Welcome to the first issue of Climate Corps, the newsletter of the National Military Fish and Wildlife Association (NMFWA) Climate Change Working Group! We’re incredibly excited to be rolling out the newsletter, which we envision not just as a source for the latest news and research on climate change and its ecological effects, but a way to connect DoD natural resources managers, contractors, and interested parties in climate-smart planning across installations and services. Each issue will provide news and updates, spotlight innovative natural resources work across our community, and highlight recent research of interest. As climate change has the potential to affect a vast cross-section of natural resources management, we honed the focus of this first newsletter on the theme of Wildland Fire and Climate Change. Underlined green text throughout is active hyperlinks to other sections and further reading!

By way of introduction, Climate Corps is edited by me, Charlie Lawton, an invasive species ecologist and the natural and cultural resources and NEPA manager at Schriever AFB, Colorado. Keeping the whole project organized and pointed in one direction is my collaborator, Isha Alexander, a Senior Environmental Scientist with HDR, based in Washington State. And we couldn’t do it without the steady involvement of our Working Group co-chair, Christy Wolf, Conservation Program Manager at Naval Weapons Station Seal Beach Detachment Fallbrook in southern California.

We are ALWAYS looking for news and updates, research articles, and for your work to feature in the Spotlight section, which provides a platform to feature DoD related projects or research. And, of course, we welcome your feedback as Climate Corps takes shape. Please send submissions and feedback to climatecorpsNMFWA@gmail.com!

- Charlie

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**Letter from the Editor**

**Climate News**

**IPCC releases “Special Report on the Ocean and Cryosphere in a Changing Climate”**: The latest Intergovernmental Panel on Climate Change (IPCC) Special Report highlights the urgency of prioritizing timely, ambitious and coordinated action to address unprecedented and enduring changes in the ocean and cryosphere. Follow link to download Special Report and supporting materials presented at the IPCC 51st Session held on 20 – 23 September 2019.

**Navy shuts down climate change task force**: The Navy has quietly stood down its Task Force Climate Change, created in 2009 to plan and develop "future public, strategic, and policy discussions" on the issue. The task force ended in March 2019, a spokesperson said, and the group’s tab on the Navy’s energy, environment and climate change website was removed sometime between March and July, according to public archives.

**July may have been the hottest month ever recorded, UN world meteorological organization says**: July 2019 may have been the single hottest month in recorded history, preliminary data from the World Meteorological Organization shows. Global average temperatures from July 1 to July 29, 2019, met and possibly even surpassed the previous record for the hottest month ever, which was set in July 2016. This is even more significant because the previous hottest month, July 2016, occurred during one of the strongest El Niños ever; July 2019, meanwhile, did not coincide with a strong El Niño.

**Military and intelligence officials warn of climate risk**: Senior U.S. officials warned June 5, 2019, that climate change is an increasing threat to national security. Military and intelligence officials outlined a range of long-term threats arising from climate change, including food and water shortages that can produce political turmoil and land disputes as well as melting ice in the Arctic that Russia and other adversaries could exploit for commercial gain.
COMMUNITY SPOTLIGHT: WILDLAND FIRE AND CLIMATE CHANGE

Wildfire season is a tense time for everyone, not just natural resources managers. Throughout the West, we’re all too aware that an errant cigarette butt, a sparking tire rim, or a lightning strike could result in a conflagration capable of threatening our bases, our homes, and our cities. While the West has largely been spared this year due to a wet winter and spring, wildfires have raged across Alaska, Siberia, and even the Amazon Basin. And while wildfires aren’t directly caused by climate change, its attendant droughts, heat waves and altered precipitation regimes are threat multipliers – wildfires burn larger areas, are quicker to start, and are more intense in a warming world. This issue spotlights recent work to assess climate impacts to Air Force installations nationwide and incorporation of climate considerations in wildland fire management planning at the Army’s Dugway Proving Ground, Utah.

Climate influenced changes to wildfire potential at select Air Force installations

Andrew M. Beavers

The Center for Environmental Management of Military Lands (CEMML) recently completed an Enterprise-Wide Climate Change Analysis for Integrated Natural Resource Management Plans (INRMPs) assessing climate impacts to 68 Air Force Installations. One factor in that analysis was projections of wildfire frequency and intensity, which were combined into an estimate of overall fire activity, accounting for projected changes in temperature and precipitation, ancillary changes to relative humidity, and changes to vegetation. Changes in land use, military mission, and other factors that may affect ignition probability were beyond the scope of the study.

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Building climate adaptation into a wildland fire management plan, U.S. Army Dugway Proving Ground

Elizabeth Kellogg and Robert Knight

The landscape scale and long time frames under which wildland fire planning is conducted lends itself to climate adaptation planning as a parallel and imbedded process. In Utah’s west desert region of Great Basin shrublands lies the U.S. Army’s Dugway Proving Ground (DPG). The DPG Natural Resources Program took advantage of the convergent goals of wildland fire management, restoring landscape resilience to fire, and climate adaptation while developing its Integrated Wildland Fire Management Plan (IWFMP). Wildfire’s effect on the military mission will become increasingly costly under the status quo, regardless of any management by DPG or in the region. With the projected increase in extreme fire danger days and the potential lengthening of the fire season associated with climate change, fire control will become increasingly important just to sustain the existing testing and training capacity and amplitude of available days for mission operations.

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RESEARCH FOCUS: WILDLAND FIRE AND CLIMATE CHANGE

Learning to coexist with wildfire

The impacts of escalating wildfire in many regions — the lives and homes lost, the expense of suppression and the damage to ecosystem services — necessitate a more sustainable coexistence with wildfire. Climate change and continued development on fire-prone landscapes will only compound current problems. Emerging strategies for managing ecosystems and mitigating risks to human communities provide some hope, although greater recognition of their inherent variation and links is crucial. Without a more integrated framework, fire will never operate as a natural ecosystem process, and the impact on society will continue to grow. A more coordinated approach to risk management and land-use planning in these coupled systems is needed.


How contemporary bioclimatic and human controls change global fire regimes

Anthropogenically driven declines in tropical savannah burnt area have recently received attention due to their effect on trends in global burnt area. Large-scale trends in ecosystems where vegetation has adapted to infrequent fire, especially in cooler and wetter forested areas, are less well understood. Here, small changes in fire regimes can have a substantial impact on local biogeochemistry. To investigate trends in fire across a wide range of ecosystems, we used Bayesian inference6 to quantify four primary controls on burnt area: fuel continuity, fuel moisture, ignitions and anthropogenic suppression. We found that fuel continuity and moisture are the dominant limiting factors of burnt area globally. Suppression is most important in cropland areas, whereas savannas and boreal forests are most sensitive to ignitions. We quantify fire regime shifts in areas with more than one, and often counteracting, trends in these controls. Forests are of particular concern, where we show average shifts in controls of 2.3–2.6% of their potential maximum per year, mainly driven by trends in fuel continuity and moisture. This study gives added importance to understanding long-term future changes in the controls on fire and the effect of fire trends on ecosystem function.


Climate-induced variations in global wildfire danger from 1979 to 2013

Climate strongly influences global wildfire activity, and recent wildfire surges may signal fire weather-induced pyrogeographic shifts. Here we use three daily global climate data sets and three fire danger indices to develop a simple annual metric of fire weather season length, and map spatio-temporal trends from 1979 to 2013. We show that fire weather seasons have lengthened across 29.6 million km² (25.3%) of the Earth’s vegetated surface, resulting in an 18.7% increase in global mean fire weather season length. We also show a doubling (108.1% increase) of global burnable area affected by long fire weather seasons (>1.0 σ above the historical mean) and an increased global frequency of long fire weather seasons across 62.4 million km² (53.4%) during the second half of the study period. If these fire weather changes are coupled with ignition sources and available fuel, they could markedly impact global ecosystems, societies, economies and climate.

RESEARCH FOCUS: WILDLAND FIRE AND CLIMATE CHANGE

Rapid growth of the US wildland-urban interface raises wildfire risk

When houses are built close to forests or other types of natural vegetation, they pose two problems related to wildfires. First, there will be more wildfires due to human ignitions. Second, wildfires that occur will pose a greater risk to lives and homes, they will be hard to fight, and letting natural fires burn becomes impossible. We examined the number of houses that have been built since 1990 in the United States in or near natural vegetation, in an area known as the wildland-urban interface (WUI), and found that a large number of houses have been built there. Approximately one in three houses and one in ten hectares are now in the WUI. These WUI growth trends will exacerbate wildfire problems in the future.


Global Pyrogeography: the current and future distribution of wildfire

Climate change is expected to alter the geographic distribution of wildfire, a complex abiotic process that responds to a variety of spatial and environmental gradients. How future climate change may alter global wildfire activity, however, is still largely unknown. As a first step to quantifying potential change in global wildfire, we present a multivariate quantification of environmental drivers for the observed, current distribution of vegetation fires using statistical models of the relationship between fire activity and resources to burn, climate conditions, human influence, and lightning flash rates at a coarse spatiotemporal resolution (100 km, over one decade). We then demonstrate how these statistical models can be used to project future changes in global fire patterns, highlighting regional hotspots of change in fire probabilities under future climate conditions as simulated by a global climate model. Based on current conditions, our results illustrate how the availability of resources to burn and climate conditions conducive to combustion jointly determine why some parts of the world are fire-prone and others are fire-free. In contrast to any expectation that global warming should necessarily result in more fire, we find that regional increases in fire probabilities may be counter-balanced by decreases at other locations, due to the interplay of temperature and precipitation variables.


Projected increase in lightning strikes in the United States due to global warming

Lightning plays an important role in atmospheric chemistry and in the initiation of wildfires, but the impact of global warming on lightning rates is poorly constrained. Here we propose that the lightning flash rate is proportional to the convective available potential energy (CAPE) times the precipitation rate. Using observations, the product of CAPE and precipitation explains 77% of the variance in the time series of total cloud-to-ground lightning flashes over the contiguous United States (CONUS). Storms convert CAPE times precipitated water mass to discharged lightning energy with an efficiency of 1%. When this proxy is applied to 11 climate models, CONUS lightning strikes are predicted to increase 12 ± 5% per degree Celsius of global warming and about 50% over this century.

RESEARCH FOCUS: WILDLAND FIRE AND CLIMATE CHANGE

Human presence diminishes the importance of climate in driving fire activity across the United States

Projections of worsening wildfire conditions under climate change are a major concern in policy and management, but there is little understanding of geographical variation in fire-climate relationships. Our analysis relating climate variables to historical fire activity across the United States showed substantial variability in the importance of different seasonal temperature and precipitation variables and of climate overall in explaining fire activity. Climate was significantly less important where humans were more prevalent, suggesting that human influence could override or even exceed the effect of climate change on fire activity. Although climate change may play a significant role in altering future fire regimes, geographical context and human influence should also be accounted for in management and policy decisions.


Adapt to more wildfire in western North American forests as climate changes

Wildfires across western North America have increased in number and size over the past three decades, and this trend will continue in response to further warming. As a consequence, the wildland–urban interface is projected to experience substantially higher risk of climate-driven fires in the coming decades. Although many plants, animals, and ecosystem services benefit from fire, it is unknown how ecosystems will respond to increased burning and warming. Policy and management have focused primarily on specified resilience approaches aimed at resistance to wildfire and restoration of areas burned by wildfire through fire suppression and fuels management. These strategies are inadequate to address a new era of western wildfires. In contrast, policies that promote adaptive resilience to wildfire, by which people and ecosystems adjust and reorganize in response to changing fire regimes to reduce future vulnerability, are needed. Key aspects of an adaptive resilience approach are (i) recognizing that fuels reduction cannot alter regional wildfire trends; (ii) targeting fuels reduction to increase adaptation by some ecosystems and residential communities to more frequent fire; (iii) actively managing more wild and prescribed fires with a range of severities; and (iv) incentivizing and planning residential development to withstand inevitable wildfire. These strategies represent a shift in policy and management from restoring ecosystems based on historical baselines to adapting to changing fire regimes and from unsustainable defense of the wildland–urban interface to developing fire-adapted communities. We propose an approach that accepts wildfire as an inevitable catalyst of change and that promotes adaptive responses by ecosystems and residential communities to more warming and wildfire.


Fourth National Climate Assessment links anthropogenic changes in climate to increased wildfires

The US Global Change Research Program, comprised of 13 Federal agencies, released the Fourth National Climate Assessment (NCA4) in November 2017 (Vol 1) and 2018 (Vol II), providing the foundation for the climate science and outlining the impacts and risks of climate change for the United States, including projected increases of large forest fires in certain regions.

“Got Science?” Podcast, Union of Concerned Scientists: “Baked Alaska: Fighting Fires on the Final Frontier”

Dr. Carly Phillips, a climate scientist and fellow at the Union of Concerned Scientists, explains how climate change is turning Alaska into a tinderbox, and what to do about it. (Published 30 July 2019)
Climate influenced changes to wildfire potential at select Air Force installations

Andrew M. Beavers

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The Center for Environmental Management of Military Lands (CEMML) recently completed an Enterprise-Wide Climate Change Analysis for Integrated Natural Resource Management Plans (INRMPs) assessing climate impacts to 68 Air Force Installations. One factor in that analysis was projections of wildfire frequency and intensity, which were combined into an estimate of overall fire activity, accounting for projected changes in temperature and precipitation, ancillary changes to relative humidity, and changes to vegetation. Changes in land use, military mission, and other factors that may affect ignition probability were beyond the scope of the study.

Though the analysis was limited in precision, and the selected installations did not represent an equitable cross section of the geography of the U.S., several takeaways were evident within the results. Of the installations assessed, wildfire activity was most likely to be exacerbated by climate change in Alaska, California, New Mexico eastward to Mississippi, and Hawaii. Alaska was particularly hard hit, with climate projections that almost universally produced a strong trend toward a more fire-prone future. Conversely, results were more mixed in the Southeast and East, with installations experiencing increased or decreased fire activity depending on the particulars of the climate projections and current fire activity levels. Parts of the desert southwest were relatively unimpacted, or were even projected to experience a decrease in fire activity, due to a future in which there is little to no vegetation to support fire spread.

Land managers will need many years to adjust land use, create defensive space, and appropriately address ignitions, but more detail will be required to know where at each installation fire activity needs mitigation. The results of this study were broad-scale first pass projections, but we believe that with a minor investment in climate downscaling capabilities and vegetation projection capabilities, it should be possible to apply currently available high-resolution wildfire risk analysis capabilities to climate changed scenarios representing future conditions. This would allow analysis of the fine scale spatial (10s of meters) and temporal (months) variability of wildfire risk to be addressed, providing much more useful information, as well as greater context and accuracy, to land managers and commanders in order to best address potential climate influenced fire risks at their installation.

Mr. Beavers is the Wildland Fire Program Manager at the Center for Environmental Management of Military Lands (CEMML), Colorado State University, Fort Collins, Colorado.
Building climate adaptation into a wildland fire management plan, U.S. Army Dugway Proving Ground

Elizabeth Kellogg and Robert Knight

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Regionally, the future is expected to bring increased wildfire frequency and magnitude related to:

- Increased frequency and magnitude of drought;
- Higher temperatures;
- Less snowpack (less precipitation stored as snow) and increased flooding;
- Replacement of shrubland by invasive annual grasslands (cheatgrass) resulting from an accelerated feedback loop of cheatgrass and fire; and
- Decreased carbon sequestration capacity due to loss of shrublands.

Below are five ways climate adaptation was considered in development of the IWFMP:

**Values at Risk**

The assessment of vulnerability from fire had both a military use and a natural resources component. In a collaborative, interdepartmental process, risks and vulnerability were ranked. The loss of landscape level carbon sequestration capacity that accompanies the loss of shrublands and perennial herbaceous vegetation is considered a vulnerability. It is well recognized by scientists that these arid ecosystems are out of balance due to replacement of perennial vegetation by annual grasses, and related large wildfires return at short-intervals.

One effect is a replacement of the natural cycle of carbon storage. The native, deep-rooted shrublands and bunchgrasses serve as a great sink for carbon, pulling it from the atmosphere and storing it in plants, roots, soil, and soil biological crusts. When a fire occurs, the aboveground carbon is released to the atmosphere, whereas the belowground carbon stays put. In contrast, cheatgrass stores very little carbon, and furthermore, it puts it back into the atmosphere with each fire with very little stored in the soil. Less frequent fire could allow restoration of the the carbon storage capacity of the ecosystem, which helps create resilience to climate change.

**Scenario Building**

To support suppression readiness and the placement of fuelbreaks, problem fire scenarios were developed in a collaborative process with the Natural Resources, Fire, Emergency Services, and Range Operations departments. These scenarios were built on a baseline fuel condition derived from a generalized vegetation map, with the additional overlay of a cheatgrass spread model that had been developed by Utah State University for DPG (Ramsey & McGinty 2012). As part of this scenario building, past fires were modeled with FARSITE to see if their behavior could be replicated. Two insights came out of this assessment: (a) It turned out that the 10-year projections for maximum cheatgrass spread had already been exceeded inside of 10 years, and (b) fire behavior was impacted in real time by fuel caches of tumbleweed which had accumulated in drainages, along fencelines and in ditches, which behave like fuses to launch and even leapfrog (by flying tumbleweed) fires into unburned areas.

**Climate adaptation planning demanded that a worse-than-current fuel condition be the baseline for scenario development.**

**Fuelbreak Performance Rating**

Carbon sequestration was added as an evaluation factor in the performance of individual fuelbreak segments to credit the ecosystem benefit provided by the deeper-rooted perennials that were established to replace annual grasses and forbs. Improved hydrologic function was also scored as a performance benefit of the herbaceous perennials, with

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the high root biomass of the perennials providing enhanced capacity to store landscape water, thus ameliorating drought. Fuelbreaks are sampled in the field each year to plan maintenance and enhancement interventions and priority for weed control, seeding, etc.

**Fire Management Decision Support Dashboard**

With variable rain, the establishment of bunchgrasses from seed is especially dependent on weather conditions in May, when soil temperatures warm and rain hopefully arrives. In addition, the amount of snow cover is key to establishment of some perennials which can be broadcast sown rather than buried by drilling; in this region certain bunchgrasses and perennial forb seed is broadcast on snow, with melting snow mitigating any effect of May drought. Plant establishment weather is expected to become more erratic with climate change, so there is a need to more carefully assess whether to purchase perishable seed, or whether to wait to sow, etc. Also related to annual variability in weather condition is the fire planning need to predict the amount and spatial extent of fine fuels expected each upcoming fire season, sometimes called “fuelcasting.” A “good cheatgrass year” is locally predicted by rains two years earlier than current year. In these arid lands fire spread is often limited by lack of fuel, but spread rates can become very hazardous in peak load years. DPG’s plan for an IWFMP Dashboard to track implementation of the plan includes two weather pages: one for fire danger prediction, and one for weather related to planting seed and forecasting fine fuel production.

**Reporting Program-Level Cost Effectiveness**

Carbon sequestration and carbon flux were added as factors in reporting the total cost and benefit of fire management, from a programmatic, long-term view of fire as it relates to a sustainable landscape for military use. As part of IWFMP implementation, two annual briefs are prepared, one for the Command, and one for the Natural Resources Manager. A template is under development for qualitatively weighing the cost-benefit of fire management actions to facilitate reporting to these decision makers. Certain costs are direct such as suppression and purchase of seed and herbicide for fuelbreak installation, while other costs are more indirect and less quantifiable such as disruption of testing or training schedule to fire activity, approaching a threshold of air quality regulatory compliance, or effects on health and safety of military personnel. Carbon sequestration and carbon flux with fire is valued as part of cost-benefit. The intent is to estimate and report directional trend using scenarios related to establishment of perennial versus annual herbaceous vegetation and shrubs and their differences in sequestration of carbon in roots, and the difference between large severe fires and fewer, smaller fires at volatilizing carbon on annual versus perennial vegetation landscape. The outcome is expected to demonstrate a cost to the status quo without implementation of the IWFMP: the potential for storing carbon will degrade over time due to loss of perennial vegetation and increased volatilization of carbon with fire emissions as fires become larger and more frequent. There is a significant economic cost coupled with the ecological cost of the invasion-fire cycle.

**Conclusion and Next Steps**

Implementing Dugway’s IWFMP can shift from a trajectory of continued loss of native shrubland communities and an increasingly flammable military landscape, to one of stewardship, a fire resilient landscape, restoration of shrublands, and climate adaptation as all of these goals converge.

Some next steps for Dugway’s IWFMP implementation with climate adaptation include improving means to quantify directional trend in carbon sequestration and carbon flux, using methods accepted by the Intergovernmental Panel on Climate Change, so carbon trends can be reported in Annual Brief to Command and Annual Technical Review for Natural Resource Manager.

**References**


Elizabeth Kellogg is the Principal at Tierra Data, Inc. and has over 25 years experience in wildland fire ecology and DoD wildland fire management plans.

Robert Knight is a Wildlife Biologist for the US Army at Dugway Proving Ground, Utah, with over 20 years of experience directing research initiatives in support of the DoD Mission.
ABOUT THE WORKING GROUP

The NMFWA Climate Change Working Group was established to share information among NMFWA members regarding the management of natural resources on US military lands and waters in the context of an ever-changing environment.

If you are interested in contributing to the Climate Change Working Group or to this newsletter, please contact us!

The current NMFWA Climate Change Working Group officers include: Co-Chairpersons Linda Brown and Christy Wolf, Past Co-Chairs Charlie Baum, Kevin Du Bois, and Janet Johnson and Recording Secretary, Vanessa Shoblock. If you have any questions or would like to learn more, or want to join the working group, please contact us at www.nmfwa.org/climate-change.

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PARTING SHOT

Photo by Patrick Carnahan, Dugway Proving Ground Fire Department