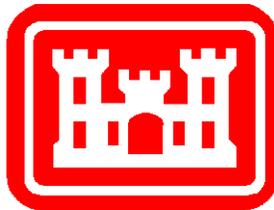


PUBLIC WORKS TECHNICAL BULLETIN 200-1-150
30 JULY 2015

**MULTINATIONAL ANALYSIS OF
MILITARY VEHICLE IMPACTS AND
REGULATORY PRESSURES
ON TRAINING LAND MANAGEMENT**



Public Works Technical Bulletins are published by the U.S. Army Corps of Engineers, Washington, DC. They are intended to provide information on specific topics in areas of Facilities Engineering and Public Works. They are not intended to establish new Department of Army policy.

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Public Works Technical Bulletin

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No. 200-1-150

Facilities Engineering
Environmental

MULTINATIONAL ANALYSIS OF MILITARY VEHICLE
IMPACTS AND REGULATORY PRESSURES ON
TRAINING LAND MANAGEMENT

1. Purpose.

a. To gain strategic insight into effective and efficient land management practices, this Public Works Technical Bulletin (PWTB) documents how certain U.S.-allied nations have dealt with challenges related to intensified human development, encroachment, soil conservation, climate change, and ecosystem management on their military training lands. The opportunities identified and lessons learned are presented to enable the U.S. Army to save money, optimize co-land utilization, and preserve training land resources long-term. Innovative technologies may have been developed in other countries to deal with more stringent regulations, and this project reviews applicable foreign solutions, identifies solutions for use within the U.S. Army, and projects potential up-and-coming regulatory pressures (e.g., proposed new Threatened and Endangered Species [TES] listings). The knowledge gained from this effort may bolster stewardship, enhance land rehabilitation, and promote military training sustainment.

b. All PWTBs are available electronically at the National Institute of Building Sciences' Whole Building Design Guide webpage, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

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2. Applicability. This PWTB applies to engineering and training land management activities at all U.S. Army facilities.

3. References.

a. Army Regulation (AR) 200-1, "Environmental Protection and Enhancement," 13 December 2007, http://www.apd.army.mil/pdf/files/r200_1.pdf.

b. This document is based on allied nations' training and environmental stewardship context. Therefore, selected legal drivers for each country are listed in Appendix C.

4. Discussion

a. AR 200-1 contains policy for environmental protection and enhancement, pollution prevention, conservation of natural resources, sustainable practices, and compliance with environmental laws. This PWTB explores how four allied nations have approached changing regulatory environment so that we might glean lessons learned.

b. Appendix A provides background into the driving concept behind this publication. It explores the need to look abroad for potential land management solutions to future regulatory and compliance scenarios.

c. Appendix B explains the investigative considerations and methods conducted in this work.

d. Appendix C provides a country-by-country review of the environmental legislative / regulatory / compliance drivers that exist, relative to military training and installations management.

e. Appendix D provides a country-by-country review of the land-based management practices that have been developed in each country relative to the regulatory restrictions and training and/or land sustainment targets.

f. Appendix E presents a synthesis discussion, allowing a summarized "compare-and-contrast" review of the findings in Appendix C and Appendix D.

g. Appendix F contains "lessons learned" and recommendations, as well as some broader takeaways that might assist U.S. installations in land management and compliance with

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potentially more stringent environmental regulations in the future.

h. Appendix G contains definitions of acronyms and abbreviations used within the text of this publication.

i. Appendix H contains references that are cited within the text of this publication.

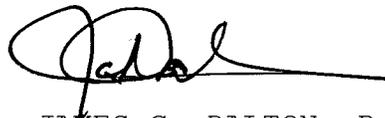
5. Points of Contact.

a. Headquarters, U.S. Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

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**APPENDIX A:
PROBLEM STATEMENT AND RELEVANT BACKGROUND**

The fieldwork, investigation, and write-up for this PWTB were conducted by Anne P. Koster, Heidi R. Howard, and Jesse Nosbaum of the Ecological Processes Branch at ERDC-CERL (CEERD-CN-N).

Sustaining Training Lands for Military Missions

The Army's ability to sustain its lands and ranges for continued training activities is a critical component to maintaining operational readiness. Such land-based training provides essential realism to support the Army's cardinal principle: "Fight as You Train, Train as You Fight." The long-term condition of soils and vegetative cover is a key to providing sufficient carrying capacity for sustained land-based training activities.

The Army also is responsible to the American public as a legally accountable caretaker of federal lands, as outlined in AR-200-1. This responsibility contributes to the many compliance-driven actions taken across the Army enterprise. These activities range from: (a) caring for threatened and endangered species (TES) populations, to (b) cultivation, maintenance, and protection of habitat for any species with a protected status (whether state or federal), to (c) environmental compliance associated with stormwater, pollution prevention, or erosion control.

The U.S. Army has pioneered land rehabilitation with land management practices (LMPs) and innovative technologies for maintaining their training lands under the Integrated Training Area Management (ITAM) program. These efforts respond to legal compliance requirements and proactively sustain land resources for continuous and future training capabilities. However, changing environmental regulation and funding is putting added pressure on training land management.

Changing Environmental Regulatory Environment in the United States

By reviewing historic environmental regulatory requirements, it is observed that required levels of compliance typically become more stringent over time. Graphics from multiple studies confirm this observation has held true over multiple time periods. Figure A-1 shows the cumulative number of regulatory pressures on federal lands (including military installations) between 1918

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and 1996. Figure A-2 shows the cumulative number of federal laws and amendments between 1870 and 1992. Figure A-3 shows the cumulative number of EU regulations on health, safety, and environment from 2004 through 2012. Figure A-4 shows American generational opinion toward stricter environmental laws and regulations. It can be thus concluded that environmental regulatory requirements will continue to increase in both number and restrictive nature, no matter what sector or country. This finding may be due to a number of factors, as taken from Bernosky (2011, 28):

- Increased public awareness via immediate (and ever more visual) news media.
- Advent of the Baby Boomer generation.
- Improved laboratory analytical techniques with lower and lower detection limits (see "The Vanishing Zero" in chapter 15).
- A growing middle class with higher standards of living.
- Growing social movements and accompanying activism (not necessarily related to environmental issues).
- Greater understanding of environmental epidemiology in the medical profession.

The above-listed factors remain true today.

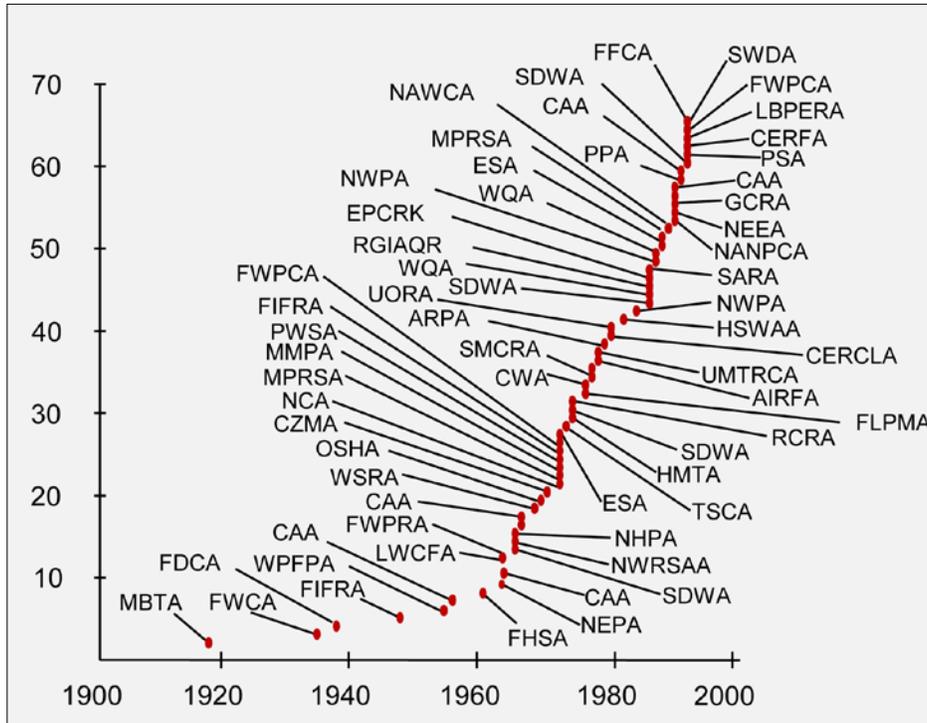


Figure A-1. Chart showing accumulation of regulatory pressures on federal lands (including military installations) within the 20th century (Lacey et al. 2011).

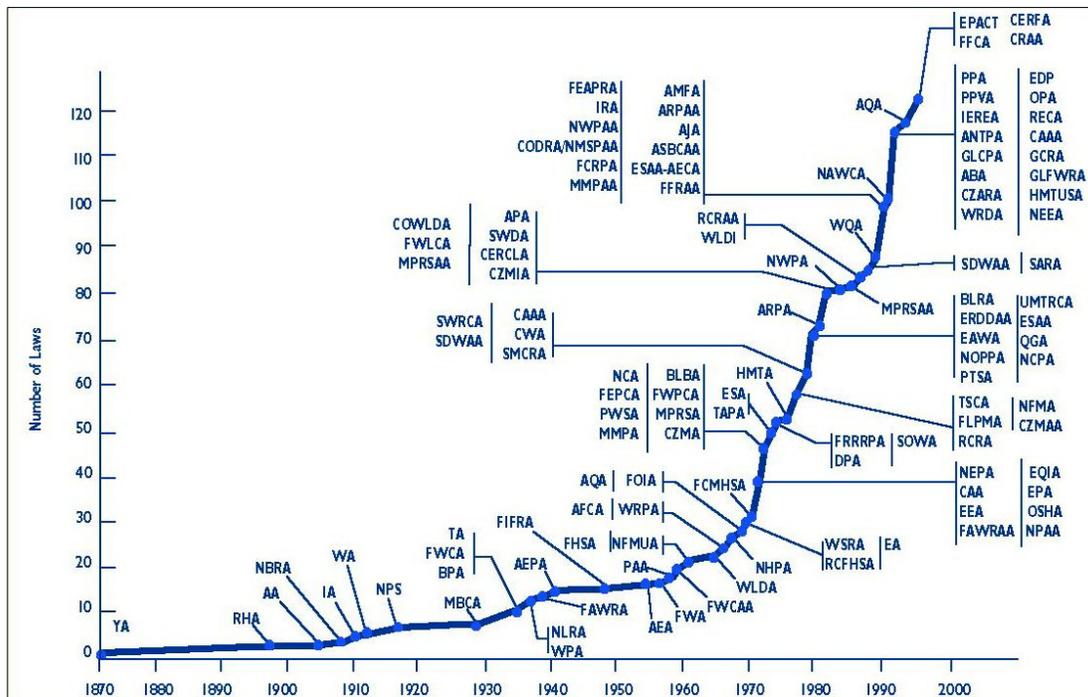


Figure A-2. Chart showing "cumulative growth in the federal environmental laws and amendments" from 1870 through 1992 (does not include current day) (Allen and Shonnard 2002).

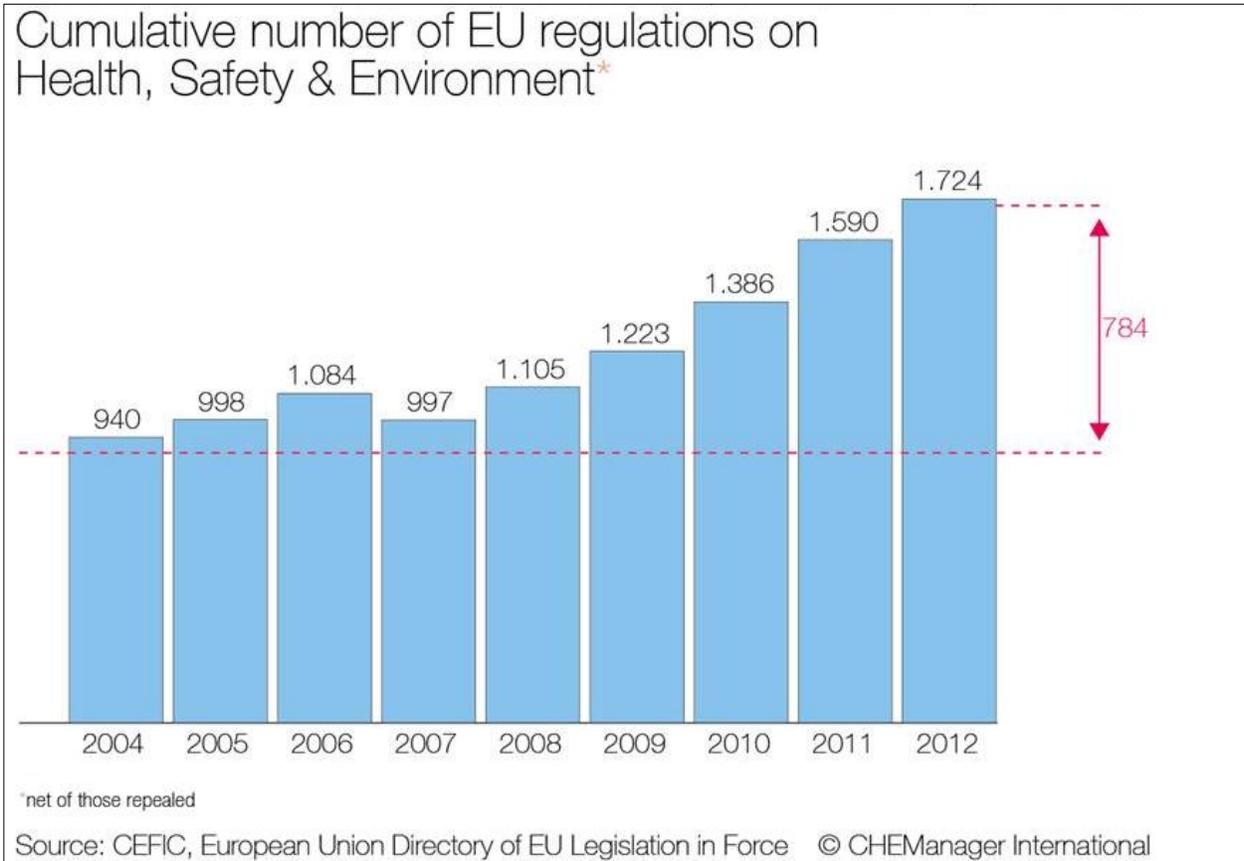


Figure A-3. Cumulative number of EU regulations on health, safety, and environment from 2004 through 2012 (CHEManager International 2014).

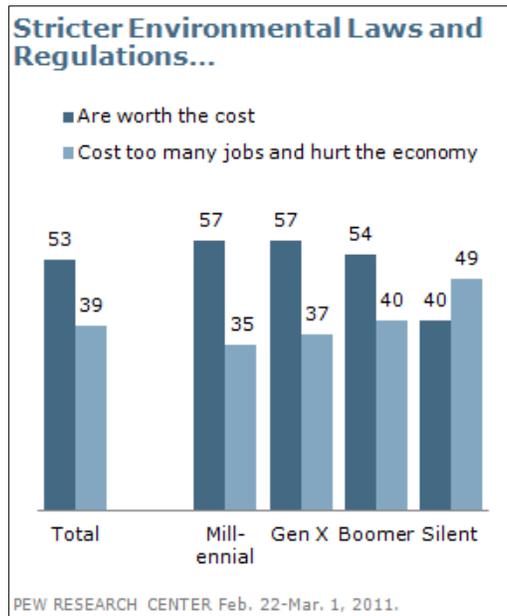


Figure A-4. American generational opinion toward stricter environmental laws and regulations (Pew Research Center 2011, 96).

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At the same time, Department of Defense (DoD) installations are facing heavy budget cuts that will likely reduce the amount of money available for training land rehabilitation and sustainment efforts.

A possible solution for the current scenario of increased regulation that is coupled with decreased funding is to incorporate new developments from ongoing compliance-related research in the following areas:

- increasing training land availability by maintaining environmental regulatory standards;
- increasing capacity of military activities on lands;
- supporting training realism;¹ and
- supporting natural resources management and conservation objectives

As a proactive measure, this bulletin was created to assist the U.S. Army with potential future adjustments or implementation of new LMPs that would be able to efficiently solve potential stringent future compliance requirements. Thus, from this research, novel responses to environmental regulatory requirements could be developed and/or incorporated (if another LMP exists elsewhere) for military training and response to mission requirements. These novel developments could relate to vehicles utilized, particular training doctrine and cultural contexts, as well as governmental requirements. Differences in the installation training environment versus the operational environment can also be realized in developing LMPs and actions, as the environmental sensitivities might differ per the context of the activity. LMPs included in this bulletin are considered to be not only physical/structural practices but also management strategies, logistical approaches, and good housekeeping practices to reduce environmental impacts and meet regulatory needs.

This study was conducted in order to seek out approaches that may exist outside of the United States to address environmental compliance and to prevent excessive land impacts from future military training conducted in the United States. This bulletin

¹ In this document, "sustainable lands" means those lands on which units can carry out their training mission without the need to replicate an environment or a location.

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does not assume or imply that methods currently in use by the U.S. Army are faulty; however, it is recognized that environmental compliance and associated land management issues are dynamic and that by historic precedence, it can be assumed that the future regulatory oversight will only become more restrictive.

This bulletin's proactive approach looks at what allied nations' military organizations are doing in the area of training land management. Whether or not the U.S. land management model was utilized in their planning and land management process development, it is expected that these countries have followed their individual trajectories in developing their approach to military land care. Hence, their management systems and LMPs may differ from practices on U.S. military installations simply due to the customized response to varying operating conditions, funding levels, cultural differences, availability of materials and supplies, and differing regulatory conditions. At the same time, it is also likely that emerging technologies developed in response to contextual pressures in allied countries may have direct application to military, civil works, and/or research programs within the United States.

It is hoped that the knowledge gained about environmental compliance response, land rehabilitation LMPs, and other strategies and technologies developed elsewhere will provide U.S. installations with insight and lessons learned to bolster stewardship and land rehabilitation measures, with the goal of saving money and enhancing efficiency of military training to help ensure its sustainment.

**APPENDIX B:
METHODS AND COUNTRIES REVIEWED**

Over the course of this project, a range of reviews were conducted of allied nations' training land management approaches. The extent and depth of the analysis for each country varied greatly because access to lands, points-of-contact, and general availability of information was not always entirely forthcoming. However, much information was gained from the investigations. Methods of review are reported here and review summaries are provided in subsequent appendices.

This publication includes reviews of training land management for the United Kingdom (UK), Germany, Canada, and Australia. In addition, site visits were made by authors to the United Kingdom (England) 11-21 September 2012, Germany 05-10 May 2013, and Canada 19-25 June 2014.

For each country, in-person interviews were conducted as much as possible with land management personnel at multiple military installations. These interviews helped to gain perspective and information about training lands, management practices, and laws involving these topics. Where direct contact was not feasible, conference calls and/or emails were utilized to solicit information; where neither was feasible, available documentation was referenced.

In the United Kingdom, Cranfield University at Shrivenham participated, as they have strong ties to the UK Ministry of Defence (MOD). University personnel work with land degradation and restoration, and also assist in prescribing environmental LMPs for military land (Hooper 1, 2013). In Germany, a site visit was conducted to U.S. Army Garrison (USAG) Grafenwoehr and USAG Hohenfels, two installations under control of the United States, but which also must conform to certain German/European Union (EU) regulations for training land management and environmental LMPs. In Canada, a site visit was conducted at Canadian Forces Base (CFB) Suffield in Alberta. For Australia, a series of emails followed by a telephone interview were conducted with the Director for the Environmental Systems, Integration, Department of Defence (Zentelis 2012).

Key points of contact (POCs) at each site were the natural resources staff members who are responsible for land care and rehabilitation. Information was sought based on the following general questions:

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- What are the military installations in your country that provide land-training capabilities to your military?
- What laws, regulations, and guidance exist that govern: (a) military training operations and (b) military land maintenance, rehabilitation, and reclamation that relate to environmental compliance (and land management, soils, water, etc.)?
- Who utilizes your training lands (i.e., which countries send groups for training)?
- What types of military training activities are conducted on your training lands? What intensity is this training and how frequently does it occur?
- What vehicles do these training lands typically utilize?
- How is your training schedule decided?
- Are there any safeguards in place against overuse of the land or training in overly wet conditions (or otherwise non-optimal conditions)?
- Are there any LMPs/ guidelines that exist for trainers and soldiers on environmental stewardship?
- Who performs your training land maintenance/ rehabilitation/ reclamation (i.e., natural resource staff on the installation or is it contracted out)?
- How are various land maintenance/ rehabilitation/ reclamation projects prioritized?
- What are the indicators that land managers utilize to decide if an area requires maintenance/ rehabilitation/ reclamation?
- What department/ division funds the land maintenance/ rehabilitation/ reclamation?
- What types of multiple activities are allowed on training lands, and how are these activities integrated together (e.g., military training, recreation, agriculture activity, farming activity, natural resource habitat maintenance, prescribed burning)?

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- What land care operations are performed on the installation for maintenance/ rehabilitation/ reclamation?
- What are the typical LMPs that have been identified for implementation at the installation for land, soil, and water management/ maintenance/ rehabilitation within the training lands?
- Have there ever been training activities resulting in large-scale land degradation on the installation? How was the land rehabilitated afterwards? Was the project successful? Were there any lessons learned that have changed the way that the installation natural resources managers operate?
- What machines does the installation use for military training land's maintenance/ rehabilitation/ reclamation (e.g., tractors, bulldozers, sprayers) and what implements (e.g., subsoilers, tines, plows, seed drills)?
- How often do these types of activities occur (e.g., seasonally, monthly, weekly) or just a general idea of frequency of use?
- What are the soils on the installation (soil type, any other general info relative to vegetative cover establishment and soil erosion, etc.)?
- What is the target vegetation community or profile for your installation?
- If reseeding is performed, what types of vegetation are planted?
- Are there any invasive plants that are managed at your installation?
- What are the other natural resource targets that the land maintenance/ rehabilitation/ reclamation activities are aimed at (e.g., threatened and endangered species, habitat management, invasive control, etc.)?

In general, the questions asked were more detailed than most responses gained; however, having the questions at hand to spur discussion points helped to provide better insight into each

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nation's land management regulations and plans as covered in Appendix C and Appendix D, respectively.

APPENDIX C: COUNTRY REVIEW

Environmental Regulatory Drivers and Defense Planning Processes

Every country has its own suite of regulatory drivers and policies that must be abided by, relative to environmental protection and stewardship. Compliance and regulatory standards can be linked to political drivers; consequently, some nations are facing more stringent standards. Each country's military must comply with its own country's rules as well as to any regulations that apply if they are training within the boundaries of another country. For example, if an element of the U.S. military goes to the UK to train, it must comply with UK regulatory policies and laws as well as any applicable U.S. laws and regulation.

The following listings offer some insight into the range of regulations that exist within the four countries selected for this study.

United Kingdom

- EU
 - Birds Directive (1979; updated 2009)
 - Habitats Directive (1992; updated 2007)
 - Natura 2000 Networking Programme (<http://www.natura.org/>)
- United Kingdom
 - Environmental Protection Act 1990
 - Environmental Act 1995
 - International Organization for Standardization (ISO) 14001: Environmental management
 - ISO 14040: Environmental management - Life cycle assessment - Principles and framework
 - Listed Buildings and Conservation Areas Act 1990
 - Ancient Monuments and Archaeological Areas Act 1979
 - Wildlife and Countryside Act 1981

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- MOD
 - Defence Equipment and Support Acquisition Safety and Environmental Management System (ASEMS) Project Oriented Environmental Management System (POEMS) Manual
 - Sustainable Development and Environmental Manual (Joint Service Publication [JSP] 418)
 - Defence, Health, Safety and Environmental Protection (JSP 815)

Germany

- EU
 - Birds Directive, 1979; updated 2009.
 - Habitats Directive, 1992; updated 2007.
 - Natura 2000 Networking Programme
<http://www.natura.org/>
- U.S. Army, DoD
 - AR 200-1, "Environmental Quality - Environmental Protection and Enhancement," December 2007.
 - Memorandum, "Management of Cultural, Historical and Archeological Resources on Properties Accommodated to the U.S. in Germany," October 2009.
 - Army in Europe (AE) Regulation 200-1, "Environmental Quality - Army in Europe Environmental Quality Program," May 2012.
 - DoD Final Governing Standard for Belgium, Germany, and Netherlands, July 2012.
 - Memorandum, "Standard Operating Procedure for the Conservation and Management of Natural Resources," January 2013.
 - Environmental Handbook and Environmental Standard Operating Procedure for Tenant Units/Activities
 - Soldier Field Card

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- Germany
 - Bundesnaturschutzgesetz (German Federal Act on Nature Conservation), July 2009.
 - Bayerisches Naturschutzgesetz (Bavarian law on Nature Conservation), February 2011.

Canada

- Canadian Environmental Assessment Act, 2012.
<https://www.ceaa-acee.gc.ca/default.asp?lang=en&n=16254939-1>
- Canadian Environmental Protection Act, 1999.
<http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=26A03BFA-1>
- Fisheries Act, 1985. <http://laws-lois.justice.gc.ca/eng/acts/F-14/FullText.html>
- Report of the Auditor General of Canada: Chapter 7– “National Defence–Environmental Stewardship of Military Training and Test Areas,” 2003. http://www.oag-bvg.gc.ca/internet/English/parl_oag_200304_07_e_12913.html
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Australia

- Environment Protection and Biodiversity Conservation Act, 1999.
- Defence Environmental Strategic Plan 2010-2014.
http://www.defence.gov.au/environment/strat_plan.pdf
- Defence Environmental Policy, 1999.
<http://www.defence.gov.au/environment/>
- Hazardous Waste (Regulation of Exports and Imports) Act, 1989. <http://www.environment.gov.au/topics/environment-protection/hazardous-waste/about-hazardous-waste-act>

**APPENDIX D:
COUNTRY-SPECIFIC TRAINING LAND MANAGEMENT PRACTICES**

LMPs, Approach, Strategy

Within the countries that could be reviewed for this work, it was clear that they had developed their own assortment of LMPs according to their specific environmental needs and requirements. For example, LMPs were very context-specific relative to the local soils and water regime. Figure D-1 is a diagram that illustrates where the nexus exists between meeting the training requirements and combining them with environmental stewardship to create a sustainable training land resource. Key aspects of maintaining the sustainability measure are ensuring training area maintenance and ensuring correct resource allocation. Oversight into maneuver area design and implementation are essential. Ensuring soldier awareness of suitable sustainability practices and approaches to training area utilization is critical to regulatory compliance and maneuver area capacity (MAC) sustainment. Ongoing monitoring of the environmental resource is also always essential to long-term sustainment.

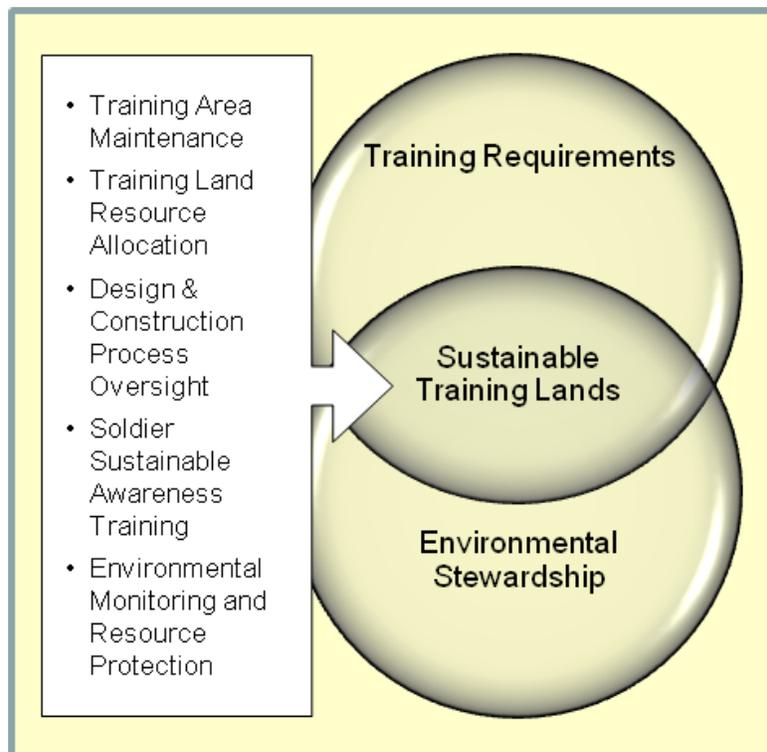


Figure D-1. Land-management nexus of sustainable training lands.

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**United Kingdom: Site Visit to Cranfield University, Shrivenham
(11-21 September 2012)**

Two-thirds of the 240,000 ha of land owned by the MOD is held for training of armed forces. The land collectively is known as the Defence Training Estate (DTE). The DTE comprises 16 major Armed Forces training areas and 104 other minor training areas, ranges, and camps. The DTE is managed to ensure that it delivers military training facilities which prepare the troops for operations worldwide. There is an average daily throughput of 9,000 service personnel on DTE lands (MOD 2014).

Training areas are highly managed within the UK due to its relatively limited land mass. Overall, limited land availability results in multipurpose use and co-utilization of training lands. For instance, target practice can occupy the same area as a reconnaissance exercise and a force-on-force event. Training lands also are utilized by tenant farmers and as open-access public areas. It is not uncommon to see civilians walking, hiking, biking, or simply cohabitating an active military training area. Therefore, an extensive management system (complete with warning signs) is in place to ensure the safety and well-being of all occupants (Figure D-2). Currently, both the U.S. Army and the MOD are integrating this type of management approach into U.S. Army systems of record Range Field Management Scheduling System (RFMSS).

Grazing of sheep and cattle is used for vegetation control, specifically for control of invasive species and for fire management. Grazing is the most common LMP; grazing agreements with local farmers allow for minimal fire risk and protect species that evolved under the naturally occurring grazing regime (Figure D-3).

Unlike in the United States, however, the presence of TES will not close down a training area in the United Kingdom. Instead, management tactics are utilized to coexist with and to minimize impacts to the TES, but priority is given to the MOD actions. To ensure success, the MOD utilizes installation personnel (similar to U.S. Army's ITAM office) along with local experts and regulators to form an Environmental Steering Committee. The Environmental Steering Committee will determine productivity goals for any TES present, such as three chicks or fledglings per pair per year.



Figure D-2. At Defence Training Estate Otterburn (DTE Otterburn), Barricades and warning signs (inset photo) are prominent to alert anyone driving on-range of the current use status of training areas (ERDC-CERL, 2012).



Figure D-3. At DTE Otterburn and DTE Salisbury Plain, grazing is a LMP for vegetative cover maintenance. Tenant farmers (non-military) utilize the landscape, and some even live on-range. As shown in these pictures, old structures and vernacular herding practices are still in use today, proving the tried-and-true success of contextual LMPs and the value of keeping them intact over time (ERDC-CERL, 2012).

Unique to the UK are "Wet Weather Restrictions" on training lands. Soil moisture is closely monitored remotely to predict if the area is too wet to sustain training. Additionally, a Field Marshal will use a "boot test" to determine if a training area can be utilized and sustain intended loads. To do this, the

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Field Marshall assigned to the unit will dismount, walk the training area, and see how deep their boot sinks into the soil. The Field Marshall will then make a call on the type of training to be allowed: dismounted only, light vehicles only, or "all green" for any type. Additionally, the UK utilizes remote sensing data and field data to determine instances of bare ground. Linking the current state of the training area with past "wet weather training" conditions is now providing recovery data to better refine training land utilization.

Finally, another management technique is a rotational approach to digging activities. Digging areas within the training areas are on a three-year rotation, allowing for recovery over time of the impact areas and providing for more realistic training experiences. Finally, land repair occurs immediately after any ground-disturbing activities.

Germany: Site Visits to USAG Grafenwoehr and USAG Hohenfels (05-10 May 2013)

The USAG Grafenwoehr Training Area is spread over 223 km² in the center portion of USAG Grafenwoehr in Bavaria, Germany. It is the largest North American Treaty Organization (NATO) training area in Europe and is under the auspices of the U.S. Army Europe (USAREUR) Command (Grafenwoehr 2014). The training area is also home to the critically endangered Common Snipe (*Gallinago gallinago*), that inhabits one of the area's largest transitional bogs. There is also a significant population of beavers (250-300) which often create flooded landscapes (Hayden 2013).

The USAG Hohenfels Training Area is located 72.5 km. southwest of USAG Grafenwoehr and was first used by U.S. military forces in 1951. In 1988, it became home to the Combat Maneuver Training Center (CMTC), the mission of which was to provide realistic combined arms training for the USAREUR. In December 2005, the CMTC was transformed and named the Joint Multinational Readiness Center (JMRC), part of the Joint Multinational Training Center (JMTC) which oversees training for all of USAREUR. Hohenfels Training Area is the largest of USAREUR maneuver training areas and comes under the command of the Commanding General, JMTC, at Grafenwoehr. More than 60,000 soldiers train here annually (Installation Management Command [IMCOM] n.d.).

There is an accepted list of LMPs available for use at the German training areas. These are included within a handbook from the Directorate of Public Works (DPW) Environmental Division, the "Environmental Handbook," and from Tab A of the handbook,

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"Environmental Standard Operating Procedure for Tenant Units/Activities."

There is also a "Soldier Field Card," provided either via hard copy or as a digital smart-phone application, that gives a detailed training area "do and don't" list for soldiers. This Soldier Field Card also includes a POC list to contact should any issue arise.

ITAM also participates in a wide variety of events that provide outreach to the soldiers, and it shares information with them on impacts to training lands from training activities. There is also a smart-phone application released in 2014 by the USAREUR Sustainable Range Program, "USAREUR Environmental Officer."²

Typical land-care operations that are performed on the installations for maintenance, rehabilitation, and/or reclamation include: (a) flattening incisions and deep tracks, (b) reseeding, (c) removal of woody vegetation at drop zones and within open maneuver areas, and (d) removal of successional growth along training area boundaries and maneuver trails. Maintenance is also a constant activity at retention basins, check dams, and drainage areas. Erosion control (EC) actions include: (a) reducing the potential of land erosion due to overland flow by sustaining grass on open areas, (b) flattening any incisions and deep tracks, and (c) reseeding if necessary.

In addition, an extensive perimeter EC program has been developed over the last 20 years. This system is composed of sediment basins (lined and unlined) throughout the training areas and skirting the entire perimeter (Figure D-4). These sediment basins are done singularly and in series. Those basins in series act as a water control structure.

All in all, the land-care LMPs are very simple applications. Typically, there are not any EC LMPs deployed beyond check dams (no blankets, hydroseeding, geotextile, etc.). There have not been any large-scale or intensely degraded areas of land for some time now, due to integrated approaches to training and the successful working relationship between ITAM, DPW Environmental, and German Forestry (Figure D-5). All the LMPs now in use were learned together by all parties.

² Available for download at <https://play.google.com/store/apps/details?id=com.usareu.eo&hl=en>.



Figure D-4. JMRC Hohenfels Training Area and Grafenwoehr Training Area have the largest and most dynamic live-fire training facility in Europe. An extensive soil erosion and sediment control network system has been implemented around the entire training area to facilitate the prevention of sediment from leaving the installation (ERDC-CERL, 2013).



Figure D-5. At both Hohenfels and Grafenwoehr, integrated approaches to training have been developed to utilize existing structures while protecting both natural and cultural resources. Shown here are Siebert Staked off culturally significant orchard adjacent to a former church tower utilized as a training facility. Inset is a historic food stock location which is now open to bat species as roosting habitat (ERDC-CERL, 2013).

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Canada: Site Visit to CFB Suffield, Alberta (18-25 June 2014)

The Canadian military has modeled their land management approach very similarly to that of the United States. Like the United States, Canada's military land management is both regulatory-driven and Army-driven.

Canadian Forces Base (CFB) Suffield is host to the largest military training area in Canada. CFB Suffield's mission is to provide sustainable world-class range and training areas that enable Defence Research and Development Canada-Suffield (DRDC), the British Army Training Unit Suffield (BATUS), and other potential users to achieve their training mandates through effective stewardship and maintenance of all the range training areas' infrastructure and equipment (Canadian Forces Base Suffield 2014).

CFB Suffield and the prairie of Alberta have hosted training for the British Army on a large scale since 1972. BATUS trains on one of the most sparsely populated areas of that Alberta plain. BATUS is equipped with in excess of 1,000 vehicles including a full complement of Challenger 2 tanks and Warrior Infantry Fighting Vehicles. Each year, a regiment is sent there for six months to take the part of the "enemy" for the other regiments that are there to train each year. The duration of the exercises and size of the training area allow all elements of a combined arms battle group (Infantry, Armour, Artillery, Engineers, Air Defence, Logistics, and Equipment Support) to conduct realistic live-firing training at all levels and to practice sustaining this activity over a long period of time (The British Army in Canada 2014). Suffield's training areas also are co-utilized by visiting military units from other countries and for oil mining, cattle grazing, and native grass baling.

While CFB Suffield has extensive maneuver land, there are few restrictions as to how vehicles are allowed to traffic the open expanses of maneuver areas. Training areas there have multipurpose uses, and very few static and hardened ranges have been constructed. Considering the size of the training areas, lack of restrictions, and heavy use, advance planning for potential impacts is very difficult at CFB Suffield. The problems combine to create vehicle impacts (Figure D-6).

In addition, while military operations on urban terrain (MOUT) training areas at CFB Suffield are set up similarly to those in the United States (i.e., temporary buildings sited to mimic villages or operational environments), there are no set range

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roads at CFB Suffield to dictate how traffic must flow through or around the MOUT facilities. This type of unrestricted vehicle trafficking and lack of hardened roads opens the land to a wider range of maneuver impacts (Figure D-7).

Extensive research at Suffield has been conducted since 2008 to determine historic land use and how that history of use is driving current land conditions. This effort to quantify land utilization and recovery rates was conducted to develop a model approach to land management that would have the ability to project potential co-occupancy and land-use impacts.

Based on the developed model described above, from assessment of past utilization, and through naturally occurring "healing," land managers now know that 70% is the threshold from which the lands will not self-heal. Thus, current land rehabilitation and repair actions are only conducted after an area exceeds 70% bare ground. An extensive model development for damage quantification, repair actions (using LMPs), and cost estimation has been developed for CFB Suffield, with other installations following suit.



Figure D-6. When hills are traversed perpendicularly, any vehicle ruts or removed vegetation become instant catalysts for soil erosion by allowing the opening of preferential pathways for water flow (ERDC-CERL 2014).



Figure D-7. This panoramic view of a Canadian MOUT site shows the impact of various trafficking patterns and array of vehicular approaches (ERDC-CERL, 2014).

Australia

Australian Defence Forces training areas have a major land presence in South Australia. Of these areas, Cultana Training Area is becoming the largest due to a five-fold expansion that is increasing its mass to 2,300 km². Its climate provides year-round training to the nation's armored, mechanized, and cavalry forces and combined forces training (Defence SA 2014). The country is also host to increased U.S. military forces on short-term rotations designed to provide improved response "to a range of contingencies in the Indo-Pacific" (Robson 2013). Australia offers "great training opportunities" according to MAJ Maurice Brown, U.S. Marine Corps (Robson 2013; Figure D-8 and Figure D-9). The Modernisation and Strategic Planning Division of Australian Army Headquarters prepares an annual "Future Land Warfare Report" for the Directorate of Future Land Warfare. The report assesses long-term future trends in the operating environment including joint operations and their possible influence on Defence resources (Australian Army 2014).



Figure D-8. U.S. Marines and Australian soldiers take cover in a trench during joint training for Exercise Koolendong in 2013 at Mount Bunday Training Area, Northern Territory, Australia (Robson 2013).



Figure D-9. U.S. Marines move forward in support of Australian soldiers during joint training for Exercise Koolendong at Mount Bunday Training Area, Northern Territory, Australia, in 2013 (Robson 2013).

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Australia's regulatory system is set up similarly to that of the United States, because Australia has legislative requirements under which the Army must maintain and protect ecosystems, species, habitats, and environments. Maintaining and protecting Australia's Commonwealth Government at the state or territory level is the primary objective (Zentelis 2012). Thus, whichever legislation requirements are the most conservative—local, state, territory, or national—the Australian Government Department of Defence will maintain the capability of the training areas to those requirements. Extensive effort is used to minimize impacts from training and to take into account environmental issues including those related to climate change, contamination, and the impacts of urban encroachment, mining, and noise (Australian Department of Defence 2010, 23). Each training area is responsible and accountable for the land's condition. The Australian Army's Range Control Officers can and will close down or modify training if a perceived environmental risk is likely to occur (Zentelis 2012).

Australian training areas are very open and can be quickly reconfigured to fit the military's mission objectives. Scheduling efforts for the training areas include establishment of upper and lower levels of damages; these established damage levels then become part of the assessment and planning process prior to a rotational unit utilizing the training areas. Plans and requirements for a series of concerns (e.g., erosion guidelines) are developed to determine any need for preventive intervention. Due to the fragile soils of the training areas, extensive land-management research has been conducted by the Department of Defence and Australian universities since the 1980s (Zentelis 2012). An example LMP which came from Australian research is the Hesco® basket system³ which is a collapsible wire mesh container with heavy liner that, when filled with earthen material, serves as a barrier. It was originally designed for erosion and flood control, and it has since been modified to become a barrier for force protection which has been used frequently for that purpose in Iraq and Afghanistan (Figure D-10; Gibson 2006).

³ System was developed in late 1980s by a British entrepreneur who formed a firm of the same name (HESCO Bastion Ltd.). Due to the container's successful performance during U.S. flooding (particularly Hurricane Katrina), the firm also operates Bastion USA in Hammond, Louisiana.



Figure D-10. U.S. Navy personnel assembling HESCO bastions
(Wikipedia http://en.wikipedia.org/wiki/Hesco_bastion).

Australia does not utilize engineering for site hardening and static ranges as extensively as the United States military does. However, LMPs have been developed for the arid regions, taking into account the frequent risk of drought (either it rains or not in those regions). Guidelines for LMPs have been developed by habitat and climatic zones; these guidelines require specialized erosion and sediment control for each of Australia's climatic zones. Like the UK (but unlike the United States), Australia has the majority of its environmental monitoring and land management conducted by privately owned companies (Zentelis 2012).

**APPENDIX E:
SYNTHESIS REVIEW**

Compare and Contrast Multinational Approaches

Table E-1 summarizes the different approaches to training land management among the United States, the United Kingdom, Germany, Canada, and Australia.

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Table E-2 compares multinational methods of training land management with the nearest equivalent method in U.S. military training land management.

Table E-1. Summary of various countries' approaches to training land management for ground forces.
 (Note: See pages that follow for explanation of abbreviations, given by country in the order used.)

	United States	United Kingdom	Germany	Canada	Australia
Rule-Making Agencies	<ul style="list-style-type: none"> • Federal • Department of Defense • Army 	<ul style="list-style-type: none"> • European Union • United Kingdom • Ministry of Defense • Defense Training Estate 	<ul style="list-style-type: none"> • European Union • Germany • Province • Department of Defense • United States Army in Europe 	<ul style="list-style-type: none"> • Federal • Province • Department of National Defence • Canadian Forces Base 	<ul style="list-style-type: none"> • Federal • Commonwealth State • Territory • Australian Ministry of Defence - Defence Environmental Management
Plans and Processes	<ul style="list-style-type: none"> • ITAM • SRP • INRMP • ICRMP • RPMP • ACUB 	<ul style="list-style-type: none"> • EMS • IRMP • RA-RO-RC • RW-RTAM 	<ul style="list-style-type: none"> • ITAM • SRP • INRMP • ICRMP • EU Natura 2000 Management Plans • Federal/local management plans per host nation 	<ul style="list-style-type: none"> • SDS • SSMP • ISMP • (I)MRG • RTAC • BSO-RSO 	<ul style="list-style-type: none"> • SMRP • ESP • DEP • EWG

	United States	United Kingdom	Germany	Canada	Australia
Training Types	<ul style="list-style-type: none"> • Single service, but some ranges open to tenants from other units, commands, and organizations • Installation mission (can change) • Open ranges with impact areas off-limits 	<ul style="list-style-type: none"> • Multiple service • Training type matched with land capability • Open areas with semi-accessible impact areas (cleaned) 	<ul style="list-style-type: none"> • Multiple service • Multiple country • Range of training types from convoy to maneuver, to infantry and earthworks • Moderate frequency, low intensity (recently) 	<ul style="list-style-type: none"> • Multiple service • Multiple country (e.g., BATUS at CFB); • Large-scale brigade-type training • Full site access (across-site cleaning, biannual) 	<ul style="list-style-type: none"> • Multiple service • Multiple country (e.g., Exercise Koolendong) • Large-scale brigade-type training • Full site access (across-site)
Training Land Uses	<ul style="list-style-type: none"> • Training area allocations • Single-use • Central range control • Limited public access for agriculture, hunting, and recreation. • Semi-limited off-road maneuver access 	<ul style="list-style-type: none"> • Shared training areas • Range control and range warden real-time monitor • Public access • None or limited off-road maneuver 	<ul style="list-style-type: none"> • Shared training areas • Range operations monitoring • Open public access (certain activities are permitted, some are not) • Agricultural and forestry outleasing 	<ul style="list-style-type: none"> • Broad use of CFB over combined training areas • Central range control • No public access • Open off-road maneuver access 	<ul style="list-style-type: none"> • Broad use over entire training area, and combined training • Central range control • No public access • Open off-road maneuver access

	United States	United Kingdom	Germany	Canada	Australia
<p>LMP Takeaways</p>	<p>N/A (Recommendations for United States per other countries' takeaways is in Appendix F, Lessons Learned)</p>	<ul style="list-style-type: none"> • Heavy co-utilization of land (includes supporting coordination) for multi-service and multi-objective military training to minimize impacts • Fit-for-purpose matching of land use to environmental capacity and concentrated land uses; static stationing and training loads • Boot-Test 'tool' developed for at-risk-installations 	<ul style="list-style-type: none"> • Utilization of watershed approach for Perimeter Erosion Control system on training areas • Established methods for "minimal repair" approach to enhance soldier training experience and realism • Developed training areas to mimic natural elements found in forward operations <p>E-5</p>	<ul style="list-style-type: none"> • Developed assessment system estimating pre-training and post-training conditions to determine repair requirements and costs • Developed modeling approach to determine recovery rates for sensitive areas • Developed environmental rehabilitation techniques that match site soil and vegetation properties versus generic standard solutions 	<ul style="list-style-type: none"> • Rotational Training Approach taken to allow land to sit fallow and recover through natural processes • Developed LMP prescriptions based on climatic zones • Drought-tolerant LMPs are utilized to reduce land repair cost and increase success • Minimal site hardening to reduce repair costs and increase training realism (reliant to rotational training area approach)

Definitions of Abbreviations in Table E-1

United States:

ITAM	Integrated Training Area Management
SRP	Sustainable Range Plan
INRMP	Integrated Natural Resource Management Plan
ICRMP	Integrated Cultural Resource Management Plan
RPMP	Real Property Master Plan
ACUB	Army Compatible Use Buffer

United Kingdom:

BATUS	British Army Training Unit Suffield
EMS	Environmental Management System
IRMP	Integrated Rural Management Plans
RA-RC-RO	Range Allocation;, Range Control; Range Orders & Operating Instructions
RW-RTAM	Range Wardens, and Range Training Area Marshals

Germany:

ITAM	Integrated Training Area Management
SRP	Sustainable Range Plan
INRMP	Integrated Natural Resource Management Plan
ICRMP	Integrated Cultural Resource Management Plan

Canada:

SDS Sustainable Development Strategy

SSMP [Suffield] Sustainability Master Plan

RTAC Range and Training Area Characterization

(I)MRG (Interim) Military Reclamation Guide

BSO/RSO Base Standing Orders / Range Standing Orders

Australia:

ADF Australian Defence Force

EPBC Environment Protection and Biodiversity Conservation Act
1999 (EPBC Act)

SMRP Sustainability Management Resource Plan

ESP Environmental Strategic Partnerships

DEP Defence Environmental Policy

EWG Environmental Working Group

Table E-2. Comparison of multinational methods for training land management with the nearest equivalent method used by U.S. Army. (Note that subscript numbers relate to references that follow this table (if no other info listed, then reference is to page numbers within this PWTB.)

Multinational Method	Multinational Description / Metric	Closest U.S. Equivalent	U.S. Equivalent Description / Metric
Wet weather restrictions (UK)	<p>Boot Test: Field marshal assigned to the unit will dismount, walk the training area, and assess depth of boot sinkage. Depth that boot sinks to is used to determine type of training allowed.¹</p>	<p>Soil Moisture Monitoring (SMM) (e.g., Yakima Training Center)²</p>	<p>Code-based suitability assessment based on real-time and historical field data. Protocol involves collection of field soil sample, moisture analysis of sample, and analysis results plotted on a geographic information system (GIS) map to indicate training suitability</p>
Dictated multipurpose use / co-utilization of training lands (UK)	<p>Rotation of land uses between military and non-military uses such as tenant farming, open-access public recreation, military training; (e.g., DTE Otterburn and DTE Salisbury Plain)³</p> <p>Co-utilization of land resources is coordinated at the installation range level. This coordination is used to communicate installation status and range/training area utilization. To ensure safety of public, alerts of training area status are made available via community announcements, field barricades, and warning signs to anyone driving on-range.⁴</p>	<p>RFMSS Army-wide</p>	<p>Facility utilization requests are submitted and processed by training division support. RFMSS forms are submitted by military and nonmilitary entities for area utilization. Exact scheduling process is range-specific.⁵</p>

Multinational Method	Multinational Description / Metric	Closest U.S. Equivalent	U.S. Equivalent Description / Metric
Grazing of sheep and cattle for vegetation control (UK)	<p>Grazing of sheep and cattle is used for vegetation control: invasive species and fire management.</p> <p>Tenant farmers and shepherds raise crops and livestock. Old structures and vernacular herding practices as historically successful, contextual LMP.⁶</p>	Camp Williams, UT Goats for fire breaks and invasive species control. ⁷	Camp Williams contracted for goat services/agricultural outlease for vegetation management. The initial case study included grazing over 500 goats within high fire-risk areas.
Utilization of watershed approach for Perimeter Erosion Control system on training areas (Germany)	Using a natural system approach, an erosion and sediment control network system was developed to capture sediments prior to leaving the installation and are specific to sub-watershed boundaries ⁸	Range Facility's Land Use Planning Zones (e.g., Fort Richardson, AK) ⁹	Training redesign based on maneuver land's capability analysis. Accomplished by reconfiguring training areas so that Land Use Planning Zones maximize the use of terrain and minimize erosion impacts.
"Minimal repair" methods to enhance soldier training experience (Germany)	Land care operations include: (a) flattening incisions and deep tracks, (b) reseeding, (c) removal of woody vegetation at drop zones and within open maneuver areas, and (d) removal of successional growth along training area boundaries and maneuver trails. ¹²	No Known Equivalent — BMP uses are based on Environmental Protection Agency (EPA) and state regulations.	N/A
Context appropriate / vernacular BMPs (Australia, UK, Canada)	Drought-tolerant BMPs utilized to reduce land repair cost and increase success (Australia). ¹³	No Known Equivalent — BMP uses are based on EPA and state regulations.	N/A

Multinational Method	Multinational Description / Metric	Closest U.S. Equivalent	U.S. Equivalent Description / Metric
<p>Site rotation of land-damaging training exercises (UK & Australia)</p>	<p>Digging areas within the training areas are on a three-year rotation, allowing for recovery over time of the impact areas and providing for more realistic training experience. Land repair occurs immediately after any ground-disturbing activities. (UK).¹⁴</p> <p>Rotational Training Approach allows land to sit fallow and recover through natural processes (Australia).</p>	<p>Land Repair Rotation (e.g., Yakima Training Center, WA)²</p>	<p>Establishes monitoring protocols for land utilization. Uses rotation for land repair, land rest, and monitoring of land repair success. Determines recovery rates for trainings prior to occurrence of impacts.</p>
<p>EC actions (Germany)</p>	<p>Methods involve: (a) reducing the potential of land erosion due to overland flow by sustaining grass on open areas, (b) flattening any incisions and deep tracks, and (c) reseeding if necessary.¹⁵</p>	<p>Land Rehabilitation and Maintenance Program (LRAM) (e.g., Fort Hunter Liggett, CA)¹⁶</p> <p>Wear-Tolerant Vegetation Standards (e.g., Fort Drum, New York; Yakima Training Center, WA)¹⁷</p>	<p>Protocol designed to implement improvements and repairs of disturbed land and water crossings, improve vegetation cover and concealment for training activities, and repair other landscape damage for safety and continued availability of land for training. Contains standards for revegetation techniques to prevent wind erosion.</p> <p>Wear-resistant cultivar development by ERDC-CRREL to assist in erosion control, invasive weed prevention, fire control, and line-of-sight maintenance.</p>

Multinational Method	Multinational Description / Metric	Closest U.S. Equivalent	U.S. Equivalent Description / Metric
Assessment system to determine repair requirements, costs (Canada)	Estimation established via pre-training and post-training condition analysis. ¹⁸	Army Training and Testing Area Carrying Capacity (ATTACC), Optimal Allocation of Land for Training and Non-Training Uses (OPAL), and Maneuver Area Capacity (MAC) Development	Ongoing research to improve land managers' abilities to assess potential impacts and related land repair costs.
Modeling approach to determine recovery rates for sensitive areas (Canada)	Model based on historical land use and natural land recovery rates. Uses 70% bare ground threshold. ¹⁸	ATTACC/OPAL/MAC Development	Ongoing research to improve land managers' abilities to assess potential impacts and related land repair costs.
Environmental rehabilitation techniques that match site soil and vegetation properties versus generic standard solutions (Canada)	"[Use of] filtration materials such as activated carbon, peat moss and bone char in preventing contaminants from migrating from ranges to surface and groundwater sources." ¹⁹ (Valcartier, Quebec–Small Arms Range)	Revegetation methods implemented on disturbed sites. ²⁰	Local contractors in conjunction with state Department of Natural Resources (DNR) implement site-specific restoration measures. (e.g., Ft Carson, CO)
Establishment of upper and lower levels of damages	Plans and requirements for a series of concerns (e.g., erosion guidelines) are developed to determine any need for preventive intervention prior to scheduling land for training exercise. ²²	Training Requirements Integration (TRI) Multiple sites (Army - wide) ⁵	Coordination with NEPA and Recognized Environmental Condition in conjunction with training activities.

Multinational Method	Multinational Description / Metric	Closest U.S. Equivalent	U.S. Equivalent Description / Metric
Sustainable Range Awareness (Germany)	Soldier Field Card is provided either via hard copy or as a digital smart-phone application and gives a detailed training area "do and don't" list for soldiers. ^{15, 23}	Sustainable Range Awareness Training Program. (Army-wide) ⁵	Garrison Commander institutes a web- and classroom-based Sustainable Range Awareness training program for soldiers down to the squad level. ¹⁵

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**APPENDIX F:
LESSONS LEARNED, RECOMMENDATIONS, AND TAKEAWAYS**

Lessons Learned / Recommendations

Key lessons learned from this multi-country review are noted here. Please note that these recommendations are not meant to be prescriptive; they are noted in order to provide suggestions of how approaches that have been used by other nations could be integrated and implemented within the United States. Some of these solutions are smaller-scale and could be utilized at an installation level; others point to broader and higher-level shifts within U.S. Army training and land management.

- Opportunities to integrate variables such as training types, land access and range-control systems, and utilization of public activities should be considered, wherever possible, to improve training land management. Such integration will result in training opportunities that are more efficient and likely of higher quality. This type of training approach requires a higher level of awareness and coordination by and between soldiers and units. It also mimics reality more closely because in the operational environment, multiple service types and units as well as multiple nationalities must work together in a coordinated fashion. By previously training in an intentionally integrated and coordinated way, soldiers will function better during operational exercises.

- While training can become more integrated and system-oriented, on-the-ground activities can also be monitored in real time, so as to further enhance training. The use of field marshals in the UK, for example, is a great opportunity to promote environmental awareness and resolve implementation of sustainability measures that might not otherwise be utilized. This solution would also ensure a cross-check of a military unit's use of maneuver lands or training ranges. Often times, compliance breaches occur when a unit inadvertently crosses into a restricted area or when training occurs on susceptible soils after heavy precipitation. Having a person on hand to review advisability of current activities would prevent those types of small but expensive and publicly embarrassing mistakes.

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- If environmental compliance related to development of military vehicles is considered within and throughout the research, design, and development phases, then environmental impacts by military vehicles and other types of infrastructure can possibly be avoided. It is in the early stages that vehicle performance can be fine-tuned to match environmental concerns, thus reducing long-term costs (e.g., saving money that would have been otherwise spent on compliance fines or land rehabilitation efforts).
- Placement of field units and their associated training activities types can be planned to occur in environmental locations that are best suited to withstand any anticipated impacts. Once the training activities and environments are paired, they can be quite easily managed for indefinite sustainment of the training area. For example, maneuver ranges required for tanks and other heavy vehicles could be placed on semi-hardened landscapes or on landscapes where vegetative growth and soils are resilient to such impacts (not where soils are poor and erosive or vegetative growth is hard to establish).
- Training area delineation on U.S. Army installations typically reflects safety, infrastructure, or vernacular/historical boundaries. If it were possible to re-align training area boundaries so that they reflect subwatersheds, the resulting reorganization could allow the opportunity for more intense training activities. This is how training areas were set up in Germany, and that relation to subwatersheds, in combination with a perimeter erosion control strategy, allows the training units more freedom in how they train. The implemented erosion control approach ensures that any impacts on water quality do not travel out of that particular training area, and it remains in regulatory compliance. For most installations, full-scale training area boundary realignment would not be cost-effective; however, some effort could be made to initiate the shift. Initially, vulnerability assessments could be performed, with the intent to indicate which training areas would most benefit from boundary realignment (e.g., if they are having water quality or erosion control issues or if the training needs require impact to the watercourses). By prioritizing the vulnerability of training areas and realigning boundaries of the highly vulnerable ones by setting them to the sub-watershed boundaries, not only would compliance breaches occur less often, but training

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units also would have more leeway as to the types of activities that could be performed.

- LMPs in the United States tend to be developed for intended application nationwide. One approach that could benefit the U.S. military would be to refine its compliance guidance of LMPs. Instead of following nationwide LMPs with local modification, solutions or variations should be proposed that are paired to habitat and climatic zones. This pairing is done in Australia and to a similar extent in the United Kingdom. This approach allows the vernacular landscape to be retained and takes advantage of local skill sets and knowledge of soils and vegetation; thus, this approach ensures that LMPs are always applied in a context-appropriate manner, which typically results in a better-functioning LMP.
- Currently the allocation or shifting of training-type assignments per installation or training area are subject to NEPA analysis but can be improved with a more integrated approach prior to decisions being finalized. One area where the United States could maximize environmental compatibility of training and minimize environmental impacts and compliance breaches would be to include consideration and assessment of environmental constraints prior to any change or any new allocations of stationing, training activities, and/or training loads per location. For example, soil resiliency could be utilized to determine an installation's capability to support a particular mission. Then, once a compatible training type is matched to the environmental condition, the approach should be to allow that assignment to remain. This would allow land managers to adjust any maintenance and rehabilitation actions to better match the situation. In doing this, they would be able to function more efficiently (always having context-based solutions versus generic strategies that may or may not work), but they would also start to build a strong base of vernacular knowledge about how to deal with various issues that may arise.

Takeaways

- A proactive stance is best. Environmental regulations are typically becoming more stringent, a proactive stance means that staying ahead of the "regulatory curve" would make that moving curve less likely to impede operations.

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- In certain responses to environmental regulations, proactive and innovative thinking about training lands can actually contribute to a more efficient military by increasing soldier readiness and saving the military both time and money.
- Creating a smaller environmental footprint can create easier, quicker, and more sustained deployments of new technologies.
- The most effective strategies for sustaining training lands are tools for education and awareness that put the responsibility with the soldiers. On-the-ground training (e.g., marshals, coordinators, and range officers) and in-person outreach with educational materials (e.g., field cards) are very effective at ensuring knowledge of resources and compliance requirements. The ability to enforce this individual responsibility also assists in creating a culture of proactive stewardship.
- All nations are dealing with fewer resources, constrained finances, and enduring stressors (e.g., natural disasters, changing climates, and management reconfigurations). Land projects intending to rehabilitate and sustain existing areas, and management actions allowing sustainment activities to be effective, are long-term solutions that are much cheaper than buying new lands or losing access to training areas altogether.

APPENDIX G: ACRONYMS AND ABBREVIATIONS

Term	Definition
AE	Army in Europe
AR	Army Regulation
ASEMS	Acquisition Safety and Environmental Management System (UK)
ATTACC	Army Training and Testing Area Carrying Capacity
CECW	Directorate of Civil Works, United States Army Corps of Engineers
CEMP-CE	Directorate of Military Programs, United States Army Corps of Engineers
CERL	Construction Engineering Research Laboratory
CFB	Canadian Forces Base
CMTC	Combat Maneuver Training Center
DNR	Department of Natural Resources
DPW	Directorate of Public Works
DoD	Department of Defense (U.S.)
DTE	Defense Training Estate
EC	erosion control
EPA	Environmental Protection Agency (U.S.)
ERDC	Engineer Research and Development Center
EU	European Union
GIS	geographical information system
HQUSACE	Headquarters, United States Army Corps of Engineers
IMCOM	Installation Management Command
ISO	International Organization for Standardization
ITAM	Integrated Training Area Management
JMRC	Joint Multinational Readiness Center

Term	Definition
JMTC	Joint Multinational Training Center
JSP	Joint Service Publication
LMP	land management practices
LRAM	Land Rehabilitation and Maintenance Program
MAC	maneuver area capacity
MOD	Ministry of Defence (UK)
MOUT	military operations on urban terrain
NATO	North American Treaty Organization
OPAL	Optimal Allocation of Land
POC	point of contact
POEMS	Project Oriented Environment Management System
PWTB	Public Works Technical Bulletin
RFMSS	Range Field Management Scheduling System
SMM	soil moisture monitoring
TES	threatened and endangered species
UK	United Kingdom
U.S.	United States of America
USACE	United States Army Corps of Engineers
USAG	U.S. Army Garrison
USAREU	U.S. Army Europe
WVA	Watershed Vulnerability Assessment

APPENDIX H: REFERENCES

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