RHIZOSPHERE, SURFACE, AND AIR TEMPERATURE PATTERNS AT PARKING LOTS IN PHOENIX, ARIZONA, U.S.

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Abstract. Parking lot landscape surfaces can affect thermal microenvironments where parking lot trees grow. We studied temperatures at parking lots in Phoenix, Arizona, U.S. with expansive asphalt paving surrounding narrow parking lot landscape medians covered with decomposing granite rock (DG) mulch and also within adjoining landscaped areas covered with turfgrass or DG mulch. We recorded temperatures at two Phoenix residential landscapes that were covered with either turfgrass or DG mulch and one remnant Sonoran Desert site in the city that had a bare soil surface. Rhizosphere [30 cm (12 in.) depth] temperatures were seasonally highest under asphalt and lowest under turfgrass, and occurred 4 to 8 hr after highest air temperatures. Rhizosphere temperatures under asphalt as close as 1 m (3.3 ft) from parking lot landscape medians were above 40°C (105°F) long enough to damage any tree roots growing outside of landscape medians. Ground surface temperatures were also highest for asphalt and lowest for turfgrass, but surface temperature patterns more closely followed patterns of insolation intensity rather than air temperature. These data show that supraoptimal rhizosphere temperatures around narrow parking lot landscape medians might be one important reason why parking lot trees in the desert Southwest grow poorly when compared with trees away from asphalt surfaces.

Key Words. Asphalt; commercial; landscape; thermal environment; turfgrass; urban.

Parking lots with narrow landscape strips, islands, or medians surrounded by asphalt are a common element at commercial land use sites. In addition, parking lots are often buffered from surrounding land of other human use by contiguous perimeter landscape plantings. Parking lot landscape medians and adjoining perimeter landscapes can have a variety of surface cover types that, in southwestern U.S. desert cities such as Phoenix, Arizona, range from turfgrass to decorative inorganic mulches such as decomposing granite rock (DG). At small microclimate scales in southwestern urban areas, all of these surface covers might differentially impact the growth of parking lot landscape trees because of their contrasting thermal properties.

Trees in parking lot landscape medians are meant to give shade and enhance landscape aesthetics (McPherson 2001). Municipal ordinances can stipulate that trees must shade up to 50% of vehicle parking areas within 15 years after establishment of the parking lot (California Energy Commission, no date). But impervious surfaces around parking lot median landscapes such as asphalt and concrete absorb, store, and reradiate more heat energy per unit area than do vegetated surface covers such as turfgrass, which is able to dissipate heat energy through evapotranspiration of water (Holman 1986). As a result, air, surface, and soil temperatures near asphalt and concrete might be higher than temperatures in the near vicinity of vegetated surfaces (Asaeda et al. 1996; Montague et al. 2000).

In the past, some researchers have studied thermal microenvironments that affect the growth and performance of landscape trees. Kjelgren and Montague (1998) recorded asphalt surface temperatures that were as much as 20°C to 25°C (36°F to 45°F) higher than surrounding surfaces landscaped with vegetation. Graves and Dana (1987) reported that mean summer (July) soil temperatures at depths of 5 to 50 cm (2 to 20 in.) under street trees in downtown Lafayette, Indiana, U.S., were up to 7°C (13°F) higher than on urban and rural sites not surrounded by paved surfaces. In central California, U.S., Scott et al. (1999) found that parking lot surfaces shaded by trees were as much as 20°C (36°F) lower than adjacent sunlit surfaces during July and August.

Increasingly, public commerce is centralized in location and serviced by expansive parking lots. There is a need to better understand the parking lot thermal environment to make correct decisions about selection and placement of parking lot trees for shade and aesthetic purposes, particularly in the rapidly expanding cities of the desert southwest United States. The objective of our studies was to delineate the effect of surface cover type on temperature patterns that likely affect landscape tree growth in and around parking lot areas. We anticipated that heat conduction from asphalt surfaces downward into soil near trees in commercial parking lot landscape medians of Phoenix might result in supraoptimal rhizosphere temperatures, especially during summer months. We also expected that seasonal and daily rhizosphere temperatures patterns would be different than patterns of air and surface temperatures and would be affected by surface cover type. We also wanted to know how parking lot thermal microenvironments compared with those of other common landscape types in the Phoenix area.

METHODS

During 2001 and 2002, we conducted three studies to characterize temperature patterns in close proximity to landscape trees at 16 parking lots and three other sites, two residential and one remnant Sonoran Desert, within the Phoenix metropolitan area. Phoenix is situated in the Salt River Valley at the northeastern edge of the Sonoran Desert in the southwestern United States (33°N 112°W) at an approximate elevation of 335 m (1,100 ft). Summers are long and hot. The daily average air temperature during summer is 30.8°C (87.4°F), and maximum air temperatures during 2001 and 2002 exceeded 37.8°C (100°F) on 248 days (National Weather Service Forecast Office 2004). Winters are short and mild. The daily average air temperature during winter is 11.3°C (52.3°F). Mean annual rainfall and potential evapotranspiration are about 180 and 2,250 mm (7 and 89 in.), respectively. Because of the arid climate, commercial and residential landscapes in Phoenix are normally watered throughout the year by electronically controlled drip and overhead sprinkler irrigation systems.

Rhizosphere Temperatures in and Around a Parking Lot Landscape Median

In one study, we recorded rhizosphere temperature patterns continuously for 1 year (July 2001 to June 2002) in and adjacent to a landscape median that was located in the middle of a parking lot on the campus of Arizona State University (parking lot #44) in Tempe. The landscape median was a narrow strip about 61 m (200 ft) long and 1.2 m (4 ft) wide, oriented in a north–south direction lengthwise, and had a concrete curb partitioning it from the surrounding parking lot asphalt surface. The landscape median surface was covered with approximately 5 cm (2 in.) of DG mulch. The asphalt surface was approximately 8 cm (3 in.) thick. Parking lot #44 was approximately 1.7 ha (5 ac) in size, and there were no buildings or other large structures near the parking lot area to obstruct daily patterns of insolation.

We recorded rhizosphere temperatures with portable dataloggers (WatchDog 100-Temp 2K, Spectrum Technologies, Plainfield, IL) that were situated along linear transects [7.62 m (25 ft) in length] perpendicular to the north–south orientation of the parking lot landscape median from the median center outward in easterly or westerly directions. Each transect consisted of five portable dataloggers positioned in the rhizosphere 30 cm (12 in.) below (based on our preliminary field observations of the soil depth where local parking lot tree roots were most concentrated) the parking lot landscape median or asphalt surface at the following distances from the center of the landscape median: 0 m (center of the median), 0.46 m (1.5 ft), 1.22 m (4 ft), 3.05 m (10 ft), and 7.62 m (25 ft). Transect distances greater than 0.61 m (2 ft) away from the parking lot landscape medium center were covered by asphalt; distances less than 0.61 m (2 ft) were covered with DG mulch. The linear transects were at least 10 m (33 ft) apart and were replicated four times—two transects extended toward the east and two toward the west.

To record rhizosphere temperatures, we drilled 7.5 cm (3 in.) diameter holes through the asphalt and soil with a hand-propelled auger. Once the soil was removed, we placed the portable data loggers inside the holes at the 30 cm (12 in.) depth and compacted the soil around each datalogger to approximate the density properties of surrounding soil. To record air temperatures, we shielded portable dataloggers inside open-ended, white plastic cylinders [5 cm (2 in.) inside diameter] at a height of 2.5 m (8 ft) above the ground. Each datalogger was programmed to record temperature every hour for 85 days (datalogger storage capacity). After each 85-day interval, we removed each datalogger, electronically transferred the data to a computer, and then resituated the dataloggers using the processes just described.

Surface Temperature Patterns of Parking Lot Landscapes

In a second study, we recorded surface temperatures at the same Arizona State University parking lot #44 every 2 hr from 1200 to 2400 hr on 16 March and 20 June 2002 at surface locations coincident with measurements of the rhizosphere temperatures just described. We also recorded surface temperatures at midday (1200 to 1500 hr) in and around parking lot medians and adjoining perimeter landscape areas at 15 commercial parking lots in the Phoenix metropolitan area once per month during summer 2002 (June to August). Surface temperature recordings at the commercial parking lots were made underneath and away from four trees each in unobstructed parking lot landscape medians and adjoining landscape perimeter areas along four cardinal (north, east, south, and west) transects starting from the base of each tree at distances of 0.46 m (1.5 ft), 1.22 m (4 ft), 3.05 m (10 ft), and 7.62 m (25 ft). Surface cover types at both landscape median and perimeter areas at the 15 commercial parking lots included asphalt, concrete, DG mulch, and turfgrass. All of our surface temperature recordings were made under clear sky and seasonable conditions with a handheld infrared thermometer (IRT: Oakton InfroPro 3, model 35629-20, Vernon Hills, IL) at approximately a 45-degree angle and 1 m (3.3 ft) above the surface, with a 7-degree field of view. Simultaneously, we recorded air temperature with a shielded digital thermometer and photosynthetically active radiation using a quantum sensor (model LI-189, LI-COR, Inc., Lincoln, NE), later converting these data to total insolation using a standard conversion factor of 2 (Jones 1992).

Rhizosphere Temperature Patterns Under Landscape Surfaces Associated with Four Land Use Types

In a third study, we recorded rhizosphere and air temperatures every hour for 85 days (6 June to 29 August 2002) at four different urban landscape sites in the Phoenix metropolitan area. The four sites were (1) a drip-irrigated commercial parking lot landscape median and adjoining perimeter landscape; (2) a drip-irrigated residential landscape with a desert landscape design; (3) an overhead sprinkler–irrigated residential landscape with a mesic landscape design; and (4) a nonirrigated remnant Sonoran Desert site (Papago Park, Phoenix, AZ).

For the commercial parking lot site, rhizosphere temperatures were recorded in parking lot medians surrounded by asphalt and in a perimeter landscape area adjoining the parking lot at the Rose Mofford Sports Complex in Phoenix (which was one of the 15 parking lots previously mentioned) with portable dataloggers (WatchDog 100-Temp 2K, installed as previously described). Landscape medians within this parking lot were about 5.3 m (17 ft) long and 1.5 m (4.8 ft) wide and were oriented in a north–south direction. For rhizosphere temperatures, one portable datalogger was positioned at a depth of 30 cm (12 in.) on the north side of each of four trees in the parking lot landscape medians and perimeter landscape area, respectively, halfway between trunk base and canopy drip line. In each landscape median, the portable datalogger was at least 0.75 m (2.5 ft) from the parking lot median–asphalt interface (at about the center the landscape median center). In the landscape perimeter area, each portable datalogger was at least 6 m (19 ft) from any portion of the asphalt parking lot. The surface cover under trees at both the landscape median and perimeter areas was DG mulch.

At the two residential and remnant Sonoran Desert sites, rhizosphere and air temperatures [one replication at each site at 30 cm (12 in.) depth and 2.5 m (8 ft) height, respectively] were recorded using shielded copper constantan thermocouples wired to a 23× micrologger (Campbell Scientific, Logan, UT). Soil moisture content at the residential xeric and mesic sites and the remnant Sonoran Desert site was measured continuously with a combination of moisture sensors (ThetaProbe™, Dynamax Inc., Houston, TX) at a depth of 30 cm (12 in.) and wired to a 23× micrologger. Soil moisture content at the commercial parking lot was not measured, though all trees at this site were regularly drip irrigated.

Data Analyses

For study one, mean (+SE) hourly rhizosphere temperatures per day were calculated for each month at each transect location, and trapezoidal integration was used to determine the number of degree hours per day that rhizosphere temperatures at each datalogger location exceeded 40°C (105°F) (Schluckebier and Martin 1997). In study two, we pooled surface temperature data to report only temperature means in response to surface cover type because no significant differences were found for the effect of parking lot location, transect cardinal direction, or position along the transect on surface temperatures. We used a general linear model procedure and Type IV sums of squares (SAS version 6.03, SAS Institute, Cary, NC) in our analysis of variance because of an unequal number of surface temperature recordings per surface cover type. We then used Duncan's Multiple Range Test to separate mean effects of surface cover type on surface temperature, $\alpha = 0.05$. For study three, only mean (+SE) hourly rhizosphere temperatures per day were calculated at the commercial parking lot.

RESULTS

Rhizosphere Temperatures in and Around a Parking Lot Landscape Median

Although we recorded rhizosphere temperatures continuously for 1 year, in this paper we have chosen to report only mean hourly rhizosphere temperatures for 4 months, September and December 2001, and March and June 2002 (Figure 1). We did this because we found that changes in daily rhizosphere temperature patterns were most evident seasonally. In general, rhizosphere and air temperatures during the course of a day were offset in sin wave patterns such that (1) the daily amplitude of rhizosphere temperatures was much less than air temperature and (2) the highest daily rhizosphere temperatures occurred after the highest daily air temperature by 4 or more hours.

During September 2001, rhizosphere temperatures ranged from 36°C to 44°C (97°F to 111°F) (Figure 1a). The lowest rhizosphere temperatures [14°C (57°F)] and smallest daily amplitudes [4°C (7°F)] were recorded in December 2001 (Figure 1b). During March 2002, rhizosphere temperatures ranged from 19°C (66°F) to 27°C (81°F) (Figure 1c). The highest rhizosphere temperatures [48°C (118°F)] and greatest daily amplitudes 11°C (20°F) were recorded during June 2002 (Figure 1d).

The highest rhizosphere temperatures were always recorded 7.62 m (25 ft) away from the landscape median center under asphalt. In contrast, rhizosphere temperature patterns at the other transect locations were nearly similar except for the month of June when the lowest rhizosphere temperatures were recorded under DG mulch at the landscape median center and 0.46 m (1.5 ft) from the median center (Figure 1). In June, temperatures above 40°C (105°F) were recorded at all transect locations under asphalt [1.22 m (4 ft), 3.05 m (10 ft) and 7.62 m (25 ft) from the parking lot median center] and the highest number of degree hours per day above 40°C (105°F) was at the 7.62 m (25 ft) location (Table 1). Moreover, the maximum daily

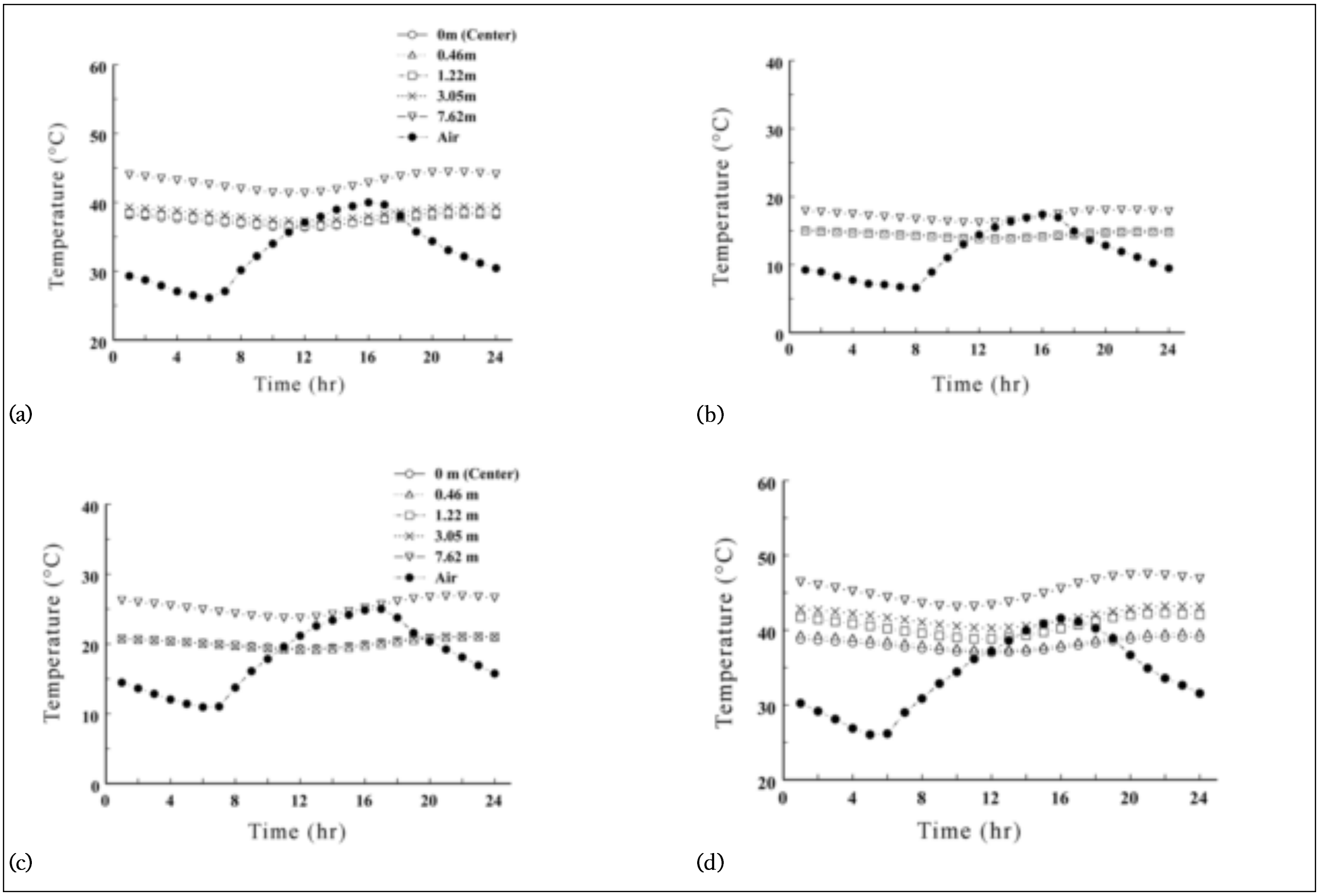

Figure 1. Mean rhizosphere temperatures [30 cm (12 in.) depth] along a gradient transect from the landscape median center into an asphalt parking lot [0 to 7.62 m (25 ft)], and air temperature [2.5 m (8 ft) height] during (a) September 2001, (b) December 2001, (c) March 2002, and (d) June 2002, at parking lot #44 on the Arizona State University campus, Tempe, Arizona. Values are location means (*n* = 4) and, where not visible, +SE is smaller than symbol size.

rhizosphere temperature at the 7.62 m (25 ft) location was about 6°C (11°F) higher than the maximum daily air temperature (Figure 1d). In September, rhizosphere temperatures above 40°C (105°F) were recorded only under asphalt 7.62 m (25 ft) away from the parking lot landscape median center. No temperatures above 40°C (105°F) were recorded during December 2001 or March 2002.

Surface Temperature Patterns of Parking Lot Landscapes

In general, surface temperature patterns were similar during March and June 2002 for all transect locations at the parking lot on the Arizona State University campus and were more responsive to insolation intensity than to air temperature (Figure 2). Surface temperatures tended to be lowest at the parking lot median center and 0.46 m (1.5 ft) from the median center, both with DG mulch cover, and highest 7.62 m (25 ft) away from the parking median center on surfaces covered with asphalt. Highest surface temperatures occurred at about 1400 hr and ranged from about 47°C (117°F) in March (Figure 2a) to nearly 65°C (149°F) in June (Figure 2b). Lowest surface temperatures occurred at about 2400 hr and ranged from about 16°C (61°F) in March to 32°C (90°F) in June.

At the 15 commercial parking lots, asphalt surfaces had the highest mid-day surface temperatures (Table 2). Concrete surfaces had higher mid-day surface temperatures than DG mulch surfaces, but they were about 12°C (22°F) lower than those of asphalt. Turfgrass surfaces had the lowest mid-day surface temperatures and averaged nearly 27°C (49°F) lower than asphalt.

Rhizosphere Temperature Patterns Under Landscape Surfaces Associated with Four Land Use Types

During summer 2002, rhizosphere temperatures under turfgrass at the residential landscape site showed relatively little daily variation and were consistently lower than

Table 1. Average degree hours (September 2001 and June 2002) over 40°C (105°F) for rhizosphere temperatures [30 cm (12 in.) depth] at five locations along transect gradients that were perpendicular to the north–south orientation of a parking lot landscape median on the Arizona State University campus in Tempe, Arizona, from the landscape median center (0.0 m) in easterly or westerly directions to a distance of 7.62 m (25 ft).

Location[z]	September 2001	June 2002
0 m (center)	0.0[y]	0.0
0.46 m	0.0	0.0
1.22 m	0.0	20.1
3.05 m	0.0	42.9
7.62 m	71.8	128.6

[z]Transect distances greater than 0.61 m (2 ft) away from the parking lot landscape medium center were covered by asphalt; distances less than 0.61 m were covered with decomposing granite mulch.
[y]Location values are treatment means, n = 4.

Table 2. Mean mid-day (1200 to 1500 hr) surface temperatures of different ground surface types surrounding landscape trees at 15 commercial parking lots in Phoenix, Arizona, under seasonally normal, clear sky conditions during July to August 2002.

Surface cover type	Temperature [°C (°F)]
Asphalt	59.4 (138.9) a*
Concrete	47.5 (117.5) b
Decomposing granite mulch	44.1 (111.4) c
Turf	32.8 (91.0) d

*Means followed by the same letter are not significantly different, Duncan's multiple range test, α = 0.05.

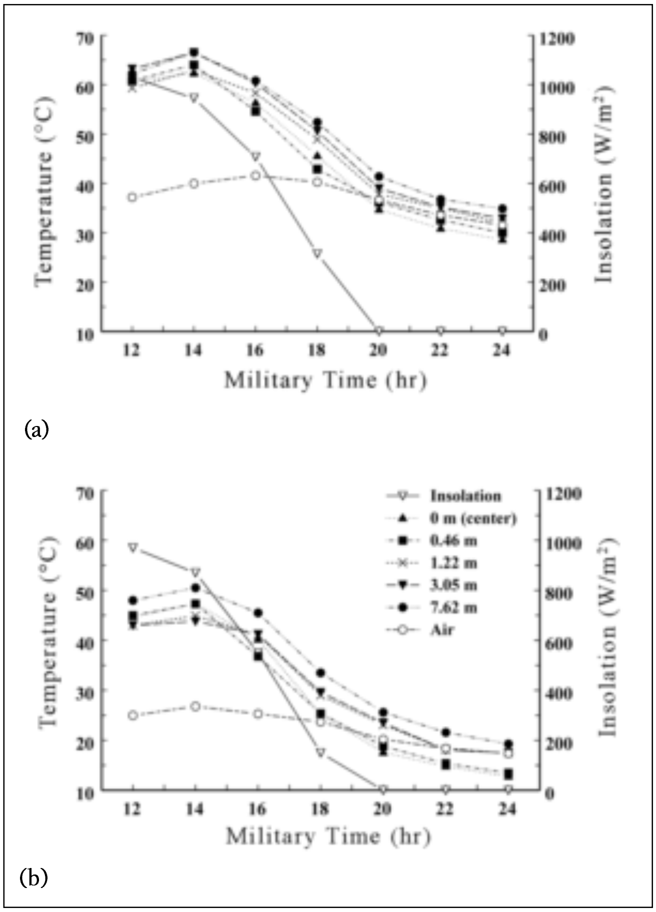

Figure 2. Mean hourly surface temperatures (1200 to 2400 hr) along a gradient transect from the landscape median center into an asphalt parking lot [0 to 7.62 m (25 ft)], air temperature [2.5 m (8 ft) height], and insolation on (a) 16 March 2002 and (b) 20 June 2002, at a parking lot on the Arizona State University campus, Tempe, Arizona. Values are location means (n = 4) and, where not visible, ±SE is smaller than symbol size.

rhizosphere temperatures under the other four landscape surface covers (Figure 3). Rhizosphere temperatures under DG mulch at the drip-irrigated xeric landscape site ranged from 32°C to 35°C (90°F to 95°F). Rhizosphere temperatures under DG mulch at the Rose Mofford Sports Complex parking lot landscape median ranged from 35°C to 37°C (9°F5 to 99°F), while rhizosphere temperatures under DG mulch in the adjoining perimeter landscape only ranged from 34°C to 35°C (93°F to 95°F).

Finally, rhizosphere temperatures at the remnant Sonoran Desert site were highest and ranged from 36°C to 38°C (97°F to 100°F). In general, the highest rhizosphere temperatures each day were recorded during the night between 2100 hr (for the DG mulch at the xeric residential site) and 2400 hr (all other surface covers), while the lowest rhizosphere temperatures were recorded during the day at about 1100 hr (Figure 3). This general daily pattern for rhizosphere temperatures lagged behind air temperature by about 4 hours for the DG mulched xeric site and 8 hours for all other surface covers. Like rhizosphere temperature patterns at the Arizona State University parking lot #44, the daily amplitude of rhizosphere temperatures at the four sites were much less than the 16°C (29°F) daily amplitude for air temperature. Relative soil moisture content ranged from 12% to 26% at the residential xeric site (DG mulch surface cover), 36% to 42% at the residential mesic site (turfgrass surface cover) and 1% to 2% at the remnant Sonoran Desert site (bare soil surface cover).

DISCUSSION

We conducted studies during 2001 and 2002 to characterize rhizosphere, surface, and air temperature patterns at parking lots and three other landscape sites in the Phoenix area. Landscapes surfaces at these sites were dominated by four cover types: asphalt, DG mulch, turfgrass, and bare soil. In general, temperatures below, at, and above asphalt surfaces were higher than for all other surface cover types.

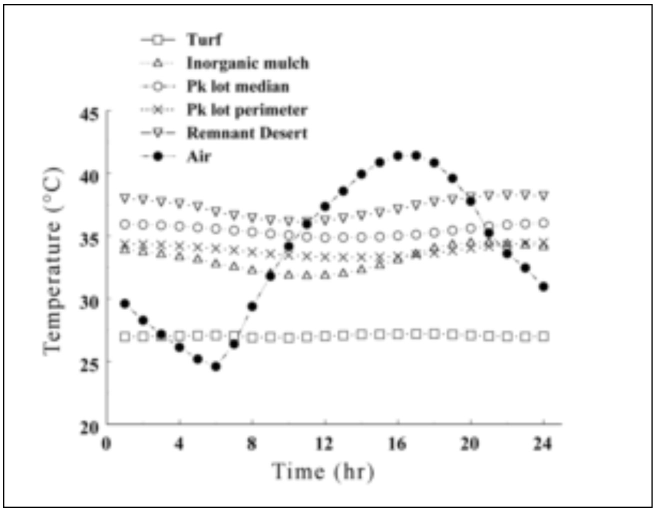

Figure 3. Mean hourly rhizosphere temperatures [30 cm (12 in.) depth] under surface covers at four sites in the Phoenix metropolitan area: (1) residential mesic with turf surface cover, *n* = 1; (2) residential xeric with an decomposing granite (DG) mulch surface cover, *n* = 1; (3) commercial parking lot landscape median and perimeter areas, DG surface mulch surface cover, *n* = 8; and (4) remnant Sonoran desert with an bare soil surface cover, *n* = 1. For air temperatures, n = 4. Hourly data for all sites are means of 35 consecutive days, calendar days 157 to 192, during summer 2002. For sites with *n* > 1, if error bars are not visible, then +SE is smaller than symbol size.

Our data support previous studies from other regions of the United States that surface and soil temperatures in the immediate vicinity of asphalt are higher than those of vegetated or mulched landscape surfaces (Halverson and Heisler 1981; Graves and Dana 1987; Kjelgren and Montague 1998). However, this study is the first to show that during summer months, rhizosphere temperatures under parking lot asphalt surfaces as near as 1 m (3.3 ft) from the median asphalt interface daily exceeded 40°C (105°F), a known critical threshold for direct injury to root tissues (Ingram et al. 1989).

The low albedo and relatively large heat storage capacity (Holman 1986; Asaeda et al. 1996) of asphalt allows it to absorb and store substantial amounts of insolation, heating it to much higher temperatures than more reflective surfaces. Conduction of this thermal energy downward into subjacent soil elevates temperatures in the rhizosphere. We found that hotter asphalt surfaces caused rhizosphere temperatures under asphalt to be about 8°C (14°F) and 16°C (29°F) higher than those under DG mulch and turfgrass landscape surfaces (Figure 1d and Figure 3), respectively.

Rhizosphere temperatures under turf surfaces showed little daily variation and maintained the coolest and most favorable rhizosphere thermal environment for tree root growth. A significant portion of heat absorbed by turfgrass is likely dissipated through evapotranspiration of water. In contrast, the remnant desert maintained the highest rhizosphere temperatures of those surfaces not covered by asphalt. This finding may be attributed to the low amounts of soil moisture for evaporative heat loss and the lack of any insulation effects provided by surface mulch covers (Li 2002). In support of this, rhizosphere temperatures beneath inorganic DG mulch were generally about 5°C (9°F) lower than those under bare soil (Figure 3).

Because daily maximum rhizosphere temperatures in parking lots occurred around 8 hr after maximum air and surface temperatures, trees growing in Phoenix parking lot medians are likely to have shoots exposed to supraoptimal temperatures during early afternoon and roots during the late nighttime hours. Elevated rhizosphere and surface temperatures above a critical threshold can cause direct and indirect damage to tree tissues, resulting in physiological and chemical changes that affect the whole tree growth and performance (Martin et al. 1991). While this threshold temperature is taxa specific, previous researchers have shown that root-zone temperatures above 40°C (105°F) can decrease tree growth (Martin and Ingram 1989). Moreover, as exposure time to supraoptimal root-zone temperatures increases, the actual temperature at which damage occurs become lower (Ingram 1985).

CONCLUSION

For landscape trees, the horizontal spread of roots is generally greater than canopy spread (Gilman 1989). However, municipal ordinances often stipulate design criteria for parking lot medians including dimensions, which can be as narrow as 1 m (3.3 ft). Our studies have shown that rhizosphere temperatures under parking lot asphalt near landscape medians are high enough to injure roots or limit the effective soil volume for normal root growth. This may be one important reason why trees in parking lot landscape medians grow poorly when compared with trees in adjoining or other landscape areas away from asphalt surfaces. Additional studies are needed to screen landscape trees to find those tree taxa best suited to perform in thermal microenvironments created by parking lots in cities of the U.S. desert southwest.

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Résumé. Les surfaces des aménagements dans les aires de stationnement peuvent affecter les microenvironnements thermiques là où des arbres poussent dans ces stationnements. Nous avons étudié les températures dans les aires de stationnement de Phoenix en Arizona qui étaient largement asphaltées autours de petits terre-pleins d'aménagement qui étaient eux-mêmes recouverts d'un paillis fait de pierre de granit décomposée, et aussi dans les parterres d'aménagements périphériques recouverts de pelouse ou du même paillis de granit. Nous avons enregistré les températures au sein de deux aménagements paysagers résidentiels de Phoenix qui étaient soient recouvert de pelouse ou de paillis de granit ainsi qu'au sein d'un site résiduel du désert de Sonoran qui était localisé à l'intérieur de la ville et dont le sol était à nu. Les températures dans la rhizosphère (30 cm de profondeur) étaient, de manière saisonnière, les plus élevées sous l'asphalte et les plus faibles sous la pelouse, et elles se produisaient entre 4 à 8 heures après que la température de l'air ait été maximale. Les température de la rhizosphère sous l'asphalte, et ce à une distance aussi proche que 1 m des terre-pleins dans les stationnements, s'élevaient à plus de 40°C suffisamment longtemps pour endommager n'importe quelle racine qui aurait poussée hors de la zone du terre-plein. Les températures à la surface du sol étaient aussi les plus élevées pour l'asphalte et les plus basses pour la pelouse, mais par contre les patrons de température en surface suivaient plus intimement ceux de l'intensité d'insolation que ceux de la température de l'air. Ces données démontrent que les températures supra-optimales de la rhizosphère autour de terre-pleins étroits d'aménagement peuvent être un important facteur qui explique pourquoi les arbres dans les aires de stationnement localisées dans le désert du Sud-Ouest poussent mal par rapport à ceux qui sont plus éloignés des surfaces asphaltées.

Zusammenfassung. Die Oberflächen von Parkplatzflächen können die thermischen Umweltbedingungen, wo Bäume wachsen. Wir studierten die Temperaturen auf Parkplätzen in Phoenix, Arizona, mit großen Asphaltflächen, die enge Pflanzflächen umschließen, die mit dekompostiertem Granitfels (DG) gemulcht waren und auch benachbarte Landschaftsflächen mit Turfgrasabdeckung oder DG-Mulch. Wir zeichneten die Temperaturen an zwei Siedlungsstandorten auf, die entweder mit Turfgras oder DG-Mulch bedeckt waren und an einem übrig gebliebenen Wüstenstandort in der Stadt mit einer unbewachsenen Oberfläche. Die Temperaturen der Rhizosphäre waren saisonal am höchsten unter Asphalt, am niedrigsten unter Turf und traten ca. 4-8 Stunden nach der höchsten Lufttemperatur auf. Die Rhizosphärentemperatur unter dem Asphalt in ca. 1 m Entfernung von den Baumscheiben waren über 40°C für so lang, um die außerhalb der Baumscheibe wachsenden Wurzeln zu beschädigen. Die Temperaturen auf der Bodenoberfläche waren ebenso über Asphalt am höchsten und über Turf am niedrigsten, aber die Oberflächentemperaturen folgten eher dem Muster der Strahlungsintensität als der Lufttemperatur. Die erhobenen Daten zeigen, dass subraoptimale Rhizosphärentemperaturen um dichte, enge Baumscheiben auf Parkplätzen ein Grund dafür sein können, warum Bäume dort schlechter wachsen als Bäume, die weiter entfernt von Asphalt wachsen.

Resumen. Las superficies de los estacionamientos vehiculares pueden afectar los ambientes térmicos donde crecen los árboles. Se estudiaron las temperaturas de los aparcamientos en Phoenix, Arizona con espacios para los árboles de mulch con roca granítica (RG) y también en áreas adyacentes cubiertas con pasto o mulch RG. Se registraron las temperaturas de las dos áreas que estuvieron cubiertas con pasto y mulch RG y un remanente del Desierto de Sonora en la ciudad con suelo desnudo. Las temperaturas de la rizófora (30 cm. de profundidad) estuvieron estacionalmente más altas bajo asfalto y menores bajo pasto, y ocurrieron 4-8 horas después de las temperaturas ambientales más altas. Las temperaturas de la rizófora bajo asfalto a un metro del lote de aparcamiento estuvieron arriba de 40°C lo suficiente para afectar cualquier raíz de los árboles que crezcan allí. Las temperaturas de la superficie fueron también más altas para asfalto y más bajas para pasto, pero las temperaturas superficiales siguieron patrones más cercanos a la intensidad de insolación antes que de la temperatura del aire. Estos datos muestran que las temperaturas óptimas de la rizófora alrededor de los estacionamientos pueden ser importantes, razón por la cual los árboles en estos sitios crecen pobremente comparados con aquellos lejos de esas superficies.