3.6. Trees in commercial parking lots

Introduction

Parking lots can occupy a substantial amount of a City's land area. In Sacramento for instance, 5.6% of the land area is occupied by parking lots (McPherson 2001). Trees in parking lots help mitigate some of the negative environmental impacts of parking lots while improving their appearance. Adequate numbers of appropriately placed trees can mitigate stormwater runoff and reduce the temperatures of both pavement and vehicles, thereby improving both water quality and air quality. However, parking lots can be harsh sites for tree growth, so good site design and proper tree maintenance are needed to achieve the benefits that parking lot trees can provide.

Overview

Findings

- The City of Rocklin has several regulations designed to increase tree canopy in parking lots.
- Surveyed parking lots had low levels of shading provided by trees. Less than 3% of surveyed parking spaces were at least 50% shaded.
- Less than half of the surveyed parking lot trees actually provided canopy cover over parking spaces.
- Ratios of parking spaces per tree were variable, ranging from 2.25 to almost 8 parking spaces per tree.
- Small parking lots generally had higher levels of shading and fewer parking spaces per tree than larger lots.
- Most parking lot trees were well below mature size.
- Levels of parking lot shade were not correlated with parking lot age.
- Empty tree planting sites were common, averaging 9% of all planting sites overall. The number of empty sites increased with increasing parking lot age.
- About 7% of existing parking lot trees were in poor condition.
- Most parking lot trees are of only moderate size at maturity, and 18% are small-statured trees that will not provide substantial shade at maturity.
- Most native oaks retained in parking lots were in poor condition, although some have survived for over 20 years since construction.

Management issues and recommendations

- Changes in parking lot planning and tree maintenance practices will be needed to increase levels of parking lot shading in Rocklin.
- Lower ratios of parking spaces per tree can help increase shading, but only if coupled with proper tree placement and tree size.
- Soil conditions need to be improved in parking lot tree planting sites to improve tree growth, condition, and survival. Soil problems should be avoided or corrected before the original planting and corrected as needed before replanting empty sites.

- Tree species used in parking lots should only include those that are adapted to the relatively harsh site conditions.
- Native oaks retained in parking lots can sometimes provide many years of substantial canopy cover even if the rootzone has been excessively encroached upon by construction activity. Greater levels of rootzone protection would improve the long-term health and survival prospects of most retained trees.
- Follow-up monitoring of parking lots is needed to ensure that trees are properly maintained and replacements are planted as needed.

Current status

Existing Regulations and Plans

The City of Rocklin has enacted regulations designed to enhance tree planting and shading in parking lots. Section 6 of the Design Review Resolution adopted in 2000 has requirements for landscaping in parking lots. It specifies a ratio of 5 parking spaces per tree, calls for trees to be distributed throughout the parking lot, and mandates the use of drought resistant species and that the overall landscaping plan conforms to the State Water Conservation in Landscaping Act (AB325). In addition it requires existing trees be incorporated into the parking lot design where possible.

Phytosphere also reviewed the Northwest Rocklin General Development Plan and the Northwest Rocklin Design Guidelines. These plans are typical of those used in new developments within the City. The General Development Plan requires that parking lot landscaping be designed to filter light and daytime glare from distant views through the use of dense canopy shade trees, earth berms, and continuous perimeter landscape plants. Parking lots must also include a minimum 15-foot wide perimeter landscaping area and/or earth berm along adjacent streets to assist in screening the views of parked cars (Northwest Rocklin GDP, Section N Landscaping, item 1).

The design guidelines require that one tree be provided for every five parking spaces within non-residential parking lots (Northwest Rocklin Design Guidelines, Section 6 Landscaping, Item G). Landscaping materials are to be selected with consideration for water requirements over the lifetime of the plants. The use of materials with low water requirements, particularly plants that are considered drought tolerant, and the use of efficient irrigation systems are strongly recommended and may be required (Northwest Rocklin Design Guidelines, Section 6 Landscaping, Item I).

Field assessment of parking lot trees

Phytosphere surveyed portions of ten parking lots on commercial properties in Rocklin in late August and early September 2003. Within the sampled portion of each lot, Phytosphere collected data on the number of trees, empty planting spaces, and parking spaces. In all, 867 parking spaces were surveyed. Phytosphere directly assessed the number of trees that were currently shading parking spaces, the number of spaces being shaded, and the degree to which parking spaces were shaded. Phytosphere also collected data on tree age class, condition, and species. Details of the survey methods used are presented in Appendix 7.1.6.

Characteristics of surveyed areas

The randomly-selected parking lots in the survey included large retail centers (Figures 3.6-1, 3.6-2), business professional complexes (Figure 3.6-3), a single small commercial building (Figure 3.6-4), and a hotel/restaurant site. The locations and characteristics of the parking lots are listed in Table 3.6-1. Four of the parking lots (1, 8, 9, and 10) were constructed within the previous 10 years. All other lots were constructed prior to May 1993.

Table 3.6-1. Locations and characteristics of commercial parking lots included in the survey. For all lots other than number 2, only a portion of the lot was sampled. Parking lots that include retained native oaks are noted.

Lot	Type of business	Location	Number of parking spaces surveyed	Includes retained oaks	Approximate year landscape installed
1	Retail center	Pacific St. / Sunset Bl. SE (Dollar Tree)	89	no	1995
2	Bank branch	Whitney Bl. / Sunset Bl.	23	no	1975
3	Professional offices	4200-4240 Rocklin Rd.	97	yes	1986
4	Retail center	Stanford Ranch Rd. / Sunset Bl.	86	no	1991
5	Retail center	Granite Dr./Sierra Meadows Dr. S (Safeway/Longs)	91	yes	1982
6	Retail center	Pacific St. / Sunset Bl. NE (K Mart)	118	no	1989
7	Professional offices	Fairway Dr. / Sunset Bl.	81	no	1992
8	Retail center	Stanford Ranch Rd. / Park Dr.	100	no	2002
9	Retail center	Five Star Bl. / South Whitney Bl.	81	no	1998
10	Hotel / restaurant	China Garden Rd.	101	yes	1997

Almost all of the parking lots had some trees in planting beds located along the adjacent streets or along buildings. Most larger lots also had trees in planters of various sizes and configurations that were located within the lot. Three parking lots (Table 3.6-1) included one or more native oaks that were retained on site during development (Figure 3.6-2).

The bank parking lot (number 2, Figure 3.6-4) was the smallest lot surveyed, and all of its spaces were included in the survey. All of the non-covered spaces at lot 7 were also included in the survey. For the remaining lots, two or more aisles of parking spaces were selected at random for the survey.

Figure 3.6-1. Parking lot 6 has relatively large planters, but trees are widely spaced with only one tree per nearly 8 parking spaces. About 12% of the surveyed parking spaces were at least 25% shaded.

Figure 3.6-2. Large eucalyptus trees at lot 5 were being removed at the time of the survey, reducing tree canopy. This lot included several conserved oaks, including the one in the background to the right.

Figure 3.6-3. This professional office development (lot 7) had the highest percentage of shaded parking spaces and the lowest ratio of parking spaces to trees (2.25) of the surveyed lots.

Figure 3.6-4. In lot 2, the smallest and oldest lot surveyed, few trees were planted in areas where they could shade parking spaces.

Tree age class

Phytosphere compared current tree size to the typical size of a given tree species at maturity to estimate age classes of trees in the surveyed parking lots. Only about 12% of the trees in the surveyed lots were more than 75% of mature size (Figure 3.6-5). Most of the trees that were at or near their mature size were trees that develop small to medium canopy size at

maturity. Several mature oaks that had been retained in or near parking lots during development are also included in the most mature age class. Some coast redwoods were also rated as being at more than 75% of mature size because they were not likely to show much more growth given the limitations of the sites in which they were planted.

Parking lot trees were mostly in the younger/smaller age classes for several reasons. A number of the parking lots were not very old (Table 3.6-1), so trees were still young. However, many older lots still had trees that were well below mature size. This was generally due either to slow growth associated with poor site conditions, e.g., small planters in the middle of pavement or the fact that trees had died or were otherwise removed and replaced with trees that were much younger than the parking lot's age.

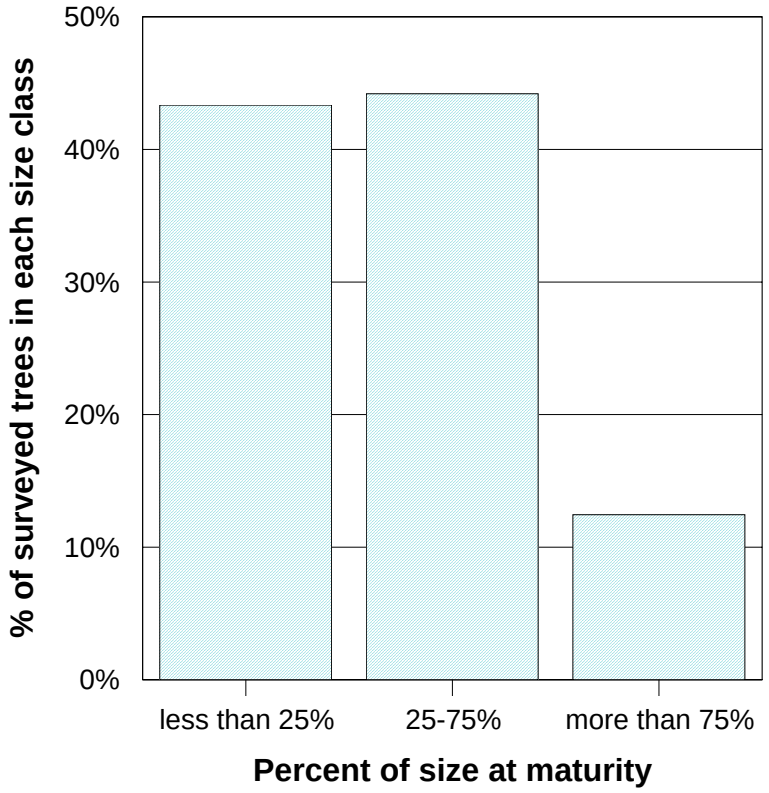

Figure 3.6-5. Age classes of surveyed parking lot trees. Most of the surveyed trees in parking lots were not yet of mature size.

Parking space to tree ratios

The ratios of parking spaces to trees for the ten surveyed lots are shown in Figure 3.6-6. The ratio ranged from one tree for every 2.25 spaces for a professional office complex to one tree for every 7.9 spaces in a large retail shopping center. These ratios exclude trees that were too far from parking spaces to provide overhead shade at maturity. If tree sizes are equal, lower parking space to tree ratios are likely to shade larger portions of the parking area. Greater levels of planting near buildings and/or along streets contributed to the lower space/tree ratios seen in narrow parking lots situated around buildings (Figure 3.6-3) compared with large parking lots (Figures 3.6-1, 3.6-2).

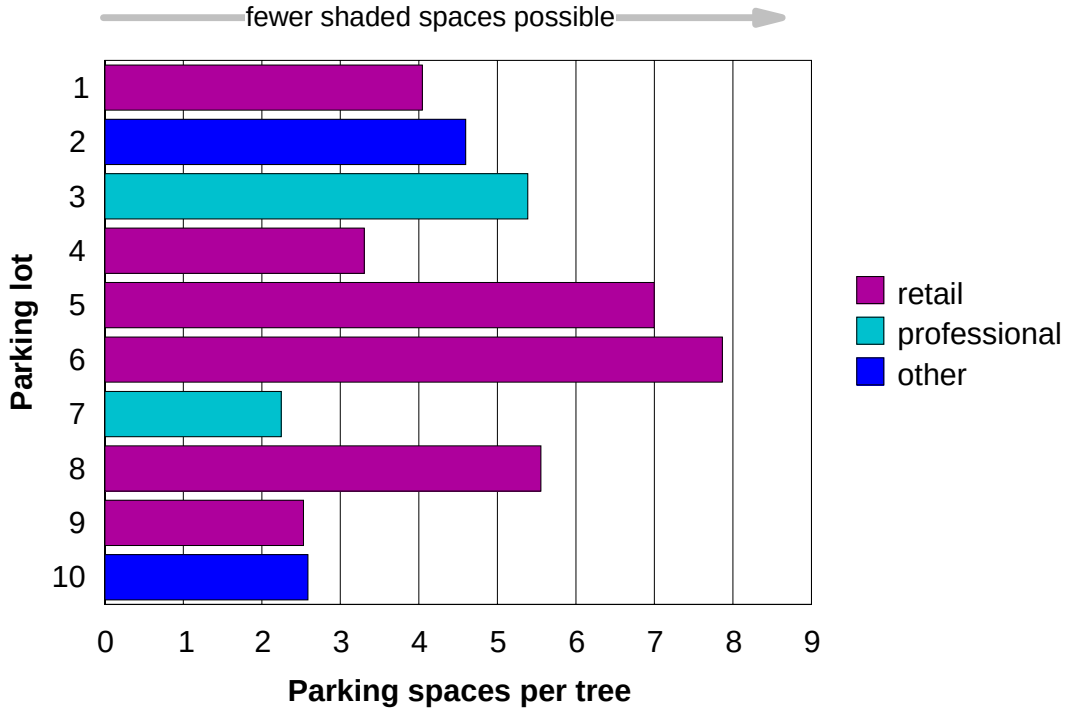

Figure 3.6-6. The number of parking spaces per tree varied by more than a factor of three between the surveyed parking lots. Even similar types of commercial developments showed a wide range in the number of spaces for each tree. Parking lot numbers are as in Table 3.6-1.

Shading of parking spaces

The survey evaluation directly addressed whether tree canopy extended over parking spaces, providing overhead shade in midsummer. In general, a parking space needs to be at least 25% shaded (green portions of bars in Figure 3.6-7) before it can provide any substantial midday shading of a car's passenger compartment. As shown in Figure 3.6-7, the proportion of spaces receiving even partial shade was low for most surveyed lots. Overall, only 2.7% of all surveyed spaces were more than 50% shaded. An additional 5.3% of the surveyed spaces were 25% to 50% shaded.

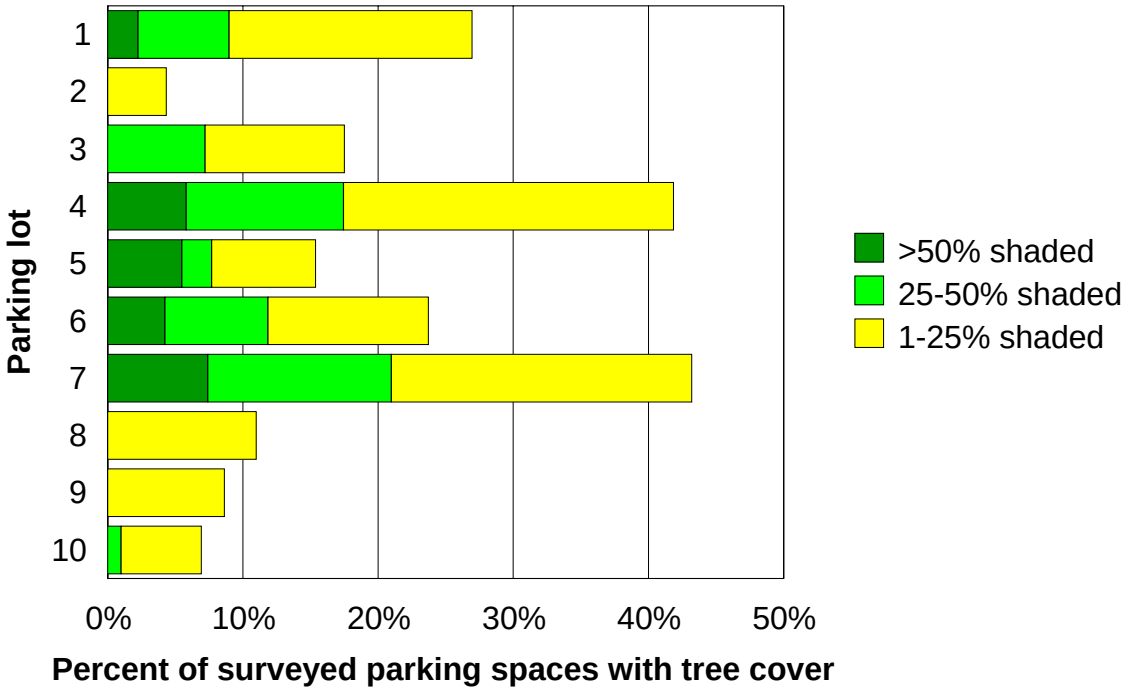

Figure 3.6-7. The percentage of parking spaces with overhead tree canopy in the ten surveyed parking lots. Spaces with more than 25% shading (green) would generally have enough canopy to at least partially shade vehicle windows. Parking lot numbers are as in Table 3.6-1.

Tree size, planter size, and the placement of trees in planters all influence whether trees actually shade parking spaces. Small-statured and young trees are less likely to extend over parking spaces, especially if they are in large planters, such as those that border parking lots. Overall, the percentage of trees in the lots that actually provided shade to parking spaces was quite variable, and ranged from 20% to 87%. On average, only 46% of the surveyed parking lot trees were actually providing canopy over parking spaces.

The highest levels of shading were seen in parking lots 4 and 7, which had 2 to 3 parking spaces per tree (Figure 3.6-6). However, because some parking lots contain trees that are too small to provide much shade at maturity, the number of parking spaces per tree doesn't necessarily predict shading levels. Parking lot 6, with about 8 parking spaces per tree, had a higher percentage of at least partially shaded spaces than most other lots because many of the trees present were relatively large London plane trees. Lots 8, 9, and 10, all had similarly low shading levels (Figure 3.6-6) even though lots 9 and 10 had much lower space to tree ratios than lot 8 (Figure 3.6-5). In all three of these lots, trees were relatively young and well below their

potential size, although at location 9, poor maintenance and site conditions may also be stunting tree growth. The low level of shading in lot 2 was due to the fact that most trees were in the planter between the street and lot, and few trees were properly positioned within the lot to shade parking spaces.

Influence of parking lot age

Over time, a tree's canopy normally increases in size until it reaches the maximum size it can attain. This maximum size is determined by both the genetics of the tree and the constraints of the site in which it is growing. Pruning can also artificially limit the maximum size a tree will attain.

In general, shading levels in parking lots are assumed to increase over time as trees grow older and larger. However, for the 10 surveyed parking lots, this did not happen. Older parking lots did not have the most shade (Figure 3.6-8, top). In part, this was because they typically had the most empty planting spaces (Figure 3.6-8, bottom). These data suggest that instead of becoming progressively shadier over time, parking lots shade levels tend to level off within a decade or so, and may actually decline thereafter due to the loss of trees.

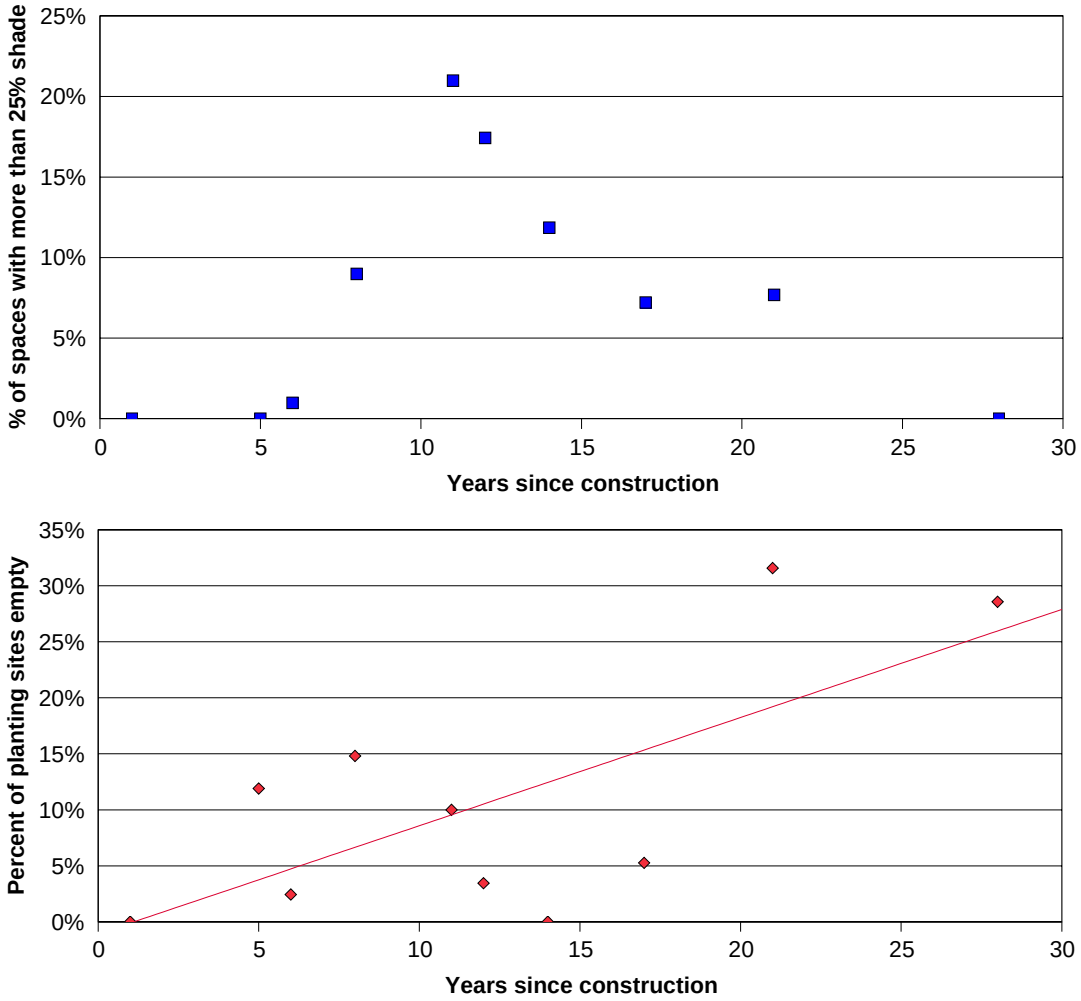

Figure 3.6-8. The percentage of parking spaces with at least moderate amounts of shade (more than 25% shaded) was not correlated with the age of surveyed parking lots (top).

However, the percentage of unoccupied planting sites did tend to increase significantly with the age of the parking lot (bottom).

Species composition

Twenty-five tree species were present in the surveyed parking lots. The number of species per lot ranged from 3 to 8, but plantings were usually dominated by a single species. For example, in lot 4, hackberry trees constituted over 70% of the surveyed trees. In most lots, at least one third of the trees were of a single species, but the most common species generally differed from lot to lot.

Overall, 32% of the surveyed trees were species that have large canopy spread at maturity. About 18% were small-canopied species, including crape myrtle and purple leaf plum. These small trees can extend over parking spaces in some situations but seldom provide significant shading in parking lots. Most of the trees in the surveyed parking lots were species that have moderate canopy spread at maturity, and therefore have a limited ability to shade parking spaces.

Conserved native blue oaks and interior live oaks were present in three lots (Table 3.6-1) and native oak species were planted in two other lots. Retained oaks made up the majority of all large-statured trees that were in the oldest age class (>75% of mature size). Other large-statured species included London plane (11% of surveyed trees), pin and/or scarlet oak (4.7%) and valley oak (12%). Valley oak was planted extensively in lot 10 only.

Although the majority of species present in parking lots were species that have the potential to survive in these relatively harsh sites, some species appear to have poor prospects of long-term survival. Trees that have high water demands, including birch, coast redwood, and Lombardy poplar, were present in several lots. These species were generally planted in linear beds that provide more rooting volume than cutouts surrounded by pavement. However, even in such sites the long-term prospects for these species are not good. As these trees reach the maximum size that the available rooting volume and applied irrigation can support, they will tend to become water-stressed during the late summer. When stressed, these species become susceptible to canker diseases and/or wood-boring insects that can cause the trees to decline.

Tree condition

About 93% of the surveyed trees in the 10 parking lots were in fair to good condition. However, this figure doesn't tell the entire story with respect to tree health in these lots because severely declining and dead trees are likely to be removed rather than left in place. Overall, 9% of all planting spaces were empty, and the percentage of empty sites was as high as 32% in one lot (Figure 3.6-9). When empty planting spaces and declining trees are considered together (Figure 3.6-9), impacts of poor tree health on parking lot tree populations are more obvious. In the case of parking lot 5, the high percentage of missing trees was due to the removal of large eucalyptus trees, which was ongoing at the time of the survey (Figure 3.6-2). It was not clear why these trees were being removed, but factors other than tree health may have been involved.

Poor tree condition was not limited to the oldest parking lots. Lot 9, which was about 5 years old at the time of the survey, had a high combined percentage of missing and declining trees (Figure 3.6-9).

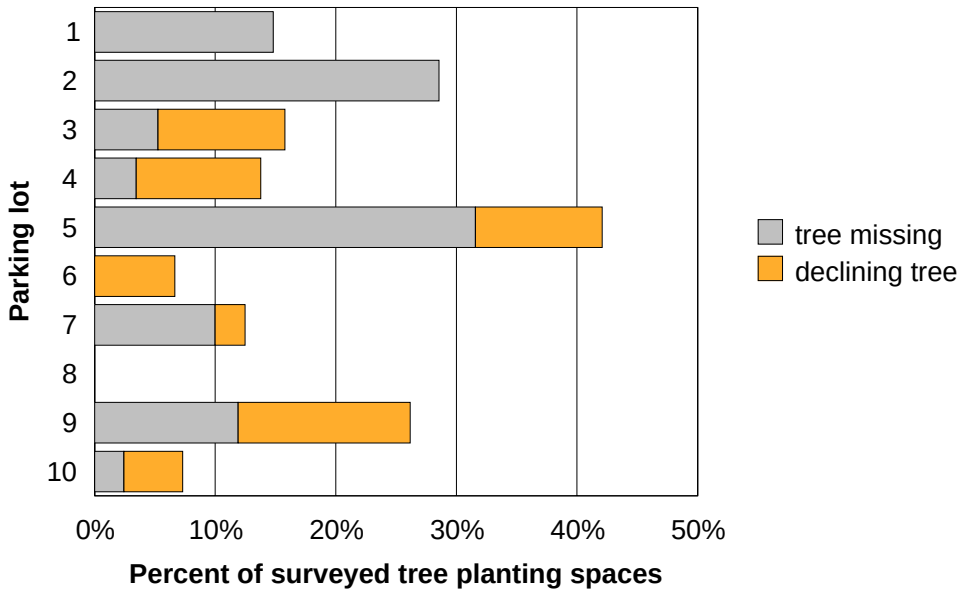

Figure 3.6-9. Combined impacts of missing trees and tree decline on tree populations in the sampled parking lots. Empty planting spaces result from tree removal due to a variety of reasons, although tree decline and death is a common cause of removal.

Because most species in the sample were present in small numbers, few conclusions can be drawn about health trends by species. One clear trend is that many of the conserved native oaks in parking lots were declining In general, mature oaks do not readily tolerate the high amounts of root loss and rootzone alteration that typically occur during parking lot construction. On the other hand, although many are beginning to decline, most of these retained oaks have already outlived some of the trees that were planted when the parking lots were developed. For example, in lot 5, the retained native oaks have already survived over 20 years since the lot was developed, while the planted eucalyptus were removed this past summer. If reasonable efforts are made to protect mature oaks during parking lot development, these trees can provide a substantial amount of canopy for many years, even if their potential lifespan is reduced.

Other species showing relatively high levels of decline in parking lots include Chinese tallow, hackberry, magnolia, and coast redwood. The two latter species generally do not perform well under the especially hot, dry conditions found in parking lots.

Management issues and recommendations

Overall, current levels of shade in Rocklin parking lots are relatively low. Aside from the nuisance factor associated with hot vehicles, lack of shade in parking lots creates a local heat island which increases cooling costs for buildings. Rates of fuel evaporation are also higher from hot vehicles, and the increased volatile organic compound (VOC) emissions lead to higher air pollution levels. In one study, researchers found that parking lot trees in Davis, CA, reduced the surface temperatures of asphalt by as much as 36°F, cabin temperatures of vehicles by over 47°F, and fuel-tank temperatures by nearly 7°F (Scott and others 1999).

Several factors contribute to low levels of shade in Rocklin parking lots. Many of the surveyed lots simply had too few trees in positions to do the job. Ratios of parking spaces to trees only partially explain the situation. Parking lots can have low numbers of well-shaded spaces for several other reasons:

- if many of the trees are planted around edges of the lot, little of the canopy may extend over parking spaces;

- trees with small canopies will provide little shading even at relatively high planting densities. Canopy size may be small because trees are young, have been stunted by poor site conditions or improper maintenance, or are simply small-statured at maturity;

- if trees are planted densely (mainly in linear planters near buildings or the edges of the lot), canopies can overlap and provide less shade than more widely spaced trees would.

Furthermore, parking spaces typically occupy only a portion of the total paved area of a parking lot. In the best-shaded lot (lot 7, Figures 3.6-3, 3.6-7), about 7% of the spaces were more than half shaded. When driveways and aisles between parking spaces are taken in to account, it is clear that the absolute level of canopy cover over the paved portion of this lot is less than 5%. To increase levels of parking lot shade beyond that seen in the surveyed lots, additional tree planting and design changes are needed to maximize the amount of effective pavement shading provided by trees.

Tree health and maintenance are other factors that influence levels of shade that develop in parking lots. If growing conditions are poor, both new and older trees will remain stunted and will not attain the size anticipated in the approved landscape plan. Tree canopy size can also be restricted by improper pruning practices, such as topping. An evaluation of Sacramento's parking lot ordinance, which requires 50% shade after 15 years, found that many trees in parking lots did not attain the canopy spreads shown in plan diagrams (McPherson 2001). Average shading in Sacramento parking lots at least 15 years old was about 8%.

Parking lot canopy cover is also adversely affected by premature tree decline and death. Tree death and removal causes an immediate loss of tree canopy. If trees are not replaced, the ratio of parking spaces per tree is increased over the long term. Even if trees are replaced, the new trees are small and typically do not provide significant shade for a number of years. Any program to develop better-shaded parking lots has to include provisions to replace lost trees and monitor the health and maintenance of existing trees.

As currently constructed, parking lots are typically not good sites for tree growth. This is a recognized problem throughout the United States and ameliorating these harsh growing conditions is the focus of much urban forest research. Soils under pavement are normally compacted to levels that inhibit root growth. Compacted soils may also drain poorly, leading to long periods of soil flooding in the winter or after irrigation. Impervious pavement reduces the amount of water and oxygen in the soil, further restricting root growth. Unshaded pavement absorbs and re-radiates heat, making summer growing conditions especially hot. Due to all of these factors, small cutouts in paved areas are very difficult environments for tree growth. Berms, mounds, and slopes, which are common in planters around the edges of parking lots, can be excessively dry sites because much of the applied irrigation runs off from the sloped areas.

These negative features can be mitigated to some degree through design and construction techniques. Increasing planter size and using linear planters can provide greater amounts of rootable soil, but only if the soil is deeply tilled to reduce soil compaction and improve drainage. Irrigation systems must be designed and operated to ensure that applied water does not simply run off. Some areas of impervious pavement can be replaced by pavers or other pervious materials within the rootzone. Structural soil mixes, which provide adequate levels of aeration and pore space when compacted to engineering specifications, can be also be used to increase the rootable area beneath pavement. Tree species that are more tolerant of heat and drought can be used in preference to species that do not perform well under such conditions. Some of these

these improvements, such as decompacting planting beds and making use of permeable paving materials may require some additional costs at the construction phase, but these modest investments will pay off in terms of reduced maintenance, superior tree performance, and more shade-related benefits over the long term. In older lots, efforts to ensure that missing trees are replaced will be more successful if they include soil modifications to improve growing conditions.

Constructing parking lots usually involves grading, compacting soil to engineering requirements, and building trenches for underground utilities. All of these activities commonly occur in the rootzone of native oaks that are incorporated into parking lots. Such activities destroy sizeable portions of the root systems of these trees, which has negative impacts on tree health, particularly for older trees and those on harsher sites. Given these impacts, it is not surprising that most of the native oaks retained around parking lots were in decline.

At least some of these retained native oaks are trees that have been counted as removed trees (i.e., mitigation fees have been paid as if the trees had been removed) but efforts are nonetheless made to retain the tree, with the knowledge that its lifespan will be significantly shortened. As noted in the discussion of tree canopy cover (Section 3.1), conserved oaks contribute significantly to Rocklin's overall canopy cover, so the retention of trees even on a temporary basis does provide significant benefits. However, whenever existing oaks can be sufficiently protected to allow for long term survival, benefits provided by these mature trees will extend for a longer period, and costs associated with tree removal will be deferred.

Protecting roots only within the dripline is usually insufficient to allow a retained tree to attain a normal lifespan. Revising standards to set a target for protecting at least half of the rootzone and a specific zone around the trunk could improve the long-term survival prospects for retained oaks (see Appendix 7.4). Incorporating oaks as a groups into parking lots can also provide for more root zone protection (Figure 3.6-10). In addition, it is necessary to closely monitor compliance with oak protection measures during development and encourage better stewardship of retained oaks. Because mature trees have such a major effect on shading, local microclimate, and aesthetics, efforts to ensure better protection of retained oaks will provide immediate benefits.

Figure 3.6-10. Conserved mature blue oaks incorporated as a group into a new parking lot, in keeping with the Design Review Resolution adopted in 2000.

Poor pruning practices, such as topping, were not observed in the surveyed lots. Excessive pruning of parking lot trees tends to occur when trees start to grow large enough to obscure signage or when property ownership changes. Given the difficulty associated with developing adequate parking lot shade, practices that could unnecessarily destroy mature canopy need to be prevented before they become a problem. Parking lot owners should be made aware of the need and advantages of developing tree canopy in their lots so that they will take the steps necessary to protect their trees.

References

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Scott, K. I.; Simpson, J. R.; McPherson, E. G. 1999. Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions. Journal of Arboriculture 25(3): 129-142.