Mojave National Preserve

National Park Service
U.S. Department of the Interior

Science Newsletter

Sweeney Granite Mountains Desert Research Center: an Interview with Director Dr. Jim André

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A significant factor in the amount of high quality research conducted in Mojave National Preserve is the Sweeney Granite Mountains Desert Research Center, part of the University of California Natural Reserve System. In this issue we interview its Director, Dr. Jim André. Dr. André is a research botanist who completed the Preserve's Vascular Plant Inventory for the National Park Service Inventory and Monitoring Program.

The Sweeney Granite Mountains Desert Research Center is located in Granite Cove at the base of the Granite Mountains.

The Sweeney Granite Mountains Desert Research Center (GMDRC) is one of 37 protected research sites operated by the University of California Natural Reserve System (UC NRS). This system of outdoor classrooms and laboratories makes relatively undisturbed examples of the state's diverse ecosystems available to researchers, teachers, and students with support facilities for long-term research projects and multi-week field courses. Established in 1978, the Sweeney Granite Mountains Desert Research Center encompasses 3,496 hectares (8,639 acres) of the pristine and rugged Granite Mountains in the East Mojave Desert ranging from piñon-juniper woodlands to creosote scrub bajadas. Housing, laboratories, and a conference room at the reserve can accommodate up to 12 researchers for long-term projects and field classes of up to 35 people. In 1994 with the passage of the California Desert Protection Act, the reserve was enclosed inside the boundary of the newly created Mojave National Preserve.

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Debra – *Some of the people who were instrumental in the formation of the UC Natural Reserve System, such as Ken Norris and Wilbur Mayhew, were very active in this area of the Mojave Desert. In fact one of the student camps is called Norris Camp. How did the Sweeney Granite Mountains Desert Research Center come to be and why did they choose this site?*

Jim – Before we get started, I wish to thank Debra Hughson for inviting me to this interview and for her continuing leadership in facilitating research and science education throughout the California Deserts. And to the Mojave National Preserve for the initiation of the

This Science Newsletter:

The Mojave Desert is internationally known as a place to conduct scientific research on desert ecosystems. In fact Mojave National Preserve was designated in part to "retain and enhance opportunities for scientific research in undisturbed ecosystems" as stated in the California Desert Protection Act of 1994. Significant research is conducted through the Sweeney Granite Mountains Desert Research Center, part of the University of California Natural Reserve System, and the Desert Studies Center, operated by the California Desert Studies Consortium of California State Universities. Both are located in the Preserve.

The purpose of this newsletter is threefold. First, we would like to highlight some of the research being done by university scientists in the Preserve and to distribute this information to park staff and management. Second, this periodical will allow us to inform the public and research community about science being done by Preserve staff or funded through the National Park Service. And most importantly, we would like to build collaboration between scientists and resource managers so that scientists are made aware of the needs of managers and top quality science is brought to bear on the problems facing resource managers.

Our intention is to publish this newsletter twice per year, once in the spring and again in the fall; distributed in print at our Visitor Centers and electronically on the web. Articles will range from non-technical news stories to highly technical research reports. All material in this newsletter has been peer-reviewed by subject-matter experts. In each issue we will discuss a resource management issue or research need along with possible means of obtaining funding. The resource management concern highlighted in this issue is managing the effects of climate change.

Debra Hughson, Science Advisor

Science Newsletter, an effort that is strongly supported by the staff at the GMDRC, as well as many of our colleagues at the University of California. The Granite Mountains played a significant historical role in the development of the UC Natural Reserve System (NRS). Use of the Granite Mountains in the 1960s by UC professors Dr. Ken Norris (UCLA/UCSC) and Dr. Wilbur Mayhew (UCR) as a favorite destination for their natural history field courses helped spur the idea for the creation of the entire UC Natural Reserve System in 1965, which now includes 37 reserves located throughout California. Joined by Ken's brother, Dr. Bob Norris (UCSB), and Dr. Mildred Mathias (UCLA), it was the enthusiasm of this prominent group of four professors that led to the University of California's purchase of several sections of railroad lands and parcels of private lands in the eastern Granite Mountains. After several years of dogged persistence and diplomacy with land owners and a very supportive Bureau of Land Management, their efforts culminated in the establishment of the Granite Mountains Desert Research Center in 1978.

Debra – *The UC Natural Reserve System is available for use by institutions outside of the University of California. What proportion of researchers and students come from out of the state and what do you think brings them here to Granite Mountains and the Mojave Desert?*

Jim – Perhaps more than any NRS reserve, the GMDRC sustains a very diverse array of research from scientists who come from all parts of the world. Of the more than 350 research projects that have been conducted at the GMDRC in the past 30 years, about 40% were by UC scientists, while roughly one-third were by scientists from outside of California. Presently, we support more than 155 active research projects, including studies in microbiotic soil crust development, taxonomy and evolution of insects and plants, population ecology of large mammals such as the desert bighorn sheep, and studies of landscape-level processes, such as erosion dynamics of alluvial surfaces. A number of projects at the GMDRC focus on long-term processes, such as global climate change, soil disturbance recovery monitoring, or the survivorship of long-lived shrub species. By design, such studies may span decades, if not centuries.

As a hub of research activity in the Mojave Desert, the question of why researchers seek the GMDRC and the eastern Mojave Desert in general is one that has drawn our interest, and probably requires a more lengthy discussion than we have room for here. But every reserve is unique in its capabilities and what it emphasizes in its mission. What the GMDRC offers to visiting researchers and classes, as much perhaps as any field station in the western U.S., is access to a tremendous natural area—pristine, wild, and expansive. The 9,000-acre GMDRC is located within a region of unparalleled biological and geological diversity in California. And while the facilities and staff here are vital to its operation, it really is the quality of this natural area that represents the single greatest asset of the field station. Embedded within millions of acres of federal wilderness, including the Mojave National Preserve, ecological processes are still functioning here. The GMDRC provides not only a quality setting to researchers, but a site that will be protected over the long term. For visiting students, the Granite Mountains and surrounding region represents not only an outdoor classroom, but an adventure into a frontier. Here visiting students can make observations that contribute significantly to our knowledge base, inspiring discovery and appreciation for the complexity of our natural world.

Debra – *Research projects tend to build on each other. The reserve makes this* *possible and also enables projects to be designed to go on for decades. How can researchers new to the area tap into this body of work? Is it primarily through the published literature, or are there mechanisms for sharing data internally within the reserve system?*

Jim – Over the past 30 years the GMDRC has supported more than 350 academic research projects that have generated over 450 publications. But one of the great surprises for me in my tenure as resident director for the past 15 years has been the near exponential growth of our research program. It took 20 years to reach 50 active research projects. Today, just 10 years later, the number of active research projects has tripled.

Many factors have contributed to this rapid growth in research, including the addition of lodging and laboratory space, collaboration with agencies, staff expertise, organization of workshops and symposiums, and the protected lands – some of the only lands protected for research in the 25 million-acre Mojave Desert. But the single most important factor that stands out more than any other is the phenomena of building a body of research. Like stepping stones, over time one research project builds on the previous one. For example, a site becomes especially interesting to a plant physiologist after a soil scientist has mapped the age of the surfaces there. Some research is only made possible by the data collected by a prior investigation. This nurturing process takes time to evolve, but after 30 years we are beginning to cultivate and sustain an active research program at GMDRC because we have developed a body of research. Plant a seed and it will grow.

As a member of the NRS and national Organization of Biological Field Stations (OBFS), the GMDRC has several mechanisms for storing data collected by researchers and making it available to future investigators. The NRS maintains a website (http://nrs.ucop.edu) that includes a Research Database, where research applications, metadata, and bibliographies are accessible to the public. In addition, OBFS (http://www.obfs.org) offers a Data Registry, where a variety of datasets and protocols are made available. Finally, we do house a small collection of dissertations, reports, and datasets from projects completed here at the GMDRC; you can also see a list of current research and publications on our website (http://granites.ucnrs.org/).

As is the case at all reserves in the NRS, it has in fact been a great challenge to obtain raw data from researchers who are wary to part with it prior to completion of their analyses and publications. And because data management can be time-consuming, the GMDRC may select certain datasets over those with low probability of being used again. Thus, most of the projects that build from previous projects do so through the personal correspondence and cooperation among individual researchers. The GMDRC has been successful as a conduit for linking researchers with similar academic interests, and that has likely been our greatest active influence on this stepping-stone process.

Debra *– Your own research interests include the flora of the Mojave Desert. In your floristic inventory for the National Park Service Inventory and Monitoring Program you added 85 new taxa to the known 831 species of vascular plants in the Preserve, including several that are new to science, and 885 occurrences of special-status plants. What makes this region so floristically diverse?*

Jim – There is a broad misconception by the public and even by some scientists that the California deserts lack botanical diversity, and perhaps an even bigger misconception is that the desert has already been well documented, that there are few remaining taxonomic discoveries left for science. Nothing could be farther from the truth. The California deserts collectively make up 28% of California's landmass, yet contain 37% of its native plant taxa. Some of the mid-elevation zones of the eastern Mojave support 60 to 70 species of shrubs per hectare—some of the highest shrub diversity found in North America! New species are being discovered every year. I estimate that 6 to 9% of the California deserts flora is presently undescribed. So next time you're out and about looking down at those desert plants, do not assume they all have names!

I was immediately drawn to the Mojave National Preserve by its geographical position and high-elevation linkages. The Preserve lies at the hub of the Mojave, Great Basin and Sonoran Deserts with lowland and mountain corridors interdigitating in all directions. And while these corridors promote a dynamic long-distance flux of genotypes into the region, the complex local topography, soils, and geomorphic diversity found in the Preserve create niches where species may persist on the margin of their range, or act as isolating mechanisms where speciation may be facilitated. Additionally, in contrast to the west Mojave, the eastern Mojave Desert flora is significantly influenced by summer monsoonal precipitation. There exists a whole suite of plant species (mostly summer annuals) in the Preserve's flora that occur nowhere else in California. These are species that rapidly germinate, flower, and set seed in a matter of weeks following summer rain events.

My work on a Flora of the Mojave National Preserve and surrounding areas has been ongoing since 1994 when I first arrived at the GMDRC. I wish to again thank NPS and the Inventory and Monitoring Program for the financial support of this project several years ago. The three-year grant helped fund a major push in the botanical inventory of the

Preserve by bringing in additional field assistance for the surveys. Though we continue to add new vascular plant taxa (*1*) to the overall park list (total number of known taxa in the Preserve stands today at 928), the rate of new finds has slowed down considerably. Still, additional spring surveys in remote areas and during fall following summer rains will likely add an additional 15-20 taxa to the overall list.

The floristic effort at the Preserve underscores two significant truths: 1) the Mojave National Preserve is indeed floristically diverse with a high concentration of rare and endemic species, and 2) the Preserve lies within a region of California where taxonomic inventory is far from complete. With the near completion of the flora, the Preserve now represents one of the few areas in the California Deserts that has been well-documented. The only other recent and comprehensive floristic inventories are at the Whipple Mountains (*2*) and at Joshua Tree National Park, led by GMDRC scientist Dr. Tasha La Doux. One does not need to go to New Guinea or the Brazilian rainforest to make important botanical discoveries, as 90% of the California Deserts remain a floristic frontier ripe for taxonomic discovery.

Debra *– Threats to rare plant assemblages in Mojave National Preserve include local factors such as cattle grazing and fire and larger global issues such as climate change. How do you think the National Park Service could best protect these populations? Are there specific management actions that could be developed into project funding requests?*

Jim – Inventory of the botanical resources is obviously critical to this management mission, as we can only protect what we know exists. While the inventory of the Preserve has focused initially on developing a park species list, we are now working to map many hundreds of rare plant populations as well as unique plant assemblages throughout the park. It will be important to assess the needs of each of the approximately 120 special-status plant species that occur in the park, starting with the rarest and most imperiled taxa and developing detailed management guidelines for each. Often threats are obvious, such as those caused by the direct impacts of vehicles or livestock trampling. Yet other threats are more cryptic, requiring fairly sophisticated biological research (population genetics, demography, reproductive biology) or modeling/long term monitoring (climate change, soil nutrient, hydrological alteration) before remedial actions or protection measures are taken. It is human nature to feel compelled to take action to heal the wounds of an impact, but actions must be tempered with the very risks they pose and be based upon the best science. For example, removal of invasive alien plants using either mechanical or herbicide applications may or may not adversely impact rare plant populations, but should be carefully assessed prior to implementation.

Considerations for the long-term viability of native plants in the Preserve extend well beyond its borders. With the increasing fragmentation of the eastern Mojave Desert by energy and other development, the long-term viability of many populations within the park cannot be sustained without the preservation of external corridors and trans-boundary processes such as dispersal of pollen by pollinators and the movement, or colonization, of plants through seed dispersal. As large as the Preserve is, it will require collaboration with neighboring agencies to develop regional conservation strategies.

Debra *– Controlling invasive non-native weeds, such as Sahara mustard, is a high natural resource management priority for the Preserve. Although we are fortunate compared with much of the rest of the Mojave Desert, at times this seems like a Sisyphean task. If you were to lead an effort to prevent biological invasions into Mojave National Preserve, how would you go about it?*

Jim – This is a very difficult question, and one that often leads to a lively discussion in some circles of conservation biology. And being tasked with the job of preventing biological invasions into Mojave National Preserve is like trying to prevent drinking at Burning Man, one is doomed to fail. The management of invasive plants usually comes down to a triage decision that balances the likelihood for success with available resources (budget, labor force, available expertise). In the case of Sahara mustard, we have a superstar weed that disperses at extraordinary rates, can colonize undisturbed desert, and has already structurally altered millions of acres of lowland sandy habitats. Many millions of dollars are being spent on both herbicide and mechanical removal in an attempt to stem the tide. Optimists believe there is still an opportunity to control this species from spreading further into the California Deserts. The unfortunate reality, however, is that it has already entrenched itself throughout much of the Mojave, and control of its spread is probably only worthwhile, or possible, in localized cases to protect unique or rare habitats and populations. We actually know very little about the life history and ecology of Sahara mustard (e.g., tolerance to drought, seed bank and dispersal ecology, impacts on soil nutrients, etc...). Given that there is little we can do to control the spread of the species on the landscape level, I would recommend that a higher proportion of the management funds be directed towards research into the biology of Sahara mustard, as we have a lot to gain by improving our understanding of its impacts to our natural systems. And perhaps we might identify weak links or stages in its life history that might be helpful to our management.

As you know, there are many other invasive species that pose existing or future threats to the Mojave National Preserve. Some of these, such as *Erodium cicutarium* (storksbill), have been here for decades and have naturalized into the native vegetation. Unless a very sophisticated control mechanism is developed, such naturalized invasives are here to stay. The point here is that as difficult as it is to prevent invasions, it is far less an option to eradicate aliens once they have become established. Thus, it is vital to develop a coordinated multi-agency monitoring program that detects invasions early on when eradication is still a feasible option.

Finishing this discussion on a more positive note; although invasive alien plants pose perhaps the greatest threat to native ecosystems throughout California, the eastern Mojave Desert remains the least impacted region of the state. While invasive aliens comprise 15 to 35% of the species in any given subregion throughout cismontane California, they make up only 7 to 9% of the California Desert flora.

Debra *– The Hackberry Complex Fire in 2005 was quite possibly the most dramatic natural disaster in this area in some decades. But in your rare plant report on that fire you identified a number of other threats to rare plant populations besides fire. Would you care to elaborate on these and perhaps prioritize them in terms of the most immediately needed management actions?*

Jim – I agree that the Hackberry Fire event was dramatic and natural, but the term disaster does not necessarily apply in describing its impacts upon rare plant populations. Most plant ecologists agree that fire regimes are in flux, but the role of fire and its effect upon native vegetation and rare species in the eastern Mojave Desert is complex and remains poorly understood. We know that several dozen rare plant species were impacted by the Hackberry Fire, and that each species endured and responded to the event differently, depending upon their individual life-history characteristics. Because we lacked sufficient pre-fire information (distribution, population sizes, etc…) for the majority of the rare species, our assessment of impacts was limited to a post-fire snapshot.

We observed that with the sudden release of nutrients into the soil and the sunlight gaps that were opened among previously dense shrub and tree canopies, many of the rare herbaceous perennials and/or annuals showed a very positive initial response (e.g., Cima milkvetch). Rare plants that were most adversely affected by fire were those lacking the ability to survive the burn (e.g., woody such as Thorne's buckwheat), poor re-sprouters, or not likely to regenerate quickly from the seed bank. In the Hackberry Fire report I provided a general discussion of other potential threats that pertain to these particular species (*3*). Examples of these threats included grazing/trampling, road maintenance, and invasion of alien species that may or may not be related to post-fire management or processes.

Rather than focus on the Hackberry Fire, however, I believe your question relates to the Preserve's entire rare plant management program and the development of management priorities for rare plant protection in general. Many of the 120 or so rare plant species in the Preserve are being threatened by a variety of factors. In most cases, threats are associated with human actions of some sort, which implies we can often take action to remove or adapt these actions to reduce the threat. However, for many threats it is difficult to understand how they ultimately affect the viability of specific plant populations or metapopulations, to untangle their interaction with other threats, and to come up with effective methods to alleviate them. For example, habitat fragmentation caused by developments along I-15 between the Clark Range and the Ivanpah Range impacts numerous rare plant populations, but how? If we assume that larger populations that are broken into smaller ones leading to restricted exchange of pollen or seed, then this has important genetic and demographic consequences. But fragmentation also creates edge effects and deterioration of habitat quality. It may alter plant-pathogen and plant-herbivore dynamics. Due to lack of time, funding or available expertise, the full range of demographic- versus genetic-stochasticity parameters are rarely integrated into a population viability analysis. Until such detailed analyses become available, managers must work with scientists to maintain natural ecological processes and provide the best natural conditions for populations and metapopulations to persist, while delineating the most likely threats for each species and minimizing or eliminating them where possible.

In general, threats come in three types: *1)* threats imposed by changes in the environment, either by natural or human causes, *2)* threats resulting from disturbance of important interactions with other species, and *3)* genetic threats. Although the Preserve and its surrounding lands are considered well-protected, environmental threats are, in fact, considerable. These include climate change (e.g., altered precipitation and fire regimes), habitat fragmentation (e.g., roads), direct disturbance (e.g., livestock trampling, hydrological alterations, deposition of atmospheric nitrogen) and exploitation (e.g., cactus collecting). Disturbance of biotic interactions might include destruction of key pollinator guilds, altered pathogen and herbivore interactions, and hybridization with introduced natives (e.g., CalTrans revegetation programs).

Despite the complexity and multitudes of

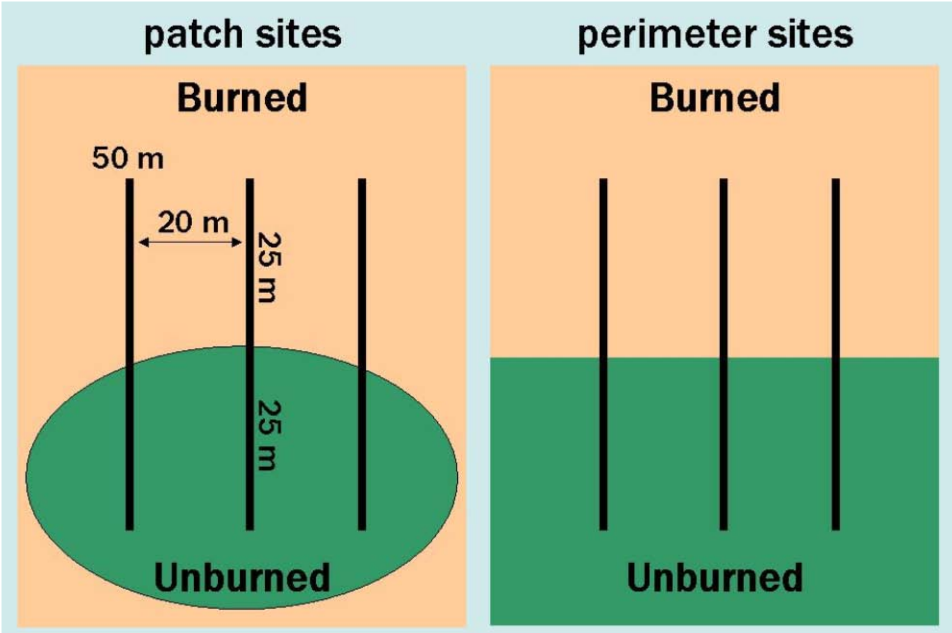
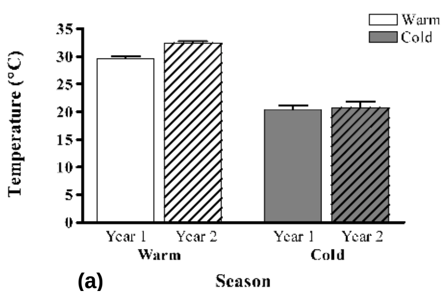


Figure 2. Transect design. Each site had three 50 m transects separated by 20 m. Half (25 m) of each transect was located in burned habitat and 25 m in unburned habitat.

using paired t-tests. Vegetation data were analyzed using χ^2, with the mean and standard deviation of each plant height class calculated to compare heights in burned and unburned areas. The reptile species observation rate during transect surveys was calculated. ANOSIM (analysis of similarity) of species diversity between years and in burned and vegetated habitats and SIMPER (similarity percentages) analyses were conducted. *U. stansburiana* data were analyzed using χ^2 and Fisher's Exact test.



Average air temperature in the warm season of 2007 was significantly higher than 2006 ($t = 5.420$, $df = 195$, $p < 0.0001$, $\bar{x}$ 2006 = 29.6 ± 5.1, $\bar{x}$ 2007 = 32.4 ± 4.5). The mean temperature of the cold season was not significantly different ($t = 0.3196$, $df = 55$, $p = 0.7505$, $\bar{x}$ = 20.6 ± 7.2) when comparing 2006 and 2007 (Figure 3a). Ground surface temperature data for 2006 and 2007 were divided by habitat type, season, and year. Burned habitats in the warm season had significantly higher ground surface temperatures ($t = 11.61$, $df = 415$, $p < 0.0001$, $\bar{x}$ unburned = 31.5 ± 5.9, $\bar{x}$ burned = 32.5 ± 6.0) than unburned habitat (Figure 3b). In the warm season subterranean temperatures in the burned areas were significantly higher ($t = 50.08$, $df = 417$, $p < 0.0001$, $\bar{x}$ unburned = 30.9 ± 6.9, $\bar{x}$ burned = 32.6 ± 6.9) than in the unburned area (Figure 3c).

The total number of plants in the unburned areas (1,440; 68.58% total cover) was higher than in burned areas (846; 40.28% total cover). There were differences in the distribution of vegetation heights in each habitat (χ^2 = 389.9, $df = 1$, $p < 0.0001$). In the burned areas plants under 10 cm in height significantly outnumbered plants in all other height classes (Table 1). In addition, the number of plants in the under-10 cm height class increased from the 2006 to 2007 growing season (264 to 345 total plants). For all heights, except <10 cm, unburned habitats had more plants per site than burned. All plants seen were not recorded to species. Of the plants identified in the unburned areas 2% were *Erodium cicutarium* and 21% were grasses of several species. In burned areas this trend was reversed with *E. cicutarium* accounting for 31% and grasses making up only 7%.

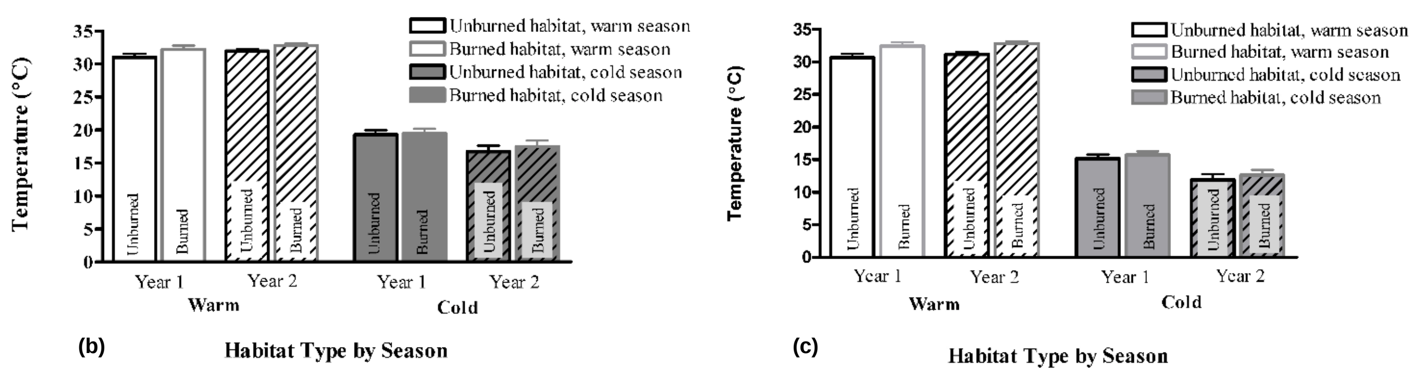


Figure 3. Ambient, ground, and subterranean temperatures ($\bar{x}$ ± SD). (a) Average ambient temperatures by year in the warm and cold seasons. (b) Average ground temperatures for unburned and burned habitats by year in each season. (c) Average subterranean temperatures for both habitats by year in each season.

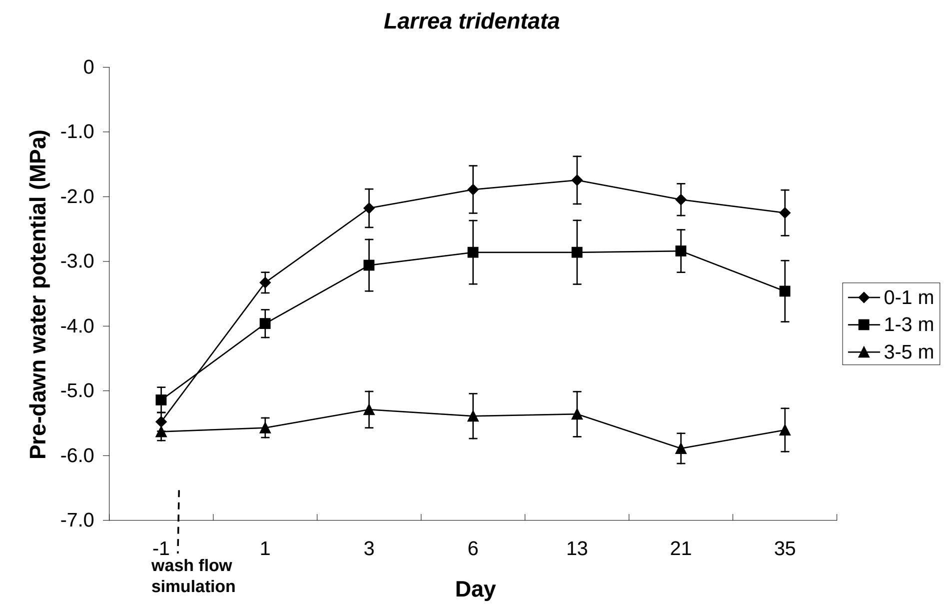


Figure 1. Pre-dawn water potential values after a simulated water pulse for *Larrea tridentata* plants at different distances from the pulsed wash. Each point is the mean +SE. n=9, 5, and 10 at distances 0-1, 1-3, and 3-5 m, respectively. Values were not significantly different on day -1 (ANOVA, f =2.09, p = 0.14). Following the simulated rain pulse plants were significantly different from each other based on distance from wash (ANOVAR; f = 42.35; p < 0.0001). The interaction of day*distance was also statistically significant (ANOVAR; f = 3.33; p = 0.0083).

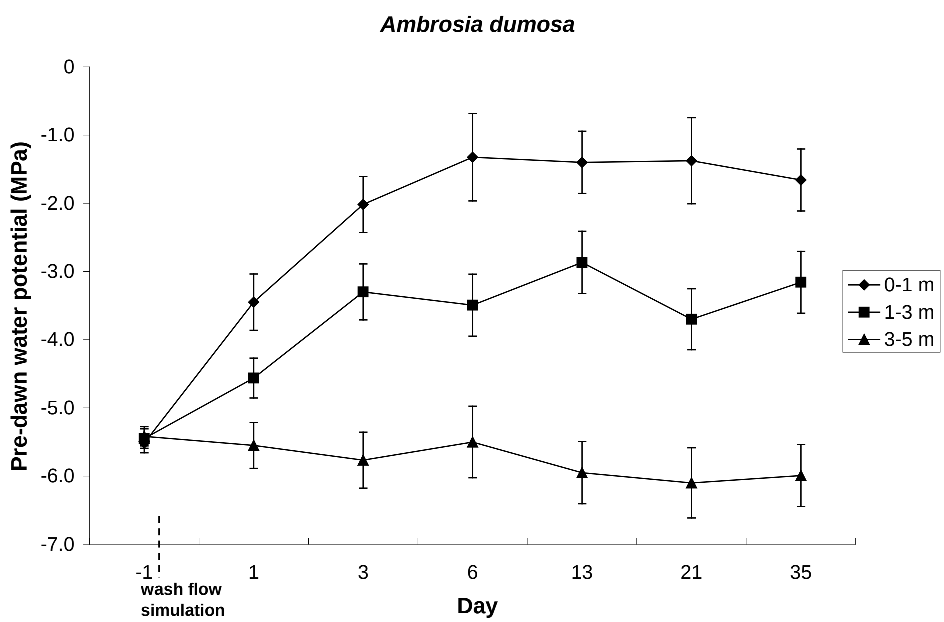


Figure 2. Pre-dawn water potential values after a simulated water pulse for *Ambrosia dumosa* plants at different distances from the pulsed wash. Each point is the mean +SE. n=10, 14, and 12 at distances 0-1, 1-3, and 3-5 m, respectively. Values were not significantly different on day -1 (ANOVA, f =0.12, p = 0.88). Following the simulated rain pulse, plants in each distance category were significantly different from each other on days 1, 6, and 21 (ANOVAR; f = 14.01; p = 0.0004) and on days 3, 13, and 35 (ANOVAR; f = 25.95; p < 0.0001). The interaction of day*distance was statistically significant on days 1, 6, and 21 (ANOVAR; f = 3.92; p = 0.0083) but was not significant on days 3, 13, and 35 (ANOVAR; f = 1.52; p > 0.05).

(p = 0.003) (Figure 3). In contrast, on day 35, values for bordering and intermediate *Ambrosia* plants were still 4x and 3x greater, respectively, than g_s values on day -1. They were also significantly greater than those farthest from the wash (p < 0.0001).

Discussion

Following the simulated wash flow event, plants bordering and at intermediate distances from the pulsed wash became significantly less water-stressed and more physiologically active. By day 6 there was a large amount of new growth on both species, and greenness of plants adjacent to wash was noticeably greater than for those farther from the wash. *Ambrosia* had new leaves in large numbers on plants near the wash. *Larrea* had broader, greener leaves, and by day 13 some plants even had flower buds (*21*). These results show that a summer precipitation event causing wash flow for ~2 hr duration results in responses for perennial plants within ~3 m of the wash and that these plants take up water through root biomass that is close to, or beneath, the wash.

Stomatal conductance response of *Ambrosia* initially lagged behind that of *Larrea*, but eventually exceeded *Larrea*, on days 13, 21 and 35. This could be attributed to the differences in leaf phonologies whereby the response of *Ambrosia*, like other drought-deciduous shrubs, is constrained early-on by the lack of leaf area. After new leaves are produced, however, these species typically exhibit greater activity leading to higher growth rates and more rapid water use than evergreen shrubs, such as *Larrea* (*22*). These results indicate some degree of resource-use partitioning, in that these two species make use of wash water by different mechanisms, at least temporally.

Little is known about how increased summer rains will affect the balance between *Larrea* and *Ambrosia* in the

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Acknowledgments

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Larrea tridentata **leaves have unfolded, and some new growth has appeared on Day 6 following the simulated rain pulse.**