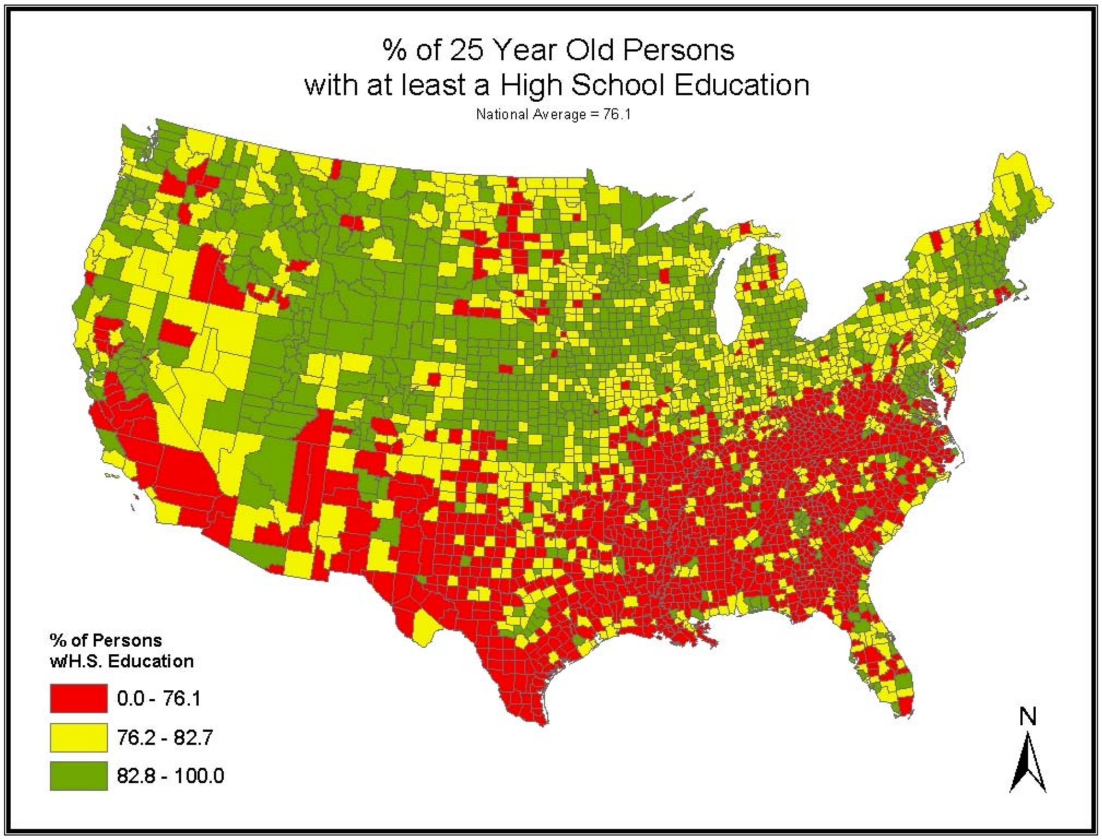

Figure 4. Educational attainment national map.

Ranges were defined as the ratio of average groundwater withdrawals (Q_{GW}) in 1990 to annual average baseflow (Q_{Base}), reflecting the extent that groundwater use rates may be exceeding recharge. The groundwater depletion ratings were grouped into the following classifications based on definitions created by the EPA. The assessments are assigned as follows:

- *Red* = greater than 25 percent
- *Amber* = 8 to 25 percent
- *Green* = less than 8 percent.

Figure 4 shows the national map for ground water depletion.

Seismic Zones (L2)

The indicator for seismic zone is a unique level indicator showing the potential level of earthquake vulnerability around the nation. Earthquakes are a threat to both built structures and human health and safety. Thus, the military must be sensitive to potential threats from the natural environment. Figure 5 shows the national map for seismic zones.

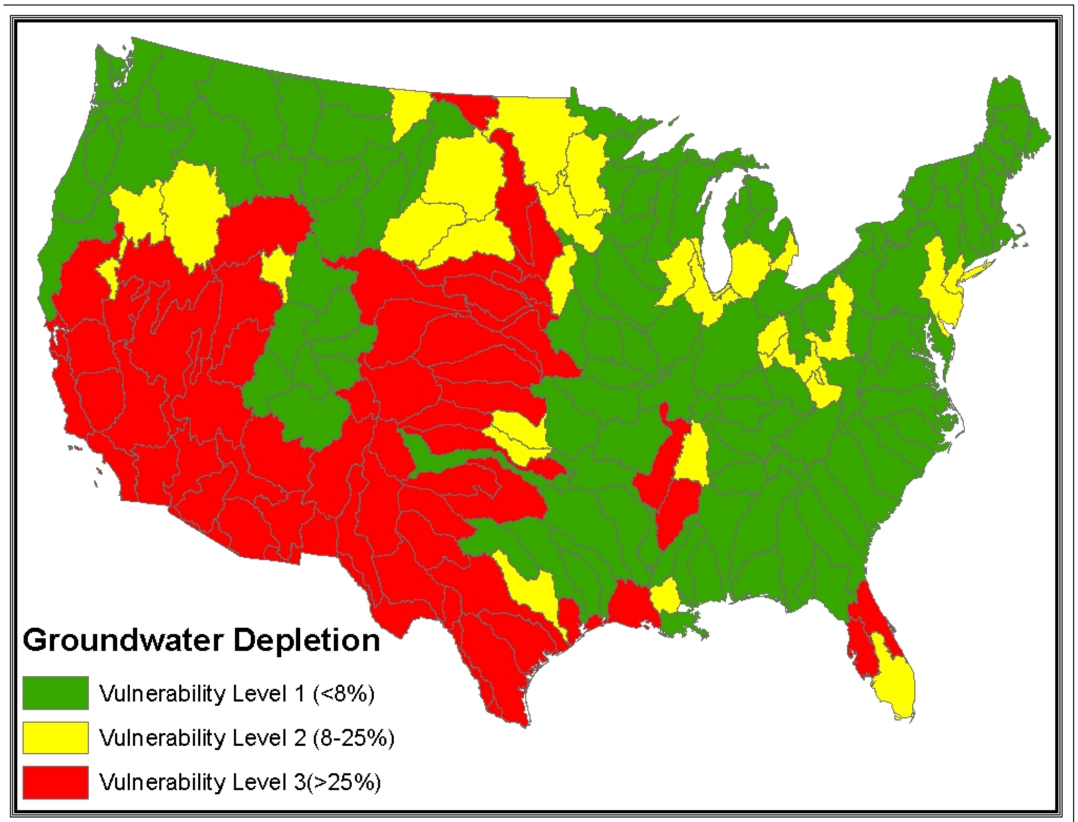

Figure 5. Ground water depletion national map.

The assessments are assigned as follows:

- *Green* = less than 8 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years
- *Amber* = 8-16 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years
- *Red* = greater than 16 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years

Comments on Data

These assessment results are not definitive. They indicate potential areas where problems could arise. The SIRRA format is intended to provide information about potential areas of stress and to inform policy decisions that relate to ameliorating that stress. Since all of the information for indicator calculations was derived from national data, some of the indicators are several years old. It takes time for these data sets to be assembled and some change only after several years, or even once a decade. In all cases, the most recent data available were used. In general, the types of data used do not change rapidly and the trends indicated are valid.

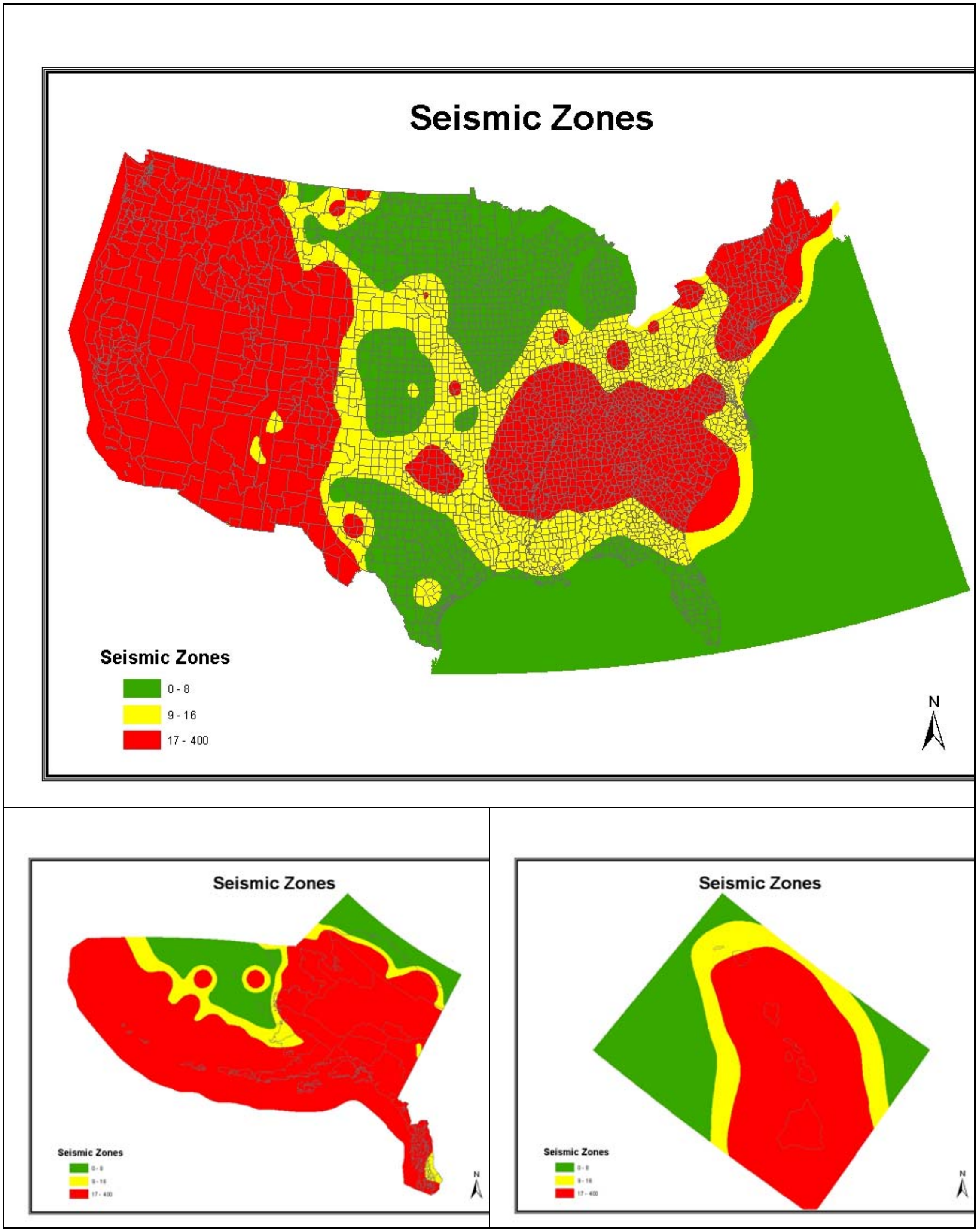

Figure 6. Seismic zones national map.

4 SIRRA Web-Based Analysis Tool

The SIRRA Web-based Analysis Tool makes available the complete 48-indicator SIRRA Database along with a family of grouping and reporting capabilities. Users may view data and criteria that enable a complete understanding of the sourcing, scale, logic, measure, limitation, and implications of the information in the database. The web tool uses commercial off-the-shelf software and provides views of the spatial expression of this data, and will facilitate spatial queries and sorts of the installation and indicator data.

The complete data set for SIRRA has been compiled, analyzed, and included on the web site. The Web Interface includes tools for grouping and filtering data and for generating reports. More detailed grouping and reporting functions will be added at a later date as more of the SIRRA-related research becomes available. At present, only about half the functionality of the final interactive tool has currently been implemented.

Attribution information that identifies the source, year, and variables of material is currently available through the metadata report for each indicator, which is available through the web tool. At this stage of the interface development, the metadata reports are the key source to help the user navigate through national assessment material. Figure 6 shows an example indicator map.

Data Grouping

The web tool contains a filtering function to support the needs of many different user groups. Installations can be sorted by DOD service, function, and agency organizational element. The DOD services included in SIRRA are Army, Air Force, Navy, and Marine Corps. Functional categories will include Major Commands. Future sorting categories will include state, region, ecoregion, and watershed.

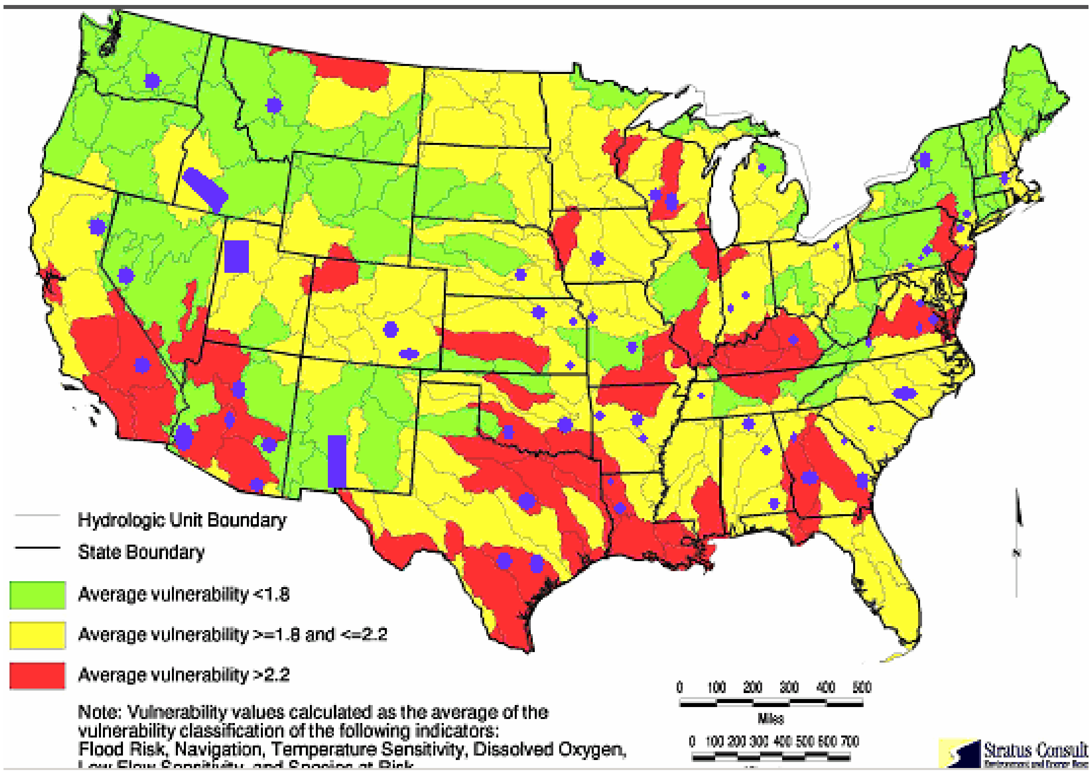

Figure 7. Sample water quality indicator on SIRRA web access.

Reports

The web tool allows users to view and generate data and reports. Users can view and print data presented in the table and map view. A prototype report function contains an indicator level report. Users can also view and print metadata for each indicator. Tables report the database entry along with its assigned rating and the defined rating scale. These are tabular reports that list the elements specified by a user. Maps give a spatial display of data coded with the assessment rating legend. The user can zoom in on an installation or view the entire United States for one indicator.

The prototype report allows a user to obtain indicator data and ratings for one indicator. This can include every installation in the web tool or just one DoD branch, such as all Army installations. The report can either be opened for immediate viewing or saved as a file. Both versions of the report are portable document format (pdf) files. Figure 7 shows a sample report.

SIRRA Installation Report Mon Feb 23 10:21:36 CST 2004

SIRRA Installation Report

This is an installation report generated by the SIRRA project. The report presents a list of installations along with the value of a single sustainability indicator for each installation. The values for some installations are weighted averages from multiple data sources. In this case, the value displayed for that installation is the weighted average. The values for each component used to generate the average, along with the component's weight, are then listed below the installation and indented. Note that due to rounding, component percentages may not add up to one hundred percent.

The sustainability indicator presented in this report is "Criteria Pollutant Non-Attainment." It is given in units of "num. violations."

Only Army facilities are listed in this report.

Installation Name	Criteria Pollutant Non-Attainment
Badger Army Ammunition Plant	0
Camp Parks	3.000
Alameda County (82%)	3
Contra Costa County (18%)	3
Camp Williams State Military R	3.000
Salt Lake County (96%)	3
Utah County (4%)	3

Figure 8. Sample report showing indicator data and ratings for one indicator.

Metadata

Metadata reports are available for each of the 48 indicators. Each report shows the variables, scale, year, data sources, logic, limitations, replicability, and assessment rating measure of the data. These reports identify the cause of an unsatisfactory rating on a specific element, or the performance of a group of elements. Figure 8 shows a sample metadata report.

We are continuing to enhance and test all the technologies and products mentioned in this document with various new types of data and presentation. As with all new products, they may contain certain deficiencies that we have not yet found, but we feel they are robust enough for early adopters and others to try.

Web Access Security

The web-based analysis tool has been developed and used to inform decisions and policies related to installation stationing and mission sustainment. Although the information in the system is not classified, when compiled, it may be considered sensitive by some users.

Sustainability Issue: Air
Indicator: Criteria Pollutant Non-Attainment
Variables: Six Principal Air Pollutants (also referred to as criteria pollutants): Nitrogen Dioxide (NO2), Ozone (O3), Sulfur Dioxide (SO2), Particulate Matter (PM), Carbon Monoxide (CO), and Lead (Pb)
Scale: County
Year: 2002
Data Source: Environmental Protection Agency, United States. (2003). Green Book Nonattainment Areas for Criteria Pollutants. Office of Air and Radiation/Office of Air Quality Planning and Standards. Washington, DC. (Nonattainment Status for Each County by Year). http://www.epa.gov/oar/oaqps/greenbk/anay.html.

Environmental Protection Agency, United States. (2003). Latest Findings on National Air Quality: 2002 Status and Trends (Summary Report). Office of Air and Radiation/Office of Air Quality Planning and Standards. Washington, DC. http://www.epa.gov/ipbpages/current/v.6/454.htm.

Logic: The Clean Air Act provides the principal framework for national, state, tribal, and local efforts to protect air quality. Under the Clean Air Act, EPA establishes air quality standards to protect public health by setting National Attainment Air Quality Standards (NAAQS) for the six principal pollutants that are considered harmful to public health and the environment and ensuring that these air quality standards are met (in cooperation with the state, tribal, and local governments) through national standards and strategies to control air pollutant emissions from vehicles, factories, and other sources (USEPA, Latest Findings on National Air Quality: 2002 Status and Trends (Summary Report), 2003).

Figure 9. A sample metadata report.

5 Conclusions and Recommendations

Conclusions

SIRRA provides a simplified national assessment of sustainability based on 10 sustainability issues: (1) air, (2) energy, (3) urban development, (4) threatened and endangered species, (5) location, (6) water, (7) economy, (8) quality of life, (9) infrastructure, and (10) security. The SIRRA methodology provides resource assessment ratings for 48 individual regional indicators. SIRRA relies on existing national data sets from reliable sources. Statistical analyses were completed for each indicator, where required, to assign sustainability thresholds and ratings. The data was then mapped into GIS coverages for individual indicators coded as red, amber, or green. Military installations are placed geographically in a location and the GIS data is applied to each one.

Collectively, indicators can aid in identifying potential issues that should be considered in making stationing, base realignment, and mission sustainment decisions. Some limitations of this study do necessitate caution in the use and application of the results. The set of indicators are based on the expert judgments and consensus of those who participated in the project team and were somewhat restricted by the available data. We required that data be readily accessible and available nationwide. The identification of specific vulnerability thresholds and classifications is subjective in some cases, and alternative classifications are possible. No attempt has been made to either weight the indicators or rank the relative importance of individual indicators. The team's goal has been to provide useful insight into identifying relative ratings for resource issues across installations. These results should not be interpreted as absolute. Different installations have different regional resource issues and differing missions. Application of the data should be done with this in mind.

Recommendations

The tremendous amount of growth and urbanization that has occurred since World War II has changed the landscape of the nation. Military installations can no longer be considered isolated and self-sufficient entities with no responsibilities to the region in which they reside. Virtually every military installation is at risk for some type of regional resource issue that could negatively impact its mission sustainment or expansion. Some installations experience greater pressures than others, but the increasingly demanding regulatory climate and urbanization patterns indicate a continued and increasing pressure on installations. Military installations will be required to address this larger issue of sustainability in the not too distant future. An installation that focuses solely on its military mission and ignores the sociopolitical and environmental issues in the region does so its own peril. This study recommends that installations take a proactive stance that increases their public involvement in the region through educational activities, partnerships, regional planning, and ecoregional problem solving to enhance the installation's long term viability and ease stationing and mission sustainment decisions.

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Appendix A: Regional Resource Assessment Indicators

Issue: Air Sustainability

Indicator A1: Criteria Pollutant Nonattainment

Variables: Six Principal Air Pollutants (also referred to as criteria pollutants): Nitrogen Dioxide (NO_2), Ozone (O_3), Sulfur Dioxide (SO_2), Particulate Matter (PM), Carbon Monoxide (CO), and Lead (Pb)

Scale: County

Year: 2002

Data Sources

U.S. Environmental Protection Agency (USEPA), *Green Book Nonattainment Areas for Criteria Pollutants* (Office of Air and Radiation/Office of Air Quality Planning and Standards, Washington, DC, 2003). (Nonattainment Status for Each County by Year), accessible through URL: http://www.epa.gov/oar/oaqps/greenbk/anay.html

USEPA, *Latest Findings on National Air Quality: 2002 Status and Trends* (Summary Report) (USEPA Office of Air and Radiation/Office of Air Quality Planning and Standards, Washington, DC, 2003), accessible through URL: http://www.epa.gov/ipbpages/current/v.6/454.htm

Logic

The Clean Air Act provides the principal framework for national, state, tribal, and local efforts to protect air quality. Under the Clean Air Act, EPA establishes air quality standards to protect public health by setting National Attainment Air Quality Standards (NAAQS) for the six principal pollutants considered harmful to public health and the environment, ensuring that these air quality standards are met (in cooperation with the state, tribal, and local governments) through national standards and strategies to control air pollutant emissions from vehicles, factories, and other sources (EPA 2003). EPA has set national air quality standards for six principal air pollutants (also referred to as criteria pollutants): nitrogen dioxide (NO2), ozone (O3), sulfur dioxide (SO2), particulate matter

(PM), carbon monoxide (CO), and lead (Pb). Four of these pollutants (CO, Pb, NO2, and SO2) result primarily from direct emissions from a variety of sources. PM results from direct emissions, but is also commonly formed when emissions of nitrogen oxides (NOx), sulfur oxides (SOx), ammonia, organic compounds, and other gases react in the atmosphere. Ozone is not directly emitted, but is formed when NOx and volatile organic compounds (VOCs) react in the presence of sunlight (EPA 2003).

EPA tracks trends in air quality based on actual measurements of pollutant concentrations in the ambient (outside) air at monitoring sites across the country. State, tribal, and local government agencies as well as some Federal agencies, including the EPA, operate monitoring stations.

Air quality is important to military operations in that areas without attainment of EPA air quality emission standards for the six criterion pollutants will have added restrictions on emissions from military operation. Gaining compliance for these regulations may cause unneeded financial strain on the DOD. Being a nonattainment zone is a strong indicator that the military may face restrictions on the amounts of certain emissions they can release (including mobility emissions). Information concerning what affects each criterion is available from the EPA at http://www.epa.gov. In summary, each criterion is vulnerable to change. Thus, the data should be updated regularly and the age of the data should be carefully noted in any analysis.

Additionally, the data reflects county level data where different values are reported for the same county in the same year in some cases. Thus, knowledge of the local area and its efforts need to be considered especially in large acreage counties.

Replicable

Each year, EPA examines changes in levels of these ambient pollutants and their precursor emissions over time and summarizes the current air pollution status (EPA 2003). The updates are available for download at:

http://www.epa.gov/air/oaqps/greenbk/anay.html

Directions

Download nonattainment status for each county by year for all U.S. counties from the EPA Green Book (2003) at:

http://www.epa.gov/air/oaqps/greenbk/anay.html.

Import the Classification data into a GIS program and join it with the county shape files to create a GIS air quality attainment status indicator layer.

Indicator Measure

Emission status indicates whether or not a U.S. County is in attainment of EPA air quality emission standards for the six criteria pollutants. The EPA designates a 0-6 rating for each criterion depending on the non-attainment status (0 being no violation through 6 being extreme violations) (EPA 2003). It should be noted that different values are reported for the same county in the same year in some cases. In this case, the worst value is indicated, because of the fact that each criterion is subject to quick change. It is more likely that the rating changes to a lower value over time than a higher value due to the amount of local efforts need to increase a rating (EPA 2003).

The emission ratings were grouped into the following classifications.

Green: No Violation (0)
Amber: Primary (1), Marginal (2), and Moderate Violations (3)
Red: Serious (4), Severe (5), and Extreme Violations (6)

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by the rating of the highest risk county that it touches. For instance, if an installation is partly in an amber risk county and partly in a red risk county, then the installation has a red risk rating.

Example

Indicator Value for the Installation =
(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator A2: Noise Complaints

Variables: Environmental Noise Complaints
Scale: Installation
Year: 2002

Data Sources

U.S. Department of the Army (DA), *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), accessible through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf.

DA, *Installation Status Report WEB Applications*, Installation Status Report WEB Applications, Environmental Pillar (Assistant Chief of Staff for Installation Management, Arlington, VA, 2002). (The number of noise related claims found to be the result of installation activities during the past FY) , accessible through URL: http://isr.pentagon.mil/

Logic

Lower noise levels will result in improved quality of life for both military personnel and the residents of the region surrounding military installations. Fewer noise problems helps to ensure that military personnel are well-trained, will remain in the military, and will be able to carry out missions with greater effectiveness and reduced losses. The training and testing capability impacts include loss of training hours, rescheduling training and testing, modifying training procedures, and the consequences of inadequate training. An effective and proactive noise management program greatly improves effective military operations as well as relations with the surrounding community (Department of the Army 2002).

The U.S. military has articulated goals in: (1) protecting the ability of personnel to train as they fight by working to limit civilian encroachment into areas exposed to high levels of military noise; (2) protecting people who live near military training areas from unhealthy levels of noise from military operations; and (3) protecting military families and military workplaces from unhealthy levels of noise from onpost and offpost noise sources (Department of the Army 2002). The ISR reports Army-unique noise complaints based on helicopter, blast (artillery, armor, detonations), and small arms noise (Department of the Army 2002).

Every installation has its own style of keeping noise complaint logs, and there is no central repository. Generally, the PAO has the noise complaint file. This noise data accurately describes the accountancy of each noise complaint per Army installation. Yet, it may not easily be used to explore circumstance patterns. Missing from this data is the day-to-day social context of noise, which may be understood more completely by community residents than by statistics because of the resident's expertise concerning neighborhood problems and activity patterns. Noise impacts many things. Small noise can make a big impact depending on the surrounding environment. At the same time large noises may generate no complaints.

Additionally, it shall be recognized that noise complaints have a direct relationship with regional land urbanization. Theoretically, noise complaints have a greater chance of occurring where surrounding civilian development is greater.

Replicable

Each year ISR provides annual environmental noise complaints (Department of the Army 2002). The updates are available for download at:

http://isr.pentagon.mil/

Directions

Download Environmental Noise Complaints by MACOM for all U.S. Army installations from the ISR at http://isr.pentagon.mil/ (Department of the Army 2002). Import the data into a GIS program and join it with the installation shapefiles to create a GIS noise complaints indicator layer.

Indicator Measure

The noise complaints were grouped into the following classifications based on natural breaks in the data.

Green: 0-1 Noise Complaints
Amber: 2-4 Noise Complaints
Red: 5-14 Noise Complaints

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, see the project database or frequency charts.

Issue: Energy Sustainability

Indicator EN1: Electrical Source

Variables: Non-Coal Fossil-Fueled Generation Capacity, Renewable Generation Capacity
Scale: State
Year: 2000

Data Sources

USEPA, *Emissions and Generation Resource Integrated Database, Version 2.01* (USEPA Office of Atmospheric Programs, Washington, DC, 2000 [Data Years 1996-2000]), available through URL: http://www.epa.gov/cleanenergy/egrid.htm

USEPA, *E-GRID: Database on the Electric Power Industry*, Fact Sheet 6202J (USEPA Office of Atmospheric Programs/Air and Radiation, Washington, DC, 2003) , available through URL: http://www.epa.gov/cleanenergy/egrid/egrid2003factsheet.pdf

Logic

The Electrical Source indicator shows the amount of non-coal fossil fuel used in the production of electricity on the grid that services the military installation. This indicator is important because the use of renewables, coal, and nuclear energy indicate a high degree of availability and low price volatility in fuel source. The use of coal does indicate a potential environmental problem for the utilities, but the resource is in great supply and domestically produced. Oil and natural gas on the other hand have looming resource availability problems and volatile prices (EPA 2003).

Replicable

This indicator could be replicated every 2 years based on information updated in E-GRID. The latest update, E-GRID 2002, Version 2.01, was made available to the public in May 2003 (EPA 2000).

Directions

The calculations for determining the grid generation mix by state are as follows. Variable data was obtained from (EPA 2000).

Non-Coal Fossil-Fueled Generation Capacity (MWh) =
Oil Capacity + Gas Capacity

Total Fossil-Fueled Generation Capacity (MWh) =

Coal Capacity + Oil Capacity + Gas Capacity + Nuclear Capacity + Other Fossil-Fueled Capacity

Total Renewable Generation Capacity (MWh) =

Wind Capacity + Solar Capacity + Geothermal Capacity + Biomass Capacity + Hydroelectric Capacity

Total Generation Capacity (MWh) =

Total Fossil-Fueled Generation Capacity + Total Renewable Generation Capacity

Percent Non-Coal Fossil-Fueled =

100 * (Non-Coal Fossil-Fueled Generation Capacity / Total Generation Capacity)

Import Emissions and Generation Resource Integrated Database, Version 2.01, from the EPA and calculate the percentage of non-coal fossil-fueled generation for each state based on the equations listed above. A detailed example calculation follows.

The percentage of non-coal fossil-fueled generation can be calculated using either one of the two methods:

1. If using the information below (Table A1) from E-GRID 2002 (PC version), add the percentages of oil and gas.

   Percent Non-Coal Fossil-Fueled =

   1.365 percent + 3.525 percent =

   4.89 percent non-coal fossil-fueled for the state of Georgia in 2000.

2. Using the spreadsheet format (Table 1) for E-GRID 2002 below, the total non-coal fossil-fueled generation capacity (oil and gas only) for the state of Georgia is (1,685,402 + 4,352,669) MWh, or 6,038,071 MWh, and the total renewable is 5,405,089 MWh. The total fossil-fueled generation capacity is 118,063,819 MWh, which includes coal, oil, gas, nuclear, and other fossil fuel. The grand total generation capacity is equal to 118,063,819 + 5,405,089, or 123,468,908 MWh.

   Percent Non-Coal Fossil-Fueled =

   100 * (6,038,071 / 123,468,908) =

   4.89 percent non-coal fossil-fueled for the state of Georgia in 1998.

Import data for each state into a GIS program and join it with the state shape files to create a GIS Electrical Source indicator layer.

Table A1. From E-GRID 2002, spreadsheet format (EPA 2000).

E-GRID2002 2000 file State sequence number	E-GRID2002 1999 file State sequence number	State abbreviation	State 2000 annual oil net generation (MWh)	State 2000 annual gas net generation (MWh)	Grand total annual oil and gas net generation (MWh)	State 2000 annual total nonrenewables generation (MWh)	State 2000 annual total renewables generation (MWh)	Grand total annual generation (MWh)
SEQST00	SEQST99	PSTATABB	STGENAOL	STGENAGS		STGENATN	STGENATR	
1	N/A	AK	640,200.2	3,975,832.4	4,616,032.6	5,154,705.6	1,001,819.0	6,156,524.6
2	N/A	AL	366,621.4	5,117,017.7	5,483,639.1	114,449,271.8	9,912,895.6	124,362,167.4
3	N/A	AR	222,122.0	4,124,813.4	4,346,935.4	40,174,267.3	3,982,548.7	44,156,816.0
4	N/A	AZ	190,841.2	8,751,806.0	8,942,647.2	80,316,347.6	8,647,755.3	88,964,102.9
5	N/A	CA	2,835,129.5	103,250,298.8	106,085,428.3	146,740,352.1	61,735,905.6	208,476,257.7
6	N/A	CO	109,386.1	7,231,127.3	7,340,513.4	42,721,732.4	1,518,974.3	44,240,706.7
7	N/A	CT	6,865,385.4	4,091,905.4	10,957,290.8	31,090,563.8	2,131,044.9	33,221,608.7
8	N/A	DC	144,373.7	0.0	144,373.7	144,373.7	0.0	144,373.7
9	N/A	DE	854,924.4	850,283.3	1,705,207.7	5,984,272.7	18,837.8	6,003,110.5
10	N/A	FL	34,256,813.8	43,042,964.9	77,299,778.7	187,107,898.1	4,798,740.9	191,906,639.0
11	N/A	GA	1,685,401.7	4,352,669.1	6,038,070.8	118,063,818.7	5,405,089.2	123,468,907.9
12	N/A	HI	8,101,704.7	0.0	8,101,704.7	9,823,192.8	820,134.5	10,643,327.3

Indicator Measure

Electrical Source ranges were defined as follows based on natural breaks in the data.

Green: Less than 10 % non-coal fossil-fueled

Amber: 10 to 30 % non-coal fossil-fueled

Red: Greater than 30 % non-coal fossil-fueled

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator EN2: Regional Natural Gas Price Variability

Variables: Natural Gas Price at City Gate

U.S. Average Natural Gas Price

Scale: State

Year: 2002

Data Sources

Energy Information Administration (EIA), U.S. Department of Energy, *National Gas Monthly. Office of Oil and Gas*, "Table 20: 2002 Annual Average Natural Gas Price at City Gate by State"(Washington, DC, 2002), available through URL: http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_monthly/current/pdf/ngm_all.pdf.

Logic

Natural gas price variability shows the relationship between the state price and the national average. This indicator is important because price variability is related to demand in the region, which affects availability and price to the military installation. The natural gas grid is highly vulnerable to disruption through terrorist acts, and natural gas is an increasingly imported commodity (USDOE Energy Information Administration 2002).

Replicable

This indicator could be replicated every year based on information updated in Energy Information Administration's Natural Gas Monthly (Energy Information Administration 2002).

Directions

The calculation for determining the percentage below the U.S. average natural gas price by state is as follows. Variable data was obtained from (Energy Information Administration 2002).

Natural Gas Price Variability =

Percent Below U.S. Average Natural Gas Price at City Gate =

100 * [(U.S. Average Natural Gas Price – Natural Gas Price at City Gate, by State) / U.S. Average Natural Gas Price]

Import 2002 Annual Average Natural Gas Price at City Gate by State from (Energy Information Administration 2002) and calculate natural gas price variability for each state based on the equation above. Table A2 gives a detailed example calculation.

Table A2. Natural gas prices at City Gate (Energy Information Administration 2002).

	Jan-02	Annual Average
Alaska	2.44	2.38
U.S. Average	4.03	4.06

Notes:

1 The annual average natural gas price at the city gate for the state of Alaska is $2.38/kcf, while the annual U.S. average natural gas price is $4.06/kcf.

2 Percent Below US Average Natural Gas Price at City Gate = ($4.06 – $2.38) / $4.06 = 41.38 percent below U.S. average natural gas price for the state of Alaska.

Import data for each state into a GIS program and join it with the state shape files to create a GIS Natural Gas Price Variability indicator layer.

Indicator Measure: Natural Gas Price Variability classifications were defined as follows based on natural breaks in the data:

Green: greater than 10% below U.S. avg natural gas price
Amber: 0 to 10% below U.S. average natural gas price
Red: at or above U.S. average natural gas price.

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Indicator EN3: Regional Petroleum Price Variability

Variables: average Petroleum Product Price
U.S. Average Petroleum Product Price
Scale: State
Year: 2002

Data Sources

EIA, *Petroleum Marketing Monthly*, "Average Petroleum Product Price" (Office of Oil and Gas, Washington, DC, 2002), available through URL: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/pmm.html.

Logic

Petroleum Price Variability indicates the relationship between the state price to the national average. This indicator is important because price variability is related to demand in the region that affects availability to the military installation. Petroleum continues as an increasingly imported commodity; the infrastructure is susceptible to interruptions (Energy Information Administration 2002).

Replicable

This indicator could be replicated every month based on information updated in Energy Information Administration's Petroleum Marketing Monthly, at URL:
http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/pmm.html (Energy Information Administration 2002)

Directions

The percentage below the U.S. average petroleum product price was determined for each state during 2002. The calculations for determining the percentage below the U.S. average petroleum product price by state are as follows. Variable data was obtained from (Energy Information Administration 2002).

Average Petroleum Product Price by State =

(Motor Gasoline Price for All Grades + Kerosene-Type Jet Fuel Price + Kerosene Price + #2 Distillate Oil Price + #2 Diesel Fuel Price + Residual Fuel Oil Price) / Number of Non-Zero Prices

U.S. Average Petroleum Product Price =

(U.S. Avg Motor Gasoline Price for All Grades + U.S. Avg Kerosene-Type Jet Fuel Price + U.S. Avg Kerosene Price + U.S. Avg #2 Distillate Oil Price + U.S. Avg #2 Diesel Fuel Price + U.S. Avg Residual Fuel Oil Price) / Number of Non-Zero Prices

Percent Below U.S. Average Petroleum Product Price =

100 *[(U.S. Average Petroleum Product Price – Average Petroleum Product Price by State) / U.S. Average Petroleum Product Price]

Import, Petroleum Product Prices, Monthly Time Series Data from the EIA and calculate the average petroleum product price for each state based on the equations listed above. Table A3 gives a detailed example calculation.

With the number of non-zero prices for the state of Alaska equal to 4:

Average Petroleum Product Price =

($1.337 + $0.748 + $0.00 + $1.103 + $1.151 + $0.00) / 4 = $1.085/gal.

Table A3. Petroleum Product Prices for Alaska (Energy Information Administration 2002).

	Alaska	U.S. Average
Annual 2002 Motor Gasoline Price, All Grades ($/Gal)	1.337	1.001
Annual 2002 Kerosene-Type Jet Fuel Price ($/Gal)	0.748	0.720
Annual 2002 Kerosene Price ($/Gal)		0.960
Annual 2002 #2 Distillate Oil Price ($/Gal)	1.103	1.110
Annual 2002 #2 Diesel Fuel Price ($/Gal)	1.151	0.859
Annual 2002 Residual Fuel Oil Price ($/Gal)		0.560

Calculate the U.S. average petroleum product price. With the number of non-zero U.S. average prices equal to 6:

U.S. Average Petroleum Product Price =

($1.001 + $0.720 + $0.960 + $1.110 + $0.859 + $0.560) / 6 = $0.868/gal.

Therefore:

Percent Below U.S. Average Petroleum Product Price =

($0.868 – $1.085) / $0.868 =

-25.00 percent below (or 25.00 percent above) the U.S. average petroleum product price for the state of Alaska.

Import data for each state into a GIS program and join it with the state shape-files to create a GIS Petroleum Price Variability indicator layer.

Indicator Measure

Petroleum Price Variability classifications were defined as follows based on natural breaks in the data:

Green: Greater than 10% Below U.S. Avg Petroleum Product Price
Amber: 0 to 10% Below U.S. Average Petroleum Product Price
Red: At or above U.S. Average Petroleum Product Price

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, see the project database or frequency charts.

Indicator EN4: Regionally Imported Natural Gas

Sustainability Issue: Energy
Indicator: Natural Gas Imports
Variables: Natural Gas Consumption, Natural Gas Imports, Natural Gas Exports
Scale: State
Year: 2000

Data Sources

EIA, *Natural Gas Annual*, "Transmission and Consumption by State"(Office of Oil and Gas, Washington, DC, 2000), available through URL: http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_002.pdf

Logic

This indicator is important because the higher the percent dependence on imported natural gas, the greater the risk for the state to obtain natural gas resources from outside the United States in the future if the supply is low (Energy Information Administration 2000). This affects the availability and price to the military installation. Thus, natural gas imports is highly sought after as an energy sustainability indicator.

Replicable

This indicator could be replicated every year based on information updated in Energy Information Administration's Natural Gas Annual (Energy Information Administration 2000). Directions: The percent dependence on imported natural gas was determined for each state during 2000. The calculation for determining the percent dependence on imported natural gas by state is as follows. Variable data was obtained from (Energy Information Administration 2000).

Dependence on Imported Natural Gas =

Percent Dependence on Imported Natural Gas =

100 * (Natural Gas Imports, by State – Natural Gas Exports, by State) / Natural Gas Consumption, by State

Import Natural Gas Imports, Exports and Consumption from (Energy Information Administration 2000) and calculate the percent dependence of imported natural gas for each state based on the equation above. Table A4 lists a detailed example calculation.

Table A4. Natural Gas Imports, Exports and Consumption, 2000 (Energy Information Administration 2000).

State	Natural Gas Imports (MMCF)	Natural Gas Exports (MMCF)	Natural Gas Consumption (MMCF)
…			
Illinois	2,464,994	1,391,241	1,020,126
…			

Percent Dependence on Imported Natural Gas for the State of Illinois =

(2,464,994 – 1,391,241) / 1,020,126 =

105.26 percent dependence on imported natural gas for Illinois

Import data for each state into a GIS program and join it with the state shapefiles to create a GIS Natural Gas Imports indicator layer.

Indicator Measure

Dependence on Imported Natural Gas classifications were defined as follows based on natural breaks in the data.

Green: Less than 25%

Amber: 25 to 50%

Red: Greater than 50%

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator EN5: Regionally Imported Petroleum

Variables: Petroleum Consumption, Petroleum Imports, Petroleum Exports

Scale: State

Year: 2002

Data Sources

EIA, *Petroleum Supply Annual*, "Supply and Disposition of Crude Oil and Petroleum Products Tables 4, 6, 8, 10, and 12" (Office of Oil and Gas/Petroleum Administration for Defense Districts I, II, III, IV, and V, Washington, DC, 2002), available through URL:

http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/current/txt/table_04.txt

http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/current/txt/table_06.txt

http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/current/txt/table_08.txt

http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/current/txt/table_10.txt
http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/current/txt/table_12.txt

EIA, *Historical Imports by Month Including Final Revisions*, "Company Level Imports" (Office of Oil and Gas, Washington, DC, 2003), available through URL: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/company_level_imports/cli.html

Logic

This indicator is important because the higher the percent dependence on imported petroleum, the greater the risk for the state to obtain petroleum resources from outside the United States in the future if the supply is low or depleted (Energy Information Administration 2002). This affects the availability and price to the military installation. Thus, petroleum imports is highly sought after as an energy sustainability indicator.

Replicable

This indicator could be replicated every year based on information updated in the *Energy Information Administration's Petroleum Supply Annual* (Energy Information Administration 2002).

Directions

The percent dependence on imported petroleum was determined for each state during 2002. The calculations for determining the percent dependence on imported petroleum by state are as follows. Variable data was obtained from (Energy Information Administration 2002).

Petroleum Consumption, by State =
Field Production, by State + Petroleum Imports, by State – Petroleum Exports, by State

Percent Dependence on Imported Petroleum =
100 * (Petroleum Imports, by State – Petroleum Exports, by State) / Petroleum Consumption, by State

Import Supply and Disposition of Crude Oil and Petroleum Products from (Energy Information Administration 2002) and calculate petroleum consumption and dependence on imports for each state based on the equations above.

Imports were determined by state level based on company level import data from the Energy Information Administration website (Energy Information Administration 2003).

Field production, refinery production, unaccounted for crude oil data, net receipts, stock change data, refinery inputs, and export data are obtained from the Energy Information Administration website (Energy Information Administration 2003), but only by Petroleum Administration for Defense (PAD) District level and not by state. State data for the aforementioned variables were determined by multiplying the total value of the variable in question (e.g., total field production for a particular PAD district) by the ratio of the individual state imports divided by the total imports for a particular PAD district. The equation for petroleum consumption can then be used after determining pro-rated values for field production, refinery production, unaccounted for crude oil data, net receipts, stock change data, refinery inputs, and export data. Once the petroleum consumption is determined, the percent dependence on imported petroleum can then be calculated. Table A5 gives a detailed example calculation.

First, calculate the petroleum consumption for the state of Texas (Table A6).

Table A5. Petroleum supply for PAD District III (Energy Information Administration 2002).

State	Imports (Barrels per Day)	Field Production (Barrels per Day)
…		
Texas	3,934,699.45	2,893,196.46
Totals	6,270,579.23	4,610,775.96

Table A6. Petroleum disposition for PAD District III (Energy Information Administration 2002).

State	Exports (Barrels per Day)
…	
Texas	407,742.33
Totals	649,803.28

The petroleum consumption for the state of Texas is calculated as follows:

Petroleum Consumption =

3,934,699.45 + 2,893,196.46 - 407,742.33 =

6,420,153.58 barrels/day.

Next, calculate the percent dependence on imported petroleum for the state of Texas (Table A7).

Table A7. Petroleum Imports, Exports and Consumption, 2002 (Energy Information Administration 2002).

State	Petroleum Imports (Barrels per Day)	Petroleum Exports (Barrels per Day)	Petroleum Consumption (Barrels per Day)
…			
Texas	3,934,699.45	407,742.33	6,420,153.58
…			

The state of Texas has petroleum imports of 3,934,699 barrels/day, petroleum exports of 407,742 barrels/day, and petroleum consumption of 6,420,154 barrels/day.

Percent Dependence on Imported Petroleum =

(3,934,699 – 407,742) / 6,420,154 =

54.94 percent dependence on imported crude oil petroleum for Texas.

Import data for each state into a GIS program and join it with the state shapefiles to create a GIS Petroleum Imports indicator layer.

Indicator Measure

Dependence on Imported Petroleum classifications were defined as follows based on natural breaks in the data.

Green: Less than 45% Dependence on Imported Petroleum
Amber: 45 to 90% Dependence on Imported Petroleum
Red: Greater than 90% Dependence on Imported Petroleum

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator EN6: Electrical Price Structure

Variables: Electric Utility Deregulation Status
Scale: State
Year: 2002

Data Source

EIA, *Status of State Electric Industry Restructuring Activity* (Office of Electricity, Washington, DC, 2002), available through URL: http://www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html

Logic

The price structure for electricity demand and delivery indicates whether the commodity has been deregulated and is thus more susceptible to market distortion such as price instability and availability fluctuations (Energy Information Administration 2002). Deregulation of electrical markets in the United States is still very much a "work in progress," and the market has not normalized. This indicator will affect the availability and price of electricity to a military installation, and is thus highly sought after as an energy sustainability indicator.

Replicable

This indicator could be replicated every year based on events that occur from states that are in the process of going to electric industry restructuring. Directions: The EIA website for electric utility deregulation:

http://www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html

contains a map showing the states that: (1) have active deregulation, (2) have deregulation activity delayed/suspended, and (3) have no deregulation activity (Energy Information Administration 2002). Details on the deregulation status of each state can be found by clicking on the desired state on the map located on the EIA website listed above. Download this data. Import it into a GIS program and join it with the state shape files to create an Electrical Price Structure indicator layer.

Indicator Measure

Electrical Price Structure classifications were defined as follows based on the definitions of the EIA (Energy Information Administration 2002).

Green: Active
Amber: Delayed/suspended

Red: No deregulation

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Issue: Urban Development

Indicator UD1: Regional Population Density

Variables: Population, Land Area (square mile)
Scale: County
Year: 2000

Data Source

Bureau of the Census, U.S. Department of Commerce, *Summary File 1: GCT-PH1-R Population, Housing Units, Area, and Density*, *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

Craig, John, *Demography*, "Averaging Population Density," vol 21, No. 3 (1984), pp 405-412, available through URL: http://www.jstor.org/

Logic

This indicator provides a measure of the population density of all counties in the United States. A high population density surrounding an installation is a strong indicator of potential encroachment issues. This can affect the type and intensity of training that can take place on an installation.

Population density is a commonly quoted statistic. Almost no general descriptive summary of the population of an area is complete without a density listing, table or map. As each such density statistic is an average, it is worth considering what kind of average is being used (Craig 1984). Additionally, it is important to note this data is on the county level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a county has one community with relatively high regional population density, the entire county is classified as high regional population density regardless of the characteristics of the remaining majority of the county. Because of this concern, it is important to use local knowledge in interpreting the roadway congestion classifications.

Replicable

This indicator could be replicated every year based on Census population estimates, or every decade based on actual, verifiable counts. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates.

Directions

Download "total population" and "land area" from Summary File 1: GCT-PH1-R Population, Housing Units, Area, and Density of the 2000 U.S. Census at http://factfinder.census.gov (Bureau of the Census 2000). The total population for each county in the United States was divided by the land area (not total area, which includes water bodies) in that county to reach a population density figure.

Regional Population Density = total population / land area

Import the resulting math into a GIS program and join it with the county shapefiles to create a GIS Regional Population Density indicator layer.

Indicator Measure

The average population density for the entire United States is 79.6 people per square mile according to the U.S. Census. The mean density for U.S. counties is 220 people per square mile. The results were then subjected to a normal statistical distribution (19%/62%/19%) to determine which counties were colored red, amber, and green. Since the data is not naturally distributed, the data was forced into a natural distribution so that the lower 19% of all counties are shown as green (Craig 1984).

Green: Less than 20 people per square mile
Amber: 20-220 people mile
Red: Greater than 220 people per square mile

Rules

Installations are sometimes located in two or more counties. Therefore, installation rating levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's rating value. The values for each county where the installation is located are then totaled to arrive at a value for the installation. This value is subjected to the same rating metric that determined the rating levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator UD2: Increasing Regional Growth Rate

Variables: Total Population 1980, 1990, and 2000

Scale: County

Year: 2000

Data Source

Bureau of the Census, U.S. Department of Commerce, *Population of Counties by Decennial Census: 1900 to 1990*, compiled and edited by Richard L. Forstall (Bureau of Census Population Division, Washington, DC, 1995), available through URL: http://www.census.gov/population/cencounts/wy190090.txt

Logic

An increasing regional growth rate is a strong indicator of increased population pressures in the future, leading to greater demands for services, access, resources, and land in competition with the military installation. This can affect the type and intensity of training that can take place on the installation.

Additionally, it is important to note this data is on the county level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a county has one community with relatively high regional growth rates, the entire county is classified as high regional growth regardless of the characteristics of the remaining majority of the county. Because of this concern, it is important to use local knowledge in interpreting the roadway congestion classifications.

Replicable

This indicator could be replicated every year based on Census population estimates, or every decade based on actual, verifiable counts. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates.

Directions

Download "total population" for all U.S. counties for 1980, 1990, and 2000 from the Population of Counties by Decennial Census: 1900 to 1990 database maintained by the U.S. Census Bureau (Bureau of the Census 1995). Given the total population for each county in the United States for 1980,1990, and 2000, the population growth rate from 1990 to 2000 is compared with the growth rate from 1980 to 1990. The increasing regional growth rate calculation used is as follows.

Increasing Regional Growth Rate =

([(Population 2000/Population 1990)/(Pop 1990/Pop 1980)]*100)

Import the resulting math into a GIS program and join it with the county shapefiles to create a GIS Increasing Regional Growth Rate indicator layer.

Indicator Measure

Increasing Regional Growth Rate is a measure of how fast a county is growing in the last decade compared with data from the previous decade. The population growth rate from 1990 to 2000 is compared with the growth rate from 1980 to 1990. This data is available from the U.S. Census (1995) at:

http://www.census.gov/population/cencounts/wy190090.txt

Range classifications were defined based on natural breaks in the data as follows:

Green: Less than 100% increasing growth rate
Amber: 100-120% increasing growth rate
Red: Greater than 120% increasing growth rate

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B) … etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator UD3: Regional Population Growth

Variables: Total Population 1990 and 2000

Scale: County

Year: 2000

Data Source

Bureau of the Census, U.S. Department of Commerce, *Population of Counties by Decennial Census: 1900 to 1990*, compiled and edited by Richard L. Forstall (Bureau of the Census Population Division, Washington, DC, 1995), available through URL: http://www.census.gov/population/cencounts/wy190090.txt

Logic

This indicator measures the population growth over the last decade of every county in the United States. Population growth is one of the leading causes of environmental degradation, because more people use more resources including water, energy, and waste disposal, and other problems. This indicator assumes that fast growing human populations are less sustainable.

The degree of regional population growth is a strong indicator of the demand for services, access, resources, and land in competition with the military installation. This can affect the type and intensity of training that can take place on the installation. This indicator was calculated based on population data from the U.S. Census Bureau.

Additionally, it is important to note this data is on the county level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a county has one community with relatively high regional population growth, the entire county is classified as high regional population growth regardless of the characteristics of the remaining majority of the county. Because of this concern, it is important to use local knowledge in interpreting the roadway congestion classifications.

Replicable

This indicator could be replicated every year based on Census population estimates, or every decade based on actual, verifiable counts. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates.

Directions

Download "total population" for each county for the year 1990 and 2000 from the Population of Counties by Decennial Census: 1900 to 1990 database maintained by the U.S. Census Bureau (Bureau of the Census 1995). Given the total population for each county in the United States for1990 and 2000, the population growth rate from 1990 to 2000 was calculated as follows.

Regional Growth Rate =
(Population 2000/Population 1990)*100

Import the resulting math into a GIS program and join it with the county shapefiles to create a GIS Regional Growth Rate indicator layer.

Indicator Measure

Regional Growth Rate is a measure of how fast a county is growing in the last decade. The population growth rate is measured from 1990 to 2000. This data (Bureau of the Census 1995) is available from the U.S. Census at:

http://www.census.gov/population/cencounts/wy190090.txt

The results were then subjected to a normal statistical distribution (19%/62%/19%) to determine which counties were colored red, amber, and green. This amounted to the following distributions.

Green: Negative to Zero Growth
Amber: 0.1% to 21% Growth
Red: Greater than 21 percent Growth Rate

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =
(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator UD4: Regional Land Urbanization

Variable: Urbanized Land Area, Total Land Area
Scale: 30 Meter Cells (Installations)
Year: 1992

Data Source

U.S. Geological Survey Bureau (USGS), *DOI*, *Land Cover Characterization Program*, "National Land Cover/MRLC" (USGS, Reston, VA, 1992), available through URL: http://landcover.usgs.gov

Logic

This indicator provides a measure (in percent) of land urbanization within a 20-mile boundary surrounding the installation. The indicator value is found by dividing the amount of urbanized land by the total land area surrounding a given installation.

The degree of regional development is a strong indicator of potential encroachment problems that can affect the type and intensity of training that can take place on the installation.

Replicable

This indicator calculation was performed with GIS using the National Land Cover Characterization data available from the U.S. Geological Survey Bureau (USGS) online at http://landcover.usgs.gov (USGS 1992). This website provides more about the data and the USGS's program for land characterization. Overall, the data set describes land use for the entire United States, for a 1992 timeframe, by 60 or so land use and vegetation types (United States Geological Survey Bureau 1992). Currently it only has 1992 data available, but the USGS is in the process of putting 2000 Land Cover data on the USGS website. Once this data is available, it is recommended that this indicator be updated.

Directions

Land coverages for each state from the USGS Internet site:

http://landcover.usgs.gov

or more directly from:

http://edcww.cr.usgs.gov/pub/data/landcover/states

were downloaded in a geotiff format (United States Geological Survey Bureau 1992). These tiff image files were then converted to raster data.

Once the data is in a grid/raster format, the only information needed for the regional land urbanization analysis for risk assessment is developed land; all other land covers are irrelevant for this task. Thus to simplify processing, reduce storage requirements, and minimize display and processing times, the dataset was reclassified to display urban or non-urban land. Cells originally labeled as attribute 21, 22, or 23 were grouped together as urban (reclassify values to 1) and all other land covers (any other attribute value) were grouped as non-urban (reclassify values to 0).

Next, using the ArcGIS buffer wizard, appropriate buffers for the analysis were made around each military installation. Finally, areas were tabulated. With the data simplified to two classifications (1 = urban; 0 = non-urban) and a polygon file with the appropriate buffers for each installation, the ratio of urbanized land surrounding each installation was determined.

Urbanization Ratio = value-1 area/(value-1 area + value-0 area).

Indicator Measure

Regional Land Urbanization classifications are defined by the percent of land urbanization within a 20-mile boundary surrounding the installation. This value is found by dividing urbanized land by the total land area. The classifications were defined by natural breaks in the data as follows.

Green: Less than 29% urbanized
Amber: 29-35% urbanized
Red: Greater than 35% urbanized

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator UD5: State Smart Growth Plans

Variables: Presence of State Smart Growth Plan
Scale: State
Year : 2002

Data Source

American Planning Association, *Planning for Smart Growth: 2002 State of the States*, "Smart Growth Network" (Chicago, IL, 2002), available through URL: http://www.planning.org/growingsmart/states2002.htm

Logic

This indicator shows the status of State Smart Growth Initiatives across the United States. Smart growth is the planning, design, development, and revitalization of cities, towns, suburbs, and rural areas to create and promote social equity, a sense of place, and community; as well as to preserve natural and cultural resources. Smart growth enhances ecological integrity over both the short- and long-term, and improves quality of life for all by expanding—in a fiscally responsible manner—the range of transportation, employment, and housing choices available to a region (American Planning Association 2002).

The presence of a state smart growth plan is important because smart growth legislation can decrease the growth of urbanized land surrounding a military installation. The potential encroachment caused by urban development can affect the type and intensity of training that can take place on the installation.

Replicable

This indicator could be replicated regularly as long as the APA continues to monitor Smart Growth (which is likely considering that one of the main tenants of the APA currently is to get smart growth passed in every state). It is recommended that this indicator be updated annually.

Directions

APA constructed a map to chart the progress of smart growth reform. That map is available at http://www.planning.org/growingsmart/states2002.htm, and was synthesized to create the map and scale used for this indicator (American Planning Association 2002). Download the map data, import it into a GIS program, and join it with the state shapefiles to create a GIS State Smart Growth Plans indicator layer.

Indicator Measure

Substantial Reforms means that smart growth legislation has been passed in the state. Moderate reforms or pursuing additional reforms means that some form of land use laws resembling smart growth have been passed, or legislation has been proposed. No reforms mean that no legislation has been passed or proposed (American Planning Association 2002).

Green: Substantial Reforms
Amber: Moderate Reforms or Pursuing Additional Reforms
Red: No Reforms

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator UD6: Joint Land Use Study

Variables: JLUS Program Participation
Scale: Installation
Year: 1985-2002

Data Source

Joint Land Use Study Assistance Grant, Title 10 U.S.C. Section 2391 (1985).

Office of Economic Adjustment (OEA), *Joint Land Use Study Program* (DOD, Washington, DC, 1985-2002), available through URL: http://www.nga.org/cda/files/1002LANDUSESUMMARY.pdf

Logic

Military operations can be loud and present safety concerns for nearby civilian communities. For example, low flying, high-performance, military aircraft create both noise and accident potential during landings, take-off, and training exercises. Likewise, ground-training exercises (e.g., artillery firing ranges, maneuver areas, and aerial bombing ranges) generate impact noise that can adversely affect the surrounding community if the civilian population chooses to locate to close. Conversely, civilian activities located adjacent to active military bases can impair the operational effectiveness, training, and readiness of the installations' mission (DOD OEA, 1985-2002). In other words, urban encroachment near a military base if allowed to go unregulated can compromise the utility and effectiveness of the installation and its mission. Thus, in the mid-1970s, the Department of Defense (DOD) established the Air Installation Compatible Use Zone (AICUZ) and the Environmental Noise Management Program (ENMP) in response to existing and potential threat of incompatible land development compromising the defense missions at military installation (DoD OEA, 1985-2002). The programs include noise propagation studies of military activities to delineate on- and off-base areas most likely to be affected by unacceptable noise levels. The programs also identify aircraft landing and take-off accident potential zones that often extend off a base into the neighboring community (DoD OEA, 1985-2002).

Since then, Congress authorized the DOD to make community planning assistance grants (1985) to state and local government to help better understand and incorporate the AICUZ/ENMP technical data into local planning programs (DOD OEA, 1985-2002). This is done in the form of a Joint Land Use Study (JLUS). The OEA manages the JLUS program. A JLUS is a cooperative land use planning effort between affected local government and the military installation. The recommendations present a rationale and justification, and provide a policy framework to support adoption and implementation of compatible development measures designed to prevent urban encroachment; safeguard the military mission; and protect the public health, safety, and welfare (DOD OEA, 1985-2002).

JLUS indicate an effort between the local community and the military installation to work together. Thus, any form of a JLUS is viewed as a positive. Whether the installation has completed, began or simply been nominated to have a JLUS preformed, the installation is classified as "green." If no effort is shown toward completing a JLUS, the installation is classified as "red." However, this puts some limitations on the data. First, the classifications do not indicate whether or not the JLUS was successful. The local community and military installation may never have agreed on a future course of action and the result was less compatibility than before the JLUS. Typically all JLUS have positive results, yet there is never a guarantee. Second, and more critical, installations not near urban development have no need to perform a JLUS yet, they are rated as "red" because they have not completed or pursued a JLUS. Thus, it is critical to read this data along with and understanding to the installation's Proximity to Metropolitan Statistical Areas and other Urban Development Sustainability issues. Any user of this data must use local knowledge in interpreting the JLUS classifications.

Replicable

This indicator could be replicated every year based on material printed by the DOD, OEA concerning the JLUS program (DOD OEA, 1985-2002).

Directions

OEA JLUS constructs a map to chart the progress of JLUS projects. That map is available at from the OEA JLUS program and updated annually (DOD OEA, 1985-2002). The data from the map was synthesized to create the map and scale used for this indicator. Download the map data, import it into a GIS program, and join it with the installations shape files to create a GIS JLUS indicator layer.

Indicator Measure

The JLUS program identifies military installations where JLUS have been "completed," "underway," and "nominated." Any installation with one of these characterizations was classified as green. All other installations were classified as red. It is assumed that if a JLUS has been completed, is underway, or is expected to occur on a military installation, then the installation is concerned about land use compatibility and therefore received a "higher" rating. However, there are concerns in this logic concerning the success of the JLUS and the relative need for such a study to be made (refer to the section labeled "Logic" of this report). The following rating classifications were defined for JLUS.

Green: JLUS Completed, Underway, or Nominated
Amber: (Not Applicable)
Red: JLUS Not Completed, Underway, or Nominated

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Theme: Threatened and Endangered Species Sustainability

Indicator TE1: Species Listed

Variables: Year-round presence/resident, Seasonal, Migratory, Contiguous, and Accidental
Scale: Installation
Year: 2002

Data Source

Bak, J.M., S. Sekscienski, and B. Woodson, *FY 2000 Survey of Threatened and Endangered Species on Army Lands*, 21010-5401. SFIM-AEC-EQ-TR-20018 (U.S. Army Environmental Center, Aberdeen Proving Ground, MD, U.S. Navy HQ NAVFAC, U.S. Air Force [AFCEE], 2002), available through URL: http://clients.emainc.com/navfac/

Sikes Act, 16 USC 670a-670o, 74 Stat, 1052 (1960), available through URL: http://laws.fws.gov/lawsdigest/sikes.html

DOD, and USFWS, USDoI, *Integrated Natural Resources Management Plans* (DOD, Washington, DC, 2002), available through URL: http://endangered.fws.gov/DOD/inrmp.pdf

USFWS, USDoI *Threatened and Endangered Species System*, "The Endangered Species Program" (Species Information) (Washington, DC, 2003), available through URL: http://endangered.fws.gov

Logic

This indicator is important as a Threatened or Endangered Species indicator because the presence of threatened or endangered species on a military installation may result in legal and other requirements regarding the conservation and management of those species (United States Department of Defense and United States Fish and Wildlife Service [USFWS] 2002). The presence of threatened or endangered species may limit certain land use actions, military or otherwise, in time or in space. In addition, other Federal requirements (e.g., Sikes Act) may require consideration and protection of state listed or other identified species identical or comparable to that required by the Endangered Species Act (1960; USFWS 2003).

Replicable

Although this information could be replicated every year from the U.S. Army Environmental Center (Bak et al. 2002), there would be relatively little reason to do so. Threatened or endangered species presence on a military installation, once identified, would not be expected to change unless the species was extirpated, or its status changed. If the species were extirpated, other political and social concerns and considerations would raise themselves.

Directions

Download number of year-round presence/resident, seasonal, migratory, contiguous, and accidental species present on each military installation from the U.S. Army Environmental Center (Bak et al. 2002). Imported the data into a GIS program and joined with the installation shape files to create a Threatened and/or Endangered Species Listed indicator layer.

Indicator Measure

Threatened and/or Endangered Species Listed were statistically classified where each installation rated at or below the mean was defined as green; each installation rated within one standard deviation above the mean was defined as amber; and each installation rated greater than one standard deviation above the mean was defined as red. Using this logic, the following Threatened and/or Endangered Species Listed classifications were defined as follows.

Green: 0-3 Threatened and/or Endangered Species Listed
Amber: 4 Threatened and/or Endangered Species Listed
Red: 5 or More Threatened and/or Endangered Species Listed

Rules

Since this data is collected by installation, there is no calculation to determine installation ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TE2: Ecological Resiliency

Variables: Ecological Resiliency
Scale: Installation
Year: 2003

Data Source

Center for the Environmental Management of Military Lands, *Applications of Bailey's Ecoregions to Military Lands, Fort Collins, Colorado* (Colorado State University, 2003), available through URL:
http://www.cemml.colostate.edu/bailey_ecoregion.htm

Sikes Act, 16 USC 670a-670o, 74 Stat. 1052 (1960), available through URL:
http://laws.fws.gov/lawsdigest/sikes.html

Logic

Ecological Resiliency is sought after as a Threatened and Endangered Species (TES) indicator because it provides an index or measure of the relative resiliency of regional landscapes in an ecological context. To the extent that threatened and endangered species are indicators of ecological stress or to the extent that they may be brought to recovery, this indicator serves to help focus ecologically related management effort decisions.

This indicator has a wider range of applicability than to solely TES within any military installation. This indicator characterizes the degree of relative stress that an ecoregion may be currently experiencing from a variety of sources, including habitat loss, pollution, predation, and disease by counting the number of at-risk species within an ecoregion.

According to the Sikes Act, the DoD, and Department of Interior (DOI), military installations must cooperate with local state agencies for the planning, management, and maintenance of fish and wildlife populations and their associated habitat on military installations (1960). Ecoregions with a high number of TES will significantly increase the possibility of regulatory restrictions on the installation's mission. This would then place the military installation in a vulnerable state, possibly affecting the type and intensity of training that would take place on the installation. Reduction and or change in military training activities may result if state and Federal agencies question military training impacts on TES and associated habitat. Restrictions, reductions, and change of training could result, including the permanent removal of land parcels from training. Supplementary applicable laws and regulations can be found at

http://www.epa.gov/win/law.html

Replicable

This classification was done as a one-time qualitative comparison of installations based on their inherent physical (natural) characteristics and attributes. The resiliency classification was determined by a group of scientists at Colorado State University's Center for the Environmental Management of Military Lands (CEMML) who had extensive experience with military training and testing impacts on the landscape (Center for the Environmental Management of Military Lands 2003). The CEMML scientists used Bailey's ecoregions because it was a logical way to spatially represent various physical regimes across the United States. The four categories used to classify resiliency are relative in that they do not attempt to quantify how much more resilient one category is from another. The map is simply used to depict what the experts viewed as significant delineations between ecotypes in terms of their response and recovery to military type impacts. It was intended as a way of helping planners and decision-makers visualize the inherent differences across the landscape (Center for the Environmental Management of Military Lands [CEMML] 2003).

This assessment has been used in various ongoing Department of the Army studies (CEMML 2003). While many data sources and map layers are available to further this initial comparison, there is no other known effort to quantify these categories at the scale used by CEMML. This information is not easily replicated, and there is relatively little reason to do so. Ecological Resiliency on a military installation, once identified, would not be expected to change.

Directions

Download ecological resiliency designation on military installations from CEMML (2003). Imported the data into a GIS program and joined with the installation shapefiles to create a Ecological Resiliency indicator layer.

Indicator Measure

Ecological Resiliency classifications are defined by CEMML and available for download at:

http://www.cemml.colostate.edu/bailey_ecoregion.htm

Ecological Resiliency classifications were defined by CEMML scientists (CEMML 2003) as follows:

Green: High Ecological Resiliency
Amber: Moderate Ecological Resiliency
Red: Low Ecological Resiliency

CEMML scientists used Bailey Ecoregions framework to measure the relative resilience of all Army installations. Since Bailey's classification has been expanded across the globe to the Domain and Division levels, it affords a logical and objective way in which to compare the geography of military lands in the United States with potential areas of conflict. CEMML scientists' classification method compared the ecological setting of each military installation against a common set of environmental fate and transport processes at the macro level, to include dissolution, absorption, and biological action. Using selected metrics for each process along with data available from various published sources, a relative ranking was achieved for each Army installation. Further explanation of their assessment may be found at (Center for the Environmental Management of Military Lands 2003):

http://www.cemml.colostate.edu/bailey_ecoregion.htm

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TE3: Critical Habitat

Variables: Designated, Proposed, Adjacent, and Contiguous Critical Habitat
Scale: Installation
Year: 2002

Data Source

Bak, J.M., S. Sekscienski, and B. Woodson, *FY 2000 Survey of Threatened and Endangered Species on Army Lands*, 21010-5401. SFIM-AEC-EQ-TR-20018 (U.S. Army Environmental Center, Aberdeen Proving Ground, MD, U.S. Navy HQ NAVFAC, U.S. Air Force [AFCEE], 2002), available through URL: http://clients.emainc.com/navfac/

Sikes Act, 16 USC 670a-670o, 74 Stat. 1052 (1960), available through URL: http://laws.fws.gov/lawsdigest/sikes.html

DOD, USFWS, and DOI, *Integrated Natural Resources Management Plans* (Washington, DC, 2002), available through URL: http://endangered.fws.gov/DOD/inrmp.pdf

USFWS, and DOI, *Threatened and Endangered Species System*, *The Endangered Species Program* (Species Information) (Washington, DC, 2003), available through URL: http://endangered.fws.gov

Logic

The identification and designation of critical habitat, in accordance with the Endangered Species Act, indicates lands that are necessary for the survival and recovery of threatened and/or endangered species (USFWS 2003). The designation of critical habitat can be expected to limit use of the designated lands to those that are compatible with and would not adversely affect the species. Concurrently, the designation of critical habitat may require or mandate other land management actions to preserve and recover the species (DOD and USFWS 2002).

This indicator characterizes the degree of relative stress that a habitat may be currently experiencing from a variety of sources, including habitat loss, pollution, predation, and disease by identifying critical habitats. According to the Sikes Act, the DoD and Department of Interior (DOI) must cooperate with local state agencies for the planning, management, and maintenance of fish and wildlife populations and their associated habitat on military installations (1960). Critical habitat designation will significantly increase the possibility of regulatory restrictions on the installation's mission. This would then place the military installation in a vulnerable state, possibly affecting the type and intensity of training that would take place on the installation. Reduction and or change in military training activities may result if state and Federal agencies question military training impacts on TES and associated habitat. Restrictions, reductions, and change of training could result, including the permanent removal of land parcels from training. (Supplementary applicable laws and regulations can be found at http://www.epa.gov/win/law.html.)

Replicable

Although critical habitat designations are updated annually through the USAEC (Bak et al. 2002) and could be replicated as such, there would be relatively little reason to do so. Critical habitat designations would not be

Directions

Download critical habitat designation on military installations from the U.S. Army Environmental Center (Bak et al. 2002). Imported the data into a GIS program and joined with the installation shapefiles to create a Critical Habitat indicator layer.

Indicator Measure

The presence of designated critical habitat on military installations were defined by the following classifications by the U.S. Army Environmental Center (Bak et al. 2002).

Green: Critical Habitat not designated
Amber: (Non-Applicable)
Red: Critical Habitat designated

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TE4: Percent of State Threatened and/or Endangered Species on a Military Installation

Variables: Year-round presence/resident, Seasonal, Migratory, Contiguous, and Accidental
Scale: Installation
Year: 2003

Data Source

Bak, J.M., S. Sekscienski, and B. Woodson *FY 2000 Survey of Threatened and Endangered Species on Army Lands*, 21010-5401. SFIM-AEC-EQ-TR-20018 (U.S. Army Environmental Center [USAEC], Aberdeen Proving Ground, MD, U.S. Navy HQ NAVFAC. U.S. Air Force [AFCEE], 2002), available through URL: http://clients.emainc.com/navfac/

Sikes Act, 16 USC 670a-670o, 74 Stat. 1052 (1960), available through URL: http://laws.fws.gov/lawsdigest/sikes.html

DOD, USFWS, and DOI, *Integrated Natural Resources Management Plans* (Washington, DC, 2002), available through URL: http://endangered.fws.gov/DOD/inrmp.pdf

USFWS, and DOI, *Threatened and Endangered Species System*, *The Endangered Species Program* (Species Information) (Washington, DC, 2003), available through URL: http://endangered.fws.gov

Logic

This indicator provides the comparative number of threatened and/or endangered species on each military installation as compared to the number of threatened or endangered species in the respective state and the same major political jurisdiction as a given military installation. This indicator presents an index value of the potential comparative importance of threatened and/or endangered species relative to the total threatened or endangered species of the state. For example, an installation with a higher percentage of listed species, as determined by the state total, might be considered of greater local and/or regional ecological importance than an installation with a smaller proportion of listed species. Additional inferences relative to biological diversity and overall ecosystem health can be made.

The presence of threatened or endangered species is highly sought after as a sustainability indicator due to the possible limitations they may put on certain land use actions, military or otherwise, in time or space. In addition, other Federal requirements (e.g., Sikes Act) may require consideration and protection of state listed or other identified species identical or comparable to that required by the Endangered Species Act (1960; USFWS 2003). Overall, the presence of threatened or endangered species on a military installation may result in legal and other requirements regarding the conservation and management of those species (United States Department of Defense and USFWS 2002).

Replicable

This information could be replicated every year based on published reports and plans from the U.S. Army Environmental Center (Bak et al. 2002). It can be anticipated that the individual state lists will increase over time and that the removal of species from state lists will be uncommon and infrequent. However, changes in numbers can be anticipated to be relative small and replication every year should not be universally necessary.

Directions

Download the number of year-round presence/resident, seasonal, migratory, contiguous, and accidental species present on each military installation and within each state from the U.S. Army Environmental Center (Bak et al. 2002). Divide the number of threatened and/or endangered species present on a military installation by the number of listed species identified for the state where installation is located to calculate the percent of state threatened and/or endangered species on a military installation.

Percent of State TES on a Military Installation =
(Number of TES present on a military installation) / (Number of listed TES identified for the state)

Import the resulting math into a GIS program and join with the installation shape files to create a Percent of State Threatened and/or Endangered Species on a Military Installation indicator layer.

Indicator Measure

The Percent of State Threatened and/or Endangered Species on a Military Installation were statistically classified where each installation rated at or below the mean was defined as green; each installation rated within one standard deviation above the mean was defined as amber; and each installation rated greater than one standard deviation above the mean was defined as red. Using this logic, the following Threatened and/or Endangered Species Listed classifications were defined as follows.

Green:	0.05% or less of state threatened or endangered species present on the military installation
Amber:	0.051 - 0.1% of state threatened or endangered species present on the military installation
Red:	0.1% or greater of state threatened or endangered species present on the military installation

Rules

Since this data is collected by installation, there is no calculation to determine installation ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Theme: Locational Sustainability

Indicator L1: Federally Declared Floods

Variables:	Number of Federally declared floods
Scale:	County
Year:	12/24/1964 through 2/10/2003, totaled

Data Source

Federal Emergency Management Agency (FEMA), U.S. Department of Homeland Security, *Federally Declared Disasters by Calendar Year*, (FEMA GIS and Data Solutions Branch, Washington, DC, 2003), available through URL: http://www.fema.gov/library/drcys.shtm

International Federation of Red Cross and Red Crescent Societies (IRRCRCS), *World Disasters Report: Focus on Reducing Risk 2002,* available through URL: http://www.ifrc.org/publicat/wdr2002/

Logic

Every year flood disasters cause damage amounting to billions of dollars worldwide. Floods inflict the greatest loss in money than any other Federally declared disaster in the United States. Floods are a threat to both built structures and human health and safety. Thus, the military must be sensitive to potential threats from the natural and built environment. The mission of the installation can be severely impacted by a flood if proper provisions are not in place.

This indicator measures the number of Federally Declared Floods occurring between 1964 and 2002. Federally Declared Floods are those floods declared by communities to the Federal government. Often times upon declaration, the Federal government offers some form of relief to the community (IFRCRCS 2002). Thus whether or not a flood is declared depends largely on the resources of the community and the aggressiveness of community leaders. Many floods of significant consequences are not declared while some of relatively little consequences are declared. In other words, declaration may have little to do with severity. Nonetheless, Federally Declared Floods offer the best indication of a community's flood risk reduction efforts. It is simply vital to use local knowledge in interpreting the Federally Declared Floods classifications.

Replicable

This indicator can be updated annually based on Federally Declared Disasters by Calendar Year data, as collected in the National Emergency Management Information System (NEMIS) maintained by the Federal Emergency Management Agency (FEMA) (2003).

Directions

The database, "declarations by type," is sorted by disaster type (FEMA 2003). All disasters except flooding are eliminated. Data is then sorted by county. Download and compile the data into a spreadsheet and calculate mean and standard deviation. Import the data into a GIS program and join it with the county shapefiles to create a Federally Declared Floods indicator layer.

Indicator Measure

The number of Federally declared floods for each county was summed to obtain a 38-year total for floods (FEMA 2003). Statistical analysis resulted in a mean of 2 and a standard deviation of 3. Fitting the data to a normal distribution created the following risk categories:

Green: Less than or equal to 2 flood declarations
Amber: 3 to 5 flood declarations
Red: Greater than or equal to 6 flood declarations

Rules

Installation risk levels will be determined by a weighted average. Installations are often in two or more counties. The weighted average calculation will determine what percentage of the installation is in each county, and that percentage for each county will be multiplied by that county's value. Those values for each county the installation will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in County A* Indicator Value for County A) + (Percent of Installation in County B* Indicator Value for County B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts.

Indicator L2: Seismicity

Variables: Peak Ground Acceleration, Probability of Exceedance in 50 years
Scale: National
Year: 2002

Data Source

Frankel, Arthur, Charles Mueller, Theodore Barnhard, David Perkins, E.V. Leyendecker, Nancy Dickman, Stanley Hanson, and Margaret Hopper. *Seismic-Hazard Maps for the Conterminous United States*, "Map F - Horizontal spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years," U.S. Geological Survey Open-File Report 97-131-F (U.S. Geological Survey Bureau, DOI, Reston, VA, 1997), accessed 12 February 2003, available through URL: http://geohazards.cr.usgs.gov/eq/

Sweeney, Steven, personal communication (U.S Army Engineer Research and Development Center, Construction Engineering Research Laboratory [ERDC-CERL], Champaign, IL, 12 February 2002).

Logic

Earthquakes are a threat to both built structures and human health and safety. Thus, the military must be sensitive to potential threats from the natural environment. The mission of the installation can be severely impacted by an earthquake.

Replicable

This indicator can be replicated as often as the USGS updates their Seismicity data. The standing trend seems to be that these maps are updated every 5 or 6 years.

Directions

GIS data concerning seismicity is available at http://geohazards.cr.usgs.gov/eq/ (Frankel et al. 1997). Download the horizontal spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years. Import the data into a GIS program to create a Seismicity indicator layer.

Indicator Measure

The values found on the map are the horizontal spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years. USGS documentation (Frankel et al. 1997) separates the data into various seismic risk levels, which were then translated into a red/amber/green scale with the assistance of seismic risk expert, Steve Sweeney at ERDC-CERL (Sweeney, 2002).

Green: Less than 8 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years

Amber: 8-16 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years

Red: Greater than 16 spectral response acceleration for 0.2 second period (5% of critical damping) with 2% probability of exceedance in 50 years

Rules

This indicator measures a location within a seismic risk zone. An installation takes on the rating of the highest risk seismic zone that it touches. For instance, if an installation is partly in an amber risk zone, and partly in a red risk zone, then the installation has a red risk rating.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator L3: Weather Related Damage

Variables: Damage in Dollars Due to Weather (crop and property)

Scale: State

Year: 1995-2001, totaled

Data Source

National Oceanographic and Atmospheric Administration (NOAA), *Summary of Natural Hazard Statistics in the United States* (National Weather Service, U.S. Department of Commerce, Office of Climate, Water, and Weather Services, Silver Spring, MD, 2001), available through URL: http://www.nws.noaa.gov/om/hazstats.shtml

Logic

The United States suffered nearly $200 billion in economic losses due to extreme weather in the 1990s, including $14 billion in damage in 1999 (USDoC. NOAA: NWS, 2001). The insurance industry is worried about the soaring costs of severe weather damage and is already refusing to cover various weather events in certain regions. The DoD lost an installation with Hurricane Andrew's destruction of Homestead AFB in Florida in August 1992. By examining historical weather related damage trends, one can see the vulnerability of the military mission to extreme weather. Thus, the military must be sensitive to potential threats from the natural environment. Weather conditions are a threat to built structures, human health and safety, and the mission of the installation. This indicator provides a measurement of the cost of the loss of crops and damage due to natural disasters for the past 7 years.

Replicable

This indicator could be updated annually as new data is posted to the National Weather Service website (USDoC. NOAA: NWS, 2001).

Directions

From the NOAA website, select a year from the "State Summaries" pull-down menu (USDoC. NOAA: NWS, 2001). This opens an Adobe acrobat document for that year containing fatalities, injuries, property damage, and crop damage for each state and U.S. territory. Download and compile the data into a spreadsheet and calculate mean and standard deviation. Import the data into a GIS program and join it with the county shapefiles to create a Weather Related Damage indicator layer.

Indicator Measure

The damage in dollars due to weather for each state and territory was summed to obtain a 7-year total for weather related crop and property damage (USDoC. NOAA: NWS, 2001). Statistical analysis resulted in a mean of $1,447 million and a standard deviation of $2,420. Fitting the data to a normal distribution created the following risk categories:

Green: Less than $1,447 million in weather related damage
Amber: $1,447 to $3,867 million in weather related damage
Red: Greater than $3,867 million in weather related damage

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator L4: Federally Declared Disasters

Variables: Number of Federally declared natural disasters in the categories of tsunami, coastal storm, drought, earthquake, flood, freezing, hurricane, typhoon, dam/levee break, mud/landslide, severe ice storm, fire, snow, tornado, volcano, and severe storm.
Scale: County
Year: 12/24/1964 through 2/10/2003, totaled

Data Source

FEMA, *Federally Declared Disasters by Calendar Year* (FEMA GIS and Data Solutions Branch, Washington, DC, 2003), available through URL: http://www.fema.gov/library/drcys.shtm

International Federation of Red Cross and Red Crescent Societies (IRRCRCS), *World Disasters Report: Focus on Reducing Risk 2002*, available through URL: http://www.ifrc.org/publicat/wdr2002/

Logic

In the 1990s, some 2 billion people were affected by disasters world-wide (IFRCRCS, 2002). No one is immune from disasters. Everyone is at risk. Only some are at a higher risk than others. By examining historical disaster trends, one can see that it is not only weather related damage causing disasters. Flawed development patterns (e.g., rapid unplanned urbanization, deforestation, installation of non-flood-proof dykes, no early warning systems, etc.) are also exposing more people to disasters (IFRCRCS, 2002). For example, earthquake fatalities are not necessarily the result of an earthquake, but rather ineffective building codes. Tornados sweeping away homes may not be a sign of strong winds as much as poorly sited housing. There is no doubt disasters are a threat to both built structures and human health and safety. Thus, the military must be sensitive to potential threats from the natural and built environment. The mission of the installation can be severely impacted by disasters if proper provisions are not in place.

This indicator measures the number of Federally Declared Disasters occurring between 1964 and 2002. Federally declared disasters are those disasters declared by communities to the Federal government. Often times upon declaration, the Federal government offers some form of relief to the community (IFRCRCS, 2002). Thus whether or not a disaster is declared depends largely on the resources of the community and the aggressiveness of community leaders. Many disasters of significant consequences are not declared while some of relatively little consequences are declared. In other words, declaration may have little to do with severity. Nonetheless, Federally declared disasters offer the best indication of a community's disaster risk reduction efforts. It is simply vital to use local knowledge in interpreting the Federally Declared Disasters classifications.

Replicable

This indicator can be updated annually based on Federally Declared Disasters by Calendar Year data, as collected in the National Emergency Management Information System (NEMIS) maintained by the Federal Emergency Management Agency (FEMA) (USDoHS. FEMA, 2003).

Directions

The database, "declarations by type," is sorted by disaster type (USDoHS. FEMA, 2003). Those disasters that are not in the categories of tsunami, coastal storm, drought, earthquake, flood freezing, hurricane, typhoon, dam/levee break, mud/landslide, sever ice storm, fire, snow, tornado, volcano, or severe storm are eliminated. Data is then sorted by county. Download and compile the data into a spreadsheet and calculate mean and standard deviation. Import the data into a GIS program and join it with the county shapefiles to create a Federally Declared Disasters indicator layer.

Indicator Measure

The number of Federally declared natural disasters in the categories of tsunami, coastal storm, drought, earthquake, flood, freezing, hurricane, typhoon, dam/levee break, mud/landslide, severe ice storm, fire, snow, tornado, volcano, and severe storm for each county was summed to obtain a 38-year total for natural disasters (USDoHS. FEMA, 2003). Statistical analysis resulted in a mean of 7 and a standard deviation of 4. Fitting the data to a normal distribution created the following risk categories:

Green:	Less than or equal to 7 disaster declarations
Amber:	8 to 11 disaster declarations
Red:	Greater than or equal to 12 disaster declarations

Rules

Installation risk levels will be determined by a weighted average. Installations are often in two or more counties. The weighted average calculation will determine what percentage of the installation is in each county, and that percentage for each county will be multiplied by that county's value. Those values for each county the installation will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in County A* Indicator Value for County A) + (Percent of Installation in County B* Indicator Value for County B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts.

Theme: Water Sustainability

Indicator W1: Level of Development

Variables: Level of Development, Stream flow levels
Scale: Watershed
Year: 1990

Data Source

USEPA (1997). *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 2002), available through URL: http://www.epa.gov/wateratlas/geo/maplist.html

Hurd, B., N. Leary, R. Jones, and J. Smith, "Relative Regional Vulnerability of Water Resources to Climate Change." *Journal of the American Water Resources Association*, vol 35, No. 6 (1999), pp 1399-1409, available through URL: http://www.awra.org

Logic

This indicator measures the ratio of current water withdrawal to mean annual unregulated stream flow. Watersheds with low water availability and high demand are vulnerable, i.e., in areas of development intensive use of off-stream water generally occurs resulting in decreased water availability (Hurd et al. 1999). With a reduction in stream flow, either via seasonal or dramatic climatic change, an increase in both in-stream and off-stream uses will occur, especially in areas of high development and high irrigation (Hurd et al. 1999). This indicator has an impact on the military mission if and when an installation is in an area with vulnerable watersheds. Water availability could be compromised resulting in a negative impact on soldiers, training, carrying capacity, and threatened and endangered species.

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6 digit accounting units and the 8 digit cataloguing units are generally referred to as basin and sub-basin. There are many states that have defined down to 16-digit HUCs (EPA 1997).

Replicable

Efforts are being made to replicate this analysis so it can be updated when new EPA data is available using the methodologies generated by the original study. This data is found in the EPA's Index of Water Quality Indicators at http://www.epa.gov/wateratlas/geo/maplist.html (EPA 1997). The EPA intends to replicate the effort and produce new data, although the timeline is unclear at this point due to lack of funding.

Directions

Download "level of development" and "stream flow levels" from the EPA Index of Watershed Indicators at http://www.epa.gov/wateratlas/geo/maplist.html (EPA 1997). Import the data into a GIS program and join it with the watershed shapefiles to create a GIS Level of Development indicator layer.

Indicator Measure

Ranges were defined as the ratio of total annual surface and groundwater withdrawals in 1990 (QW) to unregulated mean annual stream flow (QS).

Level of Development = (QW /QS)

The level of development ratings were grouped into the following classifications based on definitions created by the EPA. A complete explanation of why and how EPA chose these ranges is available at (EPA 1997) URL:

http://www.epa.gov/wateratlas/geo/maplist.html.

Green:	Less than 20%
Amber:	20 to 85%
Red:	Greater than 85%

Rules

Installation rating levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value.

Those values for each watershed the installation lies within will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) + (Percent of Installation in Watershed B* Indicator Value for Watershed B)…etc. = Indicator Value for the Installation

Map

Note, no data available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research. For data on all military installations, consult the project database or frequency charts.

Indicator W2: Groundwater Depletion

Variables: Groundwater Outflow, Groundwater Withdrawals (annual)
Scale: Watershed
Year: 1990

Data Source

USEPA, *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 1997), available through URL: http://www.epa.gov/wateratlas/geo/maplist.html

Hurd, B., N. Leary, R. Jones, and J. Smith, "Relative Regional Vulnerability of Water Resources to Climate Change," *Journal of the American Water Resources Association*, vol 35, No. 6 (1999), pp 1399-1409, available through URL: http://www.awra.org

Logic

This indicator shows the level of groundwater withdrawal in the large watersheds of the continental United States. Groundwater depletion characterizes the extent to which rates of groundwater withdrawals are exceeding long-run average recharge rates, resulting in overdraft and a condition referred to as "groundwater mining" (Hurd et al. 1999). Average groundwater withdrawals in excess of natural baseflows indicate an unsustainable rate of groundwater use. Excessive groundwater withdrawals suggest that increased groundwater use may not be a viable adaptation to changes in surface water supply or increases in water demand (Hurd et al. 1999).

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6-digit accounting units and the 8-digit cataloguing units are generally referred to as basin and sub-basin. There are many states that have defined down to 16-digit HUCs (EPA 1997).

Replicable

Efforts are being made to replicate this analysis so it can be updated when new EPA data is available using the methodologies generated by the original study. This data is found in the EPA's Index of Water Quality Indicators at http://www.epa.gov/wateratlas/geo/maplist.html (EPA 1997). The EPA intends to replicate the effort and produce new data, although the timeline is unclear at this point due to lack of funding.

Directions

Download "groundwater outflow" and "annual groundwater withdrawals" from the EPA Index of Watershed Indicators at:

http://www.epa.gov/wateratlas/geo/maplist.html

(EPA 1997). Import the data into a GIS program and join it with the watershed shape files to create a GIS Ground Water Depletion indicator layer.

Indicator Measure

Ranges were defined as the ratio of average groundwater withdrawals (QGW) in 1990 to annual average baseflow (QBase), reflecting the extent that groundwater use rates may be exceeding recharge.

Ground Water Depletion = (QGW / QBase)

The groundwater depletion ratings were grouped into the following classifications based on definitions created by the EPA:

Green: Less than 8%
Amber: 8 to 25%
Red: Greater than 25%

A complete explanation of why and how EPA (1997) chose these ranges is available at:

http://www.epa.gov/wateratlas/geo/maplist.html

Rules

Installation rating levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value. Those values for each watershed the installation lies within will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) + (Percent of Installation in Watershed B* Indicator Value for Watershed B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts. Note, no data is available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research.

Indicator W3: Flood Risk

Variable: Population
Scale: Watershed
Year: 1990

Data Source

USEPA, *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 1997), available through URL:
http://www.epa.gov/wateratlas/geo/maplist.html

Hurd, B., N. Leary, R. Jones, and J. Smith, "Relative Regional Vulnerability of Water Resources to Climate Change," *Journal of the American Water Resources Association*, vol 35, No. 6 (1999), pp 1399-1409, available through URL: http://www.awra.org

Logic

This indicator is based on the current population living within a 500-Year flood plain. The flood risk indicator characterizes the extent to which lives and property are at risk of flood damages. The 500-Year Floodplain was selected over the more commonly used 100-Year standard because most, if not all, zoning standards and building practices have been based on the 100-Year standard (Hurd et al. 1999). This means that those living within the 100-Year Flood plain have generally taken the necessary precautions to mitigate flood risks. There is more concern and risk for populations and property that lie just beyond the margin of the 100-Year Floodplain, where people have not had regulations that have required modifications to properties to mitigate flood risks generally (Hurd et al. 1999). This takes into consideration the pressures on the future of negative impacts on water quality and availability. Training mission and carrying capacity would be negatively impacted as a result of a 500-Year flood. This would then place the military installation in a vulnerable state, possibly affecting the type and intensity of training that would take place on the installation. Applicable laws and regulations can be found at

http://www.epa.gov/win/law.html

Replicable

This indicator will be replaced by the analysis of an installation's proximity to the 100- and 500-Year Floodplain once that data is released in its entirety by FEMA.

Directions

Download "flood risk" from the EPA Index of Watershed Indicators (1997) at :

http://www.epa.gov/wateratlas/geo/maplist.html

Import the data into a GIS program and join it with the watershed shapefiles to create a GIS Flood Risk indicator layer.

Indicator Measure

Ranges were defined as estimated number of people within the 500-year floodplain. The flood risk ratings were grouped into the following classifications based on definitions created by the EPA (1997):

Green: Less than 20,000 people
Amber: 20,000 to 200,000 people
Red: Greater than 200,000 people

A complete explanation of why and how EPA chose these ranges is available at:
http://www.epa.gov/wateratlas/geo/maplist.html

Rules

Installation rating levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value. Those values for each watershed the installation lies within will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) +
(Percent of Installation in Watershed B* Indicator Value for Watershed B) … etc.
= Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts. Note, no data is available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research.

Indicator W4: Low Flow Sensitivity

Variables: Baseflow in ft^3/second/square mile
Scale: Watershed
Year: 1990

Data Source

USEPA, *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 1997), available through URL: http://www.epa.gov/wateratlas/geo/maplist.html

Hurd, B., N. Leary, R. Jones, and J. Smith, "Relative Regional Vulnerability of Water Resources to Climate Change." *Journal of the American Water Resources Association*, vol 35, No. 6 (1999), pp 1399–1409, available through URL: http://www.awra.org

Logic

This indicator measures the unregulated mean baseflow per unit area (cfs/square mile). Stream flows are critical to many riparian areas, and falling below safe threshold levels can threaten individual species or potentially endanger entire aquatic ecosystems. Riparian ecosystems where seasonal periods of extreme low flow occur are the most vulnerable to climatic and hydrologic changes. This further diminishes stream flows during the low flow seasons, since there is less capacity for enduring additional stresses (Hurd et al. 1999).

Impacts to the military mission would include diminished or stressed threatened and endangered species (TES) habitat and population, which in turn could negatively impact the ability for certain training and other missions. Diminished carrying capacity across training may result due to the increased erosion, as a result. Finally, the availability of water would significantly decrease resulting in resource vulnerability.

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6 digit accounting units and the 8 digit cataloguing units are generally referred to as basin and sub-basin. There are many states that have defined down to 16-digit HUCs (EPA 1997).

Replicable

Efforts are being made to replicate this analysis so it can be updated when new EPA data is available using the methodologies generated by the original study. This data is found in the EPA's Index of Water Quality Indicators at http://www.epa.gov/wateratlas/geo/maplist.html (EPA 1997). The EPA intends to replicate the effort and produce new data, although the timeline is unclear at this point due to lack of funding.

Directions

Download "low flow sensitivity" from the EPA Index of Watershed Indicators (1997) at:

http://www.epa.gov/wateratlas/geo/maplist.html

Import the data into a GIS program and join it with the watershed shape files to create a GIS Low Flow Sensitivity indicator layer.

Indicator Measure

Baseflow was defined as the mean value of stream flow that originates from baseflow (groundwater outflow) during a typical year. This measurement is mostly independent of levels and changes in surface runoff. The low flow sensitivity ratings were grouped into the following classifications based on definitions created by the EPA (EPA 1997):

Green: Greater than 0.236 cfs/square mile
Amber: Greater than or equal to 0.065 cfs square mile and Less than or equal to 0.236 cfs/square mile
Red: Less than 0.065 cfs/square mile

A complete explanation of why and how EPA chose these ranges is available at:

http://www.epa.gov/wateratlas/geo/maplist.html

Rules

Installation rating levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value. Those values for each watershed the installation will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) +
(Percent of Installation in Watershed B* Indicator Value for Watershed B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts. Note, no data is available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research.

Indicator W5: Watershed Species at Risk

Variable: Number of Species
Scale: Watershed
Year: 1997

Data Source

USEPA, *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 1997), available through URL: http://www.epa.gov/wateratlas/geo/maplist.html

Hurd, B., N. Leary, R. Jones, and J. Smith, "Relative Regional Vulnerability of Water Resources to Climate Change." *Journal of the American Water Resources Association*, vol 35, No. 6 (1999), pp 1399–1409, available through URL: http://www.awra.org

Sikes Act, 16 USC 670a-670o, 74 Stat. 1052 (1960), available through URL: http://laws.fws.gov/lawsdigest/sikes.html

16 USC 670a-670o, 74 Stat. 1052, available through URL: http://laws.fws.gov/lawsdigest/sikes.html

Logic

This indicator measures the number of threatened and endangered species known to be in a watershed based on Federal Threatened and Endangered species (TES) counts as given by the USEPA (1997). This indicator characterizes the degree of relative stress that a watershed may be currently experiencing from a variety of sources, including habitat loss, pollution, predation, and disease by counting the number of at-risk, water-dependant species within a watershed (Hurd et al. 1999).

According to the Sikes Act, the DoD and Department of Interior (DOI) must cooperate with local state agencies for the planning, management, and maintenance of fish and wildlife populations and their associated habitat on military installations (1960). Watersheds with a high number of TES will significantly increase the possibility of regulatory restrictions on the installation's mission. This would then place the military installation in a vulnerable state, possibly affecting the type and intensity of training that would take place on the installation. Reduction and or change in military training activities may result if state and Federal agencies question military training impacts on TES and associated habitat. Restrictions, reductions, and change of training could result, including the permanent removal of land parcels from training. Supplementary applicable laws and regulations can be found at: http://www.epa.gov/win/law.html.

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6-digit accounting units and the 8-digit cataloguing units are generally referred to as basin and sub-basin. There are many states that have defined down to 16-digit HUCs (USEPA 1997).

Replicable

Efforts are being made to replicate this analysis so it can be updated when new EPA data is available using the methodologies generated by the original study. This data is found in the EPA's Index of Water Quality Indicators (1997) at:

http://www.epa.gov/wateratlas/geo/maplist.html

The EPA intends to replicate the effort and produce new data, although the timeline is unclear at this point due to lack of funding.

Directions

Download "species at risk" from the USEPA Index of Watershed Indicators (1997) at:

http://www.epa.gov/wateratlas/geo/maplist.html

Import the data into a GIS program and join it with the watershed shapefiles to create a GIS Species at Risk indicator layer.

Indicator Measure

Number of aquatic and wetland species identified were defined as either threatened or endangered, at-risk, or water-dependant, as estimated by EPA IWI (1997). The species at risk ratings were grouped into the following classifications based on definitions assigned by the EPA (1997).

Green: 1 species at risk
Amber: > 1 and < 5 species at risk
Red: > 5 species at risk

A complete explanation of why and how EPA chose these ranges is available at:
http://www.epa.gov/wateratlas/geo/maplist.html.

Rules

Installation rating levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value. Those values for each watershed the installation will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) + (Percent of Installation in Watershed B* Indicator Value for Watershed B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts. Note, no data is available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research.

Indicator W6: Water Quality

Variables: Waters meeting designated uses, Source water condition for drinking water systems, Fish & wildlife consumption advisories, Indicators of source water condition, Contaminated sediments, Ambient water quality – toxics, Water quality – conventional, Wetlands loss, Aquatic and wetlands species at risk, Loads over limits – toxics, over limits –

conventional, Urban runoff potential, Agriculture runoff potential, Population change, Hydrologic modification caused by dams, Estuarine pollution susceptibility, Deposition

Scale: Watershed

Year: 1999.

Data Source

USEPA, *The Index of Watershed Indicators*, EPA-841-R-97-010 (USEPA, Office of Water, Washington, DC, 1997), available through URL: http://www.epa.gov/wateratlas/geo/maplist.html

USEPA, *EPA Overall Watershed Characterization: September 1999 IWI Release* (USEPA, Office of Water, Washington, DC, 1999), available through URL: http://www.epa.gov/iwi/1999sept/catalog.html

Logic

The Index of Watershed Indicators (IWI) characterizes the condition and vulnerability of aquatic systems in each of the 2,262 watersheds in the 50 states and Puerto Rico (EPA 1999). This involves an assessment of condition, vulnerability, and data sufficiency. All variables taken into consideration are strong indicators of pressures in the future on water quality and vulnerability, leading to greater demands and risks to water supplies (USEPA 1999). This would then place the military installation in a vulnerable state, possibly affecting the type and intensity of training that would take place on the installation. Supplementary applicable laws and regulations can be found at:

http://www.epa.gov/win/law.html

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6 digit accounting units and the 8 digit cataloguing units are generally referred to as basin and sub-basin. There are many states that have defined down to 16-digit HUCs (EPA 1997).

Replicable

This indicator could be replicated every 2-4 years based on Regional inputs and monitoring programs. The Index of Watershed Indicators results are based on monitoring programs established within EPA Regions; monitoring programs vary across the country (USEPA 1999). Areas with strong monitoring programs may show more problems than those with weaker programs and replicability of these indicators depends heavily on current and future monitoring programs.

Directions

Download "water quality" from the EPA Overall Watershed Characterization: September 1999 IWI Release at:

http://www.epa.gov/iwi/1999sept/catalog.html

Import the data into a GIS program and join it with the watershed shapefiles to create a GIS Water Quality indicator layer.

Indicator Measure

This map combines 17 disparate data layers as listed above. Layers were weighted and then combined by the EPA (1999). The approach taken by the EPA can be found at:

http://oaspub.epa.gov/eims/direntrpt.report?p_deid=9996&p_chk=9186

Indicators of the condition of the watershed were scored and assigned to one of three categories: better water quality, water quality with less serious problems, and water quality with more serious problems (USEPA 1999). It is important to note that the strength of monitoring programs varies across the country and is reflected in the map. Areas with strong monitoring programs may show more problems than those with weaker programs. The water quality IWI ratings were defined as follows by the USEPA (1999).

Green:	Better Water Quality
Amber:	Less Serious Water Quality Problems
Red:	More Serious Water Quality Problems
Gray:	Insufficient data

Rules

Installation risk levels will be determined by a weighted average. Installations are often in two or more watersheds. The weighted average calculation will determine what percentage of the installation is in each watershed, and that percentage for each watershed will be multiplied by that watershed's value. Those values for each watershed the installation lies within will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in Watershed A* Indicator Value for Watershed A) + (Percent of Installation in Watershed B* Indicator Value for Watershed B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts. Note, no data is available for Alaska or Hawaii. The EPA does not collect data in Alaska due to the fact that most of the land area is tundra. Data for Hawaii is only partial at best, and therefore has been excluded from this research.

Theme: Economic Sustainability

Indicator EC1: DOD Local Employment

Variables: Military Employment, Total Employment
Scale: County
Year: 2000

Data Sources

Bureau of Economic Analysis, U.S. Department of Commerce, *Regional Economic Information System*, "Detailed County Annual Tables of Income and Employment by SIC Industry: CA25—Total Full-Time and Part-Time Employment by Industry)*"* (Washington, DC, 2000), available through URL: http://www.bea.doc.gov/bea/regional/reis/

National Governors Association Center for Best Practices, "State Strategies to Address Encroachment at Military Installations," *Natural Resources Policy Studies* (Washington, DC, 2003), available through URL: http://www.nga.org/cda/files/032403MILITARY.PDF

Logic

DOD local employment provides a measurement of the economic impact of military installations on the local economy. Military installations are often critical to local economies, accounting for thousands of jobs and for generating billions of dollars in economic activity and tax revenue (National Governors Association Center for Best Practices 2003).

Military installations provide many benefits to their local region in terms of economic impact. Installations in areas with strong independent economy or significant resource constraints may be economically less important to the area. This indicator is a measure of the economic investment of military employment within each county's economy. The assessment is based on the percentage of military employment within a county's total employment. It is assumed that the higher the percentage of military employment within an economy, the more likely the DOD will be looked on as a friend and field fewer complaints pertaining to stationing and mission decisions.

Replicable

Since 1969 REIS updates its datasets annually. Updated employment figures are downloadable from http://www.bea.doc.gov/bea/regional /reis/ (DOC Bureau of Economic Analysis 2000).

Directions

Download military and total employment figures by county (DOC Bureau of Economic Analysis 2000). Import the data into a GIS program and join it with the county shape files to create a GIS DOD local employment indicator layer.

Indicator Measure

The DOD local employment indicator provides a measure of the percent of military employment at a county level. The indicator is calculated by dividing the total military employment within a county by its total employment then multiplying the result by 100. This yields a percentage of military employment per county.

DoD Local Employment = [(total military employment)/(total employment)]*100

This data has evident natural breaks that have been used to classify the data into red, amber, and green. Red is the lowest level of military involvement, amber is the middle classification, and green indicates the highest level of military involvement, usually a major installation.

Red: Less than 0.77% of total local employment
Amber: 0.78 – 1.65% of total local employment
Green: Greater than 1.65% of total local employment

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B) … etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator EC2: Job Availability/Unemployment

Variables: Unemployment Rate

Scale: County

Year: 2000

Data Sources

Bureau of Labor Statistics, U.S. Department of Labor, *Employment Situation Explanatory Note* (Washington, DC, 2003), available through URL: http://www.bls.gov/news.release/empsit.tn.htm

Bureau of the Census, U.S. Department of Commerce, "Summary File 3: Geographic Comparison Table P-12, Employment Status and Commuting to Work" (Civilian Labor Force: Percent Unemployed), *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

DA, *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), available through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf

Logic

The most common measure of job availability is the unemployment rate. Theoretically the unemployment rate characterizes the job-market in a particular area. However, the system for gathering employment data is not perfect. Unemployment surveys miss self-employed and discouraged job seekers. Other workers have temporary jobs when they want permanent jobs, work part-time when they want to work full time, or hold jobs below their skill and education levels. Some workers counted as unemployed may be halfheartedly job-hunting to keep unemployment benefits (DOL Bureau of Labor Statistics 2003). Regretfully, there is not some quality of job measure available—comparing minimum and living wage and part-time and full-time employment.

Unemployment rates do, however, characterize quality of life. The Army has recognized in its Well-Being Action Plan that "Soldier and family satisfaction help to retain Soldiers" (Department of the Army [DA] 2002). Part of being "satisfied" is having the financial stability and employment needed to meet that. The military is beginning to move aggressively into addressing family member employment. Initial efforts are focused on establishing public partnerships with private corporations to provide training and career continuity to military spouses. A Spouse Telework Employment Program (STEP) is nearing completion and the Department of Defense is working with the Department of Labor to explore opportunities in the public sector. In the interim, the military's Spouse Employment Program is developing capabilities in the following areas: job search assistance, private sector job bank, and career counseling. Mid and long-term objectives focus on capturing lessons learned from the initial partnerships and expanding the program to more corporations (DA 2002).

Characteristics of the labor market reveal a lot about the economy and quality of life of a community. Although the job market may seem not to affect military Soldiers, it will affect their family members and the overall economic growth of the area. Like most economic news, a low unemployment rate is a mixed blessing. It is good news for workers and their families in terms of prosperity. But it means that employers have to scramble to fill their openings, and prospective employers may be just a bit wary about locating in areas where workers are hard to find and they have to offer higher wages to compete with other employers. Thus, economists have determined an ideal unemployment rate range of 4 to 5.6 percent (U.S. DOL. Bureau of Labor Statistics 2003). Some level of unemployment is normal. Yet, too low or too high unemployment rates leads to problems.

Replicable

The U.S. Census provides unemployment statistics every decade reported in Summary File 3 available for download at http://www.census.gov. The Economic Census profiles the U.S. economy every 5 years from the national to the local level.

Directions

Download GCT-P12 Employment Status and Commuting to Work: 2000 from the U.S. Census 2000 Summary File 3 at the county level. Available online at http://factfinder.census.gov/ (DOC Bureau of the Census 2000). Import Civilian Labor Force: Percent Unemployed data into a GIS program and join it with the county shape files to create a GIS unemployment indicator layer.

Indicator Measure

The rationale for the legend is based on unemployment levels around the ideal or "natural" unemployment rate (4-5.6 percent). Scholars disagree about what the exact natural rate of unemployment is and how it should be derived. From data and papers accessible through the U.S. Department of Labor, Bureau of Labor Statistics (http://www.bls.gov) most scholars commonly agree on 5.5 percent natural unemployment (DOL Bureau of Labor Statistics 2003). From this, levels of unemployment that are acceptable were designated green, and outside of this range natural breaks occurred to designate amber and red classifications.

Green:	Unemployment between 4 and 5.6%
Amber:	2.4 – 3.9 and 5.7 – 9.1%
Red:	Less than 2.4 or greater than 9.1%

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

Consult the project database or frequency charts for data on all military installations.

Indicator EC3: Housing Affordability

Variables: Net Rents, Net Income
Scale: County
Year: 1999

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Summary File 3: Geographic Comparison Table P-12, Employment Status and Commuting to Work" (Civilian Labor Force: Percent Unemployed), *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

U.S. Department of Housing and Urban Development (HUD), *Buying a Home: Find out How Much Mortgage Can You Afford* (HUD, Washington, DC, 2003), available through URL: http://www.hud.gov/buying/index.cfm

DA, *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), accessible through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf.

National Association of Realtors, *Housing Affordability* (Chicago, IL, 2003), available through URL: http://www.realtor.org

Logic

Housing affordability is "the ratio of median family income to the income needed to purchase the median priced home based on current interest rates and underwriting standards, expressed as an index" (National Association of Realtors 2003). The National Association of Realtors compiles such an index at the national level annually. The proportion of income spent on housing can be used as a broad measure of the ease (or difficulty) that people experience in meeting their housing requirements. Higher housing payments may reflect discretionary savings among home purchasers and care should be exercised in the use of such a measure. In the rental sector, households may choose to pay a higher rent to live close to employment and reduce travel time and cost. A comparison of the proportion of income spent on housing for different types of households and levels of income provides insight into those groups most likely to be under financial pressure through housing costs.

Housing affordability is also a characteristic of the overall cost of living. Referenced from the United States Department of Housing and Urban Development (Department of Housing and Urban Development [HUD] 2003), people should allocate 30 percent of their income to housing. This is the largest amount allocated to any one good or service. In other words, it is a large portion of a households' spending. If housing costs are high, it detracts from an individual's ability to afford other goods and services. People living where housing costs are high are less likely to be able to afford as high of standard of living as those living where housing costs are lower. If standard of living is lower, quality of life is lower—cannot afford the social and cultural aspects of personal enrichment (DA 2002). More specifically to the military are DOD housing allowances. With many military employees required to live off-base, local cost of living is an important indicator in determining the DOD housing allowance. Housing costs are determined based on gross rent within a community due to their high flexibility to change with rapidly changing market conditions.

Replicable

The U.S. Census provides housing statistics every decade reported in Summary File 3 available for download at: http://www.census.gov (DOC Bureau of the Census 1999). Housing statistics are also replicated every 5 years in a Decennial Supplementary Survey. It is recommended that the data is replicated only once a decade due to the non-comprehensiveness of the supplementary surveys.

Directions

Download table H69 Gross Rent as Percentage of Household Income: 1999 from the U.S. Census 2000 Summary File 3 at the county level available online at: http://factfinder.census.gov/ (DOC Bureau of the Census 1999). Import the data into a GIS program and join with the county shapefiles to create a GIS housing affordability indicator layer.

Indicator Measure

Gross rent as a percentage of household income in 1999 is a computed ratio of monthly gross rent to monthly household income (total household income in 1999 divided by 12). The ratio is computed separately for each unit and is rounded to the nearest tenth. Units for which no rent is paid and units occupied by households that reported no income or a net loss in 1999 comprise the category "Not computed." The sample is assumed to be relatively normal; the classifications were configured around the national average of 29.86 percent. Any county below the recommended 30 percent was designated as green. Anything within a standard deviation above the national mean were designated as amber (30.01-36.26 percent). Finally anything above this (36.26 percent) was designated as red.

Green: 0-30%
Amber: 30.01-36.26%
Red: 36.27-100%

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator EC4: Poverty Rate

Variables: Population Under 18 Years Below Poverty, Population 18–65 Years Below Poverty, Population Above 65 Years Below Poverty, Total Population

Scale: County

Year: 2000

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Glossary" (term: "Poverty"), *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov/home/en/epss/glossary_p.html

Kids Count, Annie E. Casey Foundation, "The High Cost of Being Poor: Another Perspective on Helping Low-Income Families Get By and Get Ahead," *Kids Count Online Database* (Census Data Online), (Baltimore, MD, 2000), available through URL: http://www.aecf.org/kidscount/census/

Logic

This indicator measures the economic sustainability in a particular county based on the economic indicator of income. The amount of disposable income a household or individual has to provide the basic needs determines the extent to which economic development is either self-undermining or self-renewing. Many military installations depend on the economic resources of the surrounding community. Thus, it is important that current economic practices occurring around military installations focus on providing positive options and choices of future generations. Economic development thrives when there is sufficient income and stagnates without sufficient income.

Poverty rates measure the sufficiency of income to provide basic needs. Poverty rates are most easily accessible through the U.S. Census Bureau. The U.S. Census Bureau defines poverty by following the Office of Management and Budget's (OMB's) Directive 14. The Census Bureau uses a set of money income thresholds that vary by family size and composition to detect who is poor. If the total income for a family or unrelated individual falls below the relevant poverty threshold, then the family or unrelated individual is classified as being "below the poverty level" (DOC Bureau of the Census 2000). The Kids Count project compiles these census figures into a comprehensive database addressing poverty for each U.S. County. By using these statistics, this study identifies areas with relatively high proportion of individuals without a sufficient disposable income to provide the basic needs and services (A.E.C.F. Kids Count 2000).

Lastly, it is important to note this data is on the county level, not community. Hence, it may be skewed by local "hotspots." In other words, if a county has one community raking high in poverty, the entire county is classified as high poverty regardless of the characteristics of the remaining majority of the county. Because of this concern, it is important to use local knowledge in interpreting the poverty classifications.

Replicable

The Kids Count database is maintained by the Annie E. Casey Foundation. The database includes a comprehensive source of population poverty status at the state and county level obtained from the U.S. Census Bureau (A.E.C.F. Kids Count 2000). This indicator could be replicated every year from the U.S. Census Bureau small income and poverty estimates program based on population estimates, or every decade based on actual, verifiable counts. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates. Poverty statistics may be obtained directly from the U.S. Census Bureau at http://factfinder.census.gov, or a "cleaned" version downloaded from the Kids Counts at: http://www.aecf.org/kidscount/data.htm

Directions

Download Population Under 18 Years Below Poverty, Population 18–65 Years Below Poverty, Population Above 65 Years Below Poverty, and Total Population for all U.S. counties from the Kids Count 2003 Database (AECF Kids Count 2000). Import the data into a GIS program and join it with the county shapefiles to create a GIS poverty indicator layer.

Indicator Measure

The poverty indicator provides a measure of the percent of the total population below the poverty level at a county level. The indicator is calculated by summing population under 18 years below poverty, population 18–65 years below poverty, and population above 65 years below poverty within a county and then dividing the total by the county's total population and finally multiplying the result by 100. This yields a percentage of poverty within a county.

Poverty =

[(Population Under 18 Years Below Poverty + Population 18-65 Years Below Poverty + Population Above 65 Years Below Poverty)/Total Population]*100

The data is assumed to be relatively normal and thus classification is based on the standard deviation (6.33) about a normal national mean (13.65 percent). The classes are as follows.

Green: 0-13.65% (at or below the national mean)
Amber: 13.66-16.815% (within 0.5 standard deviation of the national mean)
Red: 16.816% or above (above 0.5 standard deviation of the national mean)

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Theme: QOL Sustainability

Indicator QL1: Crime Rate

Variables: Murder, Rape, Robbery, Aggravated Assault, Burglary, Larceny, Auto Theft, and Arson Counts, Population
Scale: County
Year: 2000

Data Sources

Bureau of Investigation, U.S. Department of Justice, "Uniform Crime Reporting Program Data: County-Level Detailed Arrest and Offense Data," *National Archive of Criminal Justice Data/Inter-University Consortium for Political and Social Research*. (Washington, DC/Ann Arbor, MI, 2000), available through URL: http://www.icpsr.umich.edu/

Wilson, James Q., and George Kelling, "Broken Windows: The Police and Neighborhood Safety," *The Atlantic Monthly* (Boston, MA, 1982), available through URL: http://www.theatlantic.com/politics/crime/windows.htm

Logic

For years, practitioners and experts in the field of law enforcement assert the crime rate as an indicator of the overall quality of life and level of public services offered in a particular area. The U.S. Department of Justice supports the theory that higher incidences of crime tend to reflect economic stagnation, sprawl, and lack of community resources. If crime is prevalent in an area, people do not wish to live there, land is used inefficiently, and economic resources are spent fighting crime. The result is diverted resource away from other priorities such as protecting the environment. For these reasons, crime statistics are highly sought after as an indicator in the decisionmaking process for location of families and military development. The hosts of social and economic pressures that high crime incidences create result in large limitation on development potential of an area to military installations. These military installations are where soldiers and their families are housed. Thus, any installation must provide for their safe and secure future.

Supporting studies for these overall quality of life and level of public services assertions can be traced to a relatively simple theory referred to as "broken windows," which was first discussed by James Q. Wilson and George Kelling in 1982 (Wilson et al. 1982). Wilson and Kelling prove that on a community level, disorder and crime are inextricably linked. Their analogy is simple—linking social disorder to the condition of windows in a vacant building. If a single window is broken and goes unrepaired, it is a symbol that no one cares and thus is an acceptable act within the community. It is then only a matter of time before all of the windows are broken. The failure to repair the broken window is evidence of a social failure that results in disorder and inevitably leads to more serious disorder and crime and overall lack of stability. People move to new areas excluding themselves from others, and public services decline as more resources are put into crime defense. The overall environment declines—decreased quality of life (Wilson et al. 1982). Therefore, high incidences of crime should indicate a non-ideal location for military personal, their families, and military operations.

The Uniform Crime Reporting Program Data: County-Level Detailed Arrest and Offense Data 2000 reports counts of arrests and offenses for the Uniform Crime Reports (UCR) of the National Archive of Criminal Justice Data (NACJD) index (Part I) crimes: murder, rape, robbery, aggravated assault, burglary, larceny, auto theft, and arson (DOJ Bureau of Investigation 2000). The UCR County-level Arrest files also report arrests for additional (Part II) crimes such as forgery, fraud, vice offenses, and drug possession or sale. The Federal Bureau of Investigation (FBI) originally collected the data from reports submitted by agencies and states participating in the UCR Program. Detailed discussions of reporting procedures are found in the Uniform Crime Reporting Handbook (U.S. Government Printing Office [GPO] 1980), and in the codebooks for the Inter-university Consortium for Political and Social Research (ICPSR) data collections available at http://www.icpsr.umich.edu/NACJD/ucr.html. The FBI maintains the data in the NACJD, which is hosted by the ICPSR (DOJ Bureau of Investigation 2000).

Only Part I data—murder, rape, robbery, aggravated assault, burglary, larceny, auto theft, and arson—were used in this study. This data was summed by the ICPSR index and is a comprehensive list relevant to military installation quality of life assessment.

In one sense, this crime data is complete because it accurately describes the accountancy of each event. Yet, in another sense, it is incomplete because it may not easily be used to explore circumstance patterns. Missing from this data is the day-to-day social context of crime, which may be understood more completely by community residents than by statistics because of the resident's expertise concerning neighborhood problems and activity patterns. For community residents, there is a wealth of information that affects their perceptions of the safety of their community. These perceptions are formed not only by crime data, but graffiti, rowdiness, public drunkenness, abandoned autos, and other such factors may be as influential in coloring perceptions and appear as threatening as murder, rape, robbery, aggravated assault, burglary, larceny, auto theft, and arson.

Lastly, it is important to note this data is on the county level, not community. Hence, it may be skewed by local "hotspots." In other words, if a county has one community ranking high in crime, the entire county is classified as high crime regardless of the characteristics of the remaining majority of the county. Because of these two concerns, it is important to use local knowledge in interpreting the crime classifications.

Replicable

The Federal Bureau of Investigation provides estimations of national reported crime activity and arrest statistics from law enforcement agencies annually. These statistics are managed by the NACJD, and are also updated yearly through the ICPSR. The NACJD data are available from the ICPSR at http://www.icpsr.umich.edu (DOJ Bureau of Investigation 2000).

Directions

Download Study No. 3451. Uniform Crime Reporting Program Data [United States]: County-Level Detailed Arrest and Offense Data 2000 from the NACJD/ICPSR website (DOJ Bureau of Investigation, 2000):

http://www.icpsr.umich.edu/

Import Dataset 4: Crimes Reported data into a GIS program and join it with the county shape files to create a GIS crime indicator layer.

Indicator Measure

The Crime indicator provides a measure of murder, rape, robbery, aggravated assault, burglary, larceny, auto theft, and arson at a county level. The indicator is calculated by dividing the total number of the above-mentioned crimes within a county by its population and then multiplying the result by 1,000. This yields a rate of crime per 1,000 residents per county.

Crime Rate =

[(murder+rape+robbery+aggravated assault+burglary+larceny+auto theft+arson)/population]*1,000

Crime data was classified by a standard deviation around a relatively normal mean. The national average is 23 crimes per 1,000 population. Thus the scale is as follows.

Green:	23 or fewer crimes per 1,000 (equal to or lower than national average)
Amber:	23.01 – 37 crimes per 1,000 (within 0.5 standard deviation above the national average)
Red:	Greater than 37 crimes per 1,000 (above 0.5 standard deviation above the national average)

Rules

Installations' locations often span two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's assessment value. The values for each county contiguous to the installation are then totaled to arrive at a value for the installation. This value is subjected to the same metric that determined the assessment levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator QL2: Housing Availability

Variables:	Homeowner Vacancy Rate
Scale:	County
Year:	2000

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Summary File 1: Homeowner Vacancy Rate," *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

Heumann, Leonard F., Professor of Urban Regional Planning, personal communication (University of Illinois, Urbana-Champaign, 12 February 2002).

Logic

This indicator along with Rental Availability provides an idea of the housing availability in a particular county and its neighboring area. According to housing expert Leonard Heumann, the homeownership and rental vacancy rate is relatively tight and small movements in one direction or another can have large effects in the surrounding economy. It is important to examine owner and rental availability separately to grasp a realistic picture of available housing in a given area (Heumann 2002).

With many military employees forced to choose off base housing, housing availability is an important indicator in determining DoD stationing attractiveness and quality of life for military employees and their family. Housing availability can directly impact a number of quality of life indicators. For example, it may determine commute times, access to schools or cultural amenities, or if a family may live with a service member.

Replicable

The U.S. Census provides vacancy statistics every decade reported in Summary File 1 available for download at http://www.census.gov (DOC Bureau of the Census 2000). Vacancy statistics are also replicated as estimates annually. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates.

Directions

Download Homeowner Vacancy Rate from the U.S. Census 2000 Summary File 1 at the county level. Available online at http://factfinder.census.gov/ (DOC Bureau of the Census 2000). Import the data into a GIS program and join it with the state shape files to create a GIS housing availability indicator layer.

Indicator Measure

Map homeowner vacancy rate per county. It should be noted that some areas of high owner occupied vacancy might possibly be seasonal housing not occupied at the time of the census.

The rationale for the legend is that too high or too low an owner vacancy rate can be an indicator of difficulty of obtaining housing (too low) or serious problems in the housing market and surrounding economy (too high). These rough classifications were provided from Leonard Heumann, a professor at the University of Illinois at Urbana-Champaign with expertise in housing issues, through a personal interview in 2002 (Heumann 2002).

Green: 2-3.5%
Amber: 1.5-2 and 3.5-6%
Red: less than 1.5 and greater than 6%

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =
(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator QL3: Rental Availability

Variables: Rental Vacancy Rate
Scale: County
Year: 2000

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Summary File 1: Rental Vacancy Rate," *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

Heumann, Leonard F., Professor of Urban at Regional Planning, University of Illinois at Urbana-Champaign. Adam Hall, ed. (Champaign, IL, 2002).

Logic

This indicator along with Homeowner Availability provides an idea of the rental availability in a particular county and its neighboring area. Referenced in consultation with housing expert Leonard Heumann, the homeownership and rental vacancy rate is relatively tight and small movements in one direction or another can have large effects in the surrounding economy. It is important to examine owner and rental availability separately to grasp a realistic picture of available housing in a given area (Heumann 2002).

With many military employees forced to choose off base housing, rental availability is an important indicator in determining DoD stationing attractiveness and quality of life for military employees and their family. Similar to housing availability, rental availability also directly impacts a number of quality of life indicators. For example, it may determine commute times, access to schools or cultural amenities, or if a family may live with a service member.

Replicable

The U.S. Census provides vacancy statistics every decade reported in Summary File 1 available for download at http://www.census.gov (DOC Bureau of the Census 2000). Vacancy statistics are also replicated as estimates annually. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates.

Directions

Download Rental Vacancy Rate from the U.S. Census 2000 Summary File 1 at the county level. Available online at http://factfinder.census.gov/ (DOC Bureau of the Census 2000). Import the data into a GIS program and join it with the county shape files to create a GIS rental availability indicator layer.

Indicator Measure

Map rental vacancy rate per county. It should be noted that some areas of high rental occupied vacancy might possibly be seasonal housing not occupied at the time of the census.

The rationale for the legend is that too high or too low a rental vacancy rate can be an indicator of difficulty of obtaining housing (too low) or serious problems in the housing market and surrounding economy (too high). These rough classifications were provided from Leonard Heumann, a professor at the University of Illinois at Urbana-Champaign with expertise in housing issues, through a personal interview in 2002 (Heumann 2002).

Green: 7.02-11.25%
Amber: 4.38-7.01 and 11.26-13.68%
Red: less than 4.38 and greater than 13.68%

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. The values for each county contiguous to the installation are then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =
(Percentage of Installation in County A* Indicator Value for County A) + (Percentage of Installation in County B* Indicator Value for County B) … etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator QL4: Healthcare Availability

Variables: Medical Underservice (ratio of primary medical care physicians per 1,000 population, infant mortality rate, percentage of the population with incomes below the poverty level, and percentage of the population age 65 or over)
Scale: County

Year: 2000

Data Sources

DA, *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), accessible through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf.

Health Resources and Services Administration, U.S. Department of Health and Human Services, *Health Professional Shortage Areas* (Washington, DC, 2000), available through URL: http://bhpr.hrsa.gov/shortage/muadatadict.htm

Health Resources and Services Administration, U.S. Department of Health and Human Services, *What We Do*, (Washington, DC, 2003), available through URL: http://www.hhs.gov/news/press/2002pres/profile.html

Ringel, Jeanne S., Susan D. Hosek, Ben A. Vollaard, and Sergej Mahnovski, *The Elasticity of Demand for Health Care: A Review of the Literature and Its Application to the Military Health System* (National Defense Research Institute/RAND Health, Washington, DC, 2002), available through URL: http://www.rand.org/publications/MR/MR1355/MR1355.pdf

Logic

The U.S. Department of Health and Human Service (DoHHS) defines healthcare as an "essential human service" (DoHHS 2003). Access to preventive healthcare and treatment for families and individuals can affect both their personal and the region's quality of life. The Army's Well-Being Program acknowledges that low availability to healthcare can diminish quality of life as populations go without preventive care such as immunizations, often leading to disease (DA 2002). Unfortunately, healthcare is not provided equally across the nation nor do all individuals use it similarly. DoD-paid healthcare differs in several important ways from the demand for healthcare services in general (Ringel et al. 2002). These differences derive from the unusual organization structure of the Military Health System (MHS). Three key differences exist. First, active duty personnel have less discretion in seeking care than their civilian counterparts and some military duties involve higher risk. Moreover, "to ensure that active duty personnel are healthy and fit for duty, they are provided more frequent preventive and routine care than would be typical for civilian the same age" (Ringel et al. 2002). Second, TRICARE, insurance provider to DoD, treats military treatment facilities differently than civilian care. In other words, a recipient may receive more benefits if using a MTF instead of civilian care, thus allocation between the Military Treatment Facilities and civilian providers is a factor. Third, military beneficiaries typically use substantially more healthcare service (increased demand for prescriptions, etc.) than comparable civilians populations (Ringel et al. 2002).

Therefore, it is important to the well-being of military installations to identify areas where healthcare is underserved. Underservice is an indication of the current health status for military operations and the lives of military personnel and their families.

The DoHHS' indices of Health Professional Shortage Area (HPSA) and Medial Underservice (IMU) are currently the most comprehensive source of secondary data to characterize the health and resource capacity of communities in the United States (DoHHS 2000). Both indices are compiled by the HRSA, and are used to allocate resources for Federal and sometimes state programs including the assignment of National Health Service Corps Physicians or allowing International Medical Graduates with J-1 visas to practice in a community (DoHHS 2000). A complete definition of these measures and methods is published at:

http://bhpr.hrsa.gov/shortage/muadatadict.htm

A brief summary of the measure may also be found under "Indicator Measure" of this report.

The under service data is reported at the county level. Health analysis experts recognize that there are many potential geographic units to use in the monitoring of our health system, yet there is no agreement or evidence to suggest a preferred geography. The reason for mentioning the units is that significant disparities among neighbors and community groups exist. Health is not expressed by political boundary, gender, age, occupation, etc. In other words, there is no ideal standard for expressing the degree of need in a community or at what scale to address those needs. Therefore, it must be understood that the IMU indicator is an aggregate measure of the availability counties have to healthcare. A particular county may have many designations, yet the map aggregates all designations within any given county. Therefore, with spatially large or populous counties, the data may be skewed by local "hotspots." User knowledge of an area should be applied to the use of healthcare measurements.

Replicable

HRSA updates Medically Underserviced Area (MUA) designations annually and is accessible through the DoHHS (2000) website at:

http://bhpr.hrsa.gov/shortage/muadatadict.htm

Directions

Download MUA designations from the DoHHS website (2000). After downloading the data, "clean" the data by aggregating (averaging) rankings for counties with more than one MUA designation. It should be noted that some counties have insufficient data. Import the cleaned data set into a GIS program and join it with the county shapefile to form a healthcare availability indicator layer.

Indicator Measure

Adequate access has been defined by the DoHHS through their IMU. This index consists of a ranking that extends from 0-100 (0 indicating the highest need and 100 indicating the lowest need). It is the DoHHS that has developed this MUA designation. Under their established criteria, each service area found to have an index of 62.0 or less is designated as an MUA. The IMU involves four variables: (1) ratio of primary medical care physicians per 1,000 population, (2) infant mortality rate, (3) percentage of the population with incomes below the poverty level, and (4) percentage of the population age 65 or over. The value of each of these variables for the service area is converted to a weighted value, according to established criteria. The four values are summed to obtain the county's IMU (DoHHS 2000).

Using a classification based on the standard deviation (8.5) about a normal mean (52.32). The classes are as follows.

Red: Highly Underserved (0-52.32), Below the National Average and the DoHHS Standard of 62.0 or less designated as an MUA

Amber: Underserved (52.33-62.00), Above the National Average and Below the DoHHS Standard of 62.0 or less designated as an MUA

Green: Not Underserved (62.01-77.11), Above the National Average and the DoHHS Standard of 62.0 or less designated as an MUA

Grey: Insufficient Data

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. The values for each county contiguous to the installation are then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, see the project database or frequency charts.

Indicator QL5: Educational Attainment

Variables: Persons 25 years of age and older,% high school graduate or higher

Scale: County

Year: 2000

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Summary File 3: Geographic Comparison Table P-11, Language, School Enrollment, and Educational Attainment" (Population 25 years and over: Percent High School Graduate or Higher), *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

DA, *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), accessible through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf.

National Center for Educational Statistics, U.S. Department of Education, *Condition of Education*, (Washington, DC, 2003), available through URL: http://nces.ed.gov/programs/coe/

Logic

Educational opportunities allow individuals to grow and enrich their life. The Army places high priority on the well-being—the "personal, physical, material, mental, and spiritual state of Soldiers, civilians, and their families that contributes to their preparedness to perform the Army's mission" (DA 2002). Each year the Army updates an *Army Well-Being Action Plan*. This plan is dedicated to providing resources to meet the well-being needs of the Army as well as the entire U.S. military. These needs include the personal needs and aspirations of military personnel and family members to which education is a significant factor. The FY03 *Army Well-Being Action Plan* focuses on education and academic excellence for its personnel and their families (DA 2002). Thus, educational attainment is a highly sought after indicator for the sustainability of military installations.

The U.S. military provides all necessary education to its members. Currently, through the Education Transition Study Memorandum of Agreement, the military education focus in now shifting to nurturing relationships between civilian institutions and military institutions to ensure swift implementation of agreements for their personnel and their families (DA 2002). The military recognizes that it is easier to provide for education when there are resources to build off from within the surrounding community (DA 2002). Therefore, within this report, the quality of an educational environment is determined by the overall educational attainment of the surrounding community. It is assumed that the percentage of the population with a high school diploma or higher is an indicator of societal support for education (including the parental and community support). With strong support, it is then assumed the educational system will be strong and have a large amount of resources put into it.

In addition to having the framework for educational opportunities for military employees, a high percentage of the population with a high school diploma or higher creates a strong pool of qualified employees for military operations.

Replicable

The U.S. Census provides educational attainment statistics every decade reported in Summary File 3 available for download at http://www.census.gov (DOC, Bureau of the Census 2000). Every year the U.S. Census provides estimated educational attainment statistics through the American Community Survey Summary Tables (PCT-034), which are available for download at:

http://factfinder.census.gov/

Annual estimates are collected by the decennial census long form and blend the strength of small area estimation from the census with the quality and timeliness of a continuing survey. Continuous Measurement includes a large monthly survey, the American Community Survey, and additional estimates produced by the use of administrative records in statistical models. The American Community Survey is in a developmental period that started in 1996. When fully operational, beginning in 2003, three million different households will be selected in the sample each year. Yet, due to the current inaccuracy of U.S. Census estimates, it is recommended that the data be replicated only once a decade.

Directions

Download Geographic Comparison Table P-11. Language, School Enrollment, and Educational Attainment: 2000 from the U.S. Bureau of the Census (2000) website:

http://factfinder.census.gov/

Import Population 25 years and over: Percent High School Graduate or Higher into a GIS program and join it with the county shapefiles to create a GIS educational attainment indicator layer.

Indicator Measure

Educational Attainment measures the percent of the population 25 years or older with a high school degree or higher (as calculated by the U.S. Bureau of the Census (2000), and is available online at:

http://factfinder.census.gov/

The sample is assumed to be relatively normal. Therefore, the national average of 76.1 percent was used to figure class breaks. The breaks are defined as follows.

Green:	82.8 – 100% (greater than 0.5 standard deviation above the national average)
Amber:	76.2 – 82.7% (within 0.5 standard deviation above the national average)
Red:	Less than 76.1% (national average or lower)

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. The values for each county contiguous to the installation are then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +
(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator QL6: Commute Times

Variables: Commute Time
Scale: County
Year: 2000

Data Sources

Bureau of the Census, U.S. Department of Commerce, "Summary File 3: Geographic Comparison Table P-12, Employment Status and Commuting to Work" (Workers 16 Years and Over: Who Did Not Work at Home-Mean Travel Time to Work [Minutes]), *American Fact Finder* (Washington, DC, 2000), available through URL: http://factfinder.census.gov

DA, *FY03 Army Well-Being Action Plan* (Deputy Chief of Staff for Personnel, Washington, DC, 2002), accessible through URL: http://www.odcsper.army.mil/Directorates/wb/FY03_WBAP_Vol_1.pdf.

Surface Transportation Policy Project, *Transportation and Economic Prosperity* (Washington, DC, 2003), available through URL: http://www.transact.org/library/factsheets/transportation%20and%20economic%20prosperity%20.doc

Logic

Commute time relates to congestion of the local road network surrounding a military installation. Road congestion is an indicator of potential problems using the highway near installations. This addresses traffic from the military operations standpoint. Commute time addresses traffic from the quality of life standpoint. Individuals demand the conveniences of easy access between home and work with minimal time "wasted." The natural tendency of a city is to prosper, grow, and expand outward. By nature, transportation improvements often do not keep pace with rapid population growth. Thus, commute time is a strong indicator of local quality of life. It is a measure of the inefficiency of the transportation system, which makes for happy or unhappy users (Surface Transportation Policy Project 2003).

The Surface Transportation Policy Project is a non-for-profit organization that advocates transportation systems as a component of quality of life (Surface Transportation Policy Project 2003). They cite:

> The transportation system should provide for the efficient and reliable delivery and distribution of goods and services to all markets, serve employer needs for recruitment and retention of a high-quality workforce, and be redundant, resilient, reliable, and resistant to service and system

> disruptions. In addition, transportation investments should support local and regional economic objectives and recognize efficient activity centers as the drivers of economic prosperity and sustainable growth.

In terms of the military, installations are where the military personnel and their families live. If either is unhappy with the amount of time it takes to get anywhere, the service member will not be satisfied and may not re-enlist (DA 2002). Thus commute time are sought after as an indicator of the local quality of life

Replicable

The U.S. Bureau of the Census (2000) provides commuter statistics every decade reported in Summary File 3 available for download at:

http://www.census.gov

Commuter statistics are also replicated annually based on Census of Population estimates. It is recommended that the data be replicated only once a decade due to the inaccuracy of the census estimates.

Directions

Download GCT-P12 Employment Status and Commuting to Work: 2000 from the U.S. Census 2000 Summary File 3 at the county level. Available online at http://factfinder.census.gov/ (DOC Bureau of the Census 2000). Import Workers 16 years and over: Who did not work at home—Mean travel time to work (minutes) data into a GIS program and join it with the county shapefiles to create a GIS commute time indicator layer.

Indicator Measure

The U.S. Census Bureau reports average commute-time in minutes for each county (U.S. Bureau of the Census 2000). The national average was reported at 23 minutes for 2000. Since the sample is assumed to be relatively normal, the classifications were configured around the national average for green designations. Natural breaks were used to classify red and amber.

- Green: 0-23 minutes (at or below the national average)
- Amber: 24-26 minutes (one standard deviation above the national average)
- Red: 27 minutes or greater (greater than one standard deviation above the national average)

Rules

Installations are often in two or more counties. Therefore, installation risk levels are determined by a weighted average. The weighted average calculation determines what percentage of the installation is in each county and multiplies that percentage for each county by that county's risk value. Those values for each county of the installation is then totaled to arrive at a value for the installation. This value is subjected to the same risk metric that determined the risk levels for the individual counties.

Example

Indicator Value for the Installation =

(Percentage of Installation in County A* Indicator Value for County A) +

(Percentage of Installation in County B* Indicator Value for County B)…etc.

Map

For data on all military installations, consult the project database or frequency charts.

Theme: Infrastructure Sustainability

Indicator TA1: Capacity of Commercial Airports

Variables: Average Daily Aircraft Operations

Scale: State

Year: 2001

Data Sources

AirNav.Com, *Airports* (complete list of airport codes, 2003), available through URL: http://www.airnav.com/

Terminal Area Forecast System, Unclassified Corporate Database (Federal Aviation Administration, Air Mobility Command, Scott AFB, 2001), available through URL: http://www.apo.data.faa.gov/faatafall.HTM (https://www.afd.scott.af.mil)

Logic

This indicator provides, by state, a measurement of the number of operations performed at the airport. The number of operations performed per day is an indicator of the number of potential airborne threats near an installation, and are thus highly sought after as an indicator in the decisionmaking process for military development. Air space pressures created from numerous operations result in large limitation on development potential of an area to military installations' air space missions.

Additionally, it is important to note this data is on the state level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a state has one airport with numerous air operations, regardless of their flight paths, the entire state is classified as low available capacity regardless of the characteristics of the remaining majority of the state. Because of this concern, it is important to use local knowledge in interpreting the airport capacity classifications.

Replicable

This indicator could be replicated every year based on information updated in Federal Aviation Administration (FAA) Terminal Area Forecast (TAF) System (FAA 2001).

Directions

Download airport capacity for a given airport from the Terminal Area Forecast (TAF) System via the Internet. Airfield information is obtainable from the Air Mobility Command (Scott AFB) to determine whether each airfield is suitable for specific types of aircraft (i.e., C-141B, C-5, C-130, C-17, KC-10, KC-135, and C-9) (FAA 2001). The calculation for determining the average daily aircraft operations by state is as follows:

Average Daily Aircraft Operations = Total Annual Aircraft Operations / 365

For a complete listing of airport codes, refer to http://www.airnav.com/airports (AirNav.Com 2003). Table A8 gives a detailed example calculation for the state of New York.

Table A8. Airport Capacity Summary, 2001 (F. A. A. Terminal Area Forecast System, 2001).

State	State Abbreviation	Total Annual Aircraft Operations (2001)
…		
New York	NY	4,658,709
…		

Based on data from the Terminal Area Forecast (TAF) System, the total number of airports for the State of New York reports 4,658,709 total annual aircraft operations:

Average Daily Aircraft Operations = 4,658,709 / 365 =
12,763.59 operations/day for the state of New York

Compile the data for each state. Import the data into a GIS program and join it with the state shapefiles to create a Capacity of Commercial Airports indicator layer.

Indicator Measure

Capacity of Commercial Airports classifications were defined as follows based on definitions of the Terminal Area Forecast System, Federal Aviation Administration (FAA 2001).

Green: Less than 4000 operations per day
Amber: 4000 to 8000 operations per day
Red: Greater than 8000 operations per day

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TA2: Airport Suitability for C5 Aircraft

Variables: Mile Buffers
Scale: Airport
Year: 2001

Data Sources

AirNav.Com, *Airports* (complete list of airport codes, 2003), available through URL: http://www.airnav.com/

Terminal Area Forecast System, Unclassified Corporate Database (Federal Aviation Administration, Air Mobility Command, Scott AFB, 2001), available through URL: http://www.apo.data.faa.gov/faatafall.HTM (https://www.afd.scott.af.mil)

U.S. General Accounting Office (GAO), *Military Airlift: Comparison of C-5 and C-17 Airfield Availability Report to Congressional Committees* (GAO, National Security and International Affairs Division, Washington, DC, 1994), available through URL: http://www.globalsecurity.org/military/library/report/gao/152088.pdf

Logic

This indicator provides suitabilities for C-5 aircraft at each commercial airport within a prescribed distance. Not all aircraft types have the capability to land at every airfield due to runway strength, runway size, and runway type. Landing requirements will also vary, whether it is based on wartime or peacetime criteria. According to the July 1994 General Accounting Office (GAO) Report to Congressional Committees, Military Airlift: Comparison of C-5 and C-17 Airfield Availability the C-5, C-5 aircraft can land on a paved runway 5,000 feet long by 90 feet wide during wartime, while normal performance is defined as landing on a paved runway 6,000 ft long by 147 ft wide (R.t.C.C. United States General Accounting Office 1994).

Access to a C-5 capable runway is typically a necessity for military shipments, mobilization, and training. If access in inadequate (measured by geographical distance), then it is a strong indicator of pressures on the future use and vulnerability of air space, leading to greater demands and limitations on Military development and missions. This would then place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation.

Replicable

This indicator could be replicated every year based on information updated in Federal Aviation Administration's Terminal Area Forecast (TAF) System and Scott AFB's Airport Search Database (FAA 2001).

Directions

Download C-5 suitability airport data from the Air Mobility Command (Scott AFB) database (FAA 2001) at:

https://www.afd.scott.af.mil/

The three-letter codes for each airport (e.g., ORD for Chicago O'Hare International Airport, AirNav.Com 2003) were acquired from:

http://www.airnav.com/airports

Import the data into a GIS program and join it with the airports shapefiles to create an Airport Suitability for C-5 Aircraft indicator layer. Create "buffers" around these airports at pre-determined distances.

Indicator Measure

Airport Suitability for C-5 Aircraft classifications were defined as follows.

Green:	Buffer of airports within 5 miles
Amber:	Buffer of airports within 25 miles
Red:	Underserved areas (not within 25 miles of a C-5 suitable airport)

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TA3: Airport Suitability for C141 Aircraft

Variables:	Mile Buffers
Scale:	Airport
Year:	2001

Data Sources

AirNav.Com, *Airports* (complete list of airport codes, 2003), available through URL:
http://www.airnav.com/

Federal Aviation Administration (FAA), *Terminal Area Forecast System*, Unclassified Corporate Database (FAA, Air Mobility Command, Scott AFB, 2001), available through URL:
http://www.apo.data.faa.gov/faatafall.HTM (https://www.afd.scott.af.mil).

GAO, *C-17 Aircraft: Cost and Performance Issues*, Report to Congressional Committees (GAO, National Security and International Affairs Division, Washington, DC, 1995), available through URL:
http://www.fas.org/man/gao/gao9526.htm

Logic

This indicator provides suitabilities for C-141 aircraft at each commercial airport within a prescribed distance. Not all aircraft types have the capability to land at every airfield due to runway strength, runway size, and runway type. Landing requirements will also vary, whether it is based on wartime or peacetime criteria. According to a January 1995 General Accounting Office (GAO) report entitled, C-17 Aircraft: Cost and Performance Issues, only the C-141 and C-130 aircraft have the capability of routinely performing airdrop missions (R. t. C. C. U.S General Accounting Office 1995).

Access to a C-141 capable runway is typically a necessity for military shipments, mobilization, and training. If access in inadequate (measured by geographical distance), then it is a strong indicator of pressures on the future use and vulnerability of air space, leading to greater demands and limitations on Military development and missions. This would then place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation.

Replicable

This indicator could be replicated every year based on information updated in Federal Aviation Administration's Terminal Area Forecast (TAF) System and Scott AFB's Airport Search Database (FAA 2001).

Directions

Download C-141 suitability airport data from the Air Mobility Command (Scott AFB) database (FAA 2001) at:

https://www.afd.scott.af.mil/

The three-letter codes for each airport (e.g., ORD for Chicago O'Hare International Airport, AirNav.Com 2003) were acquired from:

http://www.airnav.com/airports

Import the data into a GIS program and join it with the airports shapefiles to create an Airport Suitability for C-141 Aircraft indicator layer. Create "buffers" around these airports at pre-determined distances.

Indicator Measure

Airport Suitability for C-141 aircraft classifications were defined as follows.

Green: Buffer of airports within 5 miles

Amber: Buffer of airports within 25 miles

Red: Underserved areas (not within 25 miles of a C-5 suitable airport)

Rules

Since this data is collected by installation, there is no calculation to determine installation risk ratings.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TRR1: Railroad Capacity

Variables: Train Movements per Crossing per Day

Scale: County

Year: 2003

Data Sources

Federal Railroad Administration (FRA), U.S. Department of Transportation (DOT), *Highway-Rail Crossing Inventory by State* (FRA, Office of Safety Analysis, Washington, DC, 2003), available through URL: http://safetydata.fra.dot.gov/OfficeofSafety/Downloads/Default.asp?page=downloaddbf.asp

Logic

This indicator provides a measurement of the number of trains passing through the terminal per day. The number of daily trains crossing the terminal is an indicator of potential availability problems and congestion on the rail system. The rail system may be required by the military for material shipment and mobilization. This would then place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation.

Additionally, it is important to note this data is on the county level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a county has one railroad with numerous train movements, regardless of the movement characteristics, the entire county is classified as low available capacity regardless of the characteristics of the remaining majority of the county. Because of this concern, it is important to use local knowledge in interpreting the railroad capacity classifications.

Replicable

This indicator could be replicated as needed based on information updated in Federal Railroad Administration's Highway-Rail Crossing Inventory by State (DOT Federal Railroad Administration 2003).

Directions

Railroad capacity is defined as the number of trains per railroad crossing per day. A complete listing of railroad crossings at the state and county levels can be found using the Highway-Rail Crossing Inventory by State database (DOT Federal Railroad Administration 2003). Download county level trains per railroad per day and number of railroad crossings from the above-mentioned database. The calculation for determining the number of trains per crossing per day by county (or state) is as follows.

Number of Trains per Crossing per Day =
Grand Total Number of Trains per Day / Number of Railroad Crossings

Table A9 gives a detailed example calculation for the state of Hawaii.

Based on the information from Table 1, the State of Hawaii has a total of 8 railroad crossings (six active, two non-active) for a grand total of 60 trains per day.

Number of Trains per Crossing per Day = 60 / 6 =
10 trains per railroad crossing per day for the state of Hawaii.

Compute the "number of trains per crossing per day" for each state. Import the resulting math into a GIS program and join it to the county shapefiles to create a Railroad Capacity indicator layer.

Table A9. List of railroad crossings in the State of Hawaii (DOT Federal Railroad Administration 2003).

Railroad Crossing #	Railroad Line	Street	Number of Railroad Tracks	Annual Average Daily Traffic through Crossing	No. of Day Through Trains per Day	No. of Day Switch Trains per Day	No. of Night Through Trains per Day	No. of Night Switch Trains per Day	Total No. of Trains per Day
311009V		KAPUNAKEA	1	3,800	10	0	0	0	10
311010P		FLEMING	1	1,700	10	0	0	0	10
311011W		WAHIKULI	1	25	10	0	0	0	10
311012D		KANIAU	1	950	10	0	0	0	10
311013K		CIVIC CENTER	1	1,500	10	0	0	0	10
311014S		PUUKOLII	1	25	10	0	0	0	10
918996X	HAWAIIAN RAILW	FT BARRETTE RD	1	2,000	0	0	0	0	0
918997E	HAWAIIAN RAILW	KALAELOA BLVD	1	17,000	0	0	0	0	0
Grand Total No. of Trains per Day					60	0	0	0	60

Indicator Measure

Railroad Capacity classifications were defined as follows based on definitions provided by the Federal Railroad Administration (DOT Federal Railroad Administration 2003).

Green:	Less than 10 Trains per Crossing per Day (Low Railroad Capacity)
Amber:	10 to 20 Trains per Crossing per Day (Medium Railroad Capacity)
Red:	Greater than 20 Trains per Crossing per Day (High Railroad Capacity)
Gray:	Insufficient Data Available

Rules

Installation risk levels will be determined by a weighted average. Installations are often in two or more counties. The weighted average calculation will determine what percentage of the installation is in each county, and that percentage for each county will be multiplied by that county's value. Those values for each county the installation will then be totaled to arrive at a value for the installation. This value will then be subjected to the same risk metric that determined the risk levels for the individual counties.

Example

(Percent of Installation in County A* Indicator Value for County A) + (Percent of Installation in County B* Indicator Value for County B)…etc. = Indicator Value for the Installation

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TR1: Proximity to Interstate

Variables:	Mile Buffers
Scale:	National
Year:	2003

Data Sources

No Data Sources. ESRI. GIS Data Layers. Available for download at: http://www.esri.com

Logic

This indicator provides a measurement of the distance from the nearest interstate highway to an installation. The proximity of an interstate to an installation is an indicator of availability of full transportation access. The interstate system is often required by the military for material shipment and mobilization. This would then place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation.

Replicable

This indicator could be replicated every year based on updated interstate highway maps as new construction occurs.

Directions

Proximity to interstates is defined as the distance from the nearest interstate highway to an installation. All areas within 25 miles of an interstate were considered to be low risk, while all areas more than 25 miles, but less than 50 miles from an interstate were considered a medium level of risk. All areas outside of these buffers are considered high risk in this analysis.

Open interstates shapefiles. Create "buffers" around these interstates at predetermined distances to develop a Proximity to Interstates indicator layer.

Indicator Measure

Proximity to Interstates classifications were defined as follows.

Green: Buffer of interstates within 25 miles
Amber: Buffer of interstates within 50 miles
Red: Underserved areas

Rules

This indicator measures an installations' proximity to interstate highways. An installation takes on the lowest risk rating depending on its proximity to an interstate. If an installation is within 24.99 miles of an interstate, although most of the installation is more than 25 miles away from an interstate, that installation takes on the lower risk rating (amber).

Green: Installation is within 25 miles of the nearest interstate
Amber: Installation is within 50 miles of the nearest interstate
Red: Installation is more than 50 miles away from the nearest interstate

Map

For data on all military installations, consult the project database or frequency charts. Note that there is no data for Alaska or Hawaii.

Indicator TR2: Roadway Congestion

Variables: Roadway Congestion Index (RCI)
Scale: State
Year: 2001

Data Sources

Chen, Ciao, Zhanfeng Jia, and Pravin Varaiya, *Causes and Cures of Highway Congestion*, (University of California at Berkeley, Berkeley, CA, 2001), available through URL: http://paleale.eecs.berkeley.edu/~varaiya/papers_ps.dir/csmpaperv3.pdf

Federal Highway Administration (FHWA), U.S. Department of Transportation (USDOT), *Highway Statistics 2001*, "Table PS-1, Selected Measures for Identifying Peer States; Table VM-2, Functional System Travel Annual Vehicle-Miles; Table HM-60, Functional System Lane-Length Lane-Miles" (FHWA, Office of Highway Policy Information, Washington, DC, 2002), available through URLs:
http://www.fhwa.dot.gov/ohim/hs01/ps1.htm
http://www.fhwa.dot.gov/ohim/hs01/vm2.htm
http://www.fhwa.dot.gov/ohim/hs01/hm60.htm;

Pima Association of Governments, *Roadway Congestion* (Tucson, AZ, 2003), available through URL: http://www.pagnet.org/TPD/rsp/rsp2000/roadway-congestion.htm

Texas Transportation Institute, *Urban Mobility Study*, "Appendix A Exhibit A-17, 2000 Roadway Congestion Index" Texas A&M University, College Station, TX, 2002), available through URL: http://mobility.tamu.edu/ums/study/appendix_A/exhibit_A-17.pdf

Texas Transportation Institute, *The Keys to Estimating Mobility*, "Chapter 5: Recommended Mobility Measures" (Texas A&M University, College Station, TX, 2003), available through URL: http://mobility.tamu.edu/ums/estimating_mobility/chapter5.pdf

Logic

This indicator provides a measurement of the congestion of the local road network surrounding a military installation. Road congestion is an indicator of potential problems using the highways near the installation. This addresses traffic from the military operations standpoint. Congestion problems would place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation. For instance, commute times for work related travel for the local community surrounding and including the installation would be extended longer than normally expected as a result of congestion problems (Texas Transportation Institute 2003). Heavy to severe congestion areas also impacts the quality of life for the local community (see Commute Times as a Quality of Life sustainability indicator). Highways and roads within the proximity of a large metropolitan statistical area (MSA) provide higher risks of congested travel and increasing potentials for vehicular accidents (Chen et al. 2001).

Additionally, it is important to note this data is on the state level, not community or installation. Hence, it may be skewed by local “hotspots.” In other words, if a state has one roadway with relatively high congestion rates, the entire state is classified as high roadway congestion regardless of the characteristics of the remaining majority of the state. Because of this concern, it is important to use local knowledge in interpreting the roadway congestion classifications.

Replicable

This indicator could be replicated every year based on information updated annually in FWA’s Highway Statistics (FWA 2002).

Directions

Road congestion is defined by the Roadway Congestion Index (RCI), which is defined as the ratio of traffic volume to road capacity, based on the 2002 Urban Mobility Study published by the Texas Transportation Institute (Texas Transportation Institute 2002). The RCI, which varies from city to city, is a function of traffic volume (also defined as annual average daily traffic in vehicles/day), road segment length, and number of lanes in the road segment (Texas Transportation Institute 2002). The United States Department of Transportation’s FWA provides annual highway statistics containing urban and rural data by state on annual vehicle miles traveled (AVMT) and lane-miles (DOT FWA 2002). The calculations for determining the RCI by state are as follows.

Daily Vehicle Miles Traveled (DVMT) =
Annual Vehicle-Miles Traveled (AVMT) / 365

Freeway DVMT =
Urban Freeway DVMT + Rural Freeway DVMT

Principal Arterial DVMT =
Urban Principal Arterial DVMT + Rural Principal Arterial DVMT

Freeway DVMT per Lane-Mile =

(Urban Freeway DVMT / Urban Freeway Lane-Miles) + (Rural Freeway DVMT / Rural Freeway Lane-Miles)

Principal Arterial DVMT per Lane-Mile =

(Urban Principal Arterial DVMT / Urban Principal Arterial Lane-Miles) + (Rural Principal Arterial DVMT / Rural Principal Arterial Lane-Miles)

Roadway Congestion Index (RCI) =

(((Freeway DVMT per Lane-Mile) * Freeway DVMT) + ((Principal Arterial DVMT per Lane-Mile) * Principal Arterial DVMT)) / ((14,000 * Freeway DVMT) + (5,500 * Principal Arterial DVMT))

Download Annual Freeway Vehicle-Miles Traveled, by State, Annual Rural Principal Arterial Vehicle-Miles Traveled, by State, Annual Urban Principal Arterial Vehicle-Miles Traveled, by State, and Lane-Miles Traveled by State data from the Highway Statistics. Calculate Roadway Congestion based on the equations above. Import the resulting math into a GIS program and join it with the state shapefiles to create a Roadway Congestion indicator layer. Table A10 lists a detailed example calculation for the state of New York.

First, Calculate the total freeway DVMT for the state of New York.

Table A10. Annual Freeway Vehicle-Miles Traveled, by State (DOT FWA 2002).

	Interstate (Rural)	Interstate (Urban)	Other Freeways and Expressways
…			
New York	7,558	17,568	15,982
…			

Using Table A10 for the state of New York:

Rural Freeway AVMT =

7,558 million miles

Urban Freeway AVMT =

17,568 + 15,982 =

33,550 million miles

Therefore:

Rural Freeway DVMT =

(7,558 * 1,000,000) / 365 =

20,706,849.32 miles

Urban Freeway DVMT =

(33,550 * 1,000,000)/ 365 =

91,917,808.22 miles

Freeway DVMT =

20,706,849.32 + 91,917,808.22 =

112,624,657.54 miles

Second, calculate the principal arterial Daily Vehicle Miles Traveled (DVMT) for the state of New York.

Table A11. Annual Rural Principal Arterial Vehicle-Miles Traveled, by State (FWA 2002).

	Principal Arterial (Rural)	Minor Arterial (Rural)	Major Collector (Rural)	Minor Collector (Rural)	Local (Rural)
…					
New York	5,120	6,232	5,279	8,903	4,361
…					

Using Table A11 for the state of New York:

Rural Principal Arterial AVMT =

5,120 + 6,232 + 5,279 + 8,903 + 4,361 =

29,895 million miles.

Therefore:

Rural Principal Arterial DVMT =

(29,895 * 1,000,000) / 365 =

81,904,109.59 miles.

Table A12. Annual Urban Principal Arterial Vehicle-Miles Traveled, by State (DOT FWA 2002).

	Principal Arterial (Urban)	Minor Arterial (Urban)	Major Collector (Urban)	Minor Collector (Urban)
…				
New York	16,888	21,646	7,691	13,494
…				

Using Table A12 for the state of New York:

Urban Principal Arterial AVMT =

16,888 + 21,646 + 7,691 + 13,494 =

59,719 million miles.

Therefore:

Urban Principal Arterial DVMT =

(59,719 * 1,000,000) / 365 =

163,613,698.63 miles

The total principal arterial DVMT can now be calculated as:

Principal Arterial DVMT =

81,904,109.59 + 163,613,698.63 =

245,517,808.22 miles

Third, calculate the freeway DVMT per lane-mile and principal arterial DVMT per lane-mile.

Table A13. Lane-Miles Traveled by State (FWA 2002 #53).

State	Urban (Freeway)	Urban (Principal Arterial)	Rural (Freeway)	Rural (Principal Arterial)
…				
New York	7,543	84,876	3,875	143,114
…				

Using Table A13 for the state of New York:

Urban Freeway Lane-Miles =

7,543 lane-miles

Rural Freeway Lane-Miles =

3,875 lane-miles

Urban Principal Arterial Lane-Miles =

84,876 lane-miles

Rural Principal Arterial Lane-Miles =

143,114 lane-miles

Therefore:

Freeway DVMT per Lane-Mile =

(Urban Freeway DVMT / Urban Freeway Lane-Miles) + (Rural Freeway DVMT / Rural Freeway Lane-Miles

Freeway DVMT per Lane-Mile =

(91,917,808.22 / 7,543) + (20,706,849.32 / 3,875) =

17,529.55 DVMT per Lane-Mile for the State of New York.

Principal Arterial DVMT per Lane-Mile =

(Urban Principal Arterial DVMT / Urban Principal Arterial Lane-Miles) + (Rural Principal Arterial DVMT / Rural Principal Arterial Lane-Miles)

Principal Arterial DVMT per Lane-Mile =

(163,613,698.63 / 84,876) + (81,904,109.59 / 143,114) =
2,499.98 DVMT per Lane-Mile for the State of New York.

Finally, calculate the RCI for the state of New York.

Roadway Congestion Index (RCI) =

(((Freeway DVMT per Lane-Mile) * Freeway DVMT) + ((Principal Arterial DVMT per Lane-Mile) * Principal Arterial DVMT)) / ((14,000 * Freeway DVMT) + (5,500 * Principal Arterial DVMT))

Therefore:

RCI =

(((17,529.55 * 112,624,657.54) + (2,499.98 * 245,517,808.22)) / ((14,000 * 112,624,657.54) + (5,500 * 245,517,808.22) =
0.884 for the State of New York.

Indicator Measure

Roadway Congestion classifications were defined as follows based on information from Pima Association of Governments (Pima Association of Governments 2003).

Green: Less than 0.57 (Low Level of Congestion)
Amber: 0.5701 to 0.90 (Moderate Level of Congestion)
Red: Greater than 0.90 (Heavy to Severe Level of Congestion)

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator TR3: Traffic Volume

Variables: Annual Average Daily Traffic per Lane
Scale: State
Year: 2001

Data Sources

Chen, Ciao, Zhanfeng Jia, and Pravin Varaiya, *Causes and Cures of Highway Congestion*, (University of California at Berkeley, Berkeley, CA, 2001), available through URL: http://paleale.eecs.berkeley.edu/~varaiya/papers_ps.dir/csmpaperv3.pdf

Federal Highway Administration (FHWA), U.S. Department of Transportation (USDOT), *Highway Statistics 2001*, “Table HM-62, Average Daily Traffic per Lane on Principal Arterials; Appendix B, Methodology for 2002 Annual Report” (FHWA, Office of Highway Policy Information, Washington, DC, 2002), available through URLs:
http://www.fhwa.dot.gov/ohim/hs01/aspublished/hm62.htm
http://mobility.tamu.edu/ums/study/methods/entire_methodology.pdf

Texas Transportation Institute, *Urban Mobility Study*, “Appendix A Exhibit A-17, 2000 Roadway Congestion Index” Texas A&M University, College Station, TX, 2002), available through URL:
http://mobility.tamu.edu/ums/study/appendix_A/exhibit_A-17.pdf

Texas Transportation Institute, *The Keys to Estimating Mobility*, “Chapter 5: Recommended Mobility Measures” (Texas A&M University, College Station, TX, 2003), available through URL:
http://mobility.tamu.edu/ums/estimating_mobility/chapter5.pdf

Logic

This indicator provides a measurement of the congestion of the local road network surrounding a military installation in terms of annual average daily traffic per lane. Traffic volume is an indicator of potential problems using the local roads near the installation. This addresses traffic from the military operations standpoint. Congestion problems would place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation. For instance, commute times for work related travel for the local community surrounding and including the installation would be extended longer than normally expected as a result of congestion problems (Texas Transportation Institute 2003). Heavy to severe congestion areas also impacts the quality of life for the local community (see Commute Times as a Quality of Life sustainability indicator). Local roads within the proximity of a large metropolitan statistical area (MSA) provide higher risks of congested travel and increasing potentials for vehicular accidents (Chen et al. 2001).

Additionally, it is important to note this data is on the state level, not community or installation. Hence, it may be skewed by local "hotspots." In other words, if a state has one area with high local traffic volumes, the entire state is classified as high traffic volumes regardless of the characteristics of the remaining majority of the state. Because of this concern, it is important to use local knowledge in interpreting the traffic volume classifications.

Replicable

This indicator could be replicated every year based on information updated annually in FWA's Highway Statistics (FWA 2002).

Directions

Road access is defined by annual average daily traffic (AADT), which is the number of vehicles passing through a particular road segment (DOT FWA 2002). The U.S. DOT FWA provides annual highway statistics containing urban and rural data by state on AADT. The traffic volume levels (as illustrated in Table 1of the above-mentioned source) were determined by information obtained from Appendix B of the 2002 Urban Mobility Study by the Texas Transportation Institute (Texas Transportation Institute 2002). Download the Highway Statistics data into a GIS program and join it with the state shapefiles to create a Traffic Volume indicator layer.

Indicator Measure

Traffic Volume classifications were defined as follows based on definitions provided in the Texas Transportation Institute's 2002 Urban Mobility Study (Texas Transportation Institute 2002).

Green: Less than 5500 AADT (Low Traffic Volume)
Amber: 5501 to 7000 AADT (Medium Traffic Volume)
Red: Greater than 7000 AADT (High Traffic Volume)

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

Consult the project database or frequency charts for data on all military installations.

Theme: Security

Indicator AS1: Airspace Demand

Variables: Restricted Air Space (MOA), Public Airport Size
Scale: National
Year: 2000-2003

Data Source

National Imagery and Mapping Agency, *Digital Aeronautical Flight Information File*, DAFIF Edition 6 (Bethesda, MD, 2003), available through URL: https://164.214.2.62/products/digitalaero/index.cfm

Geo Community.com, *GIS Data Depot: Airport Size* (Airport Size) (ThinkBurst Media Inc., 2003), available through URL: http://data.geocomm.com/

Logic

Air Space is a finite Natural Resource. Current restrictions, MOA's, commercial air space use, and population growth/urban sprawl have placed pressures on Military Installations and the surrounding air space. All variables taken into consideration are strong indicators of pressures on the future use and vulnerability of air space, leading to greater demands and limitations on Military air space. This would then place the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation.

Replicable

This indicator could be replicated yearly based on FAA, DAFIF, and GIS Data Depot updates. The distribution of DAFIF is based on the International Civil Aviation Organization (ICAO) Aeronautical Information Regulation and Control (AIRAC) cycle of every 28 days (N. I. a. M. A. Digital Aeronautical Flight Information File 2003; Geo Community.com 2003).

Directions

The following equation determines the rating for each installation using a point system for the number of MOA's in relation to the size of surrounding commercial airports, to determine Airspace Demand.

Air Space Demand =

(# and size of Airports – # of MOA's)

Download airport ratings from the Digital Aeronautical Flight Information File (N. I. a. M. A. Digital Aeronautical Flight Information File 2003). Compute calculations using the above equation to determine restricted military flight areas. Import the data into a GIS program to create an Air Space Demand indicator layer. A detailed example calculation for Camp Atterbury follows.

Camp Atterbury, IN is located approximately 35 miles SE of Indianapolis, they have a rating of Yellow, it is calculated as follows.

+5 x 3 red airports

+2.5 x 5 yellow airports

(+) +1 x 46 green airports

+73.5 airport points

–14 MOA

Total 59.5 points

Total Enplaned Passengers 2000 data, categorized airports.

Green: < 1,967,000 persons

Amber: 1,967,001 to 8,560,007 persons

Red: > 8,560,008 persons

Restricted Military Flight Areas as of March 2003.

Purple = Restricted Areas

Indicator Measure

Air Space Demand ranges were defined as follows.

Green: Less than 50 calculated points

Amber: 50 to 80 calculated points

Red: Greater than 81 calculated points

Rules

The following rules were used to classify air space demand ranges.

+5 per Red Airport within a 250 mile radius

+2.5 per Yellow Airport

+1 per Green Airport

-1 per MOA within a 250 mile radius

Map

This sample map (Figure A1) combines the two data layers as listed above, layers were overlaid rather than combined. Due to the three-dimensional nature of air space it was necessary to treat the areas surrounding and above the restricted areas as no-fly-zones.

Indicator ES1: Net Metering

Variables: Net Metering Actions

Scale: State

Year: 2002

Data Sources

Green Power Network, *Database of State Incentives for Renewable Energy (Summary of State Net Metering Programs; Map of Net Metering Programs)* (Interstate Renewable Energy Council, U.S. Department of Energy, North Carolina State University Solar Center, 2002), available through URL:
http://www.dsireusa.org/
http://www.eren.doe.gov/greenpower/netmetering/nmtable.shtml
http://www.eren.doe.gov/greenpower/netmetering/nm_map.html

Logic

The availability of net metering indicates whether a state allows non-energy producers, such as consumers, to sell excess electrical energy produced onsite back to the grid at the local rate. The implications of this indicator are whether or not the State is progressive in its approach to integrated resource planning and management. A progressive approach ensures electricity availability and security in the future, while other approaches may not. The use of distributed generation adds to the robustness of the grid and its overall reliability (Database of State Incentives for Renewable Energy 2002).

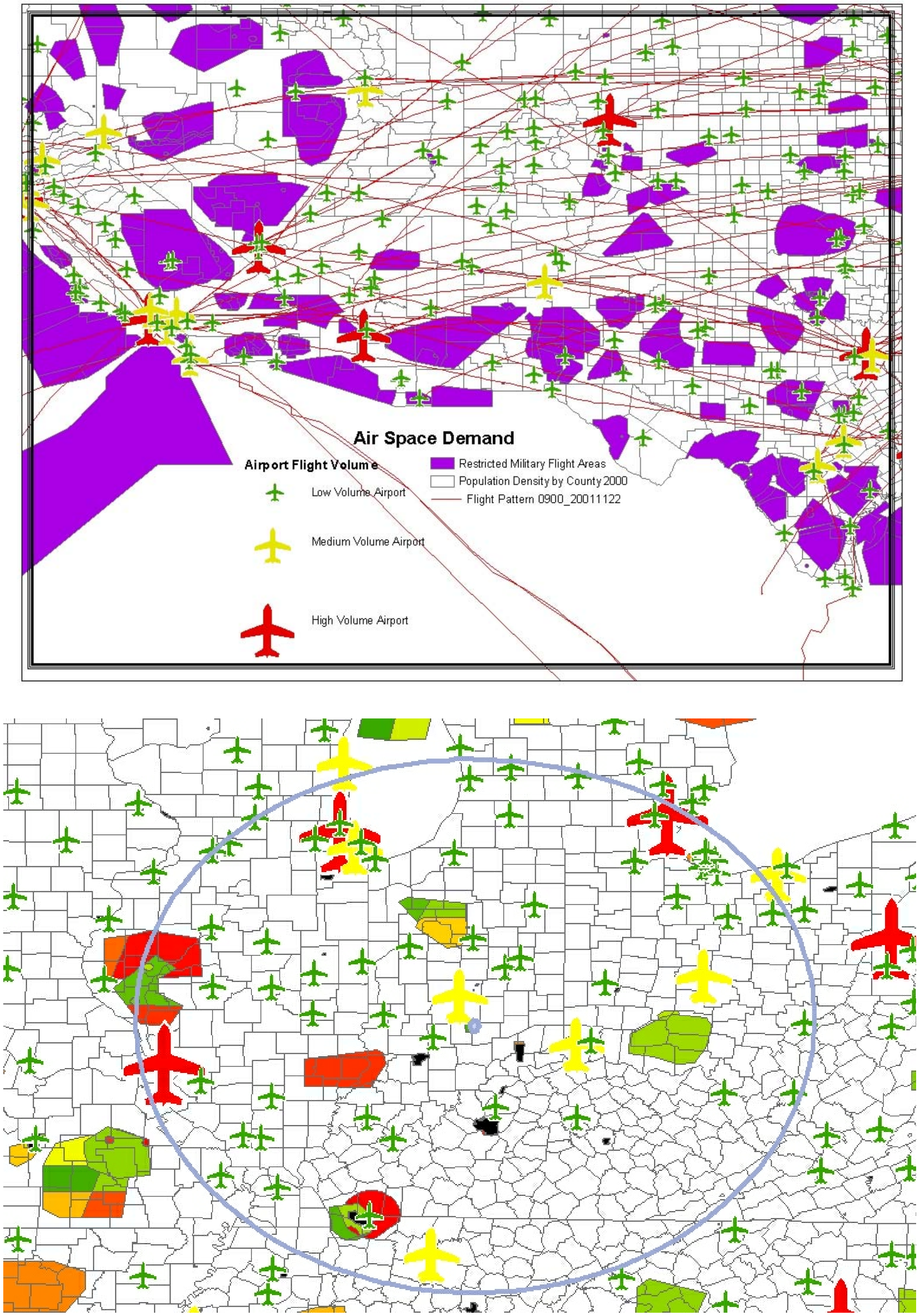

Figure A1. Sample Air Space Demand indicator layer (map) for Camp Atterbury, IN.

Replicable

This indicator could be replicated every year based on updated actions by states that do not currently have net metering regulations.

Directions

Determine if each state participates in net metering using the Green Power Network website, http://www.eren.doe.gov/greenpower/netmetering/nmtable.shtml. Determine if enactments for net metering regulations are either (a) complete, (b) underway, or (c) not considered for action. If enactments are complete, specify the year in which the state net metering rules are implemented (Database of State Incentives for Renewable Energy 2002). Download the data into a GIS program and join it to the state shapefiles to create a Net Metering indicator layer.

Indicator Measure

Net Metering classifications were defined as follows based on information provided by the Database of State Incentives for Renewable Energy (Database of State Incentives for Renewable Energy 2002).

Green: "complete" (State-Wide Net Metering Rules)
Amber: "underway" (Only Selected Utilities)
Red: "no action" (No Net Metering)

Rules

Every installation is located primarily in one state, although several installations do cross state boundaries. An installation takes on the state risk rating of the state the installation is primarily located within.

Map

For data on all military installations, consult the project database or frequency charts.

Indicator LS1: Proximity to MSA

Variables: Proximity to Metropolitan Statistical Areas
Scale: Metro Area
Year: 2003

Data Source

Bureau of the Census, U.S. Department of Commerce, *About Metropolitan and Micropolitan Statistical Areas* (Office of Management and Budget, Washington, DC, 2003), available through URL: http://www.census.gov/population/www/estimates/aboutmetro.html

Logic

This indicator shows the proximity of Military installations to Metropolitan Statistical Areas (MSA), which indicates the potential for encroachment on military facilities. MSAs are a geographic entity designated by the Federal Office of Management and Budget for use by Federal statistical agencies (DOC Bureau of the Census 2003). An MSA consists of one or more counties, except in New England, where MSAs are defined in terms of county subdivisions (primarily cities and towns) (DOC Bureau of the Census 2003). Encroachment is a strong indicator of pressures on the future use and vulnerability of military installations. Encroachment places the military installation in a vulnerable state, affecting the type and intensity of training that could take place on the installation due to greater demands and limitations on military developments.

Replicable

This indicator could be replicated every year based on Census population estimates or every decade based on actual, verifiable counts. It is recommended that the data be replicated only once a decade due to the inaccuracy of census estimates. The GIS compatible layer containing MSAs can be found at http://www.census.gov (DOC Bureau of the Census 2003).

Directions

Download the GIS layer containing MSAs from the U.S. Census Bureau (DOC Bureau of the Census 2003). Import the data into a GIS program to create a Proximity to MSA indicator layer. Create buffers at a predetermined distance from the edge of each MSA to show a level of risk.

Indicator Measure

Proximity to MSA classifications were defined as follows.

Green: Areas greater than 25 miles away from any MSA

Amber: Areas within 25 miles of one or more MSAs

Red: Within a Census designated Metropolitan Statistical Area

Rules

This indicator measures an installations' proximity to a metropolitan statistical area. If an installation is even in part located within an MSA, then that installation takes on the higher risk rating (red), and the same follows if an installation is within 24.99 miles of an installation, although most of the installation is more than 25 miles away from an MSA, that installation takes on the higher risk rating (amber).

Green: Installation is at least greater than 25 miles away from any MSA

Amber: Installation is within 25 miles of one or more MSAs

Red: Installation is at least in part within a Census designated Metropolitan Statistical Area

Map

Note, no data for Alaska or Hawaii. Consult project database for detailed installation information.

Appendix B: Map of DOD Installations in the CONUS in SIRRA

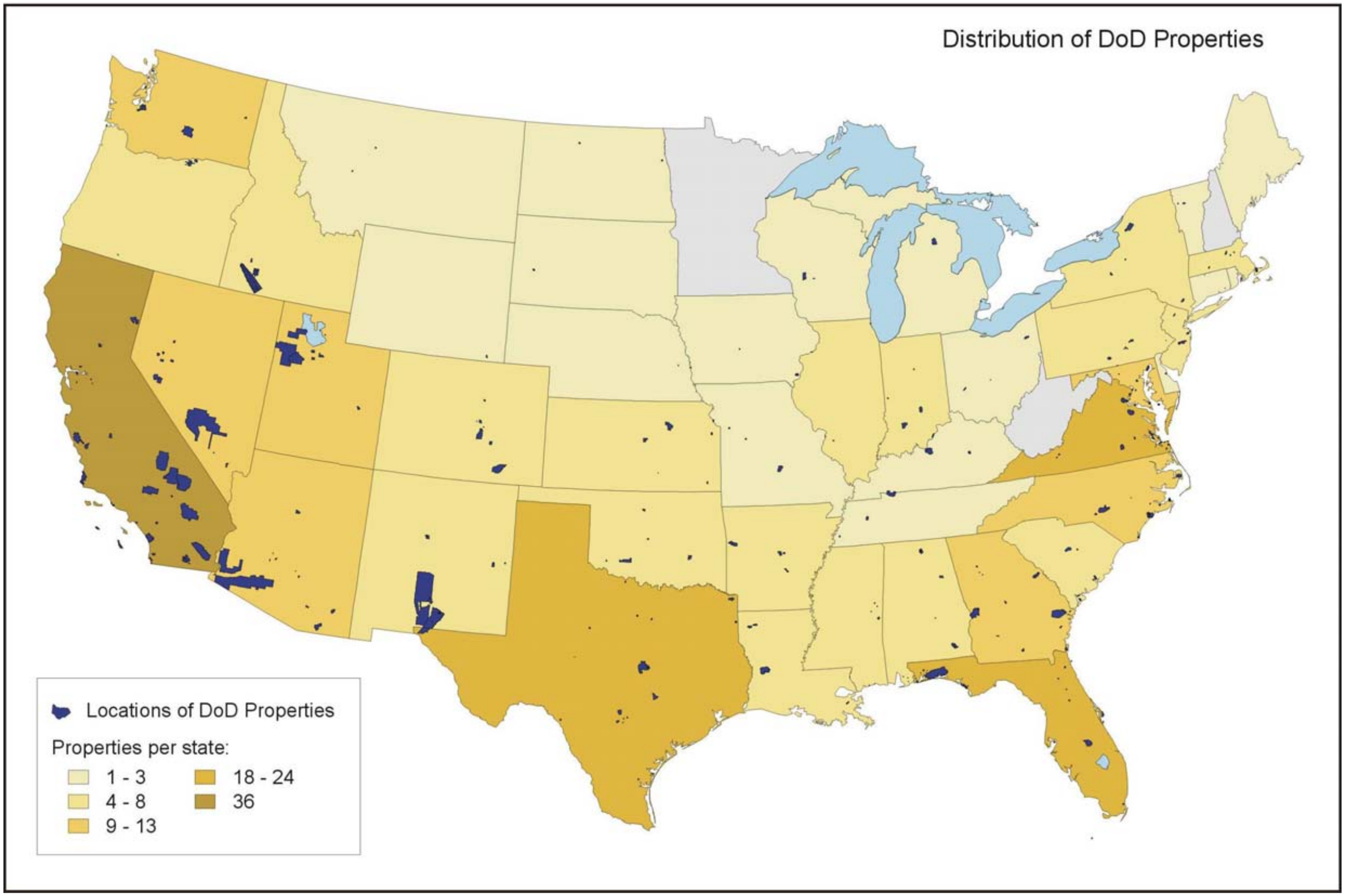

Figure B1. DOD Installations in the Continental United States (CONUS) in SIRRA.

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14. ABSTRACT
Historically, many military installations had been isolated from urban development, thus creating protected havens for unique natural and cultural resources. That has changed over the last several decades. Population growth and urban development around military installations have left installations in the midst of large urbanized areas. A combination of "encroachment" factors create significant pressure to alter land use practices on military installations. The Department of Defense (DOD) must reconcile training and stationing issues with requirements to address multi-faceted encroachment issues, to comply with environmental regulations, and with its desire to act as a good steward of natural resources.

The U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) has initiated the Sustainability, Encroachment, and Room to Maneuver (SERM) program, which is developing new tools and approaches to help maintain the traditional and future operations planned for installations. These tools, data, and analyses support decisionmaking at national, regional, and local scales. The Sustainable Installations Regional Resource Assessment (SIRRA) methodology is one such tool. SIRRA begins initial assessment to define the salient issues that may impact installations now and in the future, thereby allowing decisionmaking within a broader and more informed context.

15. SUBJECT TERMS

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land management	SIRRA	stationing

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