2005-05

Landscaping Parking Lots

Georgi, Neratzia Julia

WSEAS (World Scientific and Engineering Academy and Society)

Landscaping Parking Lots

JULIA NERAGIA GEORGI , MARIA KAPNISTOU

*Dr. Landscape Architect (MLA, Newcastle University, UK), Tutor of Hellenic Open University, Spec. Scient. of Ministry of Environment, Planning and Public Works, P.O. Box. 13680, 10310,

** Architect Engeneer, Landscape Architect (MLA, Harvard University, USA) Ministry of Environment, Planning and Public Works, P.O. Box. 13680, 10310,

Abstract: - Parking lots typically are designed to accommodate as many automobiles as possible. The common product is an expanse of asphalt lacking vegetation that negatively affects the urban microclimate. The usual design of parking areas in the urban landscape, proposes: extended areas of hard surface, and only traces, if any at all, vegetation.
Although parking lots areas can cover up about half of the land area in cities and therefore offer a great opportunity to possitively influence and improve urban climate. Landscape architects have the potential to mitigate urban heat islands, urban wind, and urban precipitation by understanding what causes these phenomena and knowing a few key principles by which to mitigate them.
This paper investigates how well principles of designing with climate have been incorporated in a specific project and refers to this case study, describing the design and the construction of a complex of 4 parking lots that aims to improve broader areas' microclimate. Finally, in the coclusion of this paper, guidelines and recommendations are gathered together in order to help designers propose well functionally and aesthetically parking lots.

Key-Words: - parking lot, design, construction, bioclimatic design, microclimate, tree planting

1 Introduction

Concerns for environmentally sustainable urban development and planning have grown in urbanization, exemplified by catchpbrases such as "smart growth" and increased legislation with regard to environmental impacts.
A trip to the central business district of most European and American cities will quickly convince anyone that urban climate modification through urban parking lots is, as a general rule, ignored.

Parking lots typically are designed to accommodate as many automobiles as possible. The common result is an expanse of asphalt lacking vegetation, that negatively affects the urban mesoclimate. This paper about the fact that parking lots can serve as more than just a storage space for automobiles. A well-designed lot, wherein climate modification has been considered from the initial design stages, will serve as a positive contributor to the urban ecosystem.
The benefits of designing with climate in general can be divided into the following classifications: environmental, economic, human health, and sociability of the city. The environmental benefits of climatically sensitive design include improvements in water and air quality. Air quality can be improved by reducing the amount of ground-level ozone and other air pollutants being emitted by automobiles and other man-made machinery [1], [2]. Water quality will be improved with the introduction of stormwater infiltration areas and vegetation capable of filtering out pollutants [3].
The economic benefit of designing with climate is lower energy consumption for the city [4] , [5]. Protecting buildings from extreme heat and cold can reduce the need for heating and air conditioning. Reducing the use of HVAC units also reduces global warming by lowering the amount of

pollutants the power plants that run these units release into the atmosphere [6].
Designing with climate can also improve the health of the city dweller [7], [8]. Designing with climate can increase urban ventilation and cleanse the city of many airborne diseases. Reducing air temperatures in the city during summer months can also help to reduce the occurrence of heatrelated illnesses. Designing with climate also reduces lower-level ozone pollution, a cause of serious health risks for children, the elderly, and those with asthma [9]
Finally, the quality of community life can be enhanced by designing with climate [2]. Creating comfortable spaces for pedestrians can help to encourage more sociable cities and improve the lifestyle of its inhabitants. Lengthening the time
of year in which people may comfortably remain outdoors will help to enrich urban life by allowing for a greater amount of activities.
It is important for designers to realize that the design of a site affects the microclimate of that site and can make an impact on pedestrian comfort within that site. Designing with climate in only one site, however, will have little effect on the mesoclimate of the city. In order to have a noticeable effect citywide, multiple sites within the city must be designed to improve climate.

Outgrowths of these concerns are the development of community tree management plans and the adoption of municipal shade tree ordinances. Within many ordinances, and in recommendation templates for ordinance development, there is language for the assignment of minimum canopy cover in the design of parking lots and industrial development areas [10], [11], [12].

Design of parking areas usually provides for some level of tree canopy establishment, in balance with space concerns and capacity parking issues [11], [12], [13], [14] . Tree ordinance language often provides formulae for calculating the required number of individual trees. Methods include using a canopy cover percentage, meeting a canopy target per unit of paved area, using a set number of trees per unit paved of area, or mandating vegetation space per number of parking spaces. Often when a percentage of cover is mandated, there is a time frame imposed for such a designated level of coverage target to be fulfilled, such as 50% shade of the lot within 15 years [11], [12]. A limitation of the growth prediction method is the lack of measured tree growth impacts from the parking lot environment, and the unfortunate lack of prophetic prowess of professionals for estimating attrition, car hits, maintenance damage severity, pavement resurfacing needs , and design changes over time.

While field wisdom and experience is useful, quite often professionals charged with the design of planting spaces have little or no training or experience beyond any casual personal observation. Alternatively, the designer may consult an industry contact who also relies on general observation rather than measurement. As a result, ordinance requirements may be met by creating tree planting spaces and tree species selection with tree growth expectations based on references for tree growth in parklike or natural settings [16], [17], [18], [19], [20]. Such references do not report reduced growth or basic tree-pavement design limitations; thus, designs meet the design letter of the law in planning for canopy but fail to meet the intent oi the law clue to lack of growth [21]. While there is anecdotal evidence that trees in parking lots are smaller than those growing in less stressful environments, little data are available to document the effect. The goal of this study was to show the first results from the designing parking areas by using several tree species in contrary with other parking areas in Greece that are designing without any trees at all.

3 Methodology

This method that is followed in this paper is:

1. Present the project of Kifisos parking lot complex
2. Present the difficulties at the construction phase (level)
3. Estimate the current growth of the tree species and the benefits that result
4. Evaluate the results
5. Make Future recommendations for Parking lots projects and concluding several guidelines for designing and construction parking lot with bioclimatic criteria

Before the Project - The Existing Landscape

The existing landscape before the constuction of the new project was a 3 lane each direction road, connecting the center of Athens and South areas of

Attica to Pireas. The project concerned a heavy structured area with damaged views, of litter and rubble disposal, suffering by heavy traffic jam. It's a coastal area with covered edges at the sea level kept far away from the physical point. The area was unorganized and without any use so the new project was necessary.

The description of the Project

The main new element of the project was the construction of a big 15 different direction interchange.

The site of the project is:

- At the edge of the urban environment of Athens, where the city meets the sea,
- in front of the main Athletic Complex (the Stadium of Peace and Friendship) and
- by big transportation node of the Metro-Subway and the Tram system.

The position of the project is very important and very critical for the car circulation both in the regional and the city scale:

- connecting Athens to Pireas (the main international port of Attica),
- connecting Athens to South areas of Attica (Glyfada, Voula, Sounio, etc),
- accessing the main National road to North and South Greece (through Kifissos Avenue),
- distributing car circulation to the local streets of Pireas and Faliro areas.

Also the project services pedestrians using the Metro or Tram system or parking their own car, to walk across the multi-intersection through underpasses, in order to access waterfront, the Athletic complex of Peace and Friendship, the Karaiskakis Soccer Stadium or the neighbourhoods around the area.

The access to the Athletic Complex of Peace and Friendship is very important, as it accommodates not only the Athletic Facilities for big events and everyday workouts but also accommodates big cultural, political and educational events that bring together thousand of visitors in one day, often for several days.

Also project's position next to the new Yacht Marine and next to the sea facilitates Yacht owners and visitors to enjoy the new facility and the waterfront.

From all above, plus:

- the proximity of the 'Karaiskaki' Soccer Stadium, 'home' of Olympiakos Soccer team, that is one of the biggest and most popular Greek soccer teams and
- Metropolitan Hospital,

there has been the need for parking lots that can accommodate hundreds of cars in one day. The challenge of course was to create parking lots with good microclimate, that function as needed but also provide spaces with aesthetical value even when those are empty.

In the general reformation of Attica, because of the Olympic Games in Athens in 2004, this project was proposed as one of great importance, since the Athletic facilities of the area would accommodate certain Olympic games. Also the greater area along (of) the coast for several kilometers, from the site of the project to the South areas of Attica, Glyfada, etc, was one of the main Olympic zones, with areas for many different Olympic Venues and spaces for other than Games Olympic events, like the Sponsors' Park, etc.

As a conclusion from the above, the functional program of the site was definied as below:

- Car and Pedestrian access to Stadiums (SEF and Karaiskaki), Marine, waterfront, Metropolitan Hospital, urban neibourghoods in the area, the new Tram station (Afetiria) and old Subway-Metro system,
- 4 new parking lots, Pedestrian walking and resting areas.

The Design challenge was about organizing all the above in a way that function and form, practical and aesthetical issues, would be addressed, within the Bioclimatic and International Construcion Standards, the best way possible. The project was divided in two main projects:

- the multi-interchange Road project, that is roads on the ground, connecting bridge-roads and ring roads, exits and entry roads coming up and down the ground level,
- the Lndscaping Project, that is the Project of remodeling and planting the areas in between, around and along the new car roads and bridges. It also includes the

pavement constructions, two new water reservoirs for irrigation and the creation of four different places for parking area.

The design concept

The main concept and priorities of this project were to landscape the surrounding area of the the multi-interchange Road project and parking areas, in order to:

- establish planted areas which aimed in future to improve the microclimate of the area,
- plant zones to work as a protection barriers against the noise,
- create an aesthetically good result,
- create nice "framed" views to the sea,
- functionally, achive elimination of the traffic problems,
- create shady area along the pedestrian routes,
- create resting areas,
- create four different parking areas with green spaces in between.

The (construction) goals

The goal (at the construction stage) was to create a parking lot for (the) pedestrians providing safety and a sense of belonging. The following are key elements of the design followed:

-Curved, narrow driving isles slow the speed of motorists.

- Raised sidewalk through the site creates safe pathway for pedestrians and speed bumps for motorists.

-Tree canopies bring the scale of the large site to the pedestrian level.

-Landscaping strips are used instead of individual tree pits to provide more growing room for trees.

-Shrubs along the perimeter are used to block the nuisance of headlights blinding street traffic.

-Large planting beds in the center and along the perimeter of the parking lot are used to filter stormwater.

-A variety of trees planted throughout the site provide at least a 50% shade cover for the parking lot.

-Paving for the site is a light-colored porous pavement that will help to filter stormwater and reduce this parking lot's impact on the city's stormwater system. The large amount of trees on the site will also help to intercept much of the rain water falling on the site.

-Tree list: The tree list includes trees that:

- are capable of providing dense shade,
- are tolerant of urban environments (high temperatures, pollution levels, etc.),
- are pest and disease resistant, and
- require little maintenance.

-The list of shrubs and ground covers where acceptable for parking lot landscaping. Vegetation prohibited for use in parking lots, such as trees with messy fruits or invasive roots were not planted.

- Irrigation: All landscaped islands have irrigation systems installed (for at least the first two years).

The difficulties

It obvious that the Landscaping Project followed the Road project, therefore any delays to the Road construction influenced the Planting construction.

The road construction has been completed in July 2004, so the Landscaping project was delayed. During the excavation procedure of the road construction, leads of gunshot, from the Second Global War, have been found, in active state, which needed the intervention of the army, in order to be transferred and that caused extra delays to the project. During the construction the constant circulation of vehicles led to the construction of secondary routes and of metal bridges which ruined the surroundings in a bigger scale. The unsteady subsoil, because the whole area was filled with rubbles, demand extra stabilization which raised the budget and created financial problems. The litter and the rubbles disposal with the completion of the project was 350.000m3 and one month before the Opening Ceremony was an extremely time consuming procedure to be transferred [22] . After all those delays, the whole project had been applied under extremely time pressure.

These delays pushed the planting period to summertime, which is a very difficult situation especially in Athens, due to the high temperatures that reaches the 40° C for several days. This was risky for the new planted trees, shrubs and grass. Also that meant greater water need. Also in order to meet te deadline, construction of planting was working in many areas of the project in parallele and double shifts and at the same time the structural soils was very difficult to be found.

Now the landscape project is under maintenance contract that is constructor's responsibility for 12 months, after completing the Planting work. Another problem is the security of the whole area.

Since it is open to the public, and certain days there are hundreds of visitors for a football game or other event, it is difficult to control the entrance and the use of the area. So people cause damages which conclude extra expanses and extra maintanance work.

Plant Maintenance

In general, maintenance is taking place in the parking lot landscape ordinance include: weeding, remulching, replacement of damaged materials, and any other practice that will ensure the health of the plant. Other maintenance work that will require more instruction include: pruning, fertilizing, and pest and disease control.

-Pruning: All pruning is administered in accordance to standard horticultural practices and administered by someone with experience.

-Fertilizing: Fertilizer applied when is needed according to soil testing

-Pest and disease control: It was appied to few trees of those used in parking isles.

Problems that did occur treated appropriately as needed.?

Plant growth

In order to improve the microclimate the plant species (table 1) have been selected according several perametres as mentioned above. Therefore the height and the breast perimetre of tree species at the establishment time have been recorded as well as the growth of the trees in one year time.

Results and discussion

The first results for this design shows that the trees are all grown:

- from 5cm to 50cm height,
- from 1cm to 3 cm the breast perimetre and
- from 10cm to 60 cm foliage diametre, in one year time.

Table 1. The growth of trees over one year

	INTERCHANGE OF KIFISOS								
Tree scientific name	Quantity	Height in m		Growth rate in height	Perimeter of trunk in m		Foliage Diametre in m		Growth rate in Foliage diametre in m
Year		2004	2005		2004	2005	2004	2005	
Acacia cyanofylla	6	2,5	3	0,5	16-18	18-20	0,8	1	0,2
Acer negudo	27	3	3,2	0,2	16-18	16-18	0,5	0,6	0,1
Albizia julbrissin	16	2	2	0	16-18	18-20	2	2,1	0,1
Brachychiton acerifolius	48	3,5	3,5	0	20-24	20-21	1	1,5	0,5
Casuarina tenuissima	8	2	2,5	0,5	18-20	18-20	1,5	2	0,5
Catalpa bignonioides	20	2,5	3	0,5	18-20	20-25	0,8	0,9	0,1
Cupressus arizonica	40	2,5	2,6	0,1	14-16	14-16	0,6	0,6	0
Cupressus sepervirens	14	3,5	4	0,5	14-16	14-16	0,3	0,3	0
Grevillea robusta	168	1	1,5	0,5	18-20	20-25	1,8	2	0,2
Melia azedarach	54	2,5	2,5	0	16-18	16-18	0,8	1	0,2
Morus alba	85	2,5	2,5	0	18-20	20-25	1,5	2	0,5
Olea europea	49	2	2	0	16-18	16-18	1,5	1,6	0,1
Quercus rubra	15	1	1	0	16-18	16-18	0,8	0,8	0
Quercus ilex	59	3	3	0	16-18	16-18	0,6	0,6	0
Robinia pseudoacacia	38	2	2,5	0,5	16-18	20-25	1,5	2,1	0,6

That means that the establishment was succesful. It is estimated that in 5 years time the trees will provide shade and comfort to users of the site.This will be recorded during the next years in order to give a more accurate estimation. Also whithin the next years, it can be estimated the overal benefits of the trees of the current parking lot.

According to McPherson [21] good tree selection choices over the long term should result in relatively healthy, productive, and sustainable urban green areas, with benefits far exceeding management costs.

Similarly the annual benefits from tree are summarized by McPherson and Gregory [23]: Energy savings, atmospheric carbon dioxide reductions, air-quality benefits, stormwater runoff reductions, and aesthetic and other benefits were calculated with models that directly connected benefits with tree size variables such as dbh and leaf surface area. Many functional benefits of trees are related to leaf-atmosphere processes (e.g., interception, transpiration); therefore, benefits increase as tree canopy cover and leaf area increase. Average annual benefits were calculated on a per-tree basis by type of benefit for each species by dbh class. Total benefits were estimated by multiplying annual per-tree benefits by total numbers of trees in each dbh class. Three major phenomena account for most climatic problems in the city: urban heat islands, urban wind, and urban precipitation.

Finally we conclude this paper with the following guidelines/recomentations:

- The use of vegetation and porous pavement within the parking lot will help manage heat in several ways. First, vegetation will provide shade reducing the amount of radiation that reaches the parking surface by either reflecting or absorbing it.

- Cooler air will also be released by the vegetation through evapotranspiration which is found to be most effective when trees and shrubs are planted in groups. Porous pavement also allows for the flow of cooler air from subsurface soil levels to the surface of the lot [24].

- Lighter colored aggregate used in the porous surface will also increase the surface albedo. Porous pavement is used in the site to reduce the amount of stormwater pumped into local stormwater systems. Stormwater ltered? and then stored beneath the surface of the pavement. This water can then be taken up by the roots of local vegetation and be used for growth. Water not used by plants will then begin to evaporate up through the pavement, using heat energy in the process and cooling the air just above the surface of the lot.

- Using structural soils along with porous pavement will further enhance root growth and tree survival rate. With structural soils, the tree roots will be able to easily manipulate their way through the soil beneath the parking lot to access the stormwater. Structural soils will also help to prevent damage to the parking lot surface by reducing buckling.

- Porous pavements also use larger aggregates in the surface layer than do traditional asphalt pavements. The large aggregates diminish the amount of surface area capable of absorbing solar radiation [25].

- Any radiated heat from the surface of the parking lot will be carried off the site by wind. Leaving space between tree canopies and underlying shrubs allows wind to move through the site. The use of a combination of large shade trees with underlying shrubs will benefit the parking lot by allowing wind to pass through the site. Allowing winds to pass through the site during the summer will help to cool the lot by allowing cooler air into the lot. As heat rises from the surface of the parking lot, the wind will carry the heat away from the site eliminating stagnant hot air above the parking lot surface.
- Large amounts of trees planted in the parking lot will also help to ameliorate winter winds. Even the bare branches of deciduous trees in the winter will cause drag and slow wind speeds.

The goal for the landscape architect, when designing with climate, is to decrease the negative effects these phenomena have on the city and its inhabitants. This can be accomplished by learning what causes these phenomena and understanding the relationship between them and the physical form of the city. Urban heat islands, urban wind, and urban precipitation are all caused by high amounts of impervious surface coupled with the lack of vegetation found in urban areas [6].
Therefore, decreasing the amount of impervious surface area and increasing the amount of vegetation throughout the city are key aspects of designing with climate.

Finally it is expected that the current parking lots will provide in few years all the above benefits and further research at the following years can come up.

References:

[1] Akbari, H., P. Martien, & A. Rosenfeld (1992). Using Light- Colored Surfaces to Cool Our Communities. In Akbari, H., S. Davis, S. Dorsano, J. Huang, & S. Winnett (Eds.), Cooling our Communities: A Guidebook on Tree Planting and Light- Colored Surfacing (LBL-31587) (43-52). United States Environmental Protection Agency and Lawrence Berkeley Laboratory.X2. Author, *Title of the Book*, Publishing House, 200X.

[2] Huang, J., R. Ritschard, N. Sampson, H. Taha (1992). The Benefits of Urban Trees. In Akbari, H., S. Davis, S. Dorsano, J. Huang, &

S. Winnett (Eds.), Cooling our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing (LBL-31587) (27-42). United States Environmental Protection Agency and Lawrence Berkeley Laboratory.

[3] Huang, J., R. Ritschard, N. Sampson, H. Taha (1992). The Benefits of Urban Trees. In Akbari, H., S. Davis, S. Dorsano, J. Huang, & S. Winnett (Eds.), Cooling our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing (LBL-31587) (27-42). United States Environmental Protection Agency and Lawrence Berkeley Laboratory.

[4] Moffat, A.S., M. Schiler, & Staff of Green Living (1993). Energy- Efficient and Environmental Landscaping. South Newfane, VT: Appropriate Solutions.

[5] U.S. Environmental Protection Agency, Climate Protection Division (2000, July). The Power to Make a Difference: Energy Star and Other Partnership Programs. Retrieved February 4, 2004, from the Environmental Protection Agency Web site: http://epa.gov /cpd/pdf/ cpdann99.pdfVitruvius, P. (1914). The Ten Books on Architecture (M.H. Morgan, Trans.). Cambridge, MA: Harvard University Press.(Original work published c.40 B.C.)

[6] Akbari, H., S. Davis, J. Huang, P. Liu, & H. Taha (1992). The Urban Heat Island: Causes and Impacts. In Akbari, H., S. Davis, S. Dorsano, J. Huang, & S. Winnett (Eds.), Cooling our Communities: A Guidebook on Tree Planting and Light- Colored Surfacing (LBL-31587) (5-26). United States Environmental Protection Agency and Lawrence Berkeley Laboratory.

[7] U.S. Environmental Protection Agency (1997, October). Climate Change and Human Health. Retrieved February 4, 2004, from the Environmental Protection Agency Web site: http:// yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNNXJ/$File/ccandpublichealth.pdf

[8] U.S. Environmental Protection Agency (1998, September). Climate Change and North Carolina. Retrieved February 4, 2004, from the Environmental Protection Agency Web site: http://www. epa.gov /cgi-bin/claritgw

[9] U.S. Environmental Protection Agency (2003, October). Heat Island Effect. Retrieved February 4, 2004, from the Environmental Protection Agency Web site: http:// yosemite.epa.gov/oar/ globalwarming.nsf/webprintview?ActionsLocalHeatIslandEffect.html

[10] Lee County, Florida. 1990. Ordinance No. 90-22. Section C.5.e.(2)(b), Internal Landscaping of Parking Areas. Board of Commissioners, Lee County, FL.

[11] International Society of Arboriculture (ISA). 2001. Guidelines for Developing and Evaluating Tree Ordinances: Part 2, Provision 25. www.isa-arbor.com/ publications/ ordinance.asp (accessed 3/26/04).

[12] City of Sacramento. California. 2003. Parking Lot Tree Shading Design and Maintenance Guidelines: Section II: Shading Requirements and Calculations. City of Sacramento, Sacramento, CA. X2. Author, *Title of the Book*, Publishing House, 200X

[13] Garber, M.P. 2000a. Natural Resource Conservation: Components of a Tree and Landscape Ordinance, Part I. University of Georgia College of Agriculture and Life Sciences Departmental Publication H-00-057. 4 pp.

[14]_____. 2000b. Natural Resource Conservation: Components of a Tree and Landscape Ordinance, Part II. University of Georgia College of Agriculture and Life Sciences Departmental Publication H-00-058. 4 pp.

[15]____. 2000c. Natural Resource Conservation: Components of a Tree and Landscape Ordinance, Part III. University of Georgia College of Agriculture and Life Sciences Departmental Publication H-00-059.

[16] Dirr, M. 1990. Manual of Woody Landscape Plants (4th ed.). Stipes Publishing. Champaign, IL. 1,007 pp.

[17] Gerhold, H., N. Lacasse, and W. Wandell (Eds.). 1993. Street Tree Fact Sheets. Municipal Tree Restoration Program, University Park, PA.

[18]Bassuk, N. 1998. Recommended Urban Trees: Site Assessment and Tree Selection for Stress Tolerance. Cornell University Urban Horticulture Institute, Ithaca, NY. 69 pp.

[19]Gilman, E.F. 1997. Trees for Urban and Suburban Landscapes. Delmar Publishing, Albany, NY. 662 pp X1..

[20] Porter, W. (Ed.). 2000. Trees for New Jersey Streets, (4th rev). New Jersey Shade Tree Federation, New Brunswick, NJ. 29 pp.

[21]McPherson, E.G. 2001. Sacramento's parking lot shading ordinance: Environmental and economic costs of compliance. Landscape Urban Plann. 57:105-123.

[22] Kontou M.,Loukas A., Karipidis G., Liringos K., Mpalaouras A. – The construction of the underpass of the node of Kifisos Avenue with Posidonos Avenue. 2nd Panhellenic Conference of Road Construction, Athens , 2005.

[23]McPherson, E.G., E. Gregory. The cost analysis of ten street tree species in Modesto, California, U.S., Journal of Arboriculture, January 2003.

[24] Georgi, N.J., Zafeiriadis K. The impact of park trees on microclimate in urban areas. Urban Ecosystems, (in press), 2005.

[25] Harris A.M. Designing With Climate:
Using Parking Lots to Mitigate Urban Climate
Thesis in Master of Landscape Architecture
Faculty of Virginia Polytechnic Institute & State University, 2004

.