ABSTRACT

The 21st century Army will be engaged in numerous joint and expeditionary operations throughout the five regional Combatant Commanders’ areas of responsibility. Currently, Army forces are deployed globally in more than 120 countries. These regions contain a wide range of natural environments that present unique operational challenges to soldiers and equipment. The distribution of climate, terrain and other environmental factors, and their potential effects on Army operations, must be fully understood. There is a direct geographical and physical relationship between where the Army trains soldiers and tests equipment at U.S. installations to where it will deploy its forces. The conduct of any military enterprise is conditioned by the character of the area of operations—the military operating environment (Palka and Galgano, 2005). Military history and military geography, as well as lessons learned from current operations, provide ample evidence that understanding and adapting to the natural environment is a critical component of operational success.

A revised framework for understanding the natural environments of operational areas, and their relationships to U.S. training and testing installations, is presented. This framework—the Global Military Operating Environments (GMOE)—is developed from a worldwide ecoregional classification system that provides a logical and scientifically based approach to characterizing the spatial distribution of climates and associated environmental factors. The GMOE framework allows for comparison of operational environments across the globe to those found on U.S. Army installations where training of soldiers and testing of equipment take place.

1. INTRODUCTION

In order to meet current and future operational demands the Army is rapidly rebasing and transforming its installations, units and war fighting doctrine to meet the demands of a new strategic reality. The Capstone Concept for Joint Operations (CCJO) describes how future joint forces are expected to operate across a broad spectrum of military operations in 2012-2025 in support of strategic objectives. (U.S. Department of Defense, 2005). Emerging and potential threats from transnational actors, regional and emerging global competitors and failed states present a complex, multi-dimensional system of adversaries and situations across the globe to which our forces must adapt. In his visionary book, The Pentagon’s New Map, Thomas Barnett defines a global region, the Non-Integrating Gap, where the majority of conflicts, disasters and military deployments have occurred over the past fifteen years (Barnett, 2004). These conflict areas include the equatorial and mid-latitudinal regions of the Caribbean Rim, Africa, the Balkans, the Caucasus, Central Asia, the Middle East, Southwest Asia and Southeast Asia. The Gap regions lie outside the Functioning Core countries and regions of North America, Europe, East Asia and Australia, and are
**Report Documentation Page**

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. **REPORT DATE**
   01 NOV 2006

2. **REPORT TYPE**
   N/A

3. **DATES COVERED**
   -

4. **TITLE AND SUBTITLE**
   Natural Environments for Testing and Training: Developing Geographic Analogs for an Expeditionary Army

5. **AUTHOR(S)**

6. **PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
   Center for Environmental Management of Military Lands, Colorado State University Fort Collins, CO 80523

7. **SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

8. **PERFORMING ORGANIZATION REPORT NUMBER**

9. **DISTRIBUTION/AVAILABILITY STATEMENT**
   Approved for public release, distribution unlimited

10. **SUPPLEMENTARY NOTES**
    See also ADM002075., The original document contains color images.

11. **ABSTRACT**

12. **SUBJECT TERMS**

13. **SECURITY CLASSIFICATION OF:**
    | a. REPORT | b. ABSTRACT | c. THIS PAGE |
    | unclassified | unclassified | unclassified |

14. **LIMITATION OF ABSTRACT**
    UU

15. **NUMBER OF PAGES**
    46

16. **NAME OF RESPONSIBLE PERSON**

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18
characterized by diverse natural settings where environmental conditions – disease, famine and poverty induced by natural disasters and resource exploitation – often contribute to the rise of conflict. King (2000) assessed the environmental issues in many of these Gap regions that pose national security concerns for the future and concluded that most environmental security issues are regional in nature and within the domain of the regional Combatant Commanders.

These future scenarios will take place amidst a wide range of natural and built environments that will shape the operational space and require soldiers and units to adapt to the associated climate, weather and terrain of these operational environments. As the nation’s major land force the Army must organize, train and equip its soldiers and units to go anywhere in the world, against any adversary, at any time, in any environment. Current deployments associated with the Global War On Terrorism (GWOT) and military support to stability, security, transition and reconstruction (SSTR) operations throughout Southwest Asia, Central Asia, Africa, Indonesia and Central/South America present Army forces in those theaters with a complex range of natural environments, ranging from remote and austere arid regions to rugged, snow covered mountains and dense tropical jungles. For each campaign it must consider more fully how the natural environment will affect operational success.

The Army’s existing frameworks and approaches to characterizing the natural environment worldwide are outdated, oversimplified, and lack scientific underpinnings. Like Barnett’s strategic and economic theories on how and why the Core and Gap regions developed, an integrated set of organizing principles and rule sets are needed to delineate the geographic boundaries and distributions of natural environments on the continental land masses. Many of the geographic concepts used in doctrinal training manuals and testing regulations preceded the Army’s current expeditionary context and mindset. These concepts generalize operational environments into broad, undifferentiated landscape categories - “jungle,” “mountains,” and “deserts,” or into broad climatic regions such as “cold,” “hot,” “wet” and “dry.” These categorizations focus on the “extremes” in climate and terrain and ignore the complexity and variability of environments found within mid-latitudinal environments where many recent and future conflicts may occur.

Thus, a new framework and approach to define natural operating environments worldwide is needed to support the Army’s contemporary operating environment and expeditionary focus. This framework should explain why certain environments occur in predictable and spatially defined patterns across the continents. Understanding these patterns and the interrelationships between climate, vegetation and topography can provide insights into when and where physical phenomena affecting operations may occur. Secondly, the framework should allow for comparison and contrast between existing training and testing environments on installations in the United States and similar environments, or analogs, found world-wide. The importance of identifying and sustaining unique environments in the Army’s training and testing land inventory is critical as the Army continues to train and test as it fights.

2. GLOBAL MILITARY OPERATING ENVIRONMENTS

In order to address these deficiencies a panel of military scholars, environmental scientists and federal researchers was organized to study how operational environments could best be characterized for testing and training scenarios. The panel conducted studies on tropical and desert environments to identify the ideal physical and environmental characteristics that represent these operational environments (King, et al., 1998; King, et al., 2004). As a component of these studies the panel recognized the need to develop a scientifically-based, comprehensive framework that could be used to characterize the world’s natural environments and be applied to Army training and testing applications. The resulting framework, entitled Global Military Operating Environments (GMOE), integrates mean annual and monthly climatic data on temperature and rainfall with other physical characteristics (e.g., vegetation, terrain and soils), using an integrated, ecoregional based classification system. The GMOE approach is hierarchical and divides the earth’s land surface into regions defined by common climatic and physical characteristics.

The GMOE classification scheme is derived from Robert G. Bailey’s ecoregional classification system (Bailey, 1998a). This system is used extensively by federal, state and regional agencies for environmental planning, research and analysis. The primary factor used in Bailey’s system to classify an ecoregion is climatic regime, defined as the seasonality of temperature and precipitation. The global distribution and patterns of climatically-similar environments depend broadly upon large-scale climate controls. These controls include: latitude, continental position, global atmospheric patterns and oceanic circulation patterns. The presence of major mountain ranges further modifies this distribution and pattern.

Ecoregions are large, regional-scale ecosystems. Climatic parameters are used to establish ecoregional differences; however, no attempt is made to use the climatic parameters to establish boundaries. Instead, climatic differences are inferred where discontinuities appear in physiography (e.g., where flat plains change to mountains) and/or vegetation physiognomy (e.g., where tall grass prairie changes to short-grass steppe or
savanna.) In other instances, geological boundaries are used because different types of geology override the climatic effect (Bailey, 2005). Generally each climate is associated with a single vegetation class (such as broadleaf deciduous forest), characterized by a broad uniformity both in appearance and in composition of the dominant plant species.

Bailey’s ecoregional classification system divides the Earth’s land surface into three different hierarchical classes, **Domains**, **Divisions** and **Provinces**. Each category of the classification system can be mapped across the Earth at different geospatial scales on the basis of specific environmental criteria. Depending on the selected geospatial scale, the defined classes are designed to exhibit similar patterns in: (i) climate, (ii) vegetation, (iii) topography and landform, (iv) hydrologic function, and (v) soils. For example, as shown in Table 1, **Domains** and **Divisions** are recognized at the 1:30,000,000 scale to 1:7,500,000 scales (Bailey, 1998). At the **Province** level the macro features of associated vegetation types are used to further distinguish climatic differences. At both the Division and Province levels, mountainous regions are distinguished from their surrounding lowland classification because mountain climates are vertically differentiated, based upon the temperature and precipitation changes that occur with altitude (Bailey, 1998). For example, a high mountain range (e.g., 4,000 meters elevation) located at an equatorial latitude may exhibit several climatic zones from its base to its peak, with associated vegetation types, ranging from tropical to subarctic.

### Table 1. Criteria and Scale for Mapping Bailey’s **Domains** and **Divisions** *(See Note)*

<table>
<thead>
<tr>
<th>Category</th>
<th>Principal Map Criteria</th>
<th>Map Scale</th>
<th>Map Area of Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain</strong></td>
<td>Broad climatic zones or groups</td>
<td>1:30,000,000 or smaller</td>
<td>1,000,000s of square miles</td>
</tr>
<tr>
<td><strong>Division</strong></td>
<td>Regional climatic types; major mountain ranges; vegetation affinities (e.g. prairie or forest); soil orders</td>
<td>1:30,000,000 to 1:7,500,000</td>
<td>100,000s of square miles</td>
</tr>
</tbody>
</table>

*(Note: the degree of map detail and resolution increases as the map scale ratio (1:x or 1/x) becomes larger – e.g., a 1:7,500,000 scale map provides four times more detail than a 1:30,000,000 scale map)*

**Domains** constitute the four principal subcontinental regions of closely-related climatic zones. These macro-environments comprise land areas of related climates that are characterized by broad differences in latitudinally-controlled annual temperature, precipitation, and evapotranspiration. Three domains are humid and differentiated on the basis of their thermal character: **Polar** with no warm season; **Humid Temperate**, rainy with mild to severe winters; and **Humid Tropical**, rainy with no winter season. The fourth, **Dry**, is defined solely on the basis of moisture and transects the otherwise humid climates.

**Divisions** are the second-order classes recognized on the basis of the seasonality of precipitation or degree of dryness or cold. The **Divisions** correspond to groups of specific climate as determined by regions of vegetative similarity (e.g. rainforest, tundra) within the same zones of regional climate. The climate is not completely uniform within each **Division**. For example, there is a wide range of aridity within dry climates, ranging from very dry deserts through areas with transitional levels of moisture in the direction of the adjacent moist areas. As previously discussed, each **Division** (less the icecap Division) has a corresponding mountainous equivalent to distinguish vertically differentiated climates.

In adapting Bailey’s system for the Army, fifteen distinct categories are used to delineate and characterize the types of natural environments in which Army operations potentially will take place. While the existence and effects of mountainous regions on military operations are fully recognized, the mountain categories, as defined by Bailey, have been incorporated into the corresponding adjacent “lowland” category for this level of analysis.

The **Global Military Operating Environment (GMOE)** system connotes the specific application to military operations worldwide. Figure 1 illustrates the worldwide distribution of the GMOEs. Table 2 illustrates the percentage distribution of the fifteen GMOEs on a worldwide basis:
Three GMOE are defined within the Polar Domain: the Icecap, dominated by permanent ice sheets (e.g., Greenland and Antarctica), the Tundra where the average annual temperature of the warmest month lies between 0-10°C, and the Subarctic, where only one month each year has an average temperature above 10°C.

The Humid Temperate Domain is divided into six GMOEs based upon distinct combinations of winter and summer temperatures. The Warm Continental is characterized by very cold, snowy winters and warm summers, the Hot Continental has cold winters and hot summers, and the Subtropical is rainy and characterized by mild winters and hot summers. The Prairie is classified as a sub-humid area that is transitional between dry and humid climates. The Mediterranean has dry, hot summers and rainy, warm winters, whereas the Marine is characterized by rainy, mild winters and warm summers.

The Dry Domain can be partitioned into very arid areas (deserts) and semi-arid areas (steppe) that separate arid regions from those of humid climate. Four GMOEs are defined: the Tropical/Subtropical Steppe is a large semi-arid zone with tropical deserts to the north and south; the Temperate Steppe is characterized by a semi-arid continental climate with cold winters and warm to hot summers; the Tropical/Subtropical Desert is characterized by extremely arid conditions with high air and soil temperatures and the Temperate Desert is arid with hot summers and cold winters.

In the Humid Tropics which contains two GMOEs, there is no winter season and each month of the year has an average temperature above 18°C. The Savanna has distinct wet and dry seasons that lead to the development of tall grasslands that contain drought-tolerant shrubs and trees. The Rainforest is located astride the Equator, ranging between 10°N and 10°S latitude and has a wet equatorial climate with no distinct dry season.

3. REGIONAL AREAS OF RESPONSIBILITY

The five regional Combatant Commanders are responsible for the allocation of joint forces to meet the national defense security objectives and missions (U.S. Department of Defense, 2005). Figure 2 depicts the geographic boundaries associated with these areas of responsibility (AOR). Table 3 identifies the occurrences of the fifteen GMOEs within each AOR. With the exception of USCENTCOM, the majority of GMOEs are found within each Combatant Commander AOR. While the percentage area of each GMOE within a given AOR varies considerably, this distribution emphasizes the need for joint and Army forces to be trained in a wide variety of natural environments and to ensure that testing of equipment occurs in multiple environments.

4. ARMY INSTALLATION ANALOGS

The Army manages a diverse installation inventory in the U.S. and at forward basing areas to train its forces and test its equipment prior to deployment (Shaw, et al., 2000; Doe, et al., 1999). The ability to conduct pre-deployment activities in similar natural environments and settings is critical to mission success. For example, the importance of the Army’s National Training Center (NTC), in the Mojave Desert of California, and the Army’s Yuma Proving Ground (YPG) in the southwestern desert region of Arizona, as locations to prepare and test units and equipment for extended operations in similar arid environments is well documented. Similarly, Army installations in Alaska and Hawaii provide training and testing capabilities in preparation for deployments to mountainous, cold regions and tropical environments found on other continents. Despite the “geographic analogs” provided by these installations many future conflict and disaster areas may differ significantly in terms of climate, physiography and other environmental parameters.

Table 4 displays the locations of thirty-six major U.S. Army installations in the United States and their corresponding GMOEs. These installations were selected because they constitute the largest (by area) of the Army’s installations and because in some cases, they represent the sole installation found within a particular GMOE. As indicated there are numerous Army installations that reside within the hot continental and subtropical climates and which therefore, are similar in their physical characteristics to major conflict areas.

<table>
<thead>
<tr>
<th>Division/GMOE Category</th>
<th>% of World Acreage-Bailey’s Division/GMOE</th>
<th>% of World Acreage - Bailey’s Domains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icecap</td>
<td>10%</td>
<td>27% Polar</td>
</tr>
<tr>
<td>Tundra</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Subarctic</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Warm continental</td>
<td>2%</td>
<td>16% Humid Temperate</td>
</tr>
<tr>
<td>Hot continental</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Subtropical</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Marine</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Prairie</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Mediterranean</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Tropical/Subtropical Steppe</td>
<td>10%</td>
<td>30% Dry</td>
</tr>
<tr>
<td>Tropical/Subtropical Desert</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Temperate Steppe</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Temperate Desert</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Savanna</td>
<td>17%</td>
<td>27% Humid Tropics</td>
</tr>
<tr>
<td>Rainforest</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Distribution of World Ecoregions by Division (GMOE) and Domain
(Russia, Kazakhstan, Georgia, Turkey, Afghanistan, China, Korea, etc.). Areas of tropical/subtropical and temperate deserts (Iraq, Iran, Sudan, Egypt, Algeria), where conflicts are occurring, are also well represented by Army installations. However, this comparison also reveals a significant lack of adequate training and testing land resources that represent potential conflict areas in the Mediterranean, savanna and tropical environments.

**CONCLUSIONS**

The Global Military Operating Environments (GMOE) system, as adapted from Bailey’s ecoregional classification scheme, provides a world-wide, scientifically-based framework to assess the natural environments of current and future deployment areas. The map of GMOEs illustrates the pattern and distribution of similar environments within the five Combatant Commanders’ areas of responsibility (AOR). The framework also allows for comparison of Army training and testing installations as “analogs” to operational areas. Detailed, site specific studies, using available digital data and remotely sensed sources, within each of the fifteen GMOEs, at both the installation level and operational area level, are needed to more fully understand potential influences and effects of the natural environment.

**ACKNOWLEDGMENTS**

The authors have served as members of a scientific peer review panel organized by the U.S. Army Research Office (ARO) (AMSRD-ARL-RO-EV), Environmental Sciences Division Research Triangle Park, NC and the U.S. Army Developmental Test Command (DTC), Natural Environments Test Office (NETO) (CSTE-DTC-YP-NE), Yuma Proving Ground, AZ. The panel was tasked to characterize tropical, desert and arctic environments for military testing, training and operations. The authors acknowledge the contributions of all panel members, to include representatives from the Desert Research Institute (DRI), University of Nevada-Reno; the Department of Geography & Environmental Engineering, U.S. Military Academy, West Point, NY; the Center for Environmental Management of Military Lands, Colorado State University; the U.S. Army Corps of Engineers Topographic Engineering Center (TEC), Fort Belvoir, VA and Engineering Research & Development Center (ERDC), Hanover, NH, and the DTC Test Centers. In particular, the authors thank Mr. Graham Stullenbarger, Chief, Natural Environments Test Office, Yuma Proving Ground, AZ and Mr. Thomas Macia, formerly Training Directorate, ODCSOPS, Department of the Army, Pentagon, Washington, D.C., for their support of previous studies related to this paper.

**REFERENCES**


### Table 3. Regional Combatant Commanders’ Areas of Responsibility

<table>
<thead>
<tr>
<th>Global Military Operational Environments</th>
<th>USCENTCOM</th>
<th>USEUCOM</th>
<th>USPACOM</th>
<th>USNORTHCOM</th>
<th>USSOUTHCOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icecap</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Tundra</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subarctic</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm Continental</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hot Continental</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtropical</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Marine</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prairie</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediterranean</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical/Subtropical Steppe</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical/Subtropical Desert</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperate Steppe</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Temperate Desert</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savanna</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainforest</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See Figure 2

### Table 4. U.S. Army Installation Analogs of Global Military Operating Environments

<table>
<thead>
<tr>
<th>Global Military Operating Environments</th>
<th>Major Army Installation Analogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subarctic</td>
<td>Camp Grayling, MI</td>
</tr>
<tr>
<td></td>
<td>Fort Knox, KY</td>
</tr>
<tr>
<td></td>
<td>Fort Benning, GA</td>
</tr>
<tr>
<td></td>
<td>Fort Leonard Wood, MO</td>
</tr>
<tr>
<td></td>
<td>Fort Campbell, KY</td>
</tr>
<tr>
<td></td>
<td>Fort Drum, KY</td>
</tr>
<tr>
<td></td>
<td>Camp Ripley, MN</td>
</tr>
<tr>
<td></td>
<td>Fort McCoy, WI</td>
</tr>
<tr>
<td>Warm Continental</td>
<td>Fort Richardson, AK</td>
</tr>
<tr>
<td></td>
<td>Donnelly TA, AK</td>
</tr>
<tr>
<td>Hot Continental</td>
<td>Aberdeen PG, MD</td>
</tr>
<tr>
<td></td>
<td>Fort Bragg, NC</td>
</tr>
<tr>
<td></td>
<td>Fort Stewart, GA</td>
</tr>
<tr>
<td>Sabrina</td>
<td>Portland, OR</td>
</tr>
<tr>
<td></td>
<td>Fort Polk, LA</td>
</tr>
<tr>
<td></td>
<td>Fort Rucker, AL</td>
</tr>
<tr>
<td></td>
<td>Fort Jackson, SC</td>
</tr>
<tr>
<td></td>
<td>Fort Gordon, GA</td>
</tr>
<tr>
<td></td>
<td>Fort McCoy, WI</td>
</tr>
<tr>
<td>Marine</td>
<td>Fort Lewis, WA</td>
</tr>
<tr>
<td></td>
<td>Fort Riley, KS</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Fort Hunter Liggett, CA</td>
</tr>
<tr>
<td>Tropical/Subtropical Steppe</td>
<td>Fort Sill, OK</td>
</tr>
<tr>
<td></td>
<td>Fort Bliss, TX</td>
</tr>
<tr>
<td></td>
<td>Fort Huachuca, AZ</td>
</tr>
<tr>
<td>Temperate Steppe</td>
<td>White Sands Missile Range, NM</td>
</tr>
<tr>
<td></td>
<td>Yuma Proving Ground, AZ</td>
</tr>
<tr>
<td>Tropical/Subtropical Desert</td>
<td>Fort Carson, CO</td>
</tr>
<tr>
<td></td>
<td>Pinyon Canyon Maneuver Site, CO</td>
</tr>
<tr>
<td>Temperate Desert</td>
<td>Fort Irwin, CA</td>
</tr>
<tr>
<td></td>
<td>Fort Bliss, TX</td>
</tr>
<tr>
<td></td>
<td>Fort Huachuca, AZ</td>
</tr>
<tr>
<td>Savanna</td>
<td>White Sands Missile Range, NM</td>
</tr>
<tr>
<td></td>
<td>Yuma Proving Ground, AZ</td>
</tr>
<tr>
<td>Rainforest</td>
<td>Schofield Barracks, HI</td>
</tr>
<tr>
<td></td>
<td>Dugway Proving Ground, UT</td>
</tr>
<tr>
<td></td>
<td>Orchard Training Area, ID</td>
</tr>
<tr>
<td></td>
<td>Camp Santiago, Puerto Rico</td>
</tr>
<tr>
<td></td>
<td>Camp Santiago, Puerto Rico</td>
</tr>
<tr>
<td></td>
<td>Schofield Barracks, HI</td>
</tr>
<tr>
<td></td>
<td>Pohakuloa Training Area, HI</td>
</tr>
</tbody>
</table>
Figure 1. World Distribution of Global Military Operating Environments
Figure 2. Regional Combatant Commanders’ Areas of Responsibility (AOR) superimposed on Global Military Operating Environments
Natural Environments for Testing and Training:

*Developing Geographic Analogs for an Expeditionary Army*

*Dr. William W. Doe III, Colorado State University*
*Dr. Robert G. Bailey, USDA Forest Service*
*Dr. Russell Harmon, US Army Research Office*
*BG (Ret) W. Chris King, US Army Command & General Staff College*
*COL Eugene Palka, US Military Academy*
Introduction

- Tenet of **Army warfighting doctrine** is to “train as it fights” - understanding the natural environment and its potential effects on Army operations is a key component of operational success.

- Tenet of **Army RDT&E requirements** is to test materiel and equipment under conditions which replicate the range of climatic and physical environments anticipated for their use.

- The *expeditionary Army of the 21st century* will operate world-wide within new and complex natural environments.
Presentation Outline

- **Natural Environments of Combatant Command Regions**
  - New geographical threats and areas of concern
- **Environmental characterization of the natural environment**
  - Physiographic (terrain) studies of operational areas by Army Corps of Engineers (WWII, Vietnam Conflict)
  - Explosion of high-resolution digital data (remote sensing, geographic information systems)
  - Development of new, integrated spatial frameworks from ecological science to better understand climatic and landscape patterns
- **Analogs of U.S. Army installations – deployment areas**
  - Where the Army tests and trains in the U.S.
  - Lack of adequate Army analogs for some environments
Army Scientific Panel –
Global Military Operating Environments (GMOE)

- Panel of military, federal and academic scientists to advise and complement internal Army agency efforts to address future needs for natural environments testing
- Integrate scientific knowledge of the physical environment with operational requirements for testing of Army materiel and equipment
- Environmental characterization studies of current inventory of Army testing installations as analogs
- Information and approach has application to Army training installations to determine adequacy of U.S. Army installation inventory to represent current and future conflict environments
Bailey’s Ecoregion Classification System

- Scientifically based, integrated system for mapping and describing natural environments
- Developed and expanded by the USDA/Forest Service in 1993 as the classification system to be used in federal land ecosystem management
- Used for ecological classification of U.S. Army installations in 1999-2002
- Has been applied to both the United States and Worldwide for a wide range of environmental applications

References:
Bailey’s Ecoregion Classification System

- Hierarchical classification system which can be applied at various mapping scales (macro to micro) and level of detail
  - 3 levels/categories in the hierarchy:
    - **Domains (4)**
      - Divisions (15)
    - Provinces (86)

- Boundaries of regions determined by **climatic controls (latitude, continental position, ocean currents, elevation)** and their tangible expression to macro-vegetation formations

- Similar (analogous) ecoregions occur in predictable locations on different continents

- Data from one ecoregion can be extended to similar ecoregions on other continents

- Similar patterns of climate and landscape can be expected on different continents
Hypothetical patterns of ecoregions are modified by latitudinal position and size of the actual continental land masses.
The climate of a location/region is determined by the annual range (high to low), distribution (seasonality) and relationship between temperature and precipitation over a long period of record. The climate is a primary determinant of a location’s vegetation formations, soil types and landscape characteristics.
Emerging Threat Environments

The “Pentagon’s New Map”

- Thomas Barnett’s “Functioning Core” vs. “Non-Integrating Gap” Regions
  - Functioning Core areas:
    - Humid temperate, Mediterranean environments (North America, Europe, China)
    - Equatorial and mid-latitudinal conflict areas:
      - Dry (desert/steppe) environments
      - Humid tropical (rainforest/savanna) environments

- Environmental conditions and lack of natural resources create “environmental security” driven conflicts
USSOUTHCOM: Distribution of Regional Environments

Global Military Operating Environments - USSOUTHCOM

- Polar
  - Subarctic
  - Tundra
  - Icecap
- Humid Temperate
  - Warm Continental
  - Hot Continental
  - Subtropical
  - Marine
  - Pasure
  - Mediterranean
- Dry
  - Tropical/Subtropical Steppe
  - Tropical/Subtropical Desert
  - Temperate Steppe
  - Temperate Desert
- Humid Tropical
  - Savanna
  - Rainforest

0.02% (Polar)
8.5%
20.5%
71.8%

USOUTHCOM

- 29.3%
- 41.2%
- 10.9%
- 6.7%
- 0.5%
- 2.4%
- 3.2%
- 0.3%
- 0.2%
USPACOM: Distribution of Regional Environments

Global Military Operating Environments - USPACOM

- Polar: Subarctic, Tundra, Icecap
- Humid Temperate: Warm Continental, Hot Continental, Subtropical, Marine, Prairie, Mediterranean
- Dry: Tropical/Subtropical Steppe, Tropical/Subtropical Desert, Temperate Steppe, Temperate Desert
- Humid Tropical: Savanna, Rainforest

*State of Alaska assigned to USNORTHCOM’s Area of Responsibility. Forces based in Alaska remain assigned to USPACOM.*
Geographic Distribution of U.S. Army Installations

- Testing/training and power projection platforms
- The scale and spatial distribution of major Army installations are:
  - 12 million acres in the 50 states (0.5% of U.S. land area)
  - 30,000 to 2 million contiguous acres of land
  - Distributed primarily in the Southeast, Southwest, Western states and Alaska
  - Represented by diverse climatic and physiographic regimes/ecosystems
## Selected Army Installations

*(40 major installations by Ecoregional Division)*

<table>
<thead>
<tr>
<th>Global Military Operational Environments</th>
<th>Major Army Installation Analogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subarctic</td>
<td>Fort Wainwright, AK</td>
</tr>
<tr>
<td></td>
<td>Donnelly TA, AK</td>
</tr>
<tr>
<td>Warm Continental</td>
<td>Camp Grayling, MI</td>
</tr>
<tr>
<td>Hot Continental</td>
<td>Fort Knox, KY</td>
</tr>
<tr>
<td></td>
<td>Fort Benning, GA</td>
</tr>
<tr>
<td></td>
<td>Fort Leonard Wood, MO</td>
</tr>
<tr>
<td></td>
<td>Fort Campbell, KY</td>
</tr>
<tr>
<td></td>
<td>Fort Drum, NY</td>
</tr>
<tr>
<td></td>
<td>Camp Ripley, MN</td>
</tr>
<tr>
<td></td>
<td>Fort McCoy, Fort Dix, NJ</td>
</tr>
<tr>
<td></td>
<td>Camp Atterbury, IN</td>
</tr>
<tr>
<td>Subtropical</td>
<td>Aberdeen PG, MD</td>
</tr>
<tr>
<td></td>
<td>Fort Bragg, NC</td>
</tr>
<tr>
<td></td>
<td>Fort Stewart, GA</td>
</tr>
<tr>
<td></td>
<td>Fort Polk, LA</td>
</tr>
<tr>
<td></td>
<td>Fort Rucker, SC</td>
</tr>
<tr>
<td></td>
<td>Fort Jackson, SC</td>
</tr>
<tr>
<td></td>
<td>Fort Gordon, Camp Blanding, FL</td>
</tr>
<tr>
<td></td>
<td>Camp Shelby, MS</td>
</tr>
<tr>
<td>Marine</td>
<td>Fort Lewis, WA</td>
</tr>
<tr>
<td>Prairie</td>
<td>Fort Riley, KS</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Fort Hunter Liggett, CA</td>
</tr>
<tr>
<td>Tropical/Subtropical Steppe</td>
<td>Fort Sill, OK</td>
</tr>
<tr>
<td></td>
<td>Fort Hood, TX</td>
</tr>
<tr>
<td>Tropical/Subtropical Desert</td>
<td>Fort Irwin, CA</td>
</tr>
<tr>
<td></td>
<td>Fort Bliss, TX</td>
</tr>
<tr>
<td></td>
<td>Fort Huachuca, AZ</td>
</tr>
<tr>
<td></td>
<td>White Sands Missile Range, NM</td>
</tr>
<tr>
<td></td>
<td>Yuma Proving Ground, AZ</td>
</tr>
<tr>
<td>Temperate Steppe</td>
<td>Fort Carson, CO</td>
</tr>
<tr>
<td></td>
<td>Pinyon Canyon, CO</td>
</tr>
<tr>
<td>Temperate Desert</td>
<td>Yakima Training Ctr, WA</td>
</tr>
<tr>
<td></td>
<td>Dugway Proving Ground, UT</td>
</tr>
<tr>
<td></td>
<td>Orchard Training Area, ID</td>
</tr>
<tr>
<td>Savanna</td>
<td>Camp Santiago, PR</td>
</tr>
<tr>
<td>Rainforest</td>
<td>Schofield Bks, HI</td>
</tr>
<tr>
<td></td>
<td>Pohakuloa Training Area, HI</td>
</tr>
</tbody>
</table>
GMOE Climographs – Tropical/Subtropical Steppe

Analog Characteristics

Locations:
- Transition zones that occur along less arid margins of tropical deserts
- Influence of higher elevations

Temperature:
- All months > 0°C

Precipitation:
- Semi-arid, evaporation exceeds precipitation

Vegetation:
- Short grasslands, shrubs
Army Installations – Tropical/Subtropical Steppe Analogs

USA TEXAS
31.08°N / 97.43°W / 281m
HOOD AAF
[6-6] +19.1°C  699mm

USA OKLAHOMA
34.38°N / 98.23°W / 362m
POST AAF
[13-13] +16.7°C  806mm
Tropical/Subtropical Desert Environments

Global Military Operating Environments - Tropical/Subtropical Desert

Dry Domain

Tropical/Subtropical Desert

86.1%
GMOE Climographs – Tropical/Subtropical Desert

Analog Characteristics

Locations:
- Vast desert belts associated with 30 N/S latitudes

Temperature:
- High direct solar radiation, highest temps > 30°C

Precipitation:
- Very dry, annual precipitation < 200 mm

Vegetation:
- Xerophytic plant formations, drought resistant
Army Installations –
Tropical/Subtropical Desert Analogs

USA CALIFORNIA
35.17°N / 116.37°W / 716m
BICYCLE LAKE AAF
[13-13] +18.4°C 64mm

USA NEW MEXICO
32.50°N / 106.00°W / 1279m
ALAMOGORDO
[53-53] +16.4°C 264mm
Temperate Steppe Environments
GMOE Climographs – Temperate Steppe

Analog Characteristics

Locations:
- Central, continental locations

Temperature:
- At least one month < 0°C; cold and dry winters, warm summers

Precipitation:
- 300-500 mm annually

Vegetation:
- shortgrass prairie, pampas
Army Installations – Temperate Steppe Analogs

USA COLORADO

°F 38°45′N / 104°47′W / 1779 m
21.7 BUTTS AAF
-1.1 [14-14] +9.49 °C 369 mm

© 2001 S. Rivas-Martínez, H. Lieth
**GMOE Climographs – Temperate Desert**

**Analog Characteristics**

**Locations:**
- Continental interiors

**Temperature:**
- Strong contrast between winter and summer
- Cold winters, at least one month < 0°C

**Precipitation:**
- Arid, winter precipitation dominant

**Vegetation:**
- Sparse, xerophytic shrubs (sagebrush)
Army Installations – Temperate Desert Analogs

USA WASHINGTON
46.34°N / 120.32°W / 323m
YAKIMA
[25-25] +9.9°C 199mm

Graph showing temperature and precipitation data.
Savanna Environments

Global Military Operating Environments - Savanna
GMOE Climographs - Savanna

Analog Characteristics

Locations:
- Latitude belt between 10-30 degrees N/S

Temperature:
- High, constant temperatures > 20 C

Precipitation:
- Alternating wet and dry seasons

Vegetation:
- Scrub woodlands, tall grasses
Army Installations – Savanna Analogs

USA HAWAII

°C 19.38°N / 156.0°W / 5 m
25.6 KONA
22.8 [12-12] +24.07 °C  629 mm

© 2001 S. Rivas-Martínez, H. Lieth
Rainforest Environments

Global Military Operating Environments - Rainforest

Humid Tropical Domain

Rainforest
GMOE Climographs - Rainforest

Analog Characteristics

Locations:
- Between equator and Tropics of Cancer/Capricorn (23.5 °N/S)

Temperature:
- Average monthly temperatures consistently above 18 °C (no winter season)

Precipitation:
- Heavy rainfall amounts generally > 60mm/month

Vegetation:
- Tropical rainforest
Army Installation Landscapes – Rainforest Analogs
Conclusions

The Global Military Operating Environments (GMOE) framework provides strategic-level, world-wide environmental characterization and analog relationships between Army installations and combatant command geographic regions. At the strategic scale,

- Installation analogs are adequate for:
  - Humid temperate environments
  - Dry environments

- Installation analogs are inadequate for:
  - Humid tropical environments

More detailed studies using available digital data at high resolution are needed to compare areas within specific installation analogs to operational areas of concern.