Fire-Induced Water-Repellent Soil Layers in Non-Hydromulched Areas of Griffith Park, Los Angeles, California

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Abstract

Questions: Have water-repellent soil layers discouraged pioneer species from successfully revegetating Griffith Park? How do the levels of water repellency vary among minimally burned, partially burned, and severely burned sites?

Location: United States, California, Los Angeles, Griffith Park (Latitude: 34.125°; Longitude: 118.302°)

Methods: Sites were classified as severely burned, partially burned, and minimally burned, based on both present and remnant plant matter found on location. GPS coordinates of all sites were recorded, and the water-drop test was performed on soil surface and five centimeters below ground. Three different levels of water repellency (hydrophilic, hydrophobic, and strongly hydrophobic) were determined based on how long it took for each drop of water to absorb into the soil.

Results: Ten sites were selected to be studied over a period of two months. Categorizing hydrophobic properties of soil with their respective burn severity level remained challenging, as there was variance within the timed results. Mode analysis was performed to clean up the nominal data, and a strong correlation was observed between minimally burned locales and their hydrophilic tendency.

Conclusion: The duration of time required for each drop of water to absorb into a soil profile can be used as an indicator of a soil's water repellency level. Minimally burned sites demonstrate superior vegetative rebounds following a fire and tend to consist of more hydrophilic soils compared to partially burned and severely burned sites.

Keywords: Fire; Soil; Vegetation; Post-fire succession; Chaparral; Burn severity; Water repellency; Los Angeles; Southern California

Introduction

The May 2007 fire that engulfed more than 3 km^2 of Griffith Park has considerably altered its chaparral-covered mountain landscape (Fig.1). Compared to historical wildfire in the region, this fire was uncharacteristically severe due to an unnatural accumulation of biomass as a result of continual fire repression, drought, poor management, and non-native species.

Fig. 1. A burned, non-hydromulched area of Griffith Park

In an attempt to prevent catastrophic post-fire erosion, the City of Los Angeles applied hydromulch in October to approximately 1.5 km^2 of most severely burned sites; other charred areas were left to recover on their own. As a year has passed by since the fire and the winter rain season has ended, it is becoming obvious that current fire recovery in Griffith Park is unusual in both hydromulched and non-hydromulched areas.

Chaparral vegetation

Chaparral, which occupies 35 000 km^2 of California, is dominated by woody, evergreen sclerophyllous shrubs (Hanes 1971). It is a complex vegetative type that is associated with ecosystems of grass, sage scrub (soft chaparral), and broadleaved and conifer plant communities (Hanes 1971; Conrad et al.1986). Chaparral vegetation has evolved to live in relatively nutrient poor and shallow soils, which generally inhibit plant growth.

Chaparral is regarded as one of the world's most fire-susceptible vegetations, owing to the climate and the density of the plant cover (Hanes 1971). In southern California, it is estimated that wildfires typically denude chaparral brushlands once every 25-40 years (DeBano 1973; DeBano 2000). As a result, vegetation in chaparral and its associated ecosystems has developed fire adaptations that encourage post-fire plant community regeneration and rejuvenation (Conrad et al. 1986). For one, these species are flammable, due to their chemical, physical, and physiological characteristics (Conrad et al. 1986). Native plants, such as *Adenostoma fasciculatum* (chamise), *Arctostaphylos* spp. (manzanita), *Malosma laurina* (laurel sumac), and *Heteromeles arbutifolia* (toyon), have leaves that are coated in flammable oils to encourage wildfire (Kramp et al. 1983). These plants are capable of quickly re-establishing themselves after a fire, by producing fire-resistant or fire-activated seeds (Hanes 1971; Conrad et al. 1986). Other plants recover from a fire by sending up sprouts from latent buds at the root collar (resprouting) (Hanes 1971; Conrad et al. 1986).

Post-fire succession begins almost immediately in the self-replacing chaparral vegetation (Hanes 1971). Resprouting starts within a few weeks after fire, even during the summer drought season (Hanes 1971). Most chaparral species in undisturbed areas as well as non-sprouting species are dormant during this time period; species in the latter category do not initiate germination until the arrival of the rain season in autumn (Hanes 1971). As a result of these vigorous revegetating activities, typical chaparral landscapes are reclothed by both resprouting and germinating woody and herbaceous species during the first year after fire (Hanes 1971).

Effects of fire on chaparral soil properties

During a fire, the combustion of plant biomass and litter aboveground releases a significant amount of heat (DeBano 1973; DeBano 1989). More than 90% of this heat is transmitted upward and is dissipated into the atmosphere (DeBano 1973; DeBano 1989). The remaining heat is radiated downward into the soil, producing changes that affect various properties of the soil (DeBano 1973; DeBano 1989). Examples include: soil chemical properties (e.g. total and available forms of plant nutrients, cation exchange capacity), soil microbiological properties (e.g. populations of microorganisms, microbial activities such as decomposition, nitrogen fixation, and nitrification), seed mortality, and soil physical properties (e.g. soil structure such as pore size, infiltration rates, the water of hydration in clays, soil wettability) (DeBano 1973; DeBano 1989). These changes are especially prone to occur in steep, unstable, chaparral-covered mountain watersheds of southern California, including Griffith Park (Krammes & Osborn 1969).

Soil wettability and fire-induced water repellency

During the late 1950s and early 1960s, studies have shown that soil wettability was one of the significant factors affecting post-fire erosion (DeBano 2000). Burning was discovered to decrease soil wettability and infiltration; these were caused by the formation and intensification of a water-repellent (hydrophobic) soil layer during fire (DeBano 1989; DeBano 2000). In other words, fire increases the water-repellent properties of the soil (Adams et al. 1970).

A water-repellent soil layer is usually located on or near (i.e. a few centimeters below) the soil surface, and is aligned parallel to the mineral soil surface (DeBano 2000). It may be covered by a layer of wettable soil, or in case of mineral soil, by an ash layer (DeBano 1973; DeBano 2000). Water repellency is exhibited in a layer of varying thickness and spatial continuity, influenced by various fire and soil characteristics; these include: fire behavior, fire severity, temperature gradients developing in the soil during fire, amount and type of organic matter, soil texture, soil water/moisture content, and the soil-plant environment (DeBano 2000).

The soil property of water repellency must be carefully examined, especially in the case of unstable and erosive chaparral brushlands, as it leads to reduced infiltration, increased surface runoff, and accelerated erosion (DeBano 1973; DeBano 2000). If a wettable layer forms near the soil surface and covers a water-repellent layer, water is infiltrated into the soil until the wetting front reaches the water-repellent layer (DeBano 1973). As more infiltration takes place, lateral water flows are generated in between the two layers and carry away soil materials from both layers (DeBano 1973). Post-fire erosion is highly problematic, as it can delay revegetation of the charred areas (Savage 1974) (Fig.2).

Fig.2. Severe erosion in Griffith Park

The formation of a water-repellent soil layer begins during the years between fires (DeBano 1973) (Fig. 3A). During these fire intervals, organic matter accumulates on the soil surface, around the transition between the A_0 and A_1 soil horizons (DeBano 1973; DeBano 2000). This organic-rich layer consists of hydrophobic substances, including desiccating partially decomposed organic matter and mineral soil, leached decomposing plant parts, and growing fungi (DeBano 1973; DeBano 2000). This accumulation occurs immediately beneath shrubs (DeBano 2000). Water repellency at this pre-fire stage, however, is relatively weak, only temporarily preventing water absorption (DeBano 1973).

Fire consumes both the chaparral cover and the underlying little layer (DeBano 1973). As shown in Fig. 3B, steep temperature gradients are formed in the upper few inches (i.e. 5 cm) of soil, as a result of combustion and heat transfer (DeBano 1973; DeBano 2000). During fire, the canopy of burning chaparral brush may exceed 1100°C, whereas temperatures at the soil-litter interface may be 850°C; at 5 cm below the soil surface, however, temperatures may even be less than 150°C due to the low heat conductivity of soil (DeBano 2000). Heat vaporizes hydrophobic organic substances on the soil surface, which causes some of the generated vapor and gases to move downward into the soil along the temperature gradients (DeBano 1973; DeBano 2000). Once they reach cooler underlying soil layers, they condense on soil particles (DeBano 1973; DeBano 2000). Water repellency is also intensified when mineral soil particles are coated by and chemically bonded to hydrophobic organic substances (DeBano 1973; DeBano 2000).

The water-repellent soil layer may experience thickening after the fire, if there is a continuous downward heat movement (DeBano 2000) (Fig. 3C). The soil may re-volatilize some of the hydrophobic substances, fixing them in situ (DeBano 2000). The thickness and depth of the resulting water-repellent soil layer are affected by several factors, including fire intensity, the nature and amount of litter, soil physical properties, and water content (DeBano 1973).

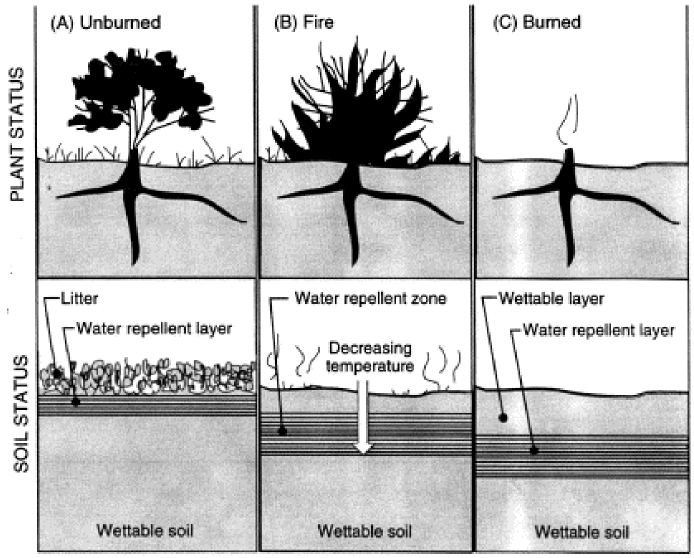

Fig. 3. Fire-induced formation/intensification of a water-repellent soil layer (DeBano 2000)

Although a fire-induced water-repellent soil layer is said to reduce infiltration, there are instances when an increased infiltration rate was reported after fire (DeBano 1973). This is due to complex relationships between water repellency and soil temperature, as shown in Table 1.

Soil temperature (when heated)	**Water repellency**
Less than 175°C	Little change occurs
175°C - 200°C	Intense
280°C - 400°C	Destruction

Table 1: Relationships between water repellency and soil temperature (DeBano 2000)

A very hot fire, therefore, may cause the complete destruction of hydrophobic organic substances that are responsible for water repellency; infiltration increases as a result (DeBano 1973). In addition, the hotter the fire, the deeper the water-repellent soil layer under the soil surface; a wettable layer may form at the surface, covering the water-repellent soil layer (Adams et al. 1970; DeBano 1973) (Fig. 3C).

In addition to infiltration, surface runoff, and erosion, water repellency influences other hydrological processes, such as rill formation, raindrop splash, and streamflow parameters (DeBano 2000).

Questions and hypothesis

It has been more than a year since the May 2007 wildfire, and Griffith Park has experienced normal to slightly above average precipitation. However, both hydromulched and non-hydromulched areas within the park are still relatively sparse in vegetation and many common pioneer species are absent from the park. Species that re-establish themselves by germinating from seed bank, such as *Yucca* spp., *Lotus scoparius* (deerweed), and *Ceanothus* spp., as well as re-sprouting species such as *Malosma laurina* (laurel sumac), *Heteromeles arbutifolia* (toyon), *Adenostoma fasciculatum* (chamise), and *Rhus ovata* (sugar bush), have not been commonly observed in the area. We believed that this phenomenon may be related to the formation of hydrophobic soil layers within Griffith Park:

1. Have water-repellent soil layers discouraged pioneer species from successfully revegetating the area?
2. How do the levels of water repellency vary among minimally burned, partially burned, and severely burned sites?

These questions have led us to create the following hypothesis and null hypothesis:

Hypothesis: The presence of fire-induced water-repellent soil layers in Griffith Park has contributed to limited chaparral vegetative succession.

Null-hypothesis: The limited chaparral vegetative succession observed in the park has not been due to fire-induced water-repellent soils layers at Griffith Park.

Data and Methods

Griffith Park is the largest municipal park with urban wilderness area in the United States, covering more than 17 km^2 (City of Los Angeles n.d.) (Fig. 4). Located in the eastern portion of Santa Monica Mountain range, the park extends from 117 to 495 m above sea level (City of Los Angeles n.d.). It is a chaparral-covered terrain, with coastal sage scrub communities, oak and walnut woodlands, and riparian vegetation (City of Los Angeles n.d.).

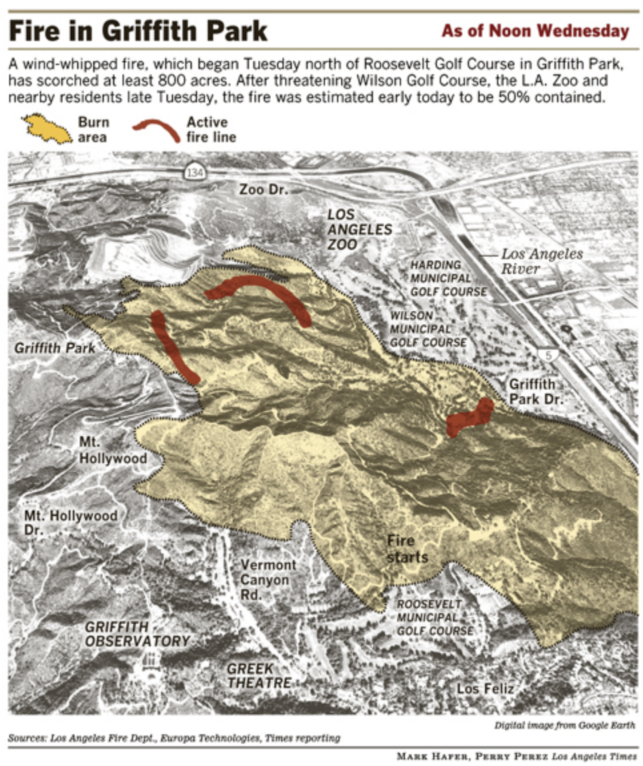

Fig. 4. Location of Griffith Park, with fire information as of May 9, 2007

Our study area is a south-facing, non-hydromulched plot of land, situated immediately off of the trail leading from Griffith Observatory to Mt. Hollywood (Fig. 5). We have noted that different parts of this plot exhibit varying degrees of burn severity, which makes it an excellent study area for investigating the presence (or absence) of fire-induced water-repellent soil layers. As is the case with the remainder of Griffith Park, this plot of land has suffered from a general lack of revegetating activities, both resprouting and germination from seed bank, for most of the duration of our study.

Fig. 5. Our study area located between Griffith Observatory and Mt. Hollywood

Our predetermined location was scouted for areas that showed signs of being severely burned, partially burned, and minimally burned (Fig. 6). We determined burn severity based on the quantity and quality of plant matter left on site. If a region was completely devoid of pre-fire plant matter, then the site was classified as severely burned. Likewise, if a site supported healthy vegetative growth and relic plant matter, then the site was classified as minimally burned. Based on this methodology, we were able to find five sites classified as severely burned, three sites as partially burned, and two sites as minimally burned.

Minimally burned sites supported ample growth of *Brassica nigra* (black mustard), whereas severely burned sites appeared to be random black islands of soil in a sea of the ubiquitous *Brassica* (Fig. 6). For each location, the GPS coordinates were recorded and the water-drop test was performed based on the procedure described by Adams et al.

(1)  (2)  (3) 

Picture 1: Severely burned; Picture 2: Partially burned; Picture 3: Minimally burned (*Brassica nigra*)

Fig. 6. Examples of our study sites with different burn severity categories

The water-drop test involved timing how long it takes for one drop of deionized water to absorb into soil. Its purpose was to explore the relationship between burn severity and water repellency. At each site, we first removed any loose or porous debris from the surface level and performed the water-drop test at three points on the soil. We then dug 5 cm into the soil profile and performed the water-drop test an additional three times. If a drop remained (i.e. not absorbed) for more than one minute, the soil was determined to be strongly hydrophobic; if it remained more than ten seconds but less than one minute, the soil was considered to be hydrophobic. We classified soil as hydrophilic, if the water drop absorbed into the soil in less than ten seconds. The entire water-drop test procedure described until this point was conducted in five severely burned sites, three partially burned sites, and two minimally burned sites, for a total of three times over a period of two months.

In order to explore the relationship between soil wettability and vegetation cover, plant surveys were carried out to quantify the amount of vegetation present in the study area. The number of plant species present within a 1 meter radius of each site was counted.

To further investigate the presence/absence of fire-induced water-repellent soil layers, soil samples for each burn severity category were collected and examined under a microscope.

We noted any similarities and differences in soil color, grain size, mineral composition, and organic matter,

Our field study was accompanied by our work with ESRI's ArcGIS software. In order to further investigate the relationship between fire severity and water repellency, a GIS map of the park was created using ArcMap. The GPS coordinates recorded from our sites were mapped with the burn severity data available from the Griffith Park Project website, which showed our study area to have experienced a moderate burn (Fig. 7). Since the website data covered the entire park, it was not specific enough to capture and illustrate the varying degrees of fire severity experimentally discovered in our specific study area.

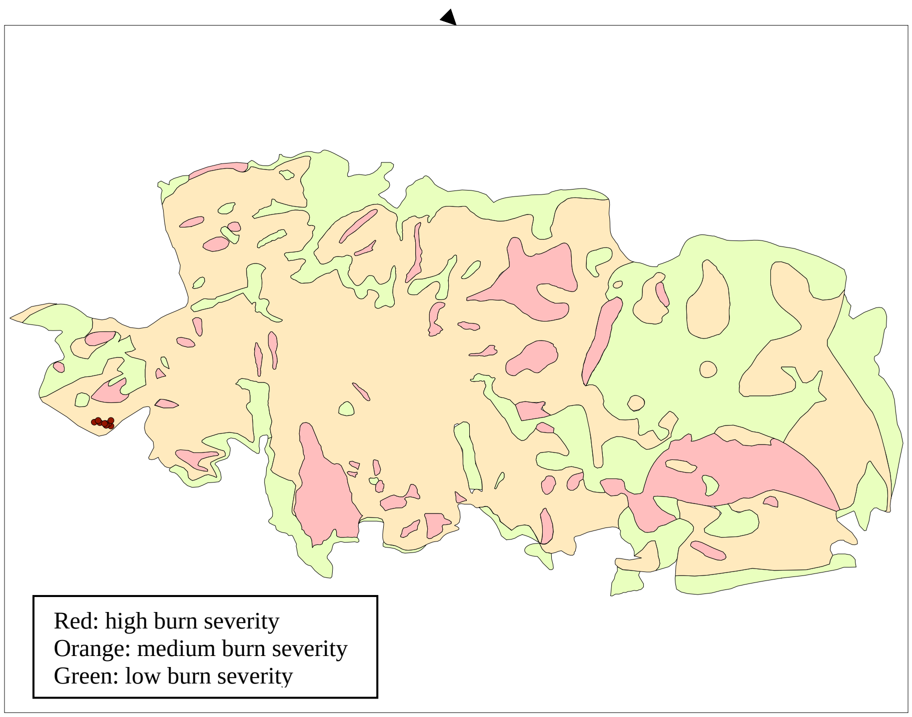

Fig. 7. Griffith Park burn severity map (our study area is indicated by red dots)

Results

Water-drop test

All soil sites were overlain by porous, hydrophilic soil layers approximately 1.5 cm deep, which had to be cautiously removed to expose underlying soil conditions. As a way to organize and analyze our data, each level of water repellency was given a scale number ranging from 1 to 3. A number one was applied, if the water drop took less than ten seconds to absorb into the soil gradient (hydrophilic). Soils were classified a number two if a water drop took more than ten seconds but less than one minute to absorb (hydrophobic). A number three was assigned to sites that took over one minute for the water to absorb (strongly hydrophobic).

Mode analysis was used to characterize the hydrophobic property of each soil site to make sense of our nominal data. The mode represented the value that occurred most frequently in the data set and categorized information in the data as single quantities. Mode analysis was performed by discretizing the data values to intervals determined on the water-drop test, since our data in raw form consisted of a continuous distribution of time. Table 2 summarizes our analysis and compares burn severity category with soil water repellency property.

Burn Category	**Site ID**	**Latitude DD**	**Longitude DD**	**Repellency top**	**Repellency 5 cm**
Severely burned	1	34.12536	-118.302	3	2
Severely burned	2	34.12544	-118.302	2	3
Severely burned	3	34.12542	-118.302	3	3
Severely burned	4	34.12547	-118.303	2	2
Severely burned	5	34.12553	-118.302	3	3
Partially burned	6	34.12533	-118.302	3	3
Partially burned	7	34.12542	-118.302	3	3
Partially burned	8	34.12536	-118.302	1	3
Minimally burned	9	34.12542	-118.302	1	1
Minimally burned	10	34.12553	-118.302	1	1
*1= hydrophilic (< 10 sec), 2= hydrophobic (10 > x < 60 sec), 3= strong hydrophobic (> 60 sec)					

Table 2. Summary of water-drop tests from mode analysis

Within the severely burned category, site 1 was classified as a level 3 on the surface, and level 2 five centimeters below ground. Sites 2, 3, 4, and 5 all were burned mound sites that were virtually devoid of plant matter with the exception of remnant tree stumps. Site 2 was classified as a level 1 on the surface, and level 3 above ground. Site 3 was classified as a level 3 for both levels. Site 4 was classified as a level 2 for both levels and the last severely burned location, site 5, was classified as a level 3 for both levels.

For the three partially burned sites, two of the sites exhibited level 3 hydrophobic characteristics above and below ground. The other site exhibited a level 1 tendency on the top soil, and level 3 five centimeters below.

The minimally burned (*Brassica nigra*) sites exhibited the most consistent results in having the most hydrophilic soils. For these sites, the hydrophobic properties are 1 for both below and above surface measurement.

Plant surveys

Table 3 is the summary of plant surveys conducted within a 1 meter radius of each study site. For severely burned sites, there are several plants that were unidentifiable and thus were not placed in the table.

Phacelia grandiflora (large-flowered phacelia), *Calystegia macrostegia* (morning glory), *Brassica nigra* (black mustard), and *Cirsium* spp. (thistle) were the most abundant plants in our study area. *Phacelia* began to proliferate during the latter part of our field study, in black islands of soil that were originally devoid of pre-fire plant matter. *Calystegia* was also found primarily in severely burned sites. *Brassica* and *Cirsium* were numerous in both severely burned and minimally burned sites; in the latter sites, these plants were virtually innumerable.

Burn severity	Species (Scientific)	Species (Common)	Quantity	Flowering time
Severely burned	*Heteromeles arbutifolia*	Toyon	1	June – July
	Malosma laurina	Laurel sumac	3	June – August
	Artemisia californica	California sagebrush	5	August – December
	Calystegia macrostegia	Morning glory	12	March – August
	Phacelia grandiflora	Large-flowered phacelia	(proliferating)	April – June
	Coreopsis californica (?)	California coreopsis (?)	2	
	Emmenanthe penduliflora (?)	Whispering bells (?)	4	April – July
	Avena spp.	Wild oats	1	
	Brassica nigra	Black mustard	22	
	Cirsium spp.	Thistle	9	
Partially burned	*Malosma laurina*	Laurel sumac	2	June – August
	Solanum xanti	Purple nightshade	1	April – July
	Calystegia macrostegia	Morning glory	1	March – August
	Phacelia grandiflora	Large-flowered phacelia	3	April – June
	Phacelia cicutaria var. *hispida*	Caterpillar phacelia	1	March – June
	Brassica nigra	Black mustard	4	
	Cirsium spp.	Thistle	4	
Minimally burned	*Brassica nigra*	Black mustard	(proliferating)	
	Cirsium spp.	Thistle	(proliferating)	

Table 3. Summary of plant surveys

Soil analysis

Soil samples collected from each burn severity category were analyzed under a microscope. Due to the resolution limitation of the microscope, it proved difficult to observe more than the overall appearance of each sample.

Severely burned sites were characterized by grey to black-colored soils, with white and brown speckles interspersed. They contained a fairly large amount of wood debris, most likely remnant from the fire. Grains tended to be small to medium-sized.

Soils in partially burned sites were similar to those in severely burned sites with the exception that partially burned sites contained no visible traces of wood debris. Grains were also smaller and yellow and brown-colored gravels were present.

Analyzing soils in minimally burned (*Brassica nigra*) sites led to an observation that though these soils were collected from two completely different locations (one inside the field and another along the trail), they appeared strikingly similar. These soils were light-colored compared to severely burned and partially burned sites, with an overall white/beige and tan-colored appearance. Both soils contained a large amount of wood debris interspersed with very large grains; other grains were small and had a crystalline structure, resembling quartz.

Discussion

No readily available changes occurred between the three times each site had been tested for water repellency. Thus, it was shown that soil water repellency at the sites was not time-dependent.

Over a two-month period of our field study, however, our study area has undergone a large degree of landscape change. With time, the area overall experienced a proliferation of both native and non-native species. Therefore, even though GPS measurements were taken near the beginning of our study, it became progressively difficult to return to the exact same sites to perform additional water-drop tests.

For severely burned sites, the major difficulty was determining the vegetation that was present prior to the fire. Most of what remained was charred tree stumps, which showed no vestigial characteristics of to which species they belonged. It is quite possible that all of these sites contained the same tree species prior to the fire, giving each site more or less the same soil characteristics. Data presented in Table 2 supports this idea, as both the soils above and below the ground for all five severely burned sites were either hydrophobic or strongly hydrophobic. The presence of water-repellent soil layers may explain why the burned mound sites, containing predominantly strongly hydrophobic soils, originally all appeared as islands of blank soil surrounded by a sea of *Brassica nigra*. The mound sites, before the fire, may have surrounded a highly volatile, mature chaparral species which leeched hydrophobic compounds into the soil when burned.

Another theory as to why these sites were initially devoid of vegetative growth is that fire temperatures were so high that the surrounding seed bank in the soil was severely burned through. Our plant surveys uphold this theory, since some of the black islands are beginning to experience a proliferation of pioneer species. *Phacelia grandiflora* (large-flowered phacelia), pictured in Fig. 8, is a native annual species that primarily grows in post-fire, disturbed areas; its presence in these sites, therefore, supports our categorization of these sites as severely burned (Fillius 2007). *Calystegia macrostegia* (morning glory), another proliferating plant, is also a pioneer herbaceous perennial species that germinates in early winter before other post-fire chaparral species (Barbour & Billings 1999). Since the plant surveys revealed that this plant basically grows only in our severely burned sites, it serves as another confirmation for our burn severity classification. Given the rapidly proliferating nature of these pioneer species, they may be filling in the niche that used to be occupied by mature chaparral species before the fire.

Fig. 8. Severely burned sites with proliferating *Phacelia grandiflora*

There was some difficulty in categorizing partially burned sites, as the water-drop test results later showed that these sites exhibited both severely burned and minimally burned soil repellency characteristics. Two of the sites which exhibited level 3 hydrophobic characteristic both surrounded a charred *Malosma laurina* (laurel sumac) tree that was in a resprouting stage. This fact was our basis for classifying the sites as partially burned and not as severely burned. From our plant surveys, we found that the partially burned sites had other resprouting native and non-native plant species, including *Solanum xanti* (purple nightshade), *Phacelia grandiflora*, and *Brassica nigra*.

Our minimally burned sites, one located inside our study area and another located along the trail, were shown to be hydrophilic, both above and below the ground. Since hydrophilic soils allow water to absorb into the ground to reach root systems, it makes sense that these locations supported ample growth of *Brassica nigra* (black mustard) as well as *Cirsium* spp.

(thistle) from the onset of our field study. Because these non-native species initiated their growth before native species and spread throughout our sites, species belonging to the latter group were prevented from vegetating these areas. Thus, no other plant species but *Brassica* and *Cirsium* could be identified in the two minimally burned sites.

In addition, soil samples collected from these locations were strikingly similar, with white/beige to tan-colored soil, the presence of very large grains, compacted crystalline particles, and an abundance of wood debris. These characteristics make it easier for water to be absorbed into the ground, thus further promoting the growth of vegetation.

Based on our plant surveys, it appears that severely burned sites support more plant diversity compared to minimally burned sites. Minimally burned sites contained predominantly *Brassica nigra* and *Cirsium* spp., while severely burned sites grew a variety of native plant species. One explanation for this phenomenon may be that *Brassica* thrives in many areas of California after rainy seasons. Their seeds are deposited in soil after plant growth has ended, and a new seed bank is established in the soil for the following year. We suspect that the intense fire inhibited the growth of *Brassica* and *Cirsium* by burning through the seed bank. The decimation of the non-native seed bank could have resulted in creating bare mounds with the potential of hosting a greater variety of native species later on in the rainy season. Thus, severely burned sites may have originally contained non-native species instead of mature chaparral species as was suggested earlier. The mound sites with newly created open niches after the fire may have helped to support a wide variety of native plants compared to the minimally burned areas.

Our project was limited in that there was a shortage of ideal sites to analyze. The actual test plot where we conducted all of our measurements was very unique in that it was non-hydromulched yet exhibited signs of being severely burned in some areas. Due to the site's uniqueness, we were not able to expand our measurements to other areas within Griffith Park.

Our study could be improved in two main ways. The number of sites that were analyzed could be increased by measuring all the burned mound sites in the study area rather than just the four we selected. Partially burned sites could be categorized simply as "burned sites" due to the ambiguity of distinguishing a partially burned site from a completely burned site many months after a wild fire. Number of minimally burned sites (with *Brassica nigra)* that were tested could have also been increased from two to well over ten.

Another way our data could be improved would have been to work directly with the continuous data series. In many instances, working with a continuous data series was impractical, since some soils appeared to be so hydrophobic that water droplets would have taken a significantly long time to absorb. In order to work with a continuous data series, it would be necessary to condense the amount of time required for the droplets to absorb into the soil. For this purpose, an ethanol and water mixture could be used. A continuous data series would enable more detailed analysis of our results by allowing us to take averages and the standard deviation, perform chi-square analysis, and extrapolate the P value of our data to further determine its statistical significance.

Conclusion

With over 150 data points measuring the hydrophobic properties of soils in Griffith Park, we were attempting to provide information on how burn severity affects vegetative regrowth following wildfire. Visual class labeling of burn severity category and performing the systematic water-drop test enabled us to correlate burn severity with soil water repellency. By conducting plant surveys around each site, we were further able to correlate how burn severity affects soil property, which in turn influences the vegetative growth of a region following a fire.

Based on the data, there is a distinction in the levels of water repellency between severely burned sites and minimally burned sites, with the former containing predominantly strongly hydrophobic soils and the latter having the most hydrophilic soils. The ambiguity lies in the partially burned sites which exhibit mixed characteristics. Although the completely burned sites exhibit more plant diversity, the most densely vegetated areas are located in the minimally burned sites. Based on visual analysis and the water-drop test, it seems that, up until our last field analysis, water-repellent soil layers have discouraged pioneer species from successfully revegetating areas in high density. Now that Griffith Park is entering its second post-fire year, some common native pioneer species are beginning to flourish, most notably *Phacelia grandiflora* and *Calystegia macrostegia*. Thus, we can reject our null hypothesis; fire-induced water-repellent soil layers in Griffith Park appear to have contributed in part to the limited chaparral vegetative succession seen one year after the most recent fire event. However, there are most likely other factors that influenced vegetative succession, including the possible destruction of seed banks as well as physical and chemical soil characteristics.

Our method of categorizing burn severity could be used as a future method for post-fire specialists to determine if certain burned regions contain soils that are prone to erosion. The high variability of the water-drop test in proximal soils remains as the main limiting factor for accurately assessing hydrophobic properties of a soil.

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