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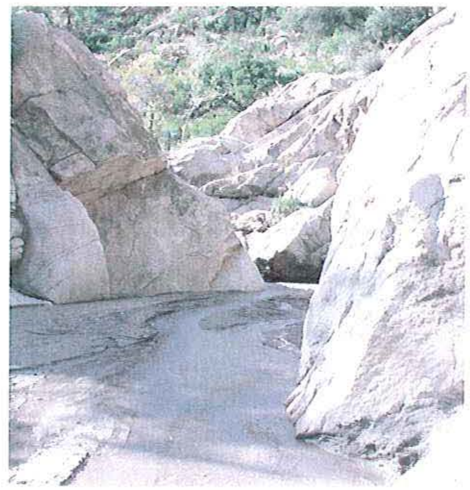
Effects of Wildland Fire on Lowland Leopard Frogs and their Habitat at Saguaro National Park



Final Report to:

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and
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Photos: Pool in Romero Canyon before the Aspen Fire, May 9, 2003 (left). The same view after the fire, November 29, 2003 (right). Photos by K. E. Bonine (left) and D. E. Swann (right)

Executive Summary

The lowland leopard frog (*Rana yavapaiensis*) is declining over much of its range in southeastern Arizona, including Saguaro National Park and the nearby Santa Catalina District of the Coronado National Forest. One factor implicated in the decline of frog populations is increased stream sedimentation following large, severe wildland fires. We investigated the impact of wildland fire on frogs and their aquatic habitat in watersheds burned by two major fires in 2003 and in unburned control areas. We surveyed frogs and habitat in both burned and unburned canyons prior to fires and twice after fires. Fires affected frog habitat dramatically and in different ways. Frog abundance and breeding success decreased in watersheds where large areas burned, yet frogs persisted in most canyons, at least over the short-term. Fire and sedimentation are natural processes that may impact leopard frogs more now than historically due to changes in fire regimes. Consequently, we recommend greater integration of studies of fire effects with long-term monitoring of watershed processes and aquatic species.

Introduction

Members of the large family of true frogs (Ranidae) have declined in recent decades throughout the western United States. Declines are probably due to a combination of factors such as loss or alteration of riverine habitat, introduced aquatic predators including fish and American Bullfrogs (*Rana catesbeiana*), and the fungal disease chytridiomycosis (Lannoo 2005). Lowland leopard frogs (*R. yavapaiensis*) are found from west-central to southeastern Arizona in association with perennial water in rivers, streams, springs and stock tanks (Platz and Frost 1984). Historically, leopard frogs occurred in the Santa Cruz River and its' major tributaries as well as in mountain canyons. They were extirpated from much of the valley-bottom waters and now are primarily found in perennial canyon pools. Lowland leopard frogs are one of three indicators of ecosystem health of Saguaro National Park, are a Priority Vulnerable Species in the Sonoran Desert Protection Plan, and are classified as a Species of Special Concern by the Arizona Game and Fish Department.

Understanding habitat requirements for amphibians is essential to developing relevant conservation and management strategies (Semlitsch 2002). To understand current habitat conditions, it is necessary to consider human impacts on the landscape, including prescribed and wildland fires, the size and severity of which has likely increased from years of fire suppression. Effects of fire on stream-breeding amphibians and their habitat remain essentially unstudied in the Southwestern U.S (Pilliod et al. 2003). A study in southern California found that increased sedimentation of the stream channel following a wildland fire reduced breeding sites for a native salamander (Gamradt and Kats 1997).

Several watersheds in Saguaro National Park have burned in the last 20 years and we have observed the loss of known leopard frog habitat due to in-filling of canyon pools by large amounts of coarse sediment. In at least one case, sedimentation contributed to the extirpation of an established population of leopard frogs in Saguaro National Park (D. Swann, unpublished data).

In 2002-2003 we surveyed leopard frogs and their habitat in canyons in Saguaro National Park (SNP) and the nearby Santa Catalina District of Coronado National Forest (CNF) that subsequently burned in the large Helens II and Aspen Fires of June 2003. We also surveyed for frogs in watersheds in SNP that did not burn in 2003. The 2003 fires thus presented an opportunity to examine the effects of wildland fire on lowland leopard frogs and their habitat by assessing frog populations and pool habitat both before and after fire. Our goals were to document changes in frog populations and habitat after fire, provide a baseline for evaluating long-term effects of past and future fires, and develop information useful for fire management at SNP and on other public lands.

Methods

We surveyed 10 canyons during the pre-monsoon period (May-July) in 2002-3, 2004, and 2006 for presence of lowland leopard frogs (tadpoles, juveniles and adults). We chose canyons based on known occupancy of frogs and recent fire history. Canyons included four that burned >25% in area from the Helens II and Aspen fires and six canyons that were unburned or burned <5% (hereafter referred to as burned and unburned canyons, respectively). We did not quantify burn severity, but both the Helens II and Aspen fires had areas of high burn severity and areas of medium and low burn severity or areas that were unburned.

We estimated relative abundance of frogs with visual encounter surveys during daylight hours (Crump and Scott 1994, Howland et al. 1997). We approached aquatic environments silently, searching along the water's edge, and recorded search effort. We used dipnets and flashlights to probe and search vegetation and undercut banks for hidden frogs and tadpoles. We determined breeding status of canyon populations based on the presence of tadpoles or recently metamorphosed frogs. Due to the relatively low counts of frogs per canyon, we grouped observations into burned and unburned canyons to assess general patterns in relative abundance between the two burn categories.

For all pools surveyed, we recorded UTM coordinates, established photographic points, and estimated pool surface area, depth, and maximum depth (high water mark). We determined degree of pool sedimentation following fires by setting the pre-fire (2002-3) condition of pools (i.e. pool volume at maximum capacity) as the baseline from which we made post-fire determinations. We then used pool measurements and photographs from 2004 and 2006 to compare with the baseline information to rank pools using one of three categories; < 25% of pool filled with sediment, 25-75% of pool filled with sediment, and > 75% of pool filled with sediment. Additionally, we used Geographic Information Systems (GIS) to characterize each canyon based on fire history and other landscape-scale variables including total watershed area, total watershed area burned, and percent watershed burned (Lowe and Bolger 2002).

Results

The Helen's II fire burned 29% and 43% of the Tanque Verde and Joaquin watersheds, respectively. The Aspen fire burned 31% and 80% of the Montrose and Romero watersheds, respectively (Table 1). Pools in burned canyons varied considerably in sedimentation where as there was essentially no change in volume of pools in unburned canyons (Figure 1). We noted dramatic sedimentation of pools within one year of the fires in two canyons (Romero and Tanque Verde) and moderate sedimentation in the remaining two canyons (Montrose and Joaquin). By 2006, >50% of pools in all burned canyons filled with sediment (Figure 1).

We observed frogs in all canyons during the pre-fire period (2002-3). In unburned canyons, counts of frogs differed little before and after fires whereas in burned canyons there was an approximately 75% decrease in counts of frogs (Figure 2). Surveys during 2006 showed a decline in frog counts in both unburned and burned canyons with only one frog observed in one (Romero) of the four burned canyons. Overall, counts in both groups declined during the study period (Figure 2). Breeding activity was noted in 9 of 10 canyons prior to fires. By 2006, breeding was noted in three of six unburned canyons and in no burned canyons (Table 2).

Discussion

Persistence of lowland leopard frogs in mountain canyons of southeastern Arizona is a function of many physical factors including drought and the degree of sedimentation of aquatic environments after wildland fires. For example, the degree to which fires affect aquatic habitat in a given watershed is likely some combination of many processes including hydrology, geomorphology, soil structure and vegetation, total watershed area, percent of watershed burned, burn severity, and timing and intensity of rainfall events (Wondzell and King 2003).

The duration of this study was too short to determine the interactions of these myriad factors and their potential effects on leopard frog populations in mountain canyons following fires. Additionally, populations of leopard frogs vary greatly from year to year and they are inherently elusive, especially when population numbers are low, thus determining population trends is a long-term endeavor. It is also important to emphasize that our study was during a region-wide drought and this likely contributed to the decline in frog counts at all sites over time.

In the short term, the Helen II and Aspen fires did not likely extirpate leopard frogs in our study canyons despite zero counts in three of the four burned canyons in 2006. Romero Canyon, one of the largest watersheds in our study area, was affected severely by the Aspen Fire. Eighty percent of the Romero watershed burned (B. Lefevre, Coronado National Forest, pers. comm.) and subsequent thunderstorms transported high loads of sediment that greatly reduced aquatic habitat and cover of terrestrial plants. Yet, after 3 years of zero counts in the canyon, we recorded frogs in 2006 and observed some large pools re-scouring in the canyon below our study site. Sedimentation from fires did potentially affect breeding success in the burned canyons, at least in the short term, as many of the large pools used for egg-laying in the past were completely filled by 2006.

Sedimentation from fires obviously reduced the amount of pool habitat in all burned canyons, but the effect was variable in time and space (Figures 3-4). Pools in Tanque Verde filled in the first year following the fire. By 2006, however, pools in the upper portion of the study site had re-scoured to near pre-fire conditions. This observation does not preclude the possibility that heavy sediment loads still exist above these pools in the Tanque Verde watershed and that subsequent flow events will re-fill these pools with sediment. The geomorphology and location of a pool in the canyon (e.g., near the mouth or headwaters) influence susceptibility to sedimentation and rate of re-scour. Smaller bedrock-bound pools (tinajas) in steep areas with a high flow velocity scour more quickly than larger pools in areas with lesser slope. The latter plunge pools are often where frogs congregate and breed, hence they are important habitat elements for leopard frogs. Indeed, the greatest indirect effects of severe fires on leopard frogs, a mesic-adapted species, may be the reduction of available surface water during stressful, dry periods.

Fire and sedimentation of aquatic systems are natural processes and lowland leopard frogs possess adaptations that allow them to persist in these environments. Of primary concern is that wildland fires in the southwestern United States have increased in size and severity due to changes in natural fire regimes resulting from years of fire suppression (Dwire and Kaufman 2003). The result of these larger, more intense fires and the subsequent aggradation of stream channels with coarse sediments could change the hydrology and geomorphology of aquatic systems so that they are no longer inhabitable by aquatic species.

The large wildland fires of 2003, including the Helen's II Fire in SNP, were a strong reminder that both the direct and indirect effects of fire can reshape the landscape on a large scale. Land managers have long been aware of the effects of catastrophic fire and have strived to reduce fuels that have built up as a result of decades of fire suppression. SNP, in particular, has used prescribed fire in the Rincon Mountains for many years and some watersheds in the range (e.g. Chiminea) probably have low potential for severe fires. Based on our observations, it seems likely that prescribed fire could benefit aquatic systems in that it reduces the size and severity of potential wildfires and thus the input of sediment loads into canyon bottoms.

Our study provides an important first step in understanding how the indirect effects of fire may affect the current distribution and abundance of leopard frogs in the Rincon and Santa Catalina mountains. Two of the most imperiled taxa in Arizona, fish and amphibians, often are found only in relatively undisturbed, isolated, low-order streams and are thus particularly susceptible to disturbances (e.g., wildland fire). As such, these rare environments are essential for conservation and management of these species and need to be considered when land-management agencies are developing fire- and land-management plans.

We recommend that reliable monitoring techniques be developed that include aquatic fauna and the availability of water and sediment inputs to these systems over the long-term. There are currently few integrated watershed studies in the desert Southwest, and little information on how fires impact aquatic animals. SNP has recently initiated hydrological and sediment monitoring in many canyons, which will provide a more reliable baseline for quantifying changes over time. Integrating this type of monitoring with other fire-monitoring activities should benefit our understanding of fire ecology and aquatic ecosystem management in the Park and throughout the desert Southwest.

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Literature Cited

Crump, M.L. and N.J. Scott, Jr. 1994. Visual encounter surveys. Pages 84-92 in W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster (eds.), Measuring and monitoring biological diversity: Standard methods for amphibians. Smithsonian Institution Press, Washington D.C.

Dwire, K.A. and J.B. Kaufman. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management 178: 61-74.

Gamradt, S.C., and L.B. Kats. 1997. Impact of chaparral wildfire-induced sedimentation on oviposition of stream-breeding California newts (*Taricha torosa*). Oecologia 110: 546-549.

Howland, J.M., M.J. Sredl, and J. E.Wallace. 1997. Validation of Visual Encounter Surveys. Pages 22-35 in M.J. Sredl, ed. Ranid Frog Conservation and Management, Tech. Report 121, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix, AZ

Lannoo, M.J. (ed.) 2005. Amphibian declines: the conservation status of United States species. Berkeley, University of California Press.

Lowe, W.H. and D.T. Bolger. 2002. Local and landscape-scale predictors of salamander abundance in New Hampshire headwater streams. Conservation Biology16: 183-193.

Platz, J.E. and J.S. Frost. 1984. *Rana yavapaiensis*, a new species of leopard frog (*Rana pipiens* complex). Copeia 1979: 383-390.

Pilliod, D.S., R.B. Bruce, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and amphibians in North America. Forest Ecology and Management 178: 163-181.

Semlitsch, R.D. 2002. Critical elements for biologically based recovery plans of aquatic-breeding amphibians. Conservation Biology 16: 619-629.

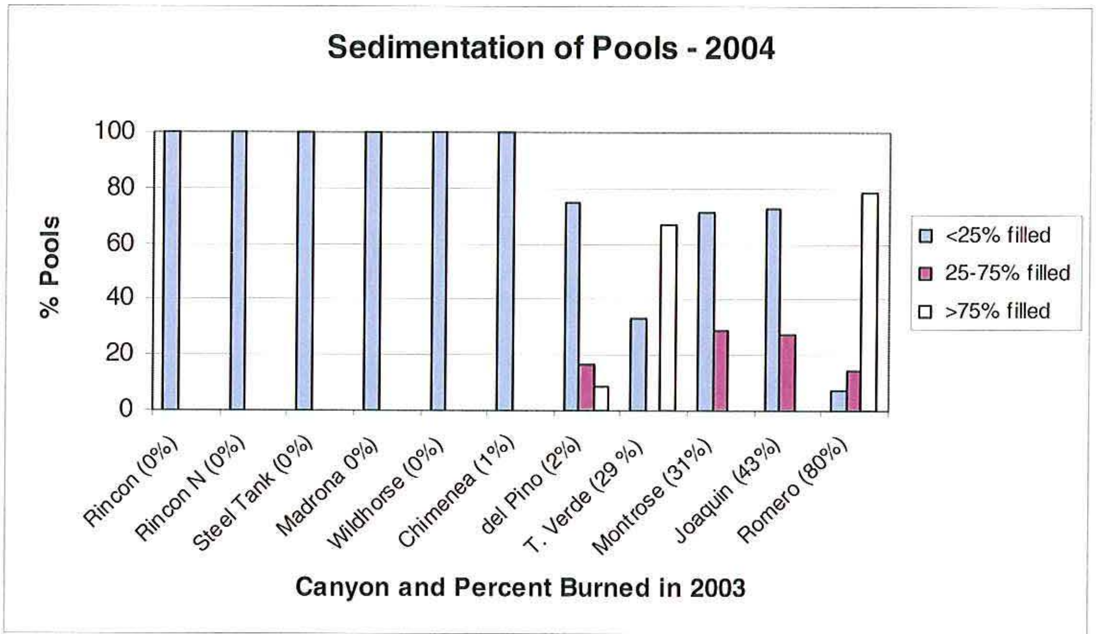
Wondzell, S.M. and J.G. King. 2003. Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions. Forest Ecology and Management 178: 75-87.

Table 1. Study canyons in the Rincon Mountains, Saguaro National Park and the Santa Catalina Mountains, Coronado National Forest, Arizona with information on total watershed area, total watershed area burned, and percentage of the total watershed burned.

Canyon	Land Ownership	Fire Name	Total Area (km^2)[a]	Burned Area (km^2)[b]	% Burned[c]
Romero	NFS	Aspen	21.2	16.98	80.2
Joaquin	NPS/NFS	Helens2	19.6	8.43	43.0
Montrose	NFS	Aspen	13.9	4.25	30.5
Tanque Verde	NPS/NFS	Helens2	15.2	4.34	28.6
Del Pino	NPS/NFS	Helens2	22.0	0.28	1.3
Chimenea	NPS	Helens2	24.9	0.10	0.4
Rincon North	NPS	None	7.4	0.00	0.0
Wildhorse	NPS	None	10.4	0.00	0.0
Rincon Proper	NPS	None	11.1	0.00	0.0
Madrona	NPS	None	14.3	0.00	0.0

Table 2. Breeding activity (i.e., presence of tadpole or recently metamorphosed juvenile frogs) combined from all burned versus unburned canyons, 2002 - 2006.

	No. of sites with breeding during survey period		
Burn category	2002-3	2004	2006
Unburned (n=6)	5	5	3
Burned (n=4)	4	2	0



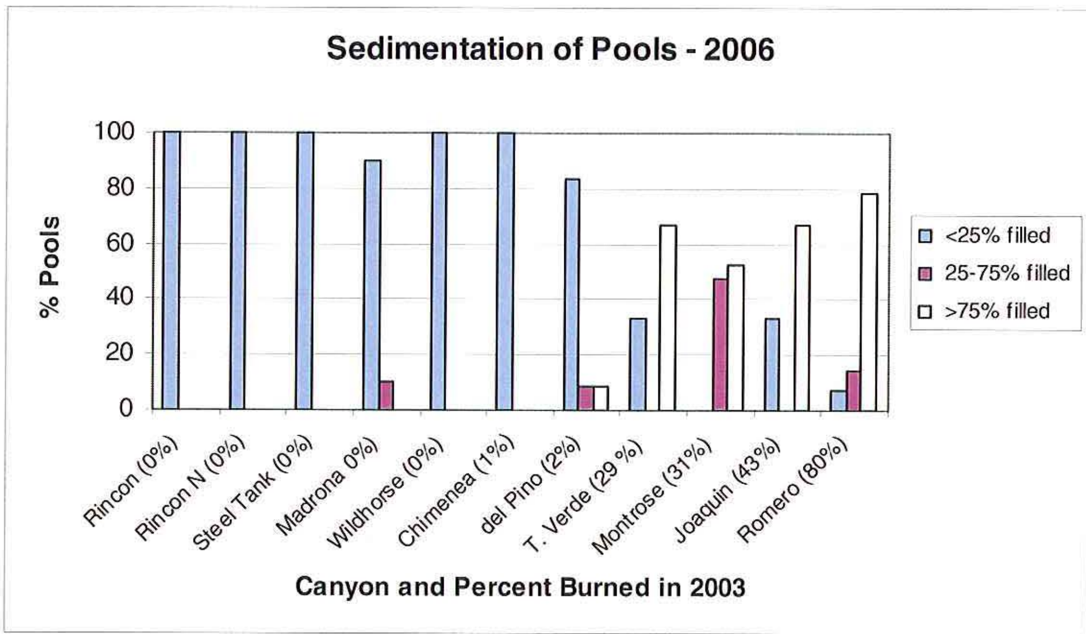


Figure 1. Percentage of total pools surveyed per canyon falling into one of three categories: <25% of pool filled with sediment, 25-75% of pool filled with sediment, and >75% of pool filled with sediment. Degree of sedimentation based on the pre-fire condition of pools.

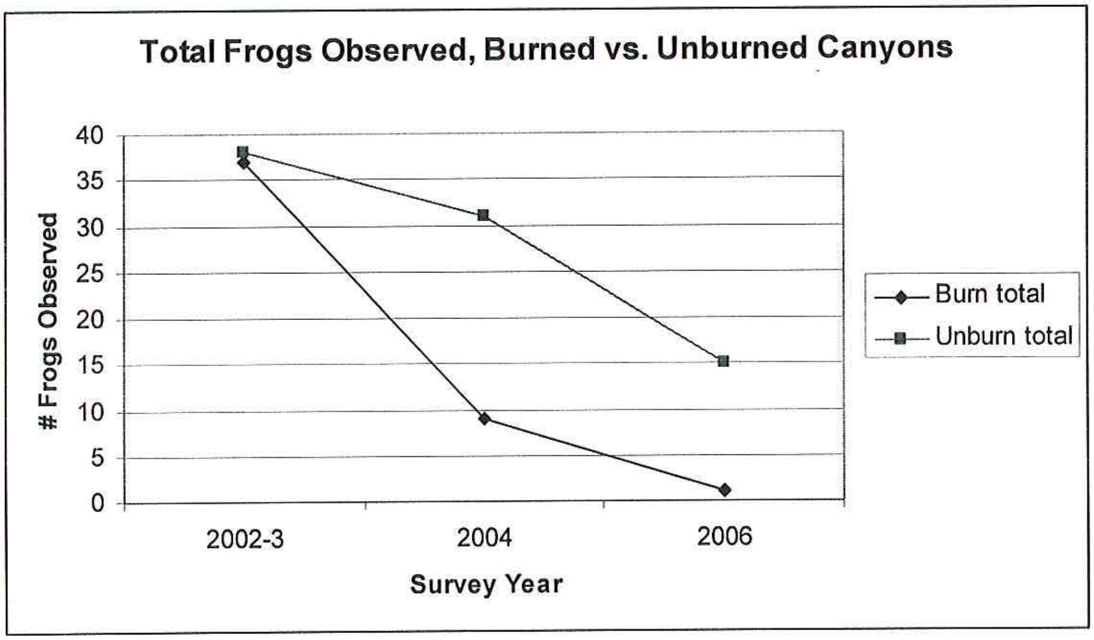


Figure 2. Combined frog observations from burned (n = 4) and unburned canyons (n = 6), 2002-2006.

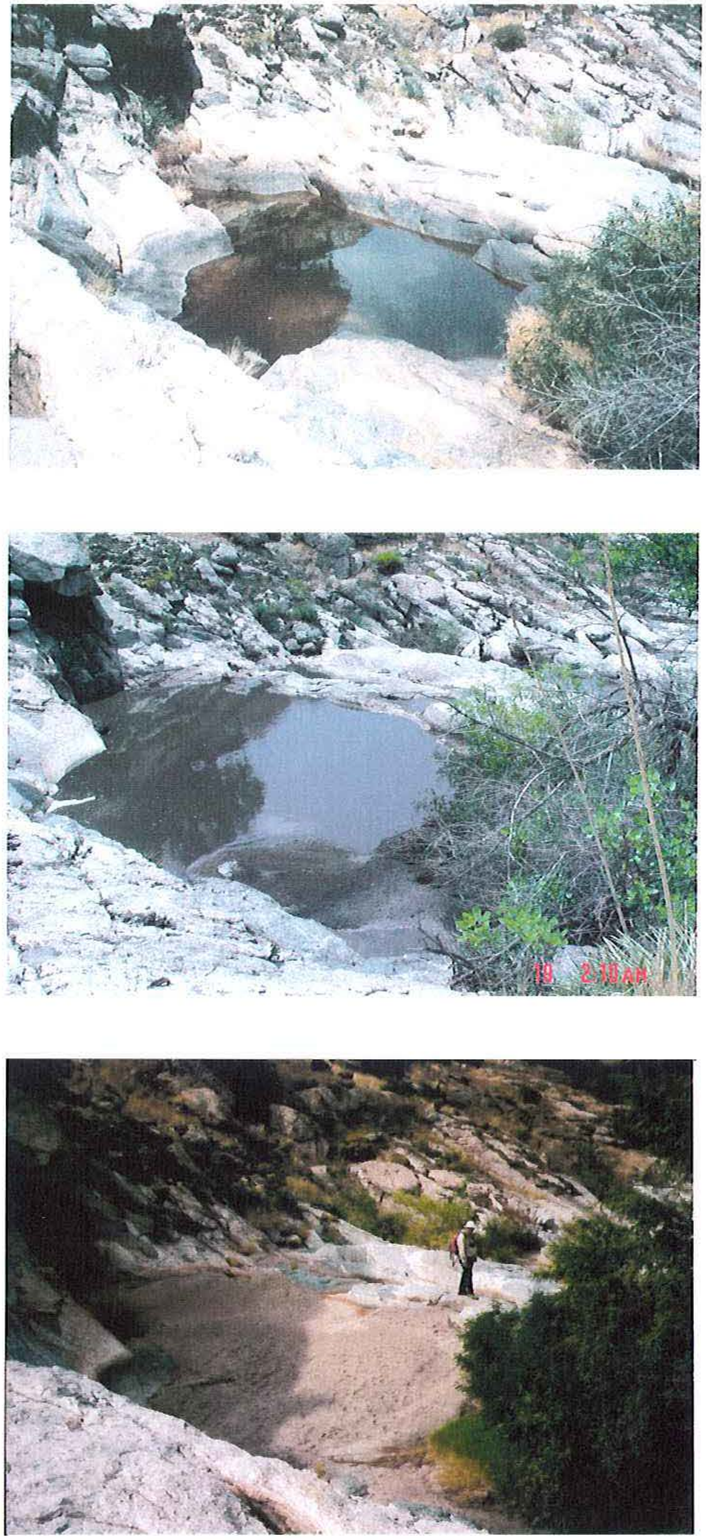


Figure 3. Pool in Joaquin Canyon below Helen's II Fire. Top: July 4, 2003, after fire but before first rain. Middle: July 19, 2003, after first flow event; note suspended ash. Bottom: November 2, 2005; sand and gravel has completely filled pool.

Figure 4. Pool in Joaquin Canyon below Helen's II Fire. Above: July 4, 2003, after fire but before first rain. Below: June 28, 2006. Note reference point of rock designated by arrows to gauge depth of sedimentation.