MRP Bas Dijkhoff - 'Walkable US desert cities facilitating walkability through urban design in support of sprawl repair'

by Bas Dijkhoff

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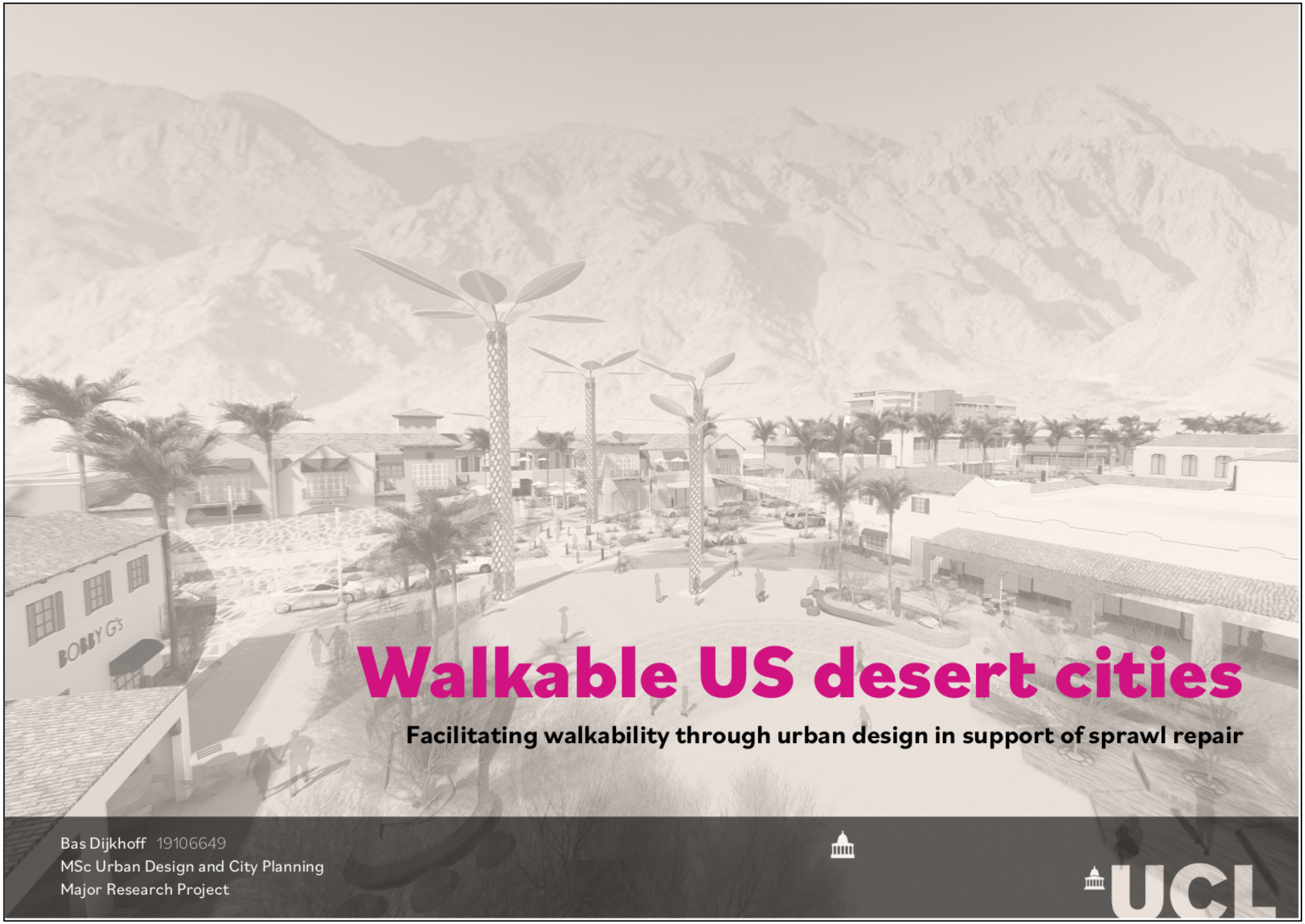

Walkable US desert cities

Facilitating walkability through urban design in support of sprawl repair

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Major Research Project:

Walkable US Desert Cities: Facilitating walkability in US desert cities through urban design in support of sprawl repair

Bas Dijkhoff, MSc Urban Design and City Planning

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Supervisor: Oliver Davey

Being a Major Project in urban design and city planning, submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc (course - Urban Design and City Planning or Sustainable Urbanism) at University College London, I declare that this project is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

30/8/32020

Acknowledgements

First and foremost, I would like to thank my supervisor, Oliver Davey, for his guidance and feedback throughout this process. Due to COVID-19, the circumstances under which this MRP was written were uncommon. Nevertheless, Oli provided me with clear and structured supervision through which I was able to work on this project to the best of my abilities. Many thanks for this.
I would also like to thank my fellow UCL students and friends, as well as UCL staff, who provided me with useful feedback during several presentations. Thanks to the local residents of Palm Springs, who took time to answer my questions about the identity of their town. Finally, I would like to extend my gratitude to my close friends and family for their support throughout this process.

Abstract

Walking is a heavily underused transportation mode in United States desert cities, due to urban sprawl and its consequences, among others. Sprawl repair can help create more walkable cities, but the sole activity of infilling open spaces is not enough to ensure walkability in desert cities. Human scale urban design interventions are necessary to mitigate the impact of the desert heat on pedestrians and to create a truly walkable environment. In this research, academic literature is reviewed and case study cities from around the world are analysed, resulting in a toolkit of urban design guidelines that facilitate walkability in US desert cities. The guidelines are applied and tested on the context of Downtown Palm Springs, California. The result is a practical toolkit for urban designers that work on US desert cities and which can serve as a base for further research into walkability in extreme climates.

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Chapter 1
Introduction

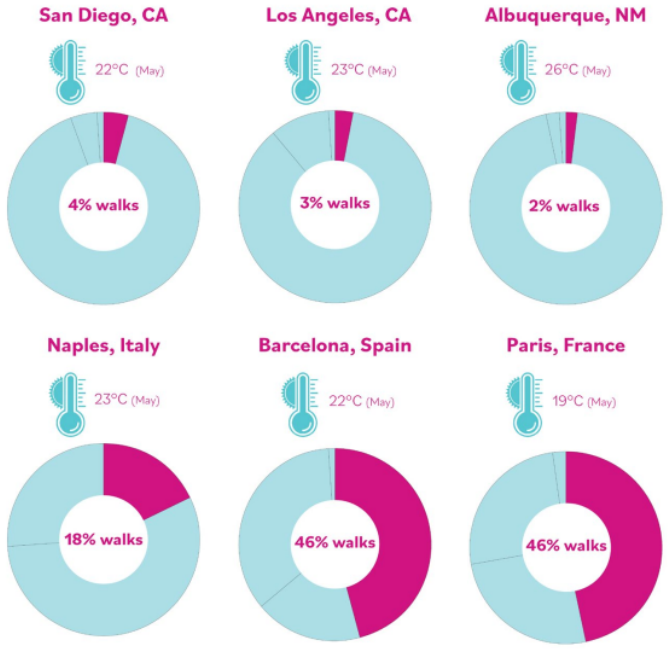
1.1 Research context & problem conceptualisation

Walking is a heavily underused transportation mode in cities in the United States, compared to cities in the rest of the world. In US cities, hardly any journeys to work are on foot compared to cities with comparable temperatures in other parts of the western world (figure 1.1) (CensusReporter, 2018; Transport Geography, 2017). Walking leads to its economic, environmental and social benefits, as well as benefits to personal health. Therefore, creating walkable environments is important.

This low share of walking in the US is due to urban sprawl, the car-culture and low-quality pedestrian infrastructure. These elements lead to travel behaviour that negatively impacts the climate, people's health and outdoor activity, among others (Barrington-Leigh & Millard-Ball, 2015; Coughenour et al, 2019; Wassmer, 2000). Throughout the US, sprawl repair efforts, mostly related to land use, aim to deal with these issues by conducting sprawl infill to create more dense and walkable urban areas (more in paragraph 3.4). US desert cities face an additional obstacle to higher modal shares of walking: they are hot and walking through the existing public realm in these temperatures is uncomfortable, making the car an even more attractive alternative to walking.

The sole activity of infilling does not guarantee walking in all US cities. In US cities with high temperatures, the share of walking is lower than in US cities with modest temperatures, even though sprawl repair has occurred in both (Censusreporter, 2018; WeatherUS, 2020). Infilling is necessary, but it is not enough to secure walking. This will be further elaborated on in paragraph 3.4.3.

Adjustments to the built environment, on the human scale, are needed to create attractive, safe and convenient pedestrian infrastructure in environments where sprawl repair has occurred, mitigating the impact of high temperatures and therefore creating truly walkable US desert cities. The objective of this research is '**to set human scale urban design guidelines that compliment sprawl repair and facilitate walkability in United States desert cities**'.



1.1 Walking modal share in US and non-US cities

1.2 Research question

To help solve the problem presented in paragraph 1.1, the set research question is: '**How can the streetscape and architectural interventions compliment sprawl repair to facilitate walking in United States desert cities?**'

1.3 Contribution to practice

1.3.1 Contribution to professional practice

Walking can help tackle challenges cities throughout the world face. As temperatures continue to rise due to climate change, more and more cities will need the solutions presented in this research to facilitate walkability. Improving the walkability of US desert cities can make these communities more healthy, sustainable and economically strong (Speck, 2018), for which this project's toolkit can be used.

Also, many studies for revitalising American Downtowns are currently being conducted, such as 'Downtown Revitalization in Small and Mid-sized Cities' by the American Planning Association (2018), where pedestrian infrastructure plays a key role. This project can contribute to these studies for US desert cities.

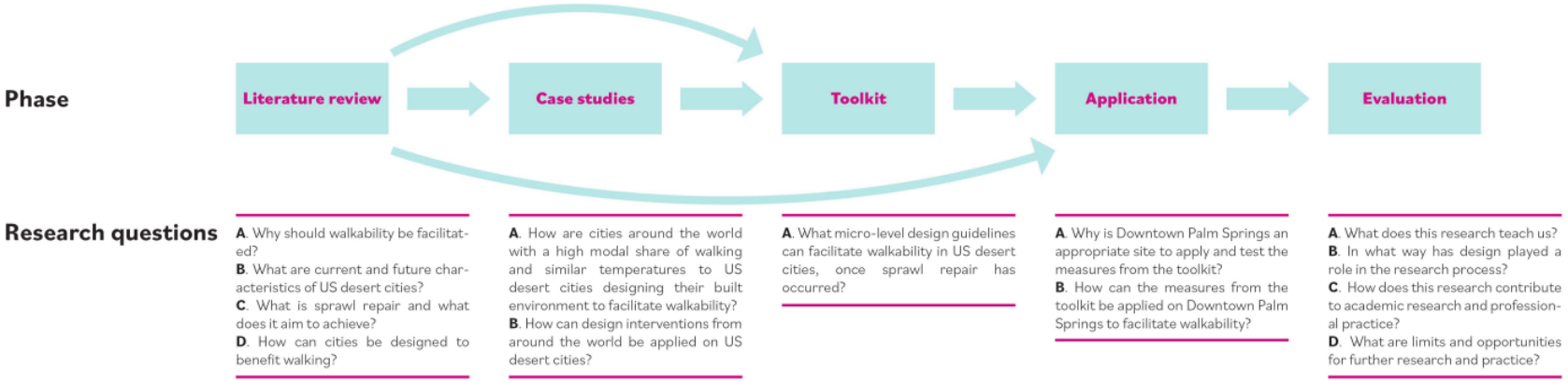
This study will be of interest to **developers**, creating sustainable and healthy communities. To **designers**, designing sustainable and resilient cities. **Governments**, offering citizens healthy places to live, work and recreate. **Health officials**, wanting more healthy patients. And the **public**, who will live a more healthy, comfortable and sustainable life in US desert cities.

1.3.2 Contribution to academia

This research also adds to the academic knowledge on the topics of walking infrastructure and heat mitigation. While guidelines for creating cooler and more walkable open spaces in cities are well known, academic literature and guidelines for walking in sprawl repaired US desert cities specifically are very limited. Much of the existing literature focuses on overcoming the first hurdle of creating more sustainable and pedestrian-friendly infrastructure in US cities through sprawl repair. This research focuses on what comes after, once sprawl repair has occurred.

Chapter 2
Methodology

2.1 Research strategy & questions



1.2 Research framework

The research starts with a literature review on topics related to this project's theme. Phase two consists of analysing 4 case studies: cities where the modal share of walking is high, while temperatures are comparable to US desert cities. What are their approaches and can they be applied in the US? The toolkit is presented in phase three. In phase four, the toolkit is applied on a master plan for an actual US desert city: Palm Springs, a city where sprawl repair has occurred, yet, the modal share of walking remains low. In the evaluation phase the research is reflected upon and the way in which design improves the toolkit is analysed. It also looks ahead towards future research worth pursuing in the direction of this topic.

2.2 Project objectives

The project objective is: **'to create a toolkit to facilitate walkability through urban design in US desert cities in support of sprawl repair'**.

Sub-objectives are to set guidelines that:

- ... fit the desert climate and the flora and fauna that inhabit this area.
- ... anticipate and respond to the consequences that climate change will have on US deserts.
- ... consider pedestrian comfort and stimulate people to spend time outdoor.

Each of these objectives indirectly benefits walkability. A healthy natural ecosystem is vital for cooling, attractiveness and shade. Anticipating consequences of climate change is vital in urban design toolkits for future use and generally leads to cooler open spaces. Pedestrian comfort and stimulating outdoor activity are important to ensure pedestrians want to be outside.

2.3 Ethics statement

One interview was conducted through Facebook with a Palm Springs resident. The identity of this resident remains anonymous in this major research project. The name, age, nationality and profession of the interviewee are not disclosed. No personal information or personal opinions of the interviewee are disclosed. The interview questions did not address sensitive topics.

Chapter 3
Literature Review

3.1 Introduction

This chapter provides a compact, yet complete overview of existing knowledge on the main topics related to the research. It focuses on the activity - walking, the setting - desert cities & sprawl repair, and on existing knowledge of solutions to facilitate walking and create cooler urban areas: very important given that this research focuses on physical activity in some of the world's hottest areas.

3.2 Why walk?

3.2.1 Intro

Walking is an active transportation mode with many benefits, of which improving physical health is the most apparent, but not the only one. This paragraph will stress how walking can have positive physical, economic, environmental, and social consequences.

3.2.2 Health

People's physical health benefits greatly from walking. 30 minutes of walking every day strengthens bones, reduces excess body fat, and boosts muscle power and endurance (Harvard Health Publishing, 2018). Walkable communities are healthy communities and inhabitants suffer less from obesity and have lower health care costs. Also, they have lower death rates from car crashes and lower levels of air pollution, reducing the risks of asthma (Speck, 2018).

3.2.3 Economy

Walking benefits the (local) economy in different ways. Property values are higher in walkable neighbourhoods. Walking attracts talent (according to Greenfield (2017), educated millennials value walkability and want to live in areas where a car is not needed), as well as businesses and jobs (Burden, 2013). It's an inexpensive mode of transportation, especially compared to driving. In fact, car-dependent cities make their citizens poorer by requiring them to drive to get around (Speck, 2018). Citizens are left with less money to invest in the local economy. Walkable environments attract tourism and revitalise retail, as more pedestrians visit these areas, more likely to enter a shop than those driving by (Burden, 2013).

3.2.4 Environment

Walking can lead to a reduction of CO2 emissions and walkable cities are more sustainable than those dominated by cars (Burden, 2013).They are denser and require less driving. It's not just the car in itself that leads to higher energy use, it's what is made possible by the car. In 'Green Metropolis', Owen (2010) explains that the car allows people to live in low dense areas, with oversized houses; big, irrigated gardens; inefficient power grid expansions; and long solo commutes.

3.2.5 Social

Walking stimulates social interaction. Walkable neighbourhoods are often stronger communities than non-walkable neighbourhoods (Burden, 2013). There are also social equity benefits to walking. For example, those who can't drive (i.e. elderly, children, disabled people or others of the nearly one third of Americans without a license) are less isolated. Due to the high cost of driving, poor and minorities are disproportionally unable to afford a car and are forced to walk or cycle on infrastructure that's built primarily for cars (with disproportionate traffic fatalities as a result). Walking is cheap, safe, and walkable environments serve all (Speck, 2018).

3.3 US desert cities

3.3.1 Intro

This research focuses on US desert cities, defined as 'cities in the United States located in the Great Basin, Mojave, Sonoran or Chihuahuan deserts' (figure 3.1). These are the four 'main' North American deserts, determined by several geologic characteristics (DesertUSA, 2019). Environmental factors are extreme in deserts. The highest temperatures are recorded here, they suffer most from drought and most types of vegetation are unable to grow here. This research focuses on cities located in these deserts to present a toolkit of interventions that are applicable to the most extreme conditions. Implementation of these guidelines on other US cities will be relatively easier, as environmental conditions are more modest.

3.3.2 Car culture

The car culture is big in the United States. For decades, successive government policies have encouraged the use and ownership of cars. These policies facilitated and accelerated the shift to private cars. This led to car-dominant cities where walking and cycling are not only difficult, but often impossible means of transportation. Due to their sprawled layout (paragraph 3.4), poor quality public transportation and lack of high-quality walking and cycling infrastructure, car dominance is big in US cities. Through the combination of extreme temperatures and the convenience of the air-conditioned car, US desert cities have an especially large car culture (Pucher, 1995).

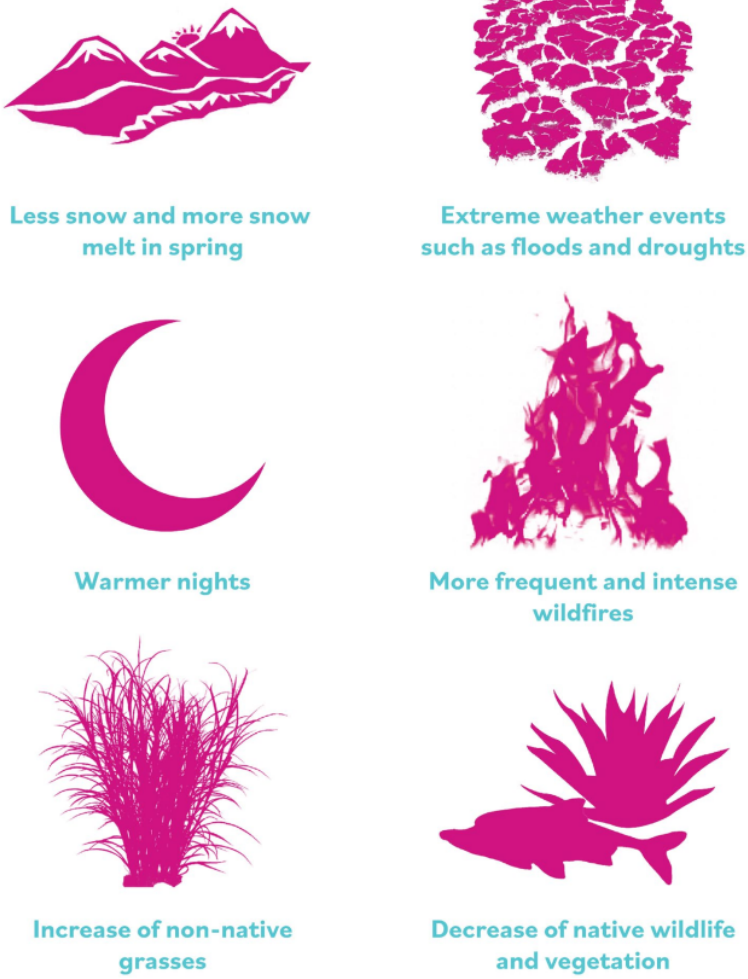
3.1 The 4 US deserts

3.3.3 Climate change: the future

Climate change will have great effect on US deserts and their cities. Archer and Predick (2020) present some inevitable changes that US deserts will undergo. Overall, the regions will become drier and the deserts' boundaries are expected to expand towards the north and east. This means that this research will apply to more cities that will become 'desert cities'.

Important consequences of climate change in US deserts are displayed in **figure 3.2**. These must be taken into account in the toolkit that will be developed later in this research.

3.2 Climate change consequences for US deserts



3.4 Sprawl repair

3.4.1 Urban sprawl

Urban sprawl is a pattern of growth that has frequently occurred in the US, recognisable by congested highways, strip malls, gated communities and cul-de-sacs throughout single-use, car-dependent, low density developments. The phenomenon negatively influences the environment (increased greenhouse gas emissions and pollution; loss of nature, water, energy), health (obesity due to limited physical activity in car-dependent areas; asthma due to air pollution), and safety (social safety due to lack of diversity in neighbourhoods, leading to concentrated poverty; poor traffic safety due to more car use and inadequate pedestrian and cycling infrastructure) (Tachieva, 2010; Barrington-Leigh & Millard-Ball, 2015; Wassmer, 2000; Coughenour et al., 2019; Speck, 2012; Frumkin, 2002).

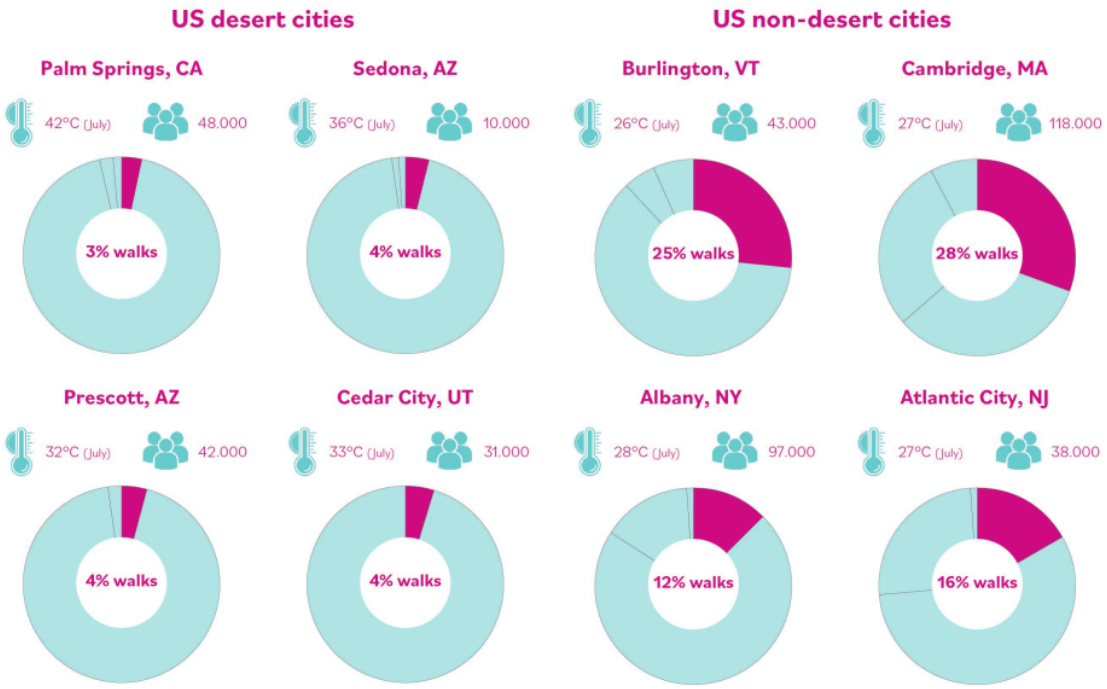
3.4.2 Sprawl repair

Sprawl repair is the activity of transforming single-use, car-dominated neighbourhoods into walkable, mixed-use communities that perform better economically, socially, and environmentally. This is done by increasing density, through infilling poorly used space (parking lots; wide arterial roads) with buildings, public spaces, or additional connections, such as cycle paths or transit lanes. These denser urban environments, where the car is no longer the primary transportation mode, instantly become more walkable: destinations are closer together and walking distances (such as pedestrian crossing distances) become shorter (Tachieva, 2010).

3.3 Sprawl repair (Tachieva, 2010)

3.4.3 The missing link for desert cities

Urban areas where the extent to which urban sprawl has occurred is limited, or where sprawl repair has occurred, are, in essence, walkable environments. Destinations are close together; large surface parking lots are not in the centre of the walkable neighbourhood and car infrastructure doesn't take up too much of the public realm. However, sprawl repair is not a 'golden ticket to success' for achieving walkability. Especially in US desert cities, the modal share of walking is low. Figure 3.4 shows the share of walking in 4 desert cities and 4 non-desert cities. In all cities, sprawl repair has occurred to a certain extent. Yet, walking occurs more frequently in non-desert cities, which are much cooler. The hot climate of desert cities can harm the walkability and the sole act of sprawl repair through infilling is not enough to ensure this. To be a successful urban area for walking, the public realm in desert cities needs to be designed to mitigate the heat and by that, create a walkable environment.



3.4 Walking share in 8 US cities (Censusreporter, 2018; Weather US, 2020)

3.5 Solutions for walkable US cities

3.5.1 Intro

To fully enjoy the benefits of walking (**paragraph 3.2**), supporting infrastructure is needed. Sprawl infill solves parts of the problem, but does not guarantee walkability. This paragraph will focus on human scale urban design interventions that enhance walkability. Although they are not specifically for desert cities, they form the base for walking in US cities.

In 'Walkable City Rules: 101 Steps To Making Better Places' (2017), Speck provides guidelines for planners and designers to transform US cities into walkable communities. These will serve as base and reference for the guidelines specified to US desert cities.

3.5.2 Sidewalks

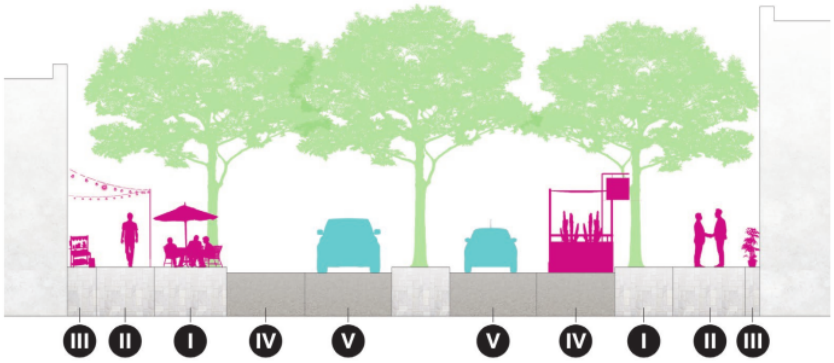
Sidewalk are the main pedestrian spaces. In general, sidewalks need to consist of three zones: the 5'-8' (1.5-2.5m) tree zone - for trees, street furniture, dining, etc., against the curb (I); the min. 6' (2m) clear zone - without obstructions, for walking, in the centre of the sidewalk (II); and the 1'-3' (0.3-1m) frontage zone - for clothing racks, book tables, dining, etc., as transition between sidewalk and building façades (III) (**figure 3.5**).
Besides this, elements such as street trees that form a canopy (20'-40'/6-12m apart, in sidewalks, and, if possible, in medians), no curb cuts, parklets (IV) (if appropriate), and wheel chair accessibility are vital to creating successful sidewalks.

3.5.3 Intersections

Centrelines should not be present in the roadway of walkable, urban areas. Build-outs at intersections, which lower vehicular speeds and decrease pedestrian crossing distances, contributes to safety and pedestrian comfort. Landscaped bulb-outs can bring a green character to the street. Cross-walks can be made interesting through design and colour to highlight pedestrian importance and slow down cars. Pedestrian bridges and tunnels should be avoided. If possible, shared spaces are worth pursuing.

3.5.4 Comfortable and interesting spaces

Comfortable and interesting spaces strengthen walkability. Pedestrians feel safer and are willing to spend time there. Adequate street lighting (holiday string lights year-round are successful), active ground level façades, breaking up large building façades and public art on blank walls are strong means.



3.5 Walkable street section

Chapter 4
Case studies

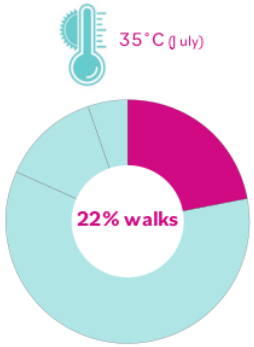
4.1 Case study cities

4.1 Introduction

In this chapter, 4 carefully selected case study cities are analysed. In summer, these cities reach temperatures equal to those in US desert cities, although the modal share of walking is higher.

By critically evaluating the approaches taken to mitigate heat and create walkable areas and by considering how these measures could be applied on US desert cities, a base for the toolkit is formed.

4.2 Bologna, Italy



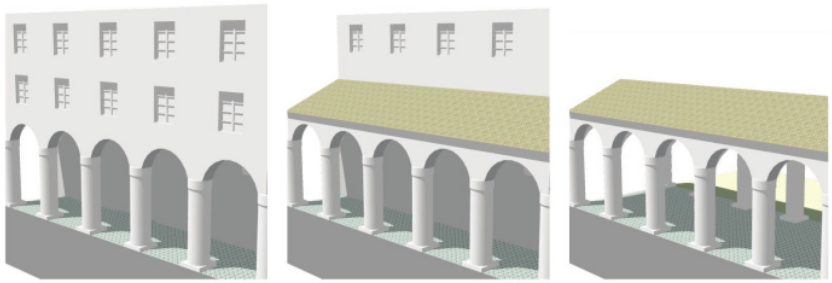
4.2 Bologna (own)

4.2.1 Intro: the porticoes of Bologna

Porticoes are covered sidewalks lined by colonnades, covering nearly 38 kilometres of sidewalk in Bologna's centre. They are a mix of private and public space. Porticoes impact the pedestrian environment by mitigating heat, mainly through shading most pedestrian walkways in the city centre (Unesco, 2006). Porticoes are between 8m and 95cm wide and between 6m and 8m high. The oldest are from 1100 (BolognaWelcome, 2020). The porticoes vary in height, width, shape and materials, depending on the building they're attached to. It's not just walking (passing) that occurs underneath the porticoes, but they also form places to stay (**figure 4.2**).

4.2.2 Three alternative porticoes

Bologna's three types of porticoes:



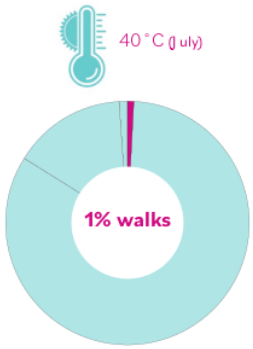
1: Under building **2: In front of building** **3: Detached**

4.3 Under building (Google, 2019) **4.4** Fronting building (Own) **4.5** Detached (Google, 2019)

4.2.3 Application to US desert cities

The porticoes could be used for shading in US desert cities. Existing buildings can be complemented by alternatives 2 & 3 and new buildings could be designed with alternative 1. Alternative 3 can also be used in plazas. The concept of having walking and other activities, like dining, happening underneath arcades can be implemented.

4.3 Dubai, UAE



4.6 Historic wind towers (own)

4.3.1 Intro: modern solutions in Dubai

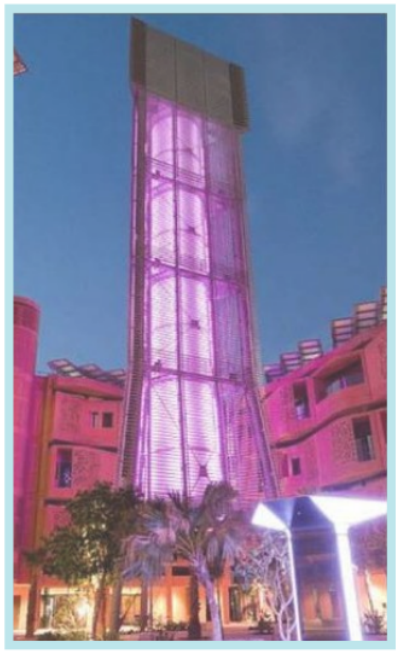
Dubai is among the world's hottest cities. Although it is car dependent and the modal share of walking is low, some areas have higher walking rates. New techniques are being tested, some based on ancient systems, such as wind towers used as air-conditioning in 1900 (**figure 4.6**). This paragraph focuses on three new techniques: Wind Towers, Cloud Cast and Climate Control.

4.3.2 Wind towers

Based on wind towers (**figure 4.6**), modern variations were designed for Dubai and its surrounding cities, such as Masdar City (**figure 4.7**). This 45 meter tall structure captures cooler wind high up in the air and directs it towards the ground level, where pedestrians walk through a cool breeze (Jin, 2012). Street temperatures around its base are 20 degrees Celsius cooler than the surrounding desert (Sanderson, 2019).

4.3.3 Cloud Cast

Cloud cast is a personalised, individual cooling system, based on the ancient technique of evaporative cooling - cooling pedestrians by water vapour. It's an energy-efficient alternative to evaporative cooling systems, which repeatedly spray water vapour into the outdoors, every set amount of time. Sensors in canopies interpret echoes from high-frequency sound waves to identify passing pedestrians. Water vapour is only sprayed when someone passes and less water is used as it's focused on individuals, not the entire sidewalk (Fernandez, 2015).



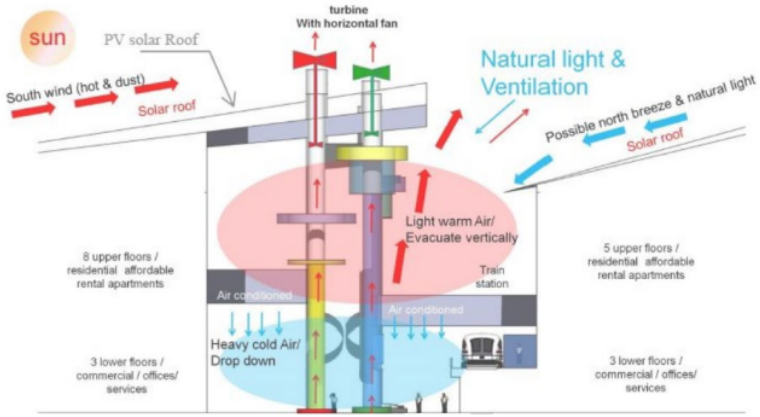
4.7 Modern wind tower (Jin, 2012)

4.8 Cloud Cast (Fernandez, 2015)

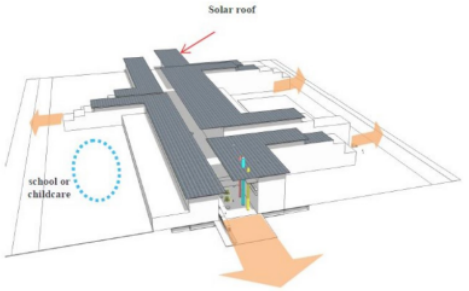
4.3.4 Desert Rose Dubai

Desert Rose is a planned smart sustainable satellite city in Dubai. Its proposed centre is a linear atrium, accessible only to pedestrians.

Figure 4.9 shows that the atrium has two solar roofs: a taller roof pointing upwards on the south-east side (blocking sunlight, hot wind and dust) and a lower roof pointing downwards on the north-west side (allowing natural light and a breeze in the atrium). Air conditioning is placed facing down, where heavy, cool air will remain and light, warm air will move upwards. Cold air remains trapped as ground levels are only accessible through closing doors (ReinventingCities, 2016).



4.9 Atrium Climate Control (ReinventingCities, 2016)

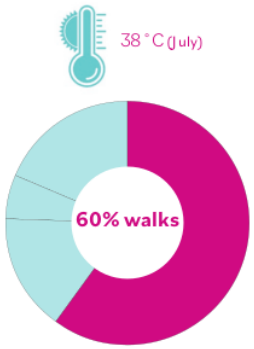


4.10 Desert Rose (ReinventingCities, 2016)

4.3.5 Application to US desert cities

Modern wind towers are worth applying. Cloud Cast could be applied on US desert cities (it might be an alternative for extremely hot days). The climate control of Desert Rose is unlikely to be successful as it requires semi-outdoor space that can be closed off. However, some principles, such object placement to maximise shade and wind benefits, can be taken from this project and applied.

4.4 Marrakesh, Morocco



4.11 Marrakesh (own)

4.4.1 Intro: shading in Marrakesh

Marrakesh is located in the Sahara. For centuries, high temperatures have encouraged its inhabitants to design a liveable place despite the heat. Shading is one of the most effective strategies to mitigate urban heat stress, especially on a small scale (Kántor, Chen & Gal, 2018). This paragraph focuses on ways in which shade provides heat mitigation in Marrakesh.

4.4.2 Wooden canopies & sun sails

Many streets and markets are covered by a wooden canopy. This relatively cheap solution blocks sunlight, while allowing natural light to enter the space. A cheap and short-term solution is installing sun sails - sheets above the public space for shade. Trees are generally more effective in providing shade then sun sails, yet, in areas where trees have trouble surviving through heat or limited space, they are an alternative (Kántor, Chen & Gál, 2018).

4.4.3 Punctured surfaces

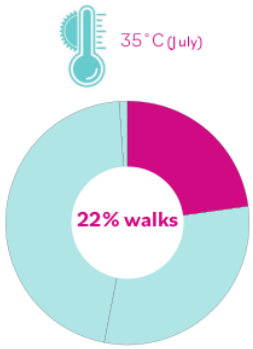
Punctured surfaces are frequently used in Marrakesh. Walls and roof structures are punctured to shade pedestrians from the sunlight, while still allowing natural light and movement of air.

4.12 Heat mitigation measures (own)

4.4.4 Application to US desert cities

Shade is a vital solution to mitigate heat on pedestrians in US desert cities. Approaches from Marrakesh are references for designing cooler and more walkable open spaces.

4.5 Singapore, Singapore



4.13 Singapore (Green Building Council, 2018)

4.5.1 Intro: cooling Singapore

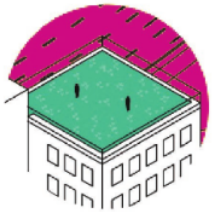
Singapore, despite its high temperatures, is rated the second most walkable city in the Global Walkability Index (Eco-business, 2013). In 'Strategies For Cooling Singapore' (2017), measures are presented to mitigate the urban heat island effect and improve outdoor thermal comfort.

4.5.2 Wind

Breeze effects outdoor temperatures, improving pedestrian comfort and air quality. Avoiding buildings and other elements from blocking wind avoids breezeway obstruction. Building porosity is also introduced: openings in buildings for air permeability, which brings a breeze to pedestrians (Ruefenacht & Pignatta, 2017).

4.5.3 Vegetation

Vegetation plays a key role in mitigating heat in Singapore. Approaches to apply vegetation are displayed in **figure 4.14**. Although Singapore's humidity allows more and diverse vegetation than US deserts, translations to desert vegetation can be made.



Green roofs

Reduce urban heat accumulation and air temperature is influenced by evapotranspiration

Vertical green

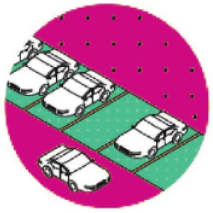
Vegetation vertically placed on buildings reduces air temperatures and enhances pedestrian thermal comfort

Green facades

Layers of vegetation attached to external building facades reduce air temperature

Infrastructure greening

Implement green on elements of the built infrastructure to increase pedestrian thermal comfort



Green parking lots

Reducing artificial material in parking lots and replace it with natural soil/grass with higher albedo

Selective planting

Be selective in where to plant vegetation so both shade and wind flow are able to mitigate the heat

4.14 Implementing green (Ruefenacht & Pignatta, 2017)

4.5.4 Water

Rain water is gathered in different bodies of water (**figure 4.15**). It absorbs thermal energy from sunlight and prevents overheating of urban surfaces. Breezes form and wind speeds increase over water bodies, cooling pedestrians along their way. Surface water also leads to more fertile soil where vegetation finds it easier to grow, resulting in heat mitigation and shade (Ruefenacht & Pignatta, 2017).

4.15 Bishan Park (Ramboll, 2014)

4.16 Artificial trees (Runsociety, 2019)

Gardens by the Bay (**figure 4.16**) are large artificial trees made of metal and concrete. Besides shading pedestrians, they feature vertical gardens and collect rain water to irrigate the park and for fountains, cooling the pedestrian realm (Greenlaunches, 2011).

4.5.5 Materials

Light coloured materials are stimulated, such as light pavement, white roofs and cement concrete, which reflect solar radiation reduce nearby temperatures. (Ruefenacht & Pignatta, 2017).

4.17 Asphalt (Miller Group, 2020)

4.18 Cement concrete (Atlantisfiber, 2020)

4.6.6 Application to US desert cities

The main differences between Singapore and US desert cities are humidity and precipitation, leading to more or less vegetation. Nevertheless, Singapore's practices can be translated to the US desert context.

Rainwater plays an integral role in cooling Singapore. Currently, US desert cities have limited precipitation, but this will change due to climate change: extreme weather events will lead to floods. It's worth implementing water-related heat mitigation measures in US desert cities.

Chapter 5
Toolkit

5.1 Introduction

5.1.1 Introduction

The toolkit came together through input from the literature review, case studies and new interpretations. This paragraph introduces two concepts that accompany the toolkit: time-sensitive urban design and pass-, wait- & stay-zones. The toolkit is a mix of human scale interventions that facilitate walkability through urban design, supporting sprawl repair. These interventions:

- ... fit the desert climate and the flora and fauna that inhabit this area.
- ... anticipate and respond to the consequences that climate change will have on US deserts.
- ... consider pedestrian comfort and stimulate people to spend time outdoor.

5.1.2 Time-sensitive urban design

The toolkit measures are in line with a new principle presented in this MRP: time-sensitive urban design: urban design that considers different users, uses and exposure to different elements throughout the day, to maximise sustainability, functionality and comfort.
US desert cities are areas that are exposed to extreme environmental conditions, the design components require this extra dimension. The way an object is designed is dependent on its orientation towards the sun, the time of day when mostly used and the temperature throughout the day.

5.1.3 Pass-, wait- and stay-zones

Reviewing the literature review and case studies, one can notice that certain interventions are more appropriate for certain types of spaces than others. For example, Bologna's porticoes mostly provide shade for pedestrians passing by, while Cloud Cast is appropriate for people spending a short amount of time.
Implementing this full toolkit is costly. To reduce costs, one can identify which zones of the public realm require more heat mitigation and which require less. Three categories can be appointed to open spaces:

- Pass-zones: areas that people pass through, such as the walking zone in the centre of the sidewalk, or pedestrian crossings at intersections, which require relatively few interventions to mitigate heat. Costs can be saved.
- Wait-zones: areas where pedestrians spend a short time without moving, that are not destinations, such as crossing lights or queuing areas.
- Stay-zones: places where people spend more time without moving in the open space, such as benches, playgrounds and transit stops. Heat mitigation must be extensive here and costs shouldn't be saved.

5.2 Building materials & pavement

5.2.1 Main idea & challenges

Building materials and pavement make up the largest part of built surfaces. Modifying existing materials or implementing requirements for new materials can play an integral part in cooling the public realm.
Challenges include dealing with stakeholders who need to invest or allow changes to their properties. These interventions also potentially threaten the existing urban character, case-by-case considerations are vital.
4 main materials to use throughout this toolkit are selected:

White plaster reflects sunlight instead of absorbing it. Relatively easy to apply on existing buildings.

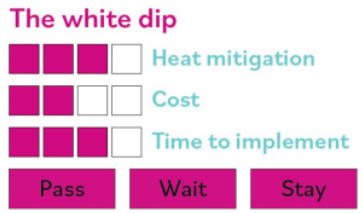
Cement concrete reflects sunlight better than dark asphalt. New or remodelled roads should be made with this material.

Desert rock is a sustainable building material as it can be retrieved from the local area and provides a desert identity.

Wood is a sustainable material that also functions as natural cooling element when moisture evaporates from wood (Kraniotis et al., 2014).

5.2.2 The white dip

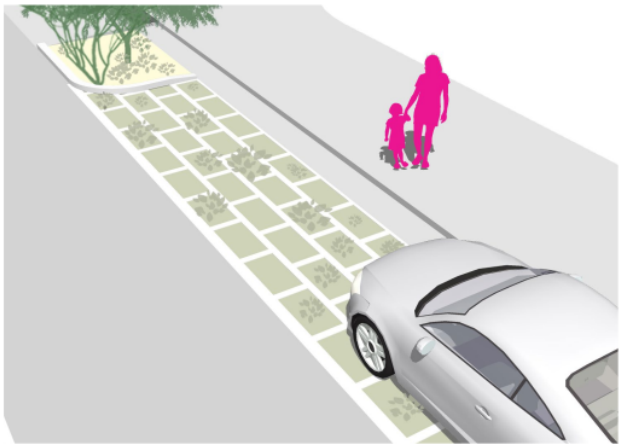
The white dip is a concept in which white paint or other materials are applied on nearly all elements in the built environment. This increase in white surfaces leads to sunlight reflection rather than absorption and reduces temperatures. Though conceptual (it's challenging painting the entire built environment white), it's is a clear goal to work towards and can serve as main concept when designing buildings and spaces.



5.1 White dip (Google, 2020)

5.2.3 Permeable pavement

Using permeable pavement for parking surfaces helps cool the surrounding space, more so than asphalt or concrete. Parallel parking is mostly located adjacent to the sidewalk - the pedestrian realm. This cooler surface is a welcome addition to mitigate heat. Also, as heavy rainfall and floods will occur more frequently in the future, it helps drain rainwater, reducing the chance of flooding.
Permeable pavement is best suited for parking lots rather than for sidewalks, as pedestrian comfort also means walking on an even surface.



5.2 Permeable pavement

Permeable pavement

Heat mitigation

Cost

Time to implement

Pass | Wait | Stay

5.3 Vegetation & nature

5.3.1 Main idea & challenges

Vegetation and nature cool the open space and create a comfortable and attractive pedestrian environment. Green (trees, plants) and blue (water) infrastructure are successful heat mitigation measures and respond to climate change consequences.

Challenges mostly relate to the arid climate. Trees that grow in this dry desert climate don't become very large, or have limited canopies. Their shade impact is limited. Also, levels of precipitation are low, although climate change will lead to more heavy rainfall.

5.3.2 Vegetation

Since this toolkit is created for cities in four US deserts, each with their own types of vegetation, it is not specific about the types of trees that should be used. Users are encouraged to implement trees and vegetation from the local context. Although introducing new species might be possible, using local vegetation is encouraged: the most self-sufficient and sustainable option.

Figure 5.3 shows a collection of the most prominent and frequently present trees in the four US deserts (Schuch & Kelly, 2007; NPS, 2009; Tentree, 2019; Smeins & Bolen, 1999). This diagram can be referred to for selecting trees for a specific location, related to desert and altitude.

5.3 Tree diagram

Tree	Joshua Tree	Western Jupiner	Saguaro	Palo Verde	Mondell Pine	California Fan Palm	Cottonwood	Mesquite	Mexican Fan Palm	Soutern Live Oak	Pinyon Pine
Apears in deserts Altitude	Mojave 2,000 - 6,000 ft	Mojave Great Basin 3,600 - 10,000 ft	Mojave Sonoran 0 - 3,500 ft	Mojave Sonoran Chihuahuan 0 - 4,000 ft	Mojave Sonoran Chihuahuan Great Basin 4,000 - 8,000 ft	Mojave Sonoran 500 - 1,000 ft	Chihuahuan 5,000 - 8,000 ft	Mojave Sonoran Chihuahuan Great Basin 0 - 5,000 ft	Sonoran 0 - 2,300 ft	Chihuahuan 0 - 300 ft	Mojave Sonoran Chihuahuan 4,500 - 7,500 ft
Shade impact	■□□□	■■■■	■□□□	■■□□	■■■□	■□□□	■■■■	■■■□	■□□□	■■■■	■■■□

5.3.3 Plateaus

Plateaus are types of green infrastructure specifically designed to provide as much shade as possible, considering time-sensitive urban design, as well as the relatively small trees and plants of US deserts.
Most trees in US deserts don't become very large, such as the mesquite and palo verde, yet, their canopy provides more shade than that of a palm. On elevated plateaus that slope up towards the north (**figure 5.5**), small trees are elevated and their shade impact on the pedestrian realm is larger. Different plateau types can help create a comfortable pedestrian environment (**figure 5.6**). By locating seating elements on the north-side of the plateaus, these 'stay-zones' benefit the most from shade caused by the plateaus, as the sun rises in the east and sets in the west (**figure 5.4**).

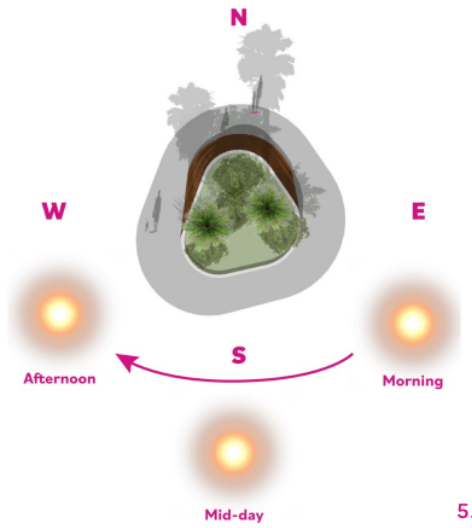
Plateaus

Heat mitigation

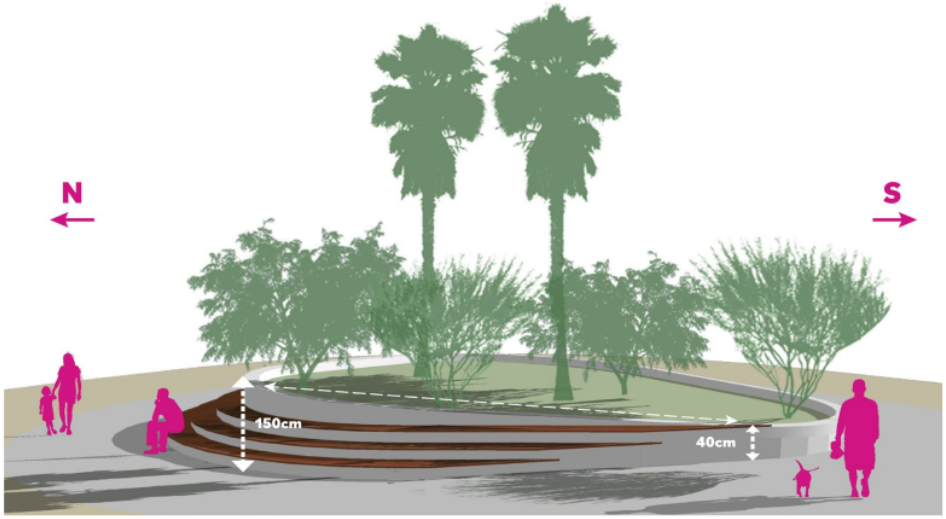
Cost

Time to implement

Pass | Wait | Stay

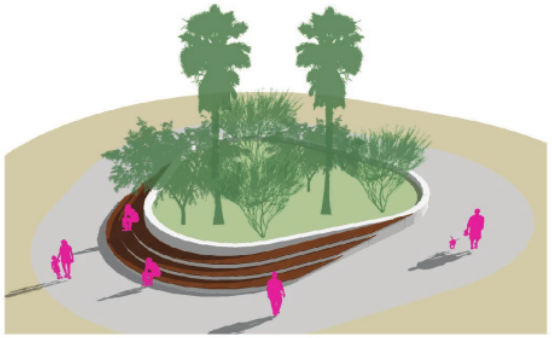


5.4 Shading plateaus



5.5 Plateaus are elevated and slope up towards the north

5.6 Plateau variations



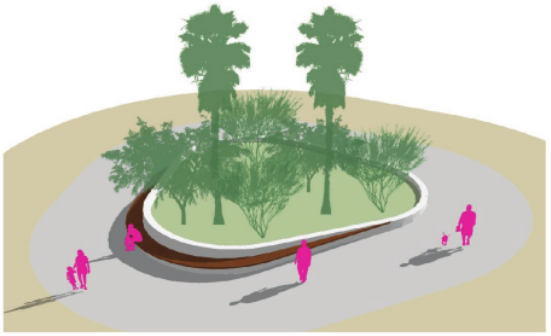
Plateau with rising edge seats

Plateau with high counter & stools

Basic plateau

Accessible plateau

Courtyard plateau with edge seats



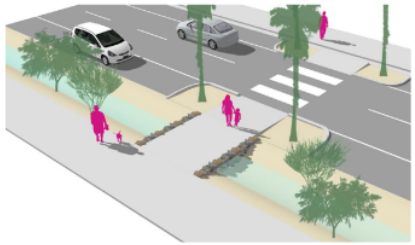
Plateau with edge seats

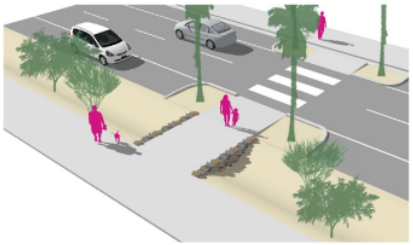
Plateau with low counter & stools

Courtyard plateau with low counter & stools

5.3.4 Bioswales

Bioswales are linear cool zones, often located adjacent to the sidewalk. Due to its less ‘stone’ surface and the opportunity for plants and trees to grow here, more shade is created. Bioswales could be made accessible to pedestrians to cool off in the water. Also, as climate change leads to more heavy rain falls, floods will occur more often in US deserts. Bioswales can help drain excessive rain water.





Bioswales

Heat mitigation

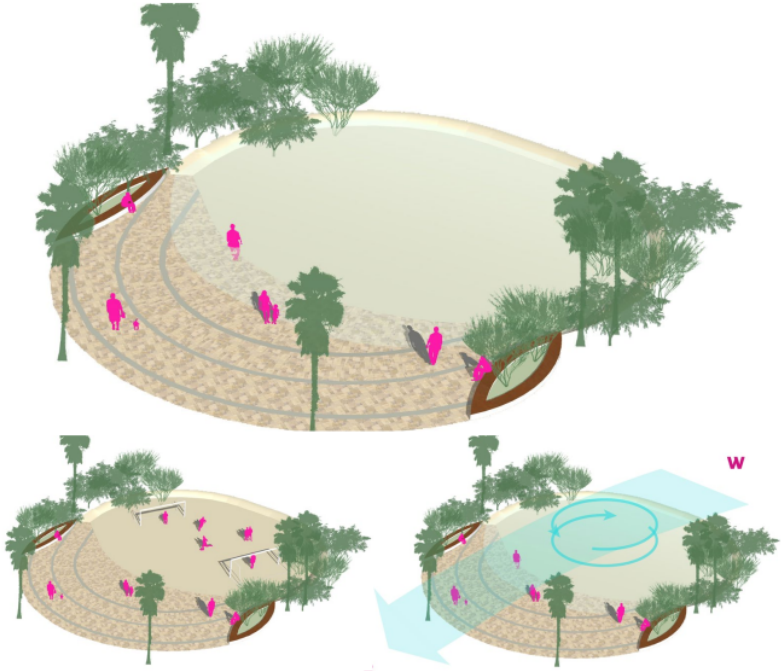
Cost

Time to implement

Pass | Wait | Stay

5.3.5 Water bodies

In Singapore ( ), water bodies are cool zones and breezes form above them. Even when dry, ponds are natural zones that aren’t paved and, therefore, are cooler than their surrounding context. Ponds can be accessible and vegetation can grow. In order for breezes to form, the wind direction should be considered when planning a water body (west to east from March to September in US deserts). It’s important to leave a corridor predominantly empty so winds aren’t blocked.



Water bodies

Heat mitigation

Cost

Time to implement

Pass | Wait | Stay

5.4 Street layout

5.4.1 Main idea & challenges

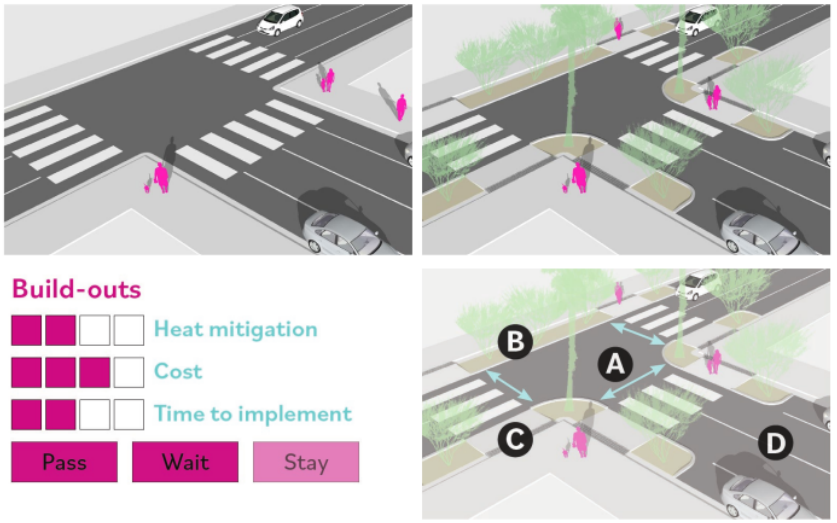
Although sprawl repair tools address modifying street layouts, more can be done to specifically enhance walkability in hot climates. Pedestrians must have priority and pedestrian infrastructure must be as comfortable and attractive as possible. After all - pedestrians are not in the AC of a car. To achieve this, streets will become (visually) narrower and greener.

It can be challenging to convince city officials or inhabitants that are used to driving to invest in these transformations. However, the result is worth pursuing, as street layout is an essential element in facilitating walkability.

5.4.2 Build-outs

Placed in the parallel parking lane or outer driving lanes, build-outs contribute to safety and pedestrian comfort at intersections (**paragraph 3.5.3**). There are multiple advantages to build-outs that benefit walking:

- Reduced pedestrian crossing distance (A)
- Space for vegetation (B)
- Comfortable pedestrian waiting spaces at intersections (C)
- Visually narrower street (D)

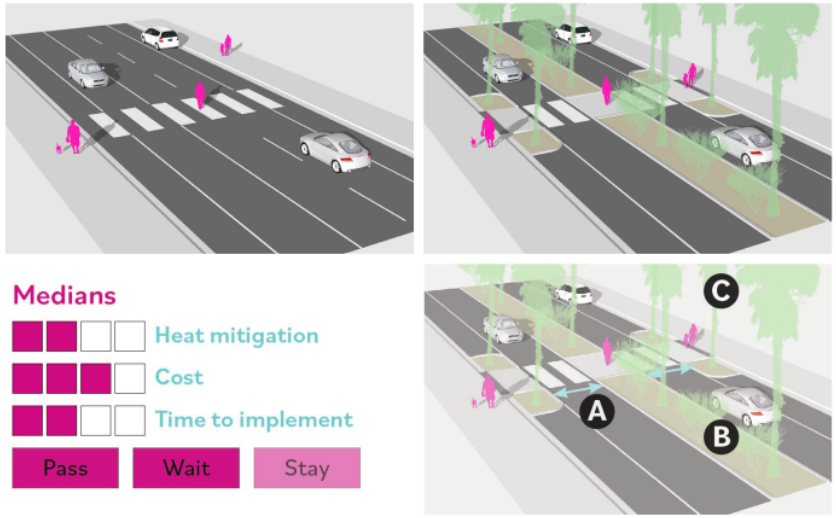


5.9 Build-outs

5.4.3 Medians

Medians also help mitigate heat and create a comfortable pedestrian realm. They are placed in the most central driving lane of a road. Advantages to medians are:

- Reduced pedestrian crossing distance (A)
- Space for vegetation (B) and formation of tree canopy (C)



5.10 Medians

5.5 Urban design & street furniture

5.5.1 Main idea & challenges

Street furniture and other urban design elements can bring shade and pedestrian comfort. They can be place making tools, leading to an interesting, active area. It can be challenging finding the right balance between maintaining an existing identity and re-branding, which these structures can contribute to.

Shade structures

Heat mitigation

Cost

Time to implement

Pass | Wait | Stay

5.5.2 Shade structures - individual structures

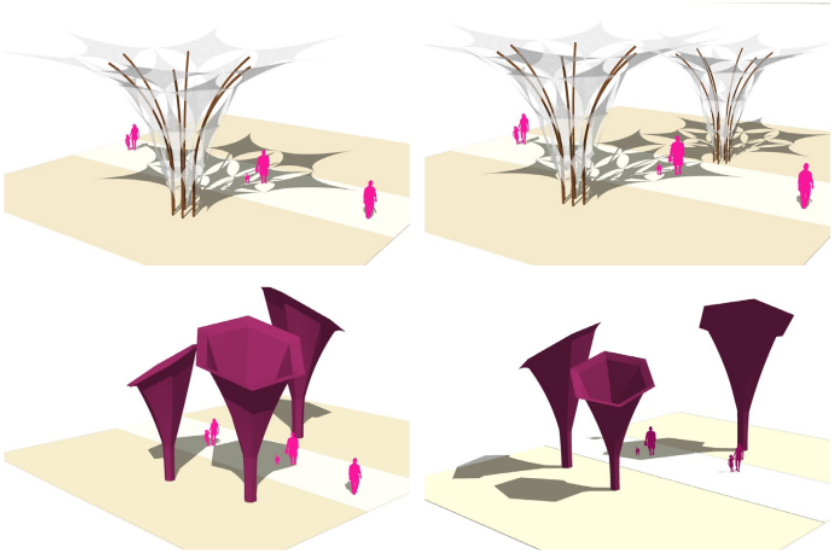
Individual shade structures have multiple benefits:

- They contribute to the area's identity.
- They are human scaled.
- They don't occupy much space at their base, but provide significant shade.

Disadvantages are:

- One structure provides shade in one concentrated place.
- As the sun rotates, these structures might not provide shade on the path anymore (therefore, they are better fit to be placed in a plaza or park).

Individual structures placed in groups are most effective: as the sun rotates, some of the structures provide shade on a path, while later, others provide shade on that same path.



5.11 Shade structures

5.5.3 Shade structures - linear canopies

Linear canopies are shade structures covering distances. Two types of linear canopies are: detached (placed above paths not bordering a building) and attached (bordering a building facade) canopies.

Detached:

- ✔ Individual style, open sides for wind, flexibility in width/height
- ✖ Poles in pedestrian space

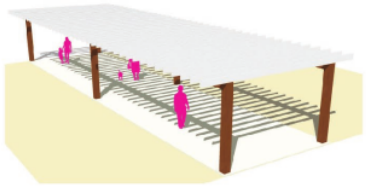
Attached:

- ✔ No need for poles in pedestrian space, unity to streetscape
- ✖ Building height must be similar, covers architecture & identity

Wind tower

The wind tower is a concept used that has been used to cool buildings and open spaces in the Middle East for centuries. Cool wind, higher than on sidewalk level, is collected through an opening at the top of the wind tower and the cool breeze is led down towards the sidewalk, where it can cool passing pedestrians. Though not very aesthetically-pleasing, it does the job.

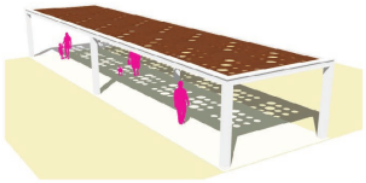
Shade impact
Wind impact
Cost



Louvres

White louvres covering pedestrian path. Able to rotate in line with the direction of sunlight.

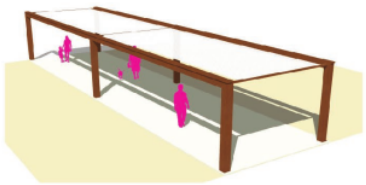
Shade impact
Wind impact
Cost



Punctured wood

Wooden board, punctured frame covers pedestrian path. Surface can display area's identity.

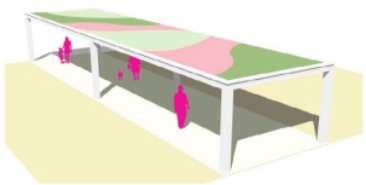
Shade impact
Wind impact
Cost



Sun sails

Sails or fabric tied between wooden beams above pedestrian path. Transparent surface.

Shade impact
Wind impact
Cost



Green canopy

Sedum roofs placed on top of canopy above pedestrian path. Reduce heat island effect and filter the air.

Shade impact
Wind impact
Cost

5.12 Linear canopies

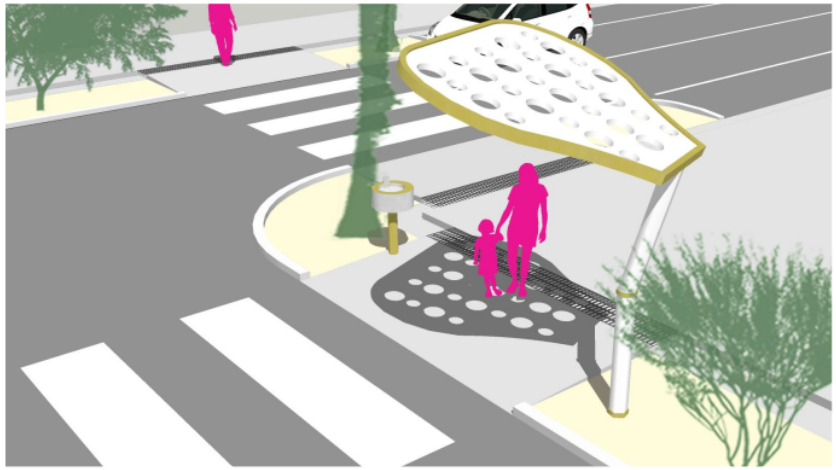
5.5.4 Pedestrian crossing

As wait-zones (paragraph 5.1.3), pedestrian crossings deserve extra attention. Being wait-zones, more should be invested in heat mitigation. Shading is essential. Water taps contribute too, so pedestrians can drink or cool their hands.

Pedestrian crossing

Heat mitigation
Cost
Time to implement

Pass | **Wait** | Stay



5.13 Pedestrian crossing

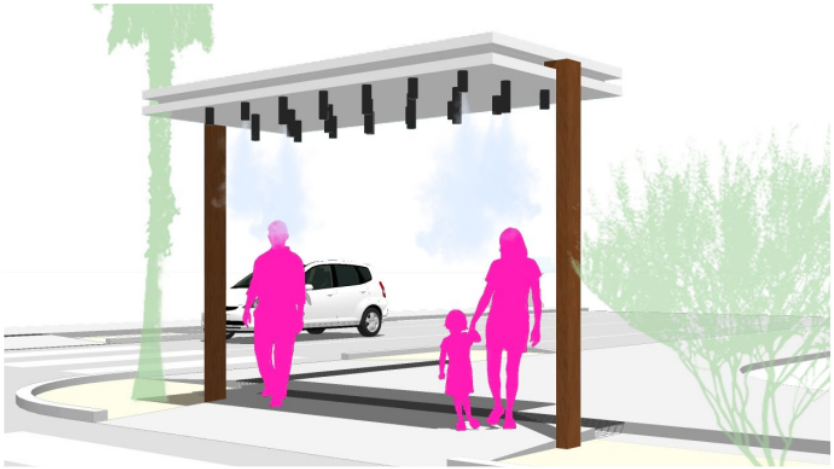
5.5.5 Cloud cast

In paragraph 4.3.3, Cloud Cast was introduced: a system to be implemented in wait-zones (unsustainable for stay-zones; not worth it for pass-zones). At pedestrian intersections, cloud cast forms a good solution, integrated in shade-providing canopies.

Cloud cast

Heat mitigation
Cost
Time to implement

Pass | **Wait** | Stay



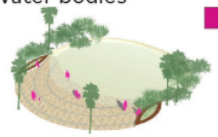
5.14 Cloud cast

5.6 Intervention matrix

Assess local character

Identify pass-, wait- & stay-zones

Toolkit

Building materials & pavement	The white dip  Pass Wait Stay  The white dip	Permeable pavement  Pass Wait  Permeable pavement	
Vegetation & nature	Plateaus  Pass Wait Stay  Green Plateaus	Bioswales  Pass  Bioswales	Water bodies  Stay  Water bodies
Street layout	Build-outs  Pass Wait  Build-outs	Medians  Pass Wait  Medians	
Urban design & street furniture	Shade structures: individual structures  Pass Wait Stay  Individual shade structures	Shade structures: linear canopies  Pass Wait Stay  Linear canopy shade structures	Pedestrian crossing enhancements  Pass Wait  Enhanced pedestrian crossings
	Cloud cast  Wait  Cloud cast		

Chapter 6

Palm Canyon Central District

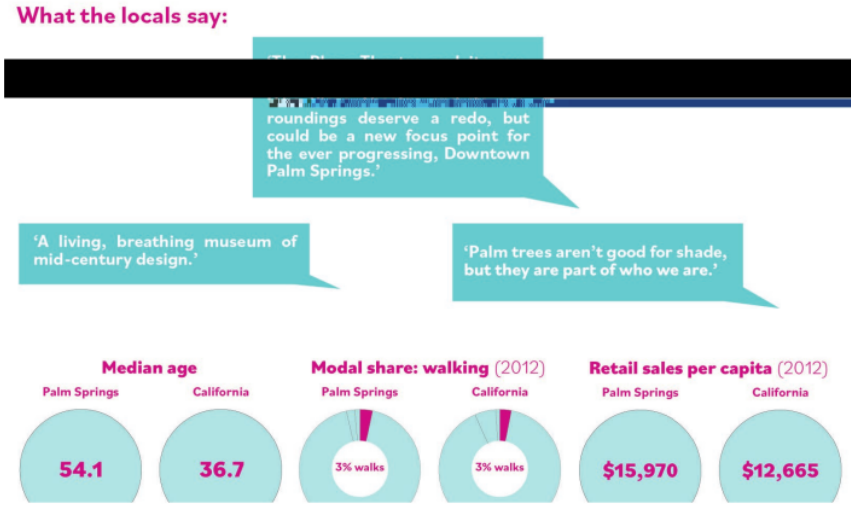
6.1.2 The character of Palm Springs

Locals

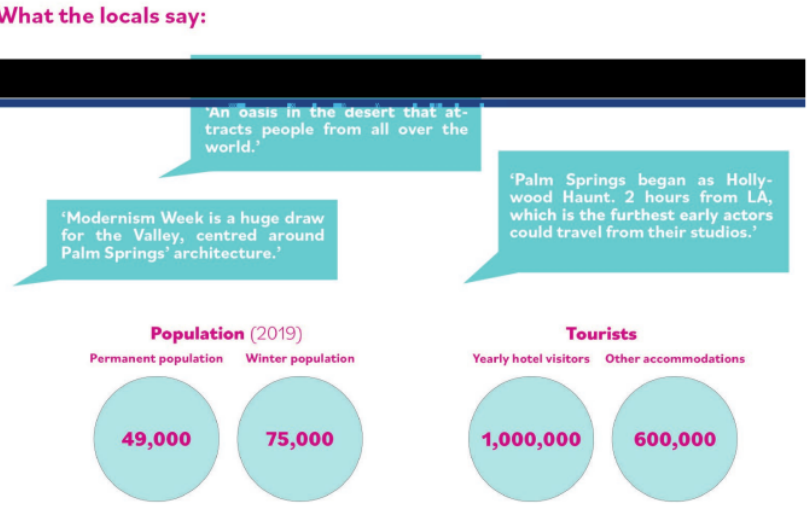
Palm Springs is a city of nearly 50,000 people with a relatively high median age. Retail sales per capita are higher than in the rest of California. The population density of Palm Springs is 94% higher than that of California (Areavibes, n.d.), which partly suggests that the city is less sprawled, making this an appropriate application site.

Visitors

Palm Springs' permanent population grows significantly in winter. Because of the warm weather (350 days of sunshine), many choose Palm Springs as a second home (Palmspringsca.gov, n.d.). Nearby national parks attract tourists.
A third of the 250,000 visitors that visit the Coachella festival each year stays in Palm Springs. Modernism Week attracts 100,000 architecturural design enthusiasts. Every two years, the Desert X arts festival attracts approximately 400,000 visitors. Festivals and sporting events also take place (Report on the economic impact on tourism, 2017).



6.4 Statistics: residents



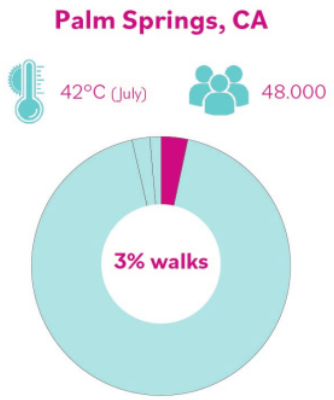
6.5 Statistics: tourism

6.1.3 Site justification

There are 5 main reasons for choosing Downtown Palm Springs to apply the toolkit:

- Downtown Palm Springs is a US desert city where sprawl repair has occurred, this is reflected by land use: large voids in the urban fabric hardly exist. Human scale urban design interventions can facilitate walkability.
- The modal share of walking in Palm Springs is low; temperatures are high.
- Located in the Sonoran Desert at an altitude of 500 ft, vegetation choices are limited, making the design challenging.
- It features a mix of commercial buildings and the Downtown area is a local draw; pedestrians are already present.

The scale of the site is relatively small, which is appropriate given the design's detail and the human scale of interventions. It forms a pilot area and the interventions can be applied on other stretches of Downtown later.

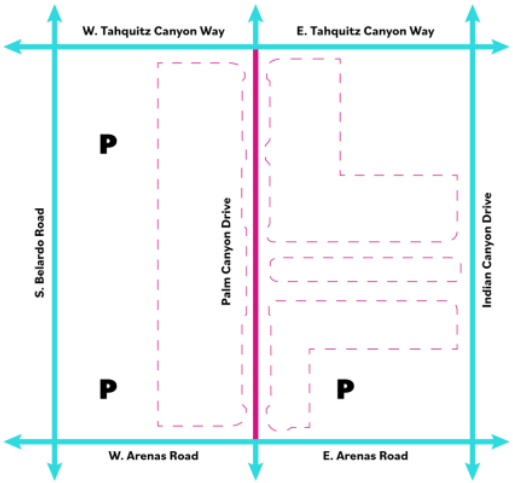


6.6 Walking share & temperature (Censusreporter, 2018; Weather US, 2020)

6.7 Site (Short of the Week, 2020)

6.1.4 Site introduction

The project site is located in Palm Springs' Central Business District: the city's commercial centre, consisting of the two blocks along Palm Canyon Drive: the main arterial through the project site, as well as the La Plaza parking lot. The district has high accessibility through wide roads, surrounding parking lots and (limited) bus stops.



6.8 Surrounding mobility

6.9 Illustrative site plan

6.1.5 Land use

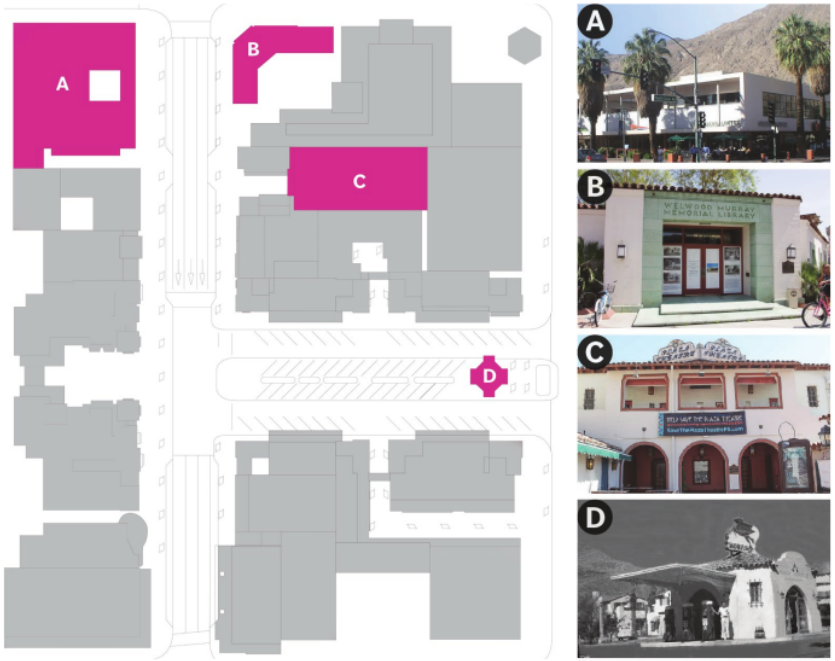
The site has a mixed commercial character, making it appropriate to enhance walkability: a destination for many that benefits from high pedestrian activity and density.

6.10 Land use

6.1.6 Notable buildings

The site features important buildings, in terms of their design and/or history:

- **A: Oasis Commercial Building**: modernist office building from 1951.
- **B: Welwood Murray Memorial Library**: library and tourist office from 1941.
- **C: Plaza Theatre**: famous theatre from 1936.
- **D: Tyler's Restaurant**: restaurant located in historic gas station (1936), bus station (1941) and shop (1949) (Brown, 2015).



6.11 Notable buildings

6.2 Walkable Palm Canyon Central District

6.2.1 Introduction to master plan

This is the Palm Canyon Central District: a walkable environment in the heart of Downtown Palm Springs. Local character assessments led to a design that's sensitive to the local context. The main changes from the existing situation are the role of the car (now a guest in a pedestrian-oriented environment), the large addition of green and blue space and the addition of urban design elements that are multi-functional and give the area a strong identity.

6.12 Illustrative master plan

6.2.2 Pass-, wait- & stay-zones

Pass-, wait- & stay-zones have been identified. Appropriate elements were introduced to accommodate each. Although the zones are constant throughout the day, the activity spread changes.

6.13 Pass-, wait- and stay-zones

6.2.3 Activity spread

9 am

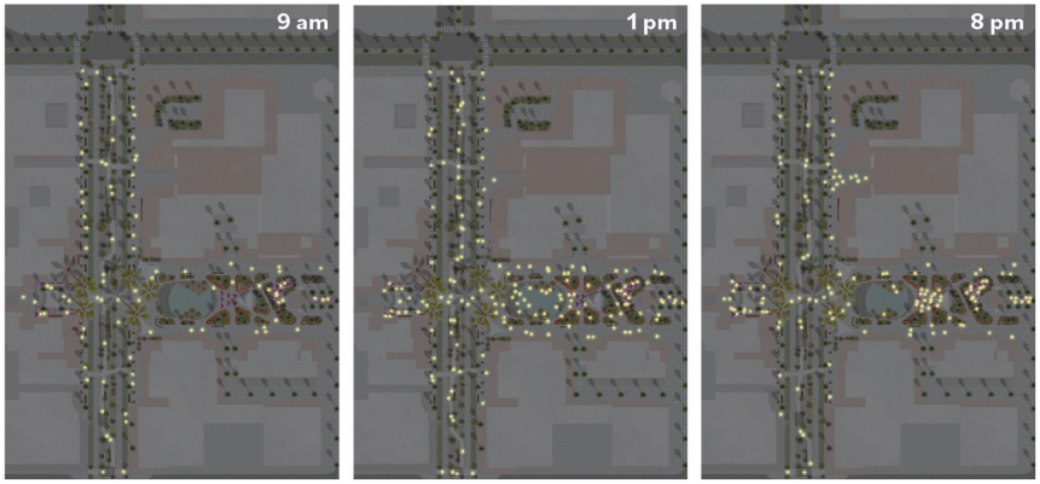
Pedestrian activity occurs on sidewalks of Palm Canyon Walk and along the park: an important east-west connection. Some activity occurs near restaurants and coffee shops.

1 pm

Activity occurs mostly in and around green spaces, in the park and on Palm Canyon Walk: the shaded areas. People gather around the pond for cooling.

8 pm

At night, the district is cooler than during the day. Outdoor terraces are busy, as are plazas. Activity occurs at the open air stage in the park where performances are held.



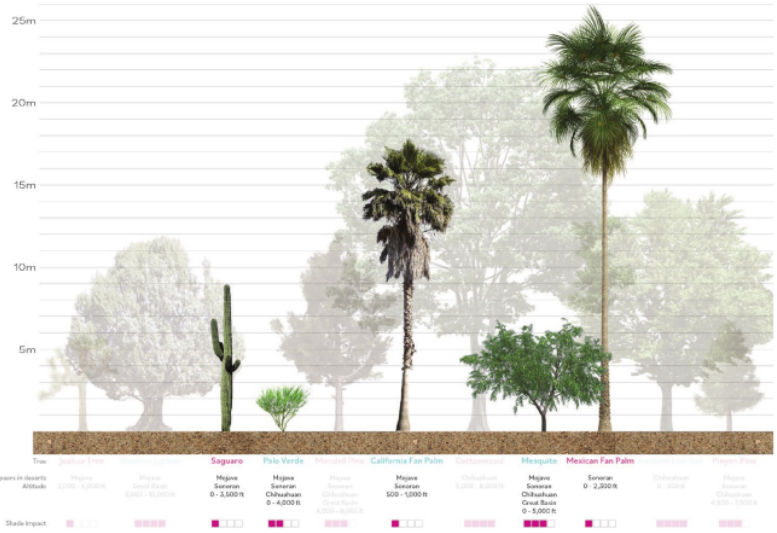
6.14 Pedestrian activity spread

6.2.4 Vegetation & water

Figure 6.15 shows the tree diagram for Palm Springs. Most shade is created by the Mojave and Mesquite, while the palms and saguaro display the city's identity as 'oasis in the desert'.

Figure 6.16 shows the water network. Collected rainwater can be stored in the pond, bioswale and green patches. The relatively large amount of surface water allows for zones that, even when dry, are cool spaces.

Figure 6.17 shows tree placement. An east-west corridor adjacent to the pond is left with hardly any trees to prevent breezeway obstruction.



6.15 Palm Springs tree diagram

6.16 Water networks

6.17 Tree placement

6.2.5 Toolkit applied

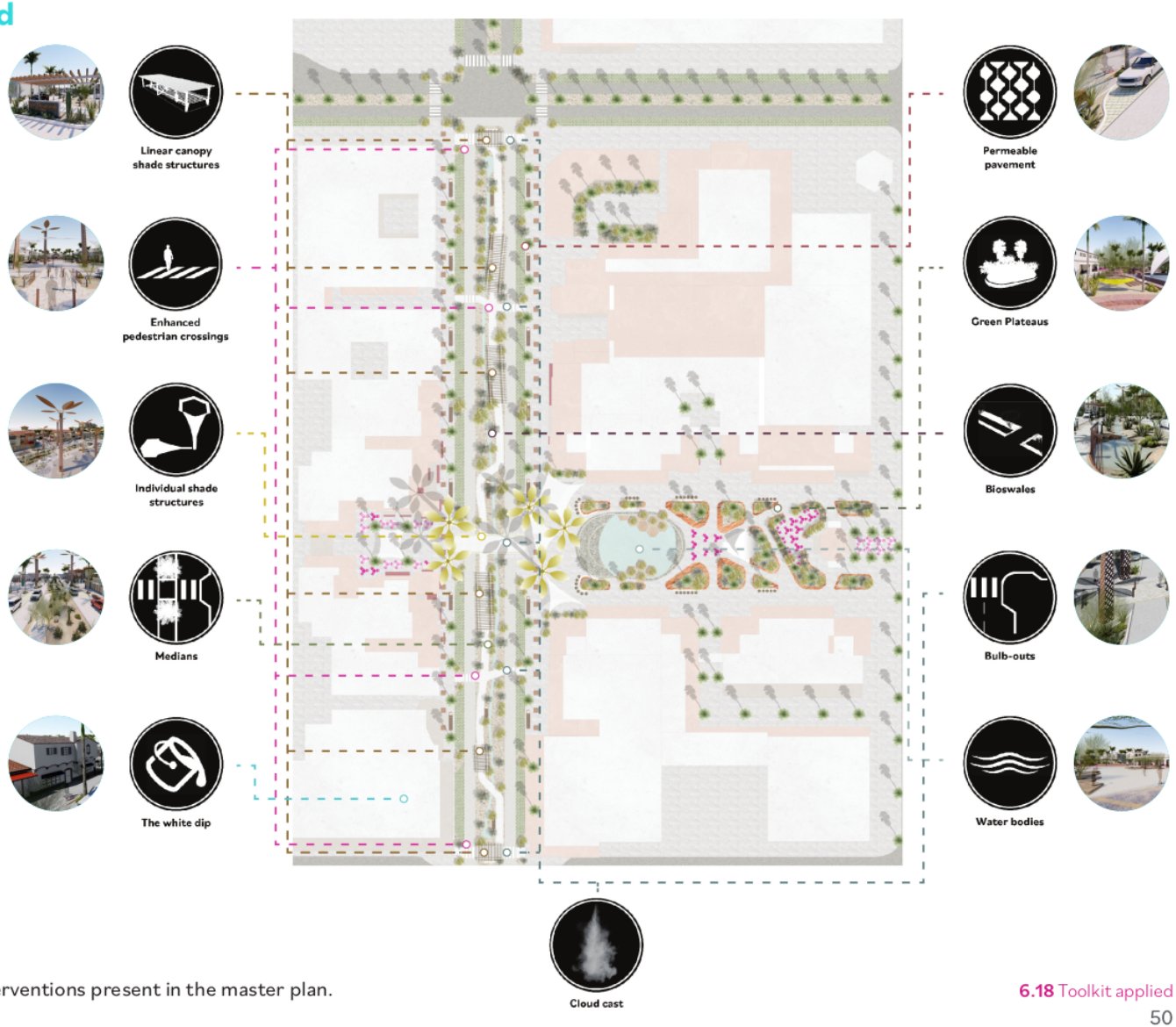


Figure 6.18 shows the toolkit interventions present in the master plan.

6.3 The 3 zones of the Palm Canyon Central District

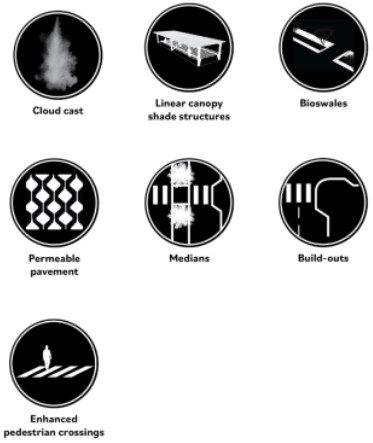
Palm Canyon Walk

6.19 Existing (Google, 2020)

6.3.1 Palm Canyon Walk

6.20 Location

This section of Palm Canyon Drive be will be renamed to Palm Canyon Walk, to highlight pedestrian importance. While the curb-to-curb remains the same, the street will transform from one-way 3-laner to a two-way street with one lane in each direction, fitting walkable districts (Speck, 2018). By narrowing lanes, vehicular speeds decrease and more room is created for pedestrians. The median will contain a bioswale and street furniture, forming a linear cool zone. Pedestrian-priority crossings and build-outs highlight the pedestrian's top role in the street hierarchy.



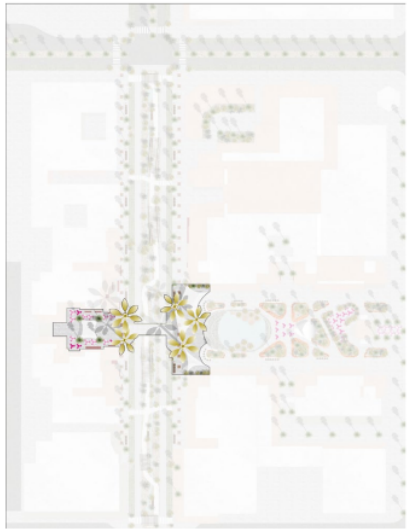
6.21 Impression

6.22 Sections

6.23 Existing (Google, 2020)

Palm Canyon Plaza

6.3.2 Palm Canyon Plaza



6.24 Location

Palm Canyon Plaza forms the heart of the Palm Canyon Central District and connects both sides of Palm Canyon Drive through a wide pedestrian-priority crossing.
Sun sails, shade structures, vegetation and water accessibility create a comfortable environment.

6.25 Impressions

Palm Canyon Park

6.26 Existing (Google, 2020)

6.3.3 Palm Canyon Park

6.27 Location

Palm Canyon Park forms the green and cool heart of the District. The main concept behind the park's design is a mixture of different types of plateaus (**paragraph 5.3.2**), placed in the park with time-sensitive urban design in mind and slope up towards the north, creating maximum shade. Rain water collected in the area is stored in a pond and it functions as a cool zone that's accessible to pedestrians. Tyler's restaurant is given an outdoor dining area in a courtyard plateau, protected from sunlight and surrounded by plants. Though hot during the day, the square with outdoor stage can be used for events in the evening (**paragraph 6.4.4**).

6.28 Impressions

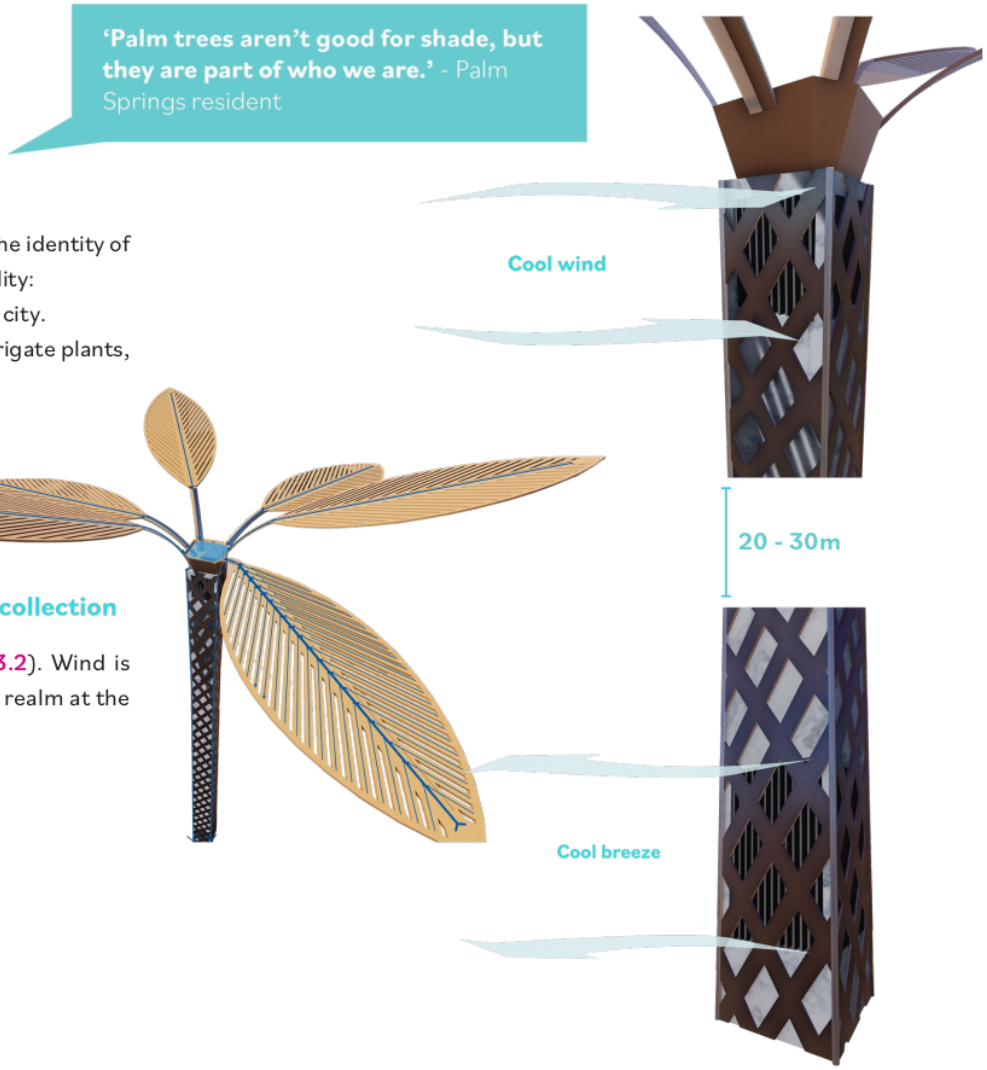
6.4 Specific design elements

6.4.1 The Palms

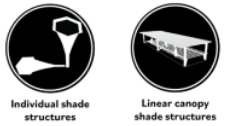
'The Palms' are 5 large, palm-shaped structures that contribute to the identity of the District. They have multiple functions that contribute to walkability:

- **Enhanced way finding**: orientation points in the district and the city.
- **Water bodies & cloud cast**: rainwater is collected and used to irrigate plants, water bodies and for cloud cast.
- **Enhance local character**: palms are Palm Springs' identity, that will make the pedestrian experience more interesting and lead to place making.
- **Shade structure:** The Palms shade the pedestrian realm.
- **Wind towers**: The Palms serve as wind towers (paragraph 4.3.2). Wind is captured at the top of the trunks and blown into the pedestrian realm at the trunk's base.

6.29 'The Palms' explained



6.4.3 Street furniture & materials



Street furniture and way finding in the District has its own style. The symbol of a palm tree is key for Palm Springs' identity and is therefore used in most of the graphic design. The placement of benches also takes heat mitigation into account and contributes to pedestrian comfort.

- Benches are placed in shaded stay-zones.
- Bollards with palm symbols light up at night, enhancing the local character.
- Wooden way finding poles guide pedestrians.
- Banners attached to light poles notify pedestrians of events.

6.30 Impressions

6.4.4 Events

Events are opportunities to attract pedestrians and allow flexibility in line with time-sensitive urban design. For example, the public space can be activated in the evening and made into a pedestrian-friendly zone when concerts are hosted. The Coachella Festival and Modernism week are examples of events during which the district can play an integral role in stimulating pedestrian activity.

A living, breathing museum of mid-century design. - Palm Springs resident

Modernism Week is a huge draw for the Valley, centred around Palm Springs' architecture. - Palm Springs resident

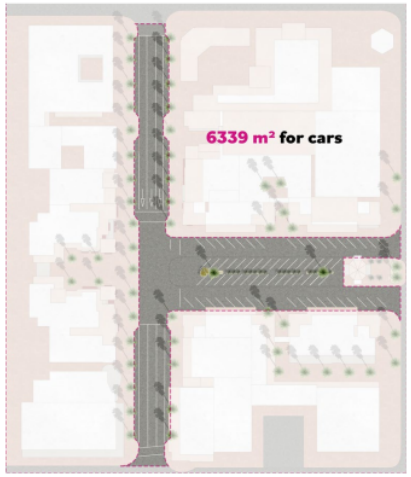
An oasis in the desert that attracts people from all over the world. - Palm Springs resident

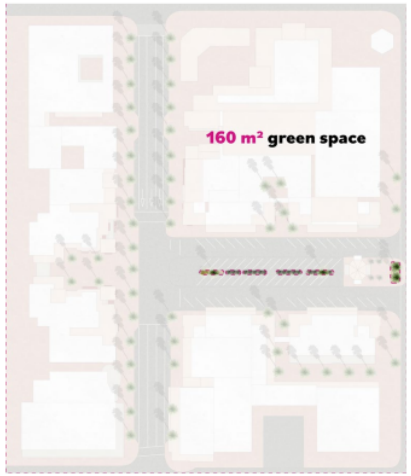
6.31 Impressions

6.5 Palm Canyon Central District: conclusion

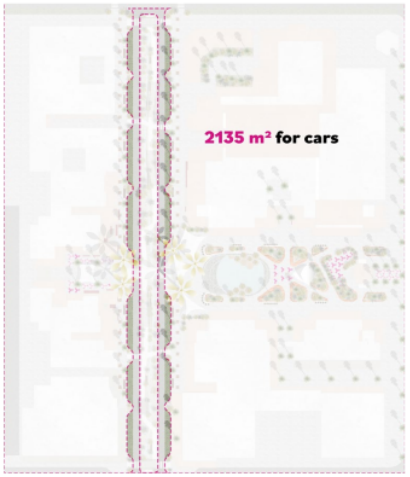
6.5.1 Changes and results

Existing situation





Proposed situation



Results

Space for cars

Pedestrians have more space in the proposed situation. In the existing situation, 6339sqm of the site is dedicated to car infrastructure. The car is the main consumer of the open space. In the proposal, the car is a guest in a pedestrian-oriented environment and its dedicated area becomes three times smaller. Remaining space is dedicated to pedestrians or cooling elements, such as water and green.

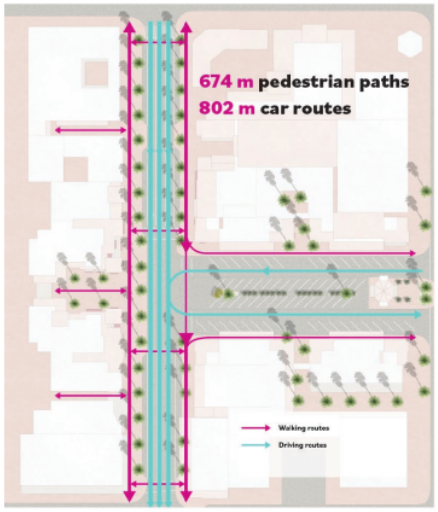
6339m2 asphalt (albedo 0.10) **VS.** 2135m2 white concrete (albedo 0.36) (Taha, Sailor and Akbari, 1992)

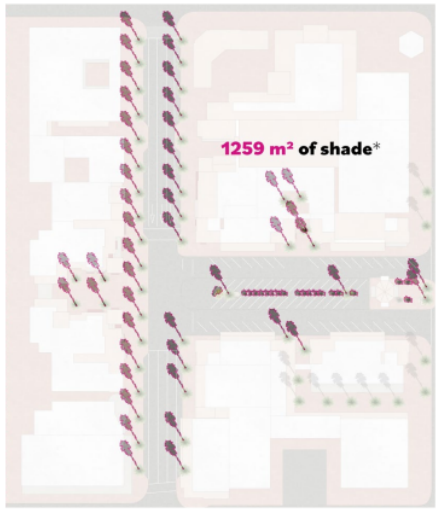
Green space

The current situation hardly has any green (160sqm). All remaining space is paved, bringing up temperatures.
In the proposed situation, green space is key and accounts for 2462 sqm of the total area, leading to less heat, better water drainage and more shade on the pedestrian realm.

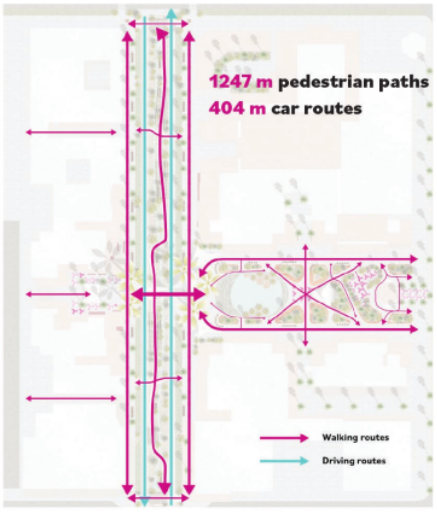
160m2 **VS.** 2462m2 desert soil (albedo 0.29) (Taha, Sailor and Akbari, 1992)

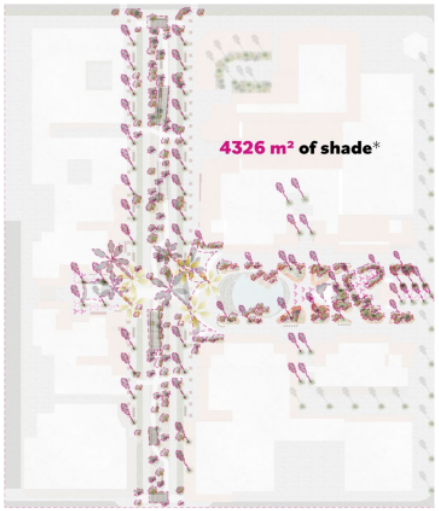
Existing situation





Proposed situation





* shade from elements in the open space, such as trees, shade structures and sun sails

Results

Routes

Related to car-dedicated space, length of routes can indicate the hierarchy of users space. Pedestrian paths will double in meters and more routes will be available to pedestrians. Car routes will decrease by half. The east-west connection through La Plaza dissapears and only 2 lanes remain, heading in both directions.

Shade

Besides buildings, only palms provide shade, which is very limited. In the proposed situation, much more shade will be added, by which the total shaded surface will grow from 1259m2 to 4326m2 at 11am in April. This shade is created through trees, plateaus and different shade structures.

6.5.2 Reflection on design process

Analysing the project site and applying the toolkit tells us more about the toolkit's strengths, limits and the way in which application is realistic.

Limits

The existing context of the site limits the abilities to fully implement the toolkit. Applying linear canopies attached to buildings is difficult, due to different heights, architectural styles and blocking views on significant buildings.

Existing trees can be limitations. Palm Canyon Drive is lined with palms, not the most suitable trees for shade. Trees with a canopy for shade must be planted and other locations must be found for these, preferably without taking away pedestrian space. Parking planters formed a solution.

The curb-to-curb of the street was kept in place to avoid dramatic costs. This limited the pedestrian space in the median, when allowing room for the bioswale, nature, driving lanes and parking.

Much depends on taking space from cars. In US desert cities, where the car-culture is large, opposition to such proposals can be great. One could start with only 2 blocks, so the potential burden on drivers is limited. People will realize the advantages and may be open to transformations of other areas too. Also, car ownership in the US decreases as carshare services, among others, have led to a 10% decline in car registrations in 2019 (Edwards, 2019).

Opportunities

An example of opportunities is 'The Palms', the wind towers in Palm Canyon Plaza. In the toolkit, wind towers are mentioned as not being aesthetically pleasing, however, applying Palm Springs' identity to the wind tower design led to iconic structures that fit the area and strengthen its identity.

Considering pass-, wait- and stay-zones helps deciding which measures to apply where. Stay-zones were identified, where more heat mitigation are needed, but also pass-zones, where this could be limited.

(Partially) closing streets for cars in US cities is possible due to the grid system. Alternative routes are available, making such interventions perhaps easier in the US than in other contexts.

Climate change is an opportunity too. As events such as heavy rainfall and floods are inevitable and must be dealt with, the tools to handle this also contribute to heat mitigation and creating an attractive pedestrian realm, mostly through the increased importance of water and green and the reduction of paved areas.

Chapter 7
Conclusion

7.1 Conclusion

Walking is a heavily underused transportation mode in United States desert cities. Sprawl repair plays an important role in creating more walkable cities, but despite its many well-accepted benefits, the sole activity of infilling open spaces is not enough to ensure walkability. Human scale urban design interventions are necessary. This report has provided a toolkit to facilitate walkability in US desert cities. It was applied on an actual US desert city, where it was tested and the limits and opportunities of the toolkit were identified. By learning from the literature review, four case study cities and by testing the toolkit, a comprehensive research has been conducted that can be applied on other US desert cities and that can potentially be translated into other desert contexts around the world. Other extreme climates can also benefit from this toolkit, where certain elements discussed here can be applied.

7.2 Role of design

The role of design was vital to test the toolkit and identify limitations and opportunities of applying it on a real-world US desert city.

Identified limitations include dealing with the existing context, in terms of architecture, existing vegetation and street dimensions. The car-culture of US desert cities should not be seen as something static that can't be changed. Although it might cause opposition at first, starting by applying measures on a relatively small area can show the benefits of this transformation without taking away people's beloved 'car rights'. Once exposed to this new, comfortable pedestrian environment, which saves money, benefits their health and enjoys social benefits, other areas can be transformed with less opposition.

Designing also brought forward opportunities, like the way in which local identity can play a role in shaping the interventions, making more interesting places and making them more appropriate for their site. Pass-, wait- and stay-zones have proven to be a great tool in dealing with cost-efficiency. Measures that deal with mitigating the consequences of climate change on US deserts benefit walkability too.

7.3 Contribution to practice

The toolkit and the learnings from applying it on Palm Springs can contribute to **professional practice** in multiple ways:

- Guidelines can be implemented on US desert cities where sprawl repair has occurred.
- Due to climate change, the toolkit will be appropriate for more cities in the future, as US deserts will become larger and more cities will fall under the category of 'desert city'.
- Though this research focuses on the US context, other deserts around the world could benefit from the toolkit. It only works in combination with sprawl repair, however.
- Though primarily made for US deserts, the tools can benefit other hot climates too, if translated into the right context regarding vegetation, climate change consequences, etc.
- The toolkit can be a valuable addition to many of the Downtown revitalization studies that are currently conducted.

Academic research also benefits from this research:

- Though academic research is extensive on heat mitigation for open spaces, specific research into how urban design can help walkability in one of the most extreme climates, the desert, was limited. This toolkit is specific to this context and focuses on the activity of walking.
- The same goes for sprawl repair. Sprawl repair literature is extensive, yet, this research can add another dimension to that literature: how walkability can be facilitated in desert climates.

7.4 Further research

This research is a comprehensive introduction to facilitating walkability through urban design in US desert cities. **Opportunities** for future research into this topic or related topics could be:

- How can walkability be facilitated in other areas with extreme climates? Very cold cities, for example. Pass-, wait- and stay-zones could be applied here too.
- Cycling is another sustainable transportation mode. Research into how cycling can be facilitated contributes to a complete network of sustainable transportation in US desert cities.
- Potential research into maximum amounts of time spent or distance covered walking in US desert cities until it becomes too uncomfortable. This could lead to pass-zones enhancements.
- Research into the economics of facilitating walkability in US desert cities could be useful to get more stakeholders involved. If local businesses can see the exact costs and benefits from heat mitigation measures, they would be more willing to invest in it.

Limits for further research could be:

- This toolkit mostly works for areas where people have a reason to walk in the first place, such as commercial districts like Downtown Palm Springs. Applying the toolkit on low dense residential neighbourhoods, for example, might produce different cost-benefit outcomes.
- The fact that it only works along with sprawl repair is a limitation to this research. Many US desert cities are still sprawled and money and time is needed for sprawl repair.

8.1 References

- American Planning Association. (2018). **Downtown Revitalization in Small and Midsized Cities.** [online] Available at: https://planning-org-uploaded-media.s3.amazonaws.com/document/PAS-Report-590-executive-summary.pdf [Accessed 28 Aug. 2020].
- Archer, S.R. and Predick, K.I. (2020). **Climate Change and Ecosystems of the Southwestern United States**. Rangelands, 30(3), pp.23–28.
- Area Vibes (n.d.). **Palm Springs, California Population & Demographics**. [online] Available at: https://www.areavibes.com/palm+springs-ca/demographics/ [Accessed 21 Jul. 2020].
- Barrington-Leigh, C. and Millard-Ball, A. (2015). **A century of sprawl in the United States**. Proceedings of the National Academy of Sciences, 112(27), pp.8244–8249.
- Berkeley.edu. (2019). **The desert biome**. [online] Available at: https://ucmp.berkeley.edu/exhibits/biomes/deserts.php.
- Bologna Welcome (2020). **The Porticoes of Bologna - Bologna Welcome**. [online] Available at: https://www.bolognawelcome.com/en/blog/the-porticoes-of-bologna [Accessed 22 Jul. 2020].
- Brown, R. (2015). **Palm Springs - history | Explore Palm Springs: Where Tyler's Burgers Now Sits**. [online] Palm Springs Life. Available at: https://www.palmspringslife.com/explore-palm-springs-where-tylers-burgers-now-sits/ [Accessed 17 Jul. 2020].
- Brueckner, J.K. (2000). **Urban Sprawl: Diagnosis and Remedies**. International Regional Science Review, 23(2), pp.160–171.
- Burayidi, M.A. (2018). [online] Available at: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-590.pdf [Accessed 10 Jun. 2020].
- Burden, D. (2013). **First fix the streets, then the people and business will follow**. [online] Local Government Commission Center for Livable Communities. Available at: https://www.lgc.org/wordpress/wp-content/uploads/2013/10/walk_to_money.pdf [Accessed 18 May 2020].
- Census Reporter. (2018). **Census Reporter**. [online] Available at: https://censusreporter.org/profiles/01000us-united-states/ [Accessed 23 May 2020].
- City of Cambridge (n.d.). **Cambridge**. Available at: https://www.cambridgema.gov/Departments/LicenseCommission [Accessed 23 May 2020a].
- Civitas.eu. (n.d.). **Naples | CIVITAS**. [online] Available at: https://civitas.eu/content/naples [Accessed 23 May 2020].
- Coughenour, C., de la Fuente-Mella, H. and Paz, A. (2019). **Analysis of Self-Reported Walking for Transit in a Sprawling Urban Metropolitan Area in the Western U.S. Sustainability**, 11(3), p.852.
- Owen, D. (2011). **Green metropolis : why living smaller, living closer, and driving less are the keys to sustainability**. London: Penguin.
- Deloitte City Mobility Index: **Future of mobility capability service and inclusion Performance and resilience vision and leadership**. (n.d.). [online] Deloitte. Available at: https://www2.deloitte.com/content/dam/insights/us/articles/4331_Deloitte-City-Mobility-Index/Paris_GlobalCityMobility_WEB.pdf [Accessed 23 May 2020].
- DesertUSA.com (2019a). **Desert Plants - Cactus - Wildflowers - Flora**. [online] Desertusa.com. Available at: https://www.desertusa.com/flora.html [Accessed 2 Jun. 2020].
- DesertUSA.com (2019b). **The North American Deserts - DesertUSA**. [online] Desertusa.com. Available at: https://www.desertusa.com/north-american-deserts.html [Accessed 19 May 2020].
- Eco-Business (2013). **The Walkable City: a Centre for Liveable Cities report**. [online] Eco-Business. Available at: https://www.eco-business.com/news/walkable-city-centre-liveable-cities-report/#:~:text=In%20the%20Index%2C%20the%20most [Accessed 17 Jun. 2020].
- Edwards, J. (2019). **Carpocalypse now: Lyft's founders are right — we're in the endgame for traditional "car ownership."** [online] Business Insider. Available at: https://www.businessinsider.com/carpocalypse-cars-automobile-sales-data-us-europe-2019-3 [Accessed 19 Aug. 2020].
- EPOMM (n.d.). **TEMS - The EPOMM Modal Split Tool**. [online] Available at: http://www.epomm.eu/tems/result_city.phtml?city=221&map=1 [Accessed 23 May 2020].
- Fernandez, K. (2015). **Cool summers ahead for Dubai**. [online] gulfnews.com. Available at: https://gulfnews.com/business/cool-summers-ahead-for-dubai-1.1685442 [Accessed 11 Jun. 2020].
- Fiorello, D., Martino, A., Zani, L., Christidis, P. and Navajas-Cawood, E. (2016). **Mobility Data across the EU 28 Member States: Results from an Extensive CAWI Survey**. Transportation Research Procedia, 14, pp.1104–1113.
- Frumkin, H. (2002). **Urban sprawl and public health**. Public Health Reports, 117(3), pp.201–217.
- Google. (2019/2020). **Google Maps & Google Streetview.**
- Green Launches. (2011). **Singapore sets up giant metal and concrete "trees" with rainwater harvesting** -. [online] Available at: https://www.greenlaunches.com/other-stuff/singapore-sets-up-giant-metal-and-concrete-trees-with-rainwater-harvesting.php [Accessed 18 Jun. 2020].
- Greenfield, J. (2017). **If the future will be walkable, how do we make sure everyone benefits?** [online] Streetsblog Chicago. Available at: https://chi.streetsblog.org/2017/05/11/if-the-future-will-be-walkable-how-do-we-make-sure-everyone-benefits/ [Accessed 18 May 2020].
- Harvard Health Publishing (2018). **Walking: Your steps to health - Harvard Health**. [online] Harvard

Health. Available at: https://www.health.harvard.edu/staying-healthy/walking-your-steps-to-health [Accessed 18 May 2020].
- Jin, J. (2012). **Urban design for sustainability: a case study of the carbon-neutral Masdar City in Abu Dhabi**. Northumbria University.
- Kántor, N., Chen, L. and Gál, C.V. (2018). **Human-biometeorological significance of shading in urban public spaces—Summertime measurements in Pécs, Hungary**. Landscape and Urban Planning, 170, pp.241–255.
- Kraniotis, D., Aurlien, T. and Thiis, T. (2014). **Investigating Instantaneous Wind-Driven Infiltration Rates using the CO2Concentration Decay Method**. International Journal of Ventilation, 13(2), pp.111–124.
- Modmansions (n.d.). **Palm Springs**. Available at: modmansions.com/palm-springs-vacation-blog/pack-a-day-bag-and-trip-around-palm-springs [Accessed 23 May 2020b].
- NPS (2009). **Common trees of the Chihuahuan Desert**. [online] Available at: https://www.nps.gov/cham/learn/nature/upload/trees_6_30_09.pdf [Accessed 19 Jun. 2020].
- Palmspringsca.gov. (n.d.). **City Profile | City of Palm Springs.** [online] Available at: https://www.palmspringsca.gov/business/city-profile [Accessed 21 Jul. 2020].
- Pucher, J. (1995). **Urban passenger transport in the United States and Europe: a comparative analysis of public policies**, Transport Reviews, 15:2, 99-117, DOI: 10.1080/01441649508716906
- Ramakrishna (2018). **What Future is There for America's Desert Cities?** [online] Literary Hub. Available at: https://lithub.com/what-future-is-there-for-americas-desert-cities/ [Accessed 29 May 2020].
- Ramboll (2014). **Singapore - A model city for water management**. [online] Ramboll Group. Available at: https://ramboll.com/media/articles/water/singapore-a-model-city-for-water-management [Accessed 18 Jun. 2020].
- Reinventing Cities (2016). **The City Centre at "Desert Rose" Smart Sustainable City**. [online] Available at: https://www.c40reinventingcities.org/data/sites_134e6/fiche/74/ssr_dubai_city_centre_desert_rose_3039a.pdf [Accessed 22 Jul. 2020].
- Report on the economic impact on tourism. (2017). [online] Greater Palm Springs Convention & Visitors Bureau. Available at: https://assets.simpleviewinc.com/simpleview/image/upload/v1/clients/palmsprings/GPS_EconomicImpactStudy_2017_0530_FINAL_8b-3dc756-6aba-4089-8a37-bf0f8bfc3f5c.pdf [Accessed 21 Jul. 2020].
- Ruefenacht, L. and Pignatta, G. (2017). **Strategies for Cooling Singapore.** Cooling Singapore (CS).
- RunSociety. (2019). **What Types of Singapore Trees You Can See While Running in 2020**. [online] Available at: http://runsociety.com/highlight/for-tree-hugger-runners-types-of-trees-you-can-see-along-singapore-road/ [Accessed 18 Jun. 2020].
- Sanderson, S. (2019). **Beat the heat: Architecture and design ideas to cool down** | DW | 25.07.2019. [online] DW.COM. Available at: https://www.dw.com/en/beat-the-heat-architecture-and-design-ideas-to-cool-down/a-49740789 [Accessed 12 Jun. 2020].
- Schuch, U. and Kelly, J. (2007). **Bulletin of The Desert Legume Program of The Boyce Thompson Southwestern Arboretum and The University of Arizona**. Aridus, [online] 19(2). Available at: https://cals.arizona.edu/desertlegumeprogram/pdf/aridus19-2.pdf [Accessed 14 Jun. 2020].
- Short of the Week (2020). **Short of the Week**. [online] Available at: https://www.shortoftheweek.com/news/watch-films-2020-palm-springs-shortfest/ [Accessed 13 Aug. 2020].
- Smeins, F.E. and Bolen, E.G. (1999). **Ecology of North America**. The Journal of Wildlife Management, 63(2), p.758.
- Speck, J. (2018). **Walkable city rules : 101 steps to making better places**. Washington, Dc: Island Press.
- Tachieva, G. (2010). **Sprawl repair manual.** Island Press.
- Taha, H., Akbari, H., Rosenfeld, A. and Huang, J. (1988). **Residential cooling loads and the urban heat island—the effects of albedo**. Building and Environment, [online] 23(4), pp.271–283. Available at: https://www.sciencedirect.com/science/article/pii/0360132388900339 [Accessed 23 Jun. 2019].
- Taha, H., Sailor, D. and Akbari, H. (1992). **High-albedo materials for reducing building cooling energy use**. [online] www.osti.gov. Available at: https://www.osti.gov/servlets/purl/7000986.
- Tentree (2019). **10 Facts About The Incredible Joshua Tree**. [online] tentree. Available at: https://www.tentree.com/blogs/posts/10-facts-about-the-incredible-joshua-tree#:~:text=Where%20do%20Joshua%20trees%20take [Accessed 22 Jul. 2020].
- TransportGeography. (2017). **Modal Split, Journey to Work Trips, Selected Cities**. [online] Available at: https://transportgeography.org/?page_id=5055 [Accessed 23 May 2020].
- Unesco. (2006). **The Porticoes of Bologna**. [online] UNESCO World Heritage Centre. Available at: https://whc.unesco.org/en/tentativelists/5010/ [Accessed 10 Jun. 2020].
- US Census Bureau (n.d.). **U.S. Census Bureau: Palm Springs city, California**. [online] Available at: https://www.census.gov/quickfacts/fact/table/palmspringscitycalifornia [Accessed 7 Jul. 2020].
- Wassmer, R.W. (2000). **Urban Sprawl in a U.S. Metropolitan Area: Ways to Measure and a Comparison of the Sacramento Area to Similar Metropolitan Areas in California and the U.S**. SSRN Electronic Journal.
- Weather US (2020). **Weather Atlas**. [online] Weather Atlas. Available at: https://www.weather-us.com/ [Accessed 12 Aug. 2020].
- World population review (n.d.). **Palm Springs, California Population 2020 (Demographics, Maps, Graphs)**. [online] Available at: https://worldpopulationreview.com/us-cities/palm-springs-ca-population.

8.2 Table of figures