Outdoor Comfort : Hot Desert and Cold Winter Cities

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Summary

Cities of extreme climate highlight the need for climate sensitive urban design at the site design scale. Relatively inexpensive energy costs have allowed cities as different climatically as Edmonton, Alberta and Phoenix, Arizona to develop more or less in the same manner. Both cities ignore their unique climate and thus any potential to capitalize on their unique characteristics. Both the Sonoran Desert and the high Canadian Prairie are starkly beautiful natural places. By using site design principles which maximize the positive aspects and minimize the negative aspects of each climate type, both cities could develop as uniquely beautiful and comfortable urban places. Most of the literature to date has focused on interior architectural issues of energy conservation or interior comfort. Some urban planning work has focused on the general issue of climate sensitive urban design. There is need for further research with extreme climate cities to develop site level outdoor design principles which will improve everyday comfort within hot desert and cold winter cities.

Résumé

Les villes jouissant d'un climat extrême mettent en évidence l'importance d'une planification qui tiendrait compte de cet aspect. Le coût relativement bas de l'énergie a permis à des villes aussi différentes sur le plan du climat qu'Edmonton, Alberta, et Phoenix, Arizona, de se développer de manière assez semblable. Ces deux villes ne tiennent pas compte du fait qu'elles jouissent d'un climat unique et négligent donc toute possibilité de profiter de cet aspect. Le désert du Sonoran et la grande prairie canadienne sont des sites naturels très beaux. Les deux villes pourraient utiliser des principes de planification pour maximiser les aspects positifs et minimiser les aspects négatifs de leur environnement climatique naturel; elles deviendraient alors des endroits à la beauté et au confort uniques. A ce jour, la plus grande partie de la littérature s'est concentrée sur des aspects architecturaux liés à la conservation de l'énergie et au confort intérieur. Certains travaux de planification urbaine se sont intéressés à la question globale d'un aménagement respectueux des

données climatiques. D'autres recherches devraient être entreprises dans des villes jouissant d'un climat extrême; elles permettraient d'élaborer des principes d'aménagement extérieur contribuant à améliorer les conditions de confort trouvées dans les villes situés dans des déserts ou dans des régions où l'hiver est très rude.

Introduction

People deny climate. Edmonton, Alberta is *not* cold and Phoenix, Arizona is *not* hot. If this were not true, why do Phoenix and Edmonton look so similar? Both are modern medium sized North American cities which do not appear to go out of their way to make the outdoor urban microclimate more comfortable for everyday use. This denial of extreme climates may come from our distant past. Humankind evolved close to the 70 degree Fahrenheit, (21 degree Celsius) isotherm, with a temperature range of about sixty degrees F. (16 C.) to seventy six degrees F. (24 C.), and a relative humidity of forty to seventy percent (Markham, 1947, 44). Outdoor climatic comfort is clearly greatest in Mediterranean climate cities such as San Diego, California or Nice, France, which have annual average temperatures close to this evolutionary ideal. Our ideal notions of urban or suburban environments are largely a product of these mild climates.

> "....northern latitudes were inundated by southern people with southern values and with very definite concepts in mind of what constitute a home or a community. These petrified images of houses, streets, and public spaces are stubbornly repeated over and over again, in spite of high energy bills, the cost of municipal services and the cost in terms of human discomfort.." (Matus, 1984, 7).

Bio-climatic comfort varies with culture, location, gender, activity and clothing. Little human comfort research has been conducted outdoors for hot Desert Cities or cold Winter Cities.

Interior Comfort Zone

United States	68-75 F (20-24 C)
England	63-68 F (17-20 C)
Inuit Snow House	41-61 F (5-16 C)
Tropical Habitat	72-86 F (22-30 C)

(Crowther, 1977, 23)

Indoor comfort for the United States lies within 68 F to 75 F (20 C to 24 C). Locally defined outdoor comfort in a cold winter city such as Edmonton, Alberta could range from 47 F (8 C) to 85 F (29 C). Locally defined outdoor comfort in a Hot Desert City such as Phoenix could range from 55 F (13 C) to 95 F (35 C).

The Desert City of Phoenix has very few people oriented shade structures or shade trees. There are some rudimentary car shading devices within apartment complexes, yet the lack of shade structures seems almost pathological in the sunniest city in the United States and the hottest western city in the world.

Fig. 1
Covered Parking to shade parked cars, Tempe AZ, 1989. Unshaded automobile interiors can reach temperatures of over 160F (71 C) (Photo: Author).

Parking couvert abritant les voitures, Tempe AZ, 1989. La température à 'intérieur d'une voiture laissée au soleil peut dépasser 160F (71 C) (Photo: auteur).

Phoenix has sunshine a full eighty-seven percent of daylight hours. Shade is clearly required for outdoor comfort. Yet architects, landscape architects and planners design and plan as if shade were not a form-giving criterion. With the exception of a small lathe house park, shade structures or desert shade trees are non-existent. (A lathe house is a traditional west coast plant nursery lattice-type structure for shielding plants from the harsh sunlight. Unfortunately exposed wood has a very short life in the heat and sunshine of the desert and this innovative park is in need of constant repair).

The re-introduction of climatic reality to design and planning will have many beneficial side effects. Cities/suburbs will have more vivid characteristics. A desert city such as Phoenix would become known for its innovative shade structures and desert shade tree allees shading pedestrian walkways and sidewalks. Functional shade structures would be located at major street corners and city parks. Low rise courtyard architecture, with many usable outdoor spaces would abound making good use of the outdoor life style which the desert climate allows. Night time lighting would make the desert especially appealing for evening strolls or café sitting. Light colored materials with low thermal mass would limit re-radiation of daytime heat. Low water use fountains would be common in courtyard areas to increase bio-climatic comfort within the immediate area.

Edmonton would be known for its south facing wind sheltered sun pockets and its east/west oriented streets maximizing the winter heat gaining southern orientation. Outdoor skating rinks and winter oriented urban landscape parks would make maximum use of evergreen native plant material such as the Alberta spruce and native pines. Signature plants such as the white birch, which require cold winters to limit natural pests will abound throughout the city.

Phoenix would look different from Edmonton and each city would be more comfortable to both visit and inhabit. By designing for bio-climatic comfort the outdoor season can be expanded and year-round daily outdoor activities can be completed with greater comfort and safety.

Two diametrically opposite climates are used as case studies to illustrate the concepts of climate sensitive design and planning. Both cities share extreme climates which are unique enough to require an adaptation of world wide western urban development trends.

Hot Desert City: Phoenix, Arizona, USA

Phoenix is centrally located within the arid southwest region. This arid region stretches from Redding, in Northern California to Dallas, Texas and into south central Kansas. The area contains five genuine desert areas, North and South Mojave, Lower and Upper Sonoran and the Trans Pecos Chihuahuan. The remaining non-desert, yet arid region is defined by having greater evaporation than annual precipitation. Extended drought conditions are common within the entire arid region.

Metropolitan Phoenix has a hot dry desert climate with short wet winters and long hot summers. It is considered a green desert, given its seven to eleven inches of annual precipitation.

During 1989, the air temperature was over 100 degrees for one hundred and forty seven days. The summer season typically lasts for seven months, with an average temperature of 100 degrees; the exterior temperatures of unshaded impervious surfaces can reach 140 degrees. Annually, the sun shines a full eighty six percent of the time.... and shade is desirable for over sixty percent of total daylight hours. Ideally, over eighty percent of a sites total area should be shaded (Pihlak et al., 1989).

The record high temperature of 126 degrees F (52 C) was recorded at Sky Harbor Airport in July 1990. Evapotranspiration, the combined water loss from transpiration by plants and evaporation from the soil surface exceeds precipitation by a factor of ten. For someone unaccustomed to desert heat these are startling figures. Given the typically low humidity, the high temperatures are not as desperate as they seem to the temperate world dweller. In fact, given appropriate light cotton clothing and a partially shaded environment, temperatures up to 100 F. (38 C) can be quite comfortable.

Built Form

Metropolitan Phoenix has a lower gross residential density than Los Angeles, California. Only Houston, Texas has a lower overall residential density. The current 2.2 million regional population is divided into nineteen cities and towns. The most rapid population growth has occurred within the last thirty years. It is an automobile oriented suburban city organized around a mile (1.6093 km) grid of arterial roadways with a posted speed limit of forty five miles an hour. Pedestrian pockets occur primarily around Arizona State University (38,000 students), portions of Scottsdale and a rebuilding Downtown Phoenix Business Core. In 1987 a 230 mile (370 km) system of freeways was approved by the voters, while in 1989 a 102 mile (164 km) rapid transit system was defeated by the voters. The air conditioned automobile is clearly the dominant form of transportation. The city fabric consists of roads, parking lots/structures and automobile oriented buildings. Some new buildings have even eliminated the pedestrian entrance. The Southwest Technology Building has a single entrance from the underground parking structure.

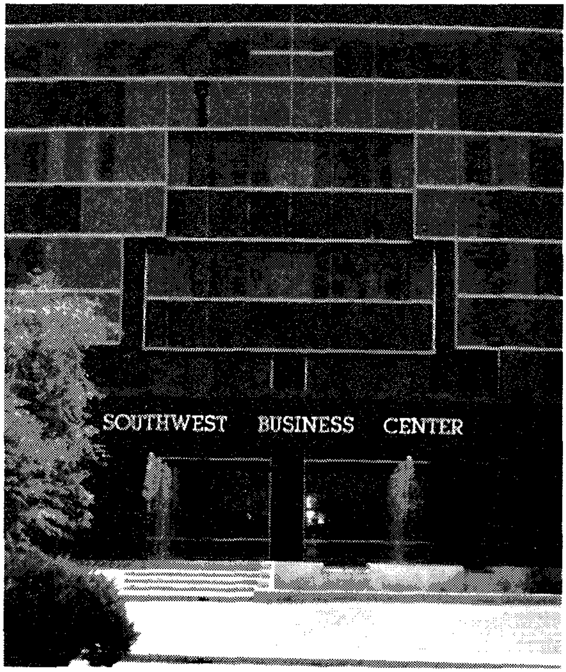


Fig. 2
Southwest Technology Building, Tempe AZ, 1989. There is no front entrance. The only building entrance is on the parking structure side away from the street (Photo: Author).

Bâtiment Southwest Technology, Tempe AZ, 1989. Il n'a pas d'entrée sur le devant, la seule entrée étant située sur le côté où se trouve le parking, à l'écart de la rue (Photo: auteur).

The Metropolitan Phoenix area ranks as the tenth largest population center within the United States. Growth has slowed with the decline of the neighboring California economy, but is expected to pick up again, given inexpensive land, low labor costs and a well developed infrastructure.

Seasonal Change and Human Responses

Typically, the one hundred degree summer weather begins in early April and continues until the end of October. Variations can both lengthen or shorten this period by two weeks at the beginning or end of the overheated period. Only after sustained 100 F (38 C) heat does the signature plant, the Saguaro Cactus (Cereus giganteus) produce its large flowers.

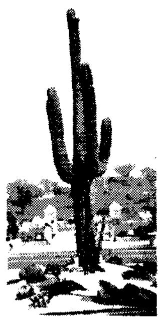


Fig. 3
Saguaro Cactus (Cereus giganteus). This particular specimen is over 100 years old (Photo: Author).

Saguaro Cactus (Cereus giganteus). Cet exemple particulier a plus de 100 ans (Photo: auteur).

Beginning in June the evening temperature does not appreciably cool down compared to the daytime temperature. These hot evenings continue into September, requiring cooling devices, water spray, or swimming pool activity for outdoor comfort. In July and August, hot, humid air from the Gulf of Mexico moves into Arizona, resulting in high winds, blowing dust and violent thunderstorms. This increased humidity raises the apparent temperature and thus the outdoor discomfort levels. With increased humidity shade is still desirable, yet less effective as a cooling device. By October the night time temperatures have become quite comfortable, with the peak winter desert destination resort season beginning in October and running until May.

The outdoor season may be said to begin when temperatures drop below 95F (35C), with low humidity. This figure is based on personal observation. No outdoor bio-climatic comfort or participant observation studies have confirmed this temperature figure. Interior comfort studies show a marked decrease in performance when temperatures reach 80F (27C). Similar to the Scandinavian research documenting outdoor activity during spring and fall, this temperature figure may be higher during early fall, given acclimatization to extreme summer temperatures. This is the mirror image of the Scandinavian work which documents acclimatization to the colder winter temperatures and an earlier response to warming temperatures in the spring time.

The human response to the outdoor temperature extremes, varies from people who say they avoid the outdoors during daylight hours when the temperature is over 100F (38C) to people who adapt their clothing, timing of activities and type of car they drive to better cope with the stressful temperatures. Early morning breakfast meetings are quite common to avoid the heat of mid-day meetings. The Phoenix Metropolitan Region is known for its outdoor lifestyle, which revolves around the inground pool. Even the most affordable rental apartments will have some sort of pool/spa recreation area. For single family home owners without pools, swimming pool clubs are common. In the late 1980s the area around Arizona State University, Mill Avenue became the pedestrian hub for a large part of the regional population. Sidewalks were widened, outdoor cafés were added and weekend activity produced the highest pedestrian counts anywhere within the region.

Fig. 4

Mill Ave Sidewalk Cafe, 8:30 AM, April 1991. Note the distribution of cafe customers at the shaded tables (Photo: Author).

Mill Ave Sidewalk Cafe, 8:30 AM, avril 1991. On remarque la manière dont les clients se sont répartis dans la zone d'ombre (Photo: auteur).

Seasonal variations in outdoor activity become apparent in late May with pedestrian activity first declining during the daylight hours. During June, night-time activity begins to taper off, with evening activity picking up again in mid-September.

Hot Desert City Design Guidelines for Exterior Space

1. Shade

Shading of the ground and building surfaces is desirable from February to December. January and early February are the only months where shade is not required. With commercial software programs it is possible for the designer/ planner to precisely calculate shadow patterns for almost any city in the world. This new computer capability is particularly important for the Desert City, where shade can make the difference between comfort and discomfort.

A. Low Water Use Shade Trees

The best way to provide shade is with natural elements. Shade trees are a well established urban tradition for improving urban micro-climates. Within arid regions water use is an important design criterion. Surprisingly it is grass turf areas and not shade providing trees which are the primary landscape water users. Approximately thirty percent of all water consumption is for turf grass irrigation. All other landscape water uses amount to approximately thirteen percent. Up to twenty percent reduction of apparent air temperature is possible with dense shade (see appendix for list of low water use trees). To maximize efficiency shade trees should directly shade pedestrian use areas, such as sidewalks, bus stops, patio areas, seating areas, bank machines, water fountains and building entrances.

Fig. 5 . September 21, 2:30 PM, shadow pattern, Phoenix AZ. Shadow calculated using a Dynaperspective Tree and form Z software to calculate shadows on a Macintosh IIfx computer.

Répartition de l'ombre le 21 septembre à 2.30 de l'après-midi, Phoenix AZ. Calculs effectués à l'aide d'un Dynapespective Tree et d'un programme de type Z, sur un ordinateur Macintosh IIfx.

B. Shade Structures

Wherever possible shade structures should be provided with new development (arcade, awning, arbor trellis, canopy, shade structure, ramada, covered parking and covered walkways). To be functional these shading devices should provide dense shade, yet allow heat to rise and dissipate in the early evening through ventilation holes. Wood is a temporary material in the desert. Metal has the lowest life cycle cost.

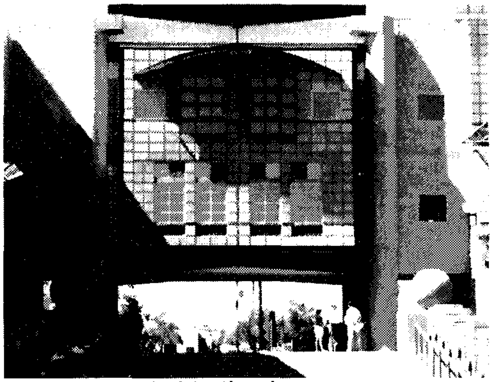


Fig. 6
The "Bridge" between the old College of Architecture and Environmental Design Building and the new building. A small passageway is created providing a new shaded entryway to the old building (Photo: Author).

Le "pont" entre l'ancienne Ecole d'architecture et d'aménagement de l'environnement et le nouveau bâtiment. Un petit passage a été créé, donnant à l'ancien bâtiment une entrée à l'ombre (Photo: auteur).

C. Shading Plan

A new concept of requiring a shading plan could be added to the design and planning process. As a minimum 30-40% of all parking areas should be shaded. All pedestrian use areas should provide a similar percentage of shade.

Fig. 7
Hyatt Resort at Gainey Ranch Master Planned Community. Four Mesquite Trees are provided for every six parking spaces. Tree growth could have been improved by linking every two circular planting pits into one larger oval planting pit (Photo: Author).

Hyatt Resort (Gainey Ranch Master Planned Community). Quatre arbres mesquite ont été plantés pour chaque groupe de six emplacements. Il aurait été possible d'en améliorer la croissance en regroupant deux fosses circulaires en une plus grande fosse ovale (Photo: auteur).

2. Orientation

A. The hot western orientation should be avoided for outdoor use areas and west facing building elevations should contain the least window area. With the daily build-up of heat, the western orientation is the most uncomfortable and prone to heat stress.

B. Ideal orientation in order of preference:

north facing: ideal for building entrances and outdoor use areas. This orientation is the best location for maximum window area to maximize indirect daylighting, without heat gain. *east* facing: acceptable for outdoor comfort, with some shading devices

south facing: with reasonable shading devices the southern orientation can be made habitable

west facing: It is almost impossible to make the western orientation comfortable for everyday outdoor use or building entrance.

C. Public Streets

The majority of the public streets should be oriented east west to maximize southern and northern building orientations and minimize western building orientations.

Fig. 8

Speedway Ave, Tucson, AZ, before pedestrian improvements of shade trees and minimization of impervious surfaces. (Photo: Greg Rossel)

Avenue Speedway, Tucson, AZ, avant que n'aient été plantés des arbres fournissant de l'ombre aux piétons et un goudron permettant un meilleur écoulement des eaux (Photo: Greg Rossel)

Fig. 9

Speedway Ave, Tucson, AZ after pedestrian improvements of shade trees and minimization of impervious surfaces. PhotoShop Computer Simulation (Kaiser Engineers and Architects, Phoenix, Greg Rossel)

Avenue Speedway, Tucson, AZ, après la plantation des arbres fournissant de l'ombre aux piétons et un goudron permettant un meilleur écoulement des eaux (photo Greg Rossel). Simulation sur ordinateur (Kaiser Engineers and Architects, Phoenix, Greg Rossel)

3. Ventilation

A. All shade structures should have some degree of porosity to facilitate the dissipation of constantly rising heat. This shade structure porosity must not be so great as to interfere with the priority of providing dense shade. All exterior structures should be constructed with adequate ventilation.

B. With even small changes in topography cold air drainage to lower elevations can be used to reduce nighttime heat build-up. A difference of as much as 15 F (9 C) can be recorded between low lying areas and higher sloping areas with good air drainage. (Duffield & Jones, 1981, 9)

C. Phoenix has a relatively stable air mass with few cooling breezes. When winds are present the speed is usually too great to be comfortable.

4. Materials

A. Impervious surfaces : Paved areas retain heat and re-radiate their stored heat during the evening. Decomposed granite or limestone screenings will keep dust down and allow daytime heat to dissipate quickly.

B. Albedo : Light non-reflective colors for heat reflection, with glare control should be used on most surfaces. Desert tan is a neutral beige which minimizes heat gain and sunshine glare.

C. Thermal Mass : A minimum of brick, stone, or block construction should be used in outdoor areas to minimize heat gain and re-radiation. Unfortunately low mass wood has a very high life cycle cost. Minimize impervious ground surfaces to maximize heat dissipation.

5. Passive Cooling:

A. Low water use appropriate water features should be located near pedestrian areas.

Water surface area of should be limited to lower water evaporation.

B. Local access to swimming pools is very high and is a very effective cooling activity in a low humidity climate.

C. Misting systems are locally popular to spray a fine mist of water into the air to evaporatively cool the immediate surroundings. This system does use significant amounts of potable water.

Fig. 10
North Pavilion of the summer house, Generalife, Alhambra, Granada, Spain (Photo: Author).
Pavillon nord de la résidence d'été, Generalife, Alhambra, Granada, Espagne (Photo: auteur).

D. Cooling tower technology has adapted this high water use misting system to use less water and to more effectively cool a larger outdoor area. This technology is still experimental and no commercial product yet exists.

6. Limit turf grass

A. Turf uses more water and adds more humidity than any other landscape plant material. Over a typical year, a turf area will use over eight vertical feet of water. Turf should only be used for active surface use, where other groundcover or plant materials are inappropriate. Turf grass does reduce surface temperatures, but the humidity and water costs and visual inappropriateness of green grass in the desert are too high to recommend use.

Cold Winter City: Edmonton, Alberta, Canada

Edmonton is located on the northern Canadian prairie. The city has a cold, continental climate, with long cold winters and short cool summers. Climatic conditions are dominated by latitude (53 degrees 30 minutes north) and influenced by a location east of the Canadian Rocky Mountains. Prevailing winds are from the west and northwest in summer and from the south in winter. The annual average wind speed of slightly under 10 mph is comparatively low for Canadian prairie cities. Substantially higher gusts of wind to speeds of 40 to 60 mph will occur, with the more severe winter winds arriving with Arctic weather fronts from the north. The Rocky Mountains block the prevailing Pacific Ocean air flows, resulting in low precipitation levels (17.5 annually), with low humidity throughout the year. Snow depths within the city average seven inches in mid-winter, with maximum depths rarely exceeding fourteen inches. The winter temperatures are usually too cold for the use of road de-icing salt. Winter temperatures of minus forty degrees F (-40C) are common. Typical winter temperatures are in the minus twenty degrees F (-29C). Freezing temperatures continue well beyond the March 21 arrival of Spring. Like Phoenix the low humidity makes the cold temperatures less uncomfortable. Edmonton's far northern location (1,000 miles north of Denver, Colorado), creates short winter daylight hours and long summer hours. The shortest winter day is eight hours on December 22 and the longest summer day is sixteen hours on June 22. The average annual hours of bright sunshine is higher in Edmonton than in other Canadian cities.

Built Form

In contrast to Phoenix, Edmonton is a typically well planned Canadian city, with realistic development controls and strict growth management. There is a light rail rapid transit/subway system and an extensive bus transit feeder network. The city form consists of pedestrian spaces, parks, an extensive regional river valley park system, freeways, roads and many high rise buildings. Edmonton is the capital of Alberta and is Canada's most northern major city.

Per capita vehicle ownership in Edmonton is surpassed only by automobile oriented cities such as Houston, Phoenix and Los Angeles. This automobile orientation is perhaps a response to the harsh winter climate. This leads to pedestrian unfriendly site planning, which in turn encourages automobile use which in turn discourages functional people oriented outdoor spaces. In areas of harsh climate this trend away from pedestrian friendly site planning is particularly pronounced. In extreme winter conditions, when the air temperature is minus 25 F (-31C) and there is a wind chill factor that adds to the danger of frost bite, it is easy to understand the traditional northern response which devalues the outdoors. The farther North one goes, the more pronounced this problem becomes of undervaluing the design potential of outdoor space. Yellowknife, North West Territories(NWT) is a capital and well established city. Yet the outdoor space is ignored to an even greater extent than one thousand miles (1600 km) south in Edmonton. The modern far northern enclaves such as Tuktoyaktuk, Inuvik and Norman Wells (NWT) all treat outdoor space simply as a place to deposit refuse and spent equipment. The northern frontier mentality of build now, civilize later, is partly at work.

This climatic isolationist design and planning philosophy is perhaps inevitable in harsh climate locations with easy access to cheap energy to create large indoor climate controlled environments. These large interior environments are necessary to maintain psychological well-being in a natural environment where the outdoor temperatures exceed the lower limits of human physiologic adaptation. Design emphasis of the private development community is placed on creating indoor environments, where comfortable temperatures are maintained mechanically. The spaces surrounding buildings to a great extent are left unimproved, because of the difficulty of significantly altering outdoor temperatures. Often these outdoor spaces are degraded by the incorrectly oriented buildings which cast long shadows or create dangerous wind tunnel conditions. In the mid 1970s the Alberta Government Telephone Building in downtown Edmonton created winter winds at sidewalk level of 90 mph (144 km/h) . The high rise Commerce Court Bank Complex in downtown Toronto, Ontario Canada, also periodically creates such high winter winds that ropes must be strung across the open place to allow pedestrians to successfully cross the open plaza.

While the immediate outdoor environment was becoming an increasingly more uncomfortable location, the interior spaces are having more and more attention paid to comfort. Kevin Lynch states that by the end of the nineteenth century, indoor climate control equipment amounted to ten percent of the total building cost. By the 1970s interior climate control equipment amounted to forty percent of building cost. (Lynch, 1984, 69)

If a harmonious relationship to the natural environment is important for man's well being... it becomes doubly so in a situation where a high degree of segregation between man and nature is a necessary response to the environmental pressures (Culjat, 1975, 68).

Seasonal Change and Human Responses

Winter in Edmonton realistically begins the last week of October and normally lasts until the last week of April, a duration of over six months. During these months the daily mean temperature remains below 32 degrees Fahrenheit (zero degrees Celsius). Spring and autumn, when defined as that period of time with mean daily temperatures between thirty two degrees F. and forty two degrees F. are short. The air temperature usually rises quickly during the last two weeks of April and falls rapidly during the last two weeks of October. Snow has fallen in late August and measurable amounts of snow are recorded in May and September. Summers, generally from May to September are pleasant although wet, with maximum precipitation coming in the form of rain from May to September. The tropical Gulf of Mexico air mass which brings hot humid weather to much of North America does not reach Edmonton.

Air temperatures are extreme. Annual temperatures can range from minus forty five degrees F (-42C) to ninety five F (35C). To function reliably, all vehicles have block heaters to ensure engines will start during the winter. Automobile air conditioning is rare. In fact there is a national luxury tax for automobile air conditioning. The more progressive shopping malls have electric block heater plugs to plug your car block heater into while you are shopping. The winter temperatures are typically too cold to use road de-icing salts. This creates a packed snow base for most side streets during the winter. Radio and television weather reports include winter warnings of how long exposed human flesh will take to freeze. Opposite warnings of skin cancer risks in Phoenix are almost non-existent. Participation in winter sports of skating, cross country skiing, ice fishing and winter walks are necessary to combat cabin fever, developed when spending too much time indoors. The west Edmonton Mall is the largest enclosed shopping mall in the world. There is an indoor amusement park, a water play area, and a professional size hockey rink. However, like in most shopping malls there is very little outdoor areas for passive use. The premise of this paper is that it is better to maximize outdoor comfort, rather than create large climate controlled interior spaces.

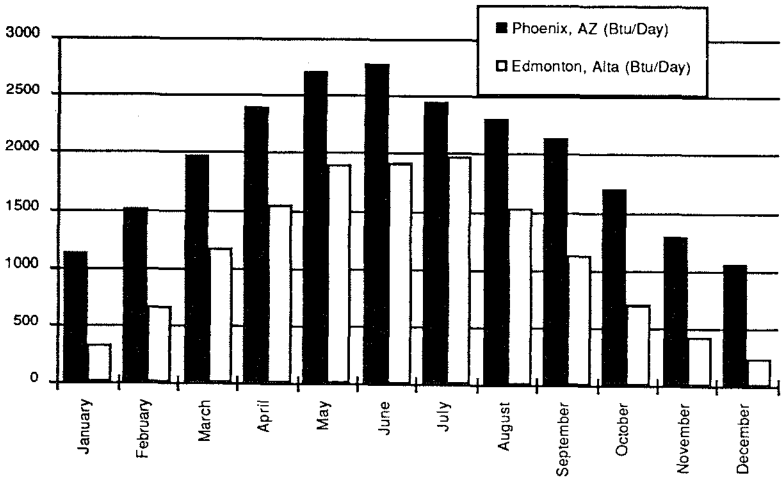
The Saskatchewan River Valley Park System allows long cross-country ski trails and large outdoor skating areas. Most Edmontonians are avid downhill skiers, given the close proximity of the Rocky mountains. Like in Phoenix, many Edmontonians boast of an active outdoor lifestyle built around the abundant mountain recreation areas. These wilderness outdoor activities are yet to be translated into the urban equivalent for inclusion in the everyday fabric of the city.

Fig. 11
Saskatchewan River Valley Park System, view towards Provincial Capital Building. Alberta Spruce trees, with freshly fallen snow in foreground (Photo: Author).

Le parc de la Saskatchewan River Valley, photographié dans la direction du Provincial Capital Building. Sapins d'Alberta et neige fraîche en avant-plan (Photo: auteur).

Comparison of Hot and Cold Climates for Bioclimatic Comfort

Sunshine



Wind

Air temperature and wind velocity are the two main environmental factors which affect heat loss and bioclimatic comfort. Much of the literature on wind is based on an undisturbed air flow in an open field, a situation which rarely occurs in the city.Significant vegetation or structural wind barriers can alter the wind flow in four ways:

obstruction: a major decrease of wind velocity
filtration: a minor decrease of wind velocity
guidance: a redirection of wind velocity laterally
deflection: a redirection of wind velocity vertically

Coniferous trees that branch close to the ground are the most effective winter city plants for year round wind control. A dense planting of deciduous shade/street/ canopy trees can also decrease winter wind problems.

Given the slow growing nature of most evergreen plant material and the restricted spaces of urban environments a canopy landscape of large deciduous trees is the most effective way to offer city wide wind control. The northern location of Edmonton makes all vegetation very slow growing. Without some wind control measure winter wind chill effects will be severe, creating frost bite danger. Edmonton regularly has considerable danger of frost bite for exposed human flesh.

Wind Chill Chart

Temp. F/C Wind Speed MPH/KM/H	32/0	23/-5	14/-10	5/-15	-4/-20	-13/-25	-22/-30	-31/-35	-40/-40	-49/45	-58/-50
				Equivalent Temperature							
0	32/0	23/-5	14/-10	5/-15	-4/-20	-13/-25	-22/-30	-31/-25	-40/-40	-49/45	-58/-50
5/8	29/-2	20/-7	10/-12	1/-17	-9/-23	-18/-28	-28/-33	-37/-38	-47/-44	-56/-49	-65/-54
10/16	18/-8	7/-14	-4/-20	-15/-26	-26/-32	-37/-38	-48/-44	-59/-50	-70/-57	-81/-63	-92/-68
15/24	13/-10	-1/-18	-13/-25	-25/-31	-37/-38	-49/45	-61/-51	-73/-58	-8/-655	-97/-72	-109/-78
20/32	7/-14	-6/-21	-19/-28	-32/-35	-44/-42	-57/-49	-70/-57	-83/-64	-90/-68	-109/-78	-121/-85
25/40	3/-16	-10/-23	-24/-31	-37/-38	-50/-45	-64/-53	-77/-60	-90/-68	-104/-75	-117/-83	-130/-90
30/48	1/-17	-13/-25	-27/-33	-41/-40	-54/-48	-68/-55	-82/-63	-97/-71	-109/-78	-123/-86	-137/-94
35/56	-1/18	-15/-26	-20/-35	-43/-42	-57/-49	-71/-57	-85/-65	-99/-73	-113/-80	-127/88	-142/-97
40/64	-3/-19	-17/-27	-31/-35	45/-42	-59/-50	-74/-59	-87/-66	-102/-75	-116/-82	-131/-90	-145/-98
45/72	-3/-19	-18/-28	-32/-35	-46/-43	-61/-52	-75/-59	-89/-67	-104/-76	-118/-83	-132/-91	-147/-99
50/80	-4/-20	-18/-28	-33/-36	-47/-44	-62/-52	-76/-60	-91/-68	-105	-120/-84	-134/-92	-148/-100
	Little Danger		*Considerable Danger*					*Very Great Danger*			

A related concept to wind chill is the Beaufort Scale which can be modified to produce a relative comfort scale for various outdoor activities. Each urban activity has different tolerance levels. Walking is the most tolerant of wind. Sitting and standing is the least tolerant of wind disruption.

Activity	Areas	Relative Comfort Scale (Beaufort Scale)			
		Perceptible	Tolerable	Unpleasant	Dangerous
Walking	Sidewalk	5 (15-20 MPH 24-32K/H)	6 (20-25 MPH 32-40K/H)	7 (25-31 MPH 40-50K/H)	8 (31-38 MPH 50-61 K/H)
Strolling/Skating	Park, Entrance	4 (10-15 MPH 16-24 K/H)	5 (15-20 MPH 24-32K/H)	6 (20-25 MPH 32-40K/H)	8 (31-38 MPH 50-61 K/H)
Standing/Sitting/Short Exposure	Park, Plaza	3 (6-10 MPH 10-16 K/H)	4 (10-15 MPH 16-24K/H)	5 (15-20 MPH 24-32K/H)	8 (31-38 MPH 50-61 K/H)
Standing/Sitting/Long Exposure	Cafe, Amphitheater	2 (3-6 MPH 5-10K/H)	3 (6-10 MPH 10-16K/H)	4 (10-15 MPH 16-24K/H)	7 (25-31 MPH 40- 50K/H)
Should Occur Less Than Once Per			Week	Month	Year

(Pihlak, 1978, 45)

Winter City Bioclimatic Comfort

Of necessity, early American farm development in the temperate northeast paid close attention to microclimatic site design. The farmstead usually faced south, on a slope if possible, with farm ancillary buildings forming a windbreak to the north and farther afield woodlots acting as large scale northern wind buffers (Stilgoe, 1984, 5). As access increased to inexpensive energy this detailed concern for micro-climatically sensitive site planning became less important. During the various energy crisis of the seventies and eighties there was a concern for energy efficient site design. With the drop in energy prices, the concern for energy savings is less urgent. With the Livable Winter Association and the beings of a Desert City Organization there is renewed concern for microclimate sensitive site design.

Research from Sweden has concluded that the urban outdoor season may be determined by counting the days between nine degrees Celsius (forty four degrees Fahrenheit) in the spring and eleven degrees (forty seven degrees Fahrenheit) in the autumn. For Edmonton this outdoor period extends from May 4 to September 15, or one hundred and thirty five days. This same outdoor period for Toronto, Canada's largest city extends from April 21 to October 17, or one hundred and eighty days. Culjat states that with micro-climatic modifications this outdoor period can be extended up to six weeks annually (Culjat, 1975).

It is important not to paint too romantic an image of how exterior public life could be encouraged in a cold winter city location. Nor is it productive to exaggerate the severity of a cold winter city. Many designers and planners from milder climates have now become advocates of generating exterior public life during the cold winter season. Structural or natural site planning supports are necessary to encourage public activity when the winter weather conditions are less than ideal.

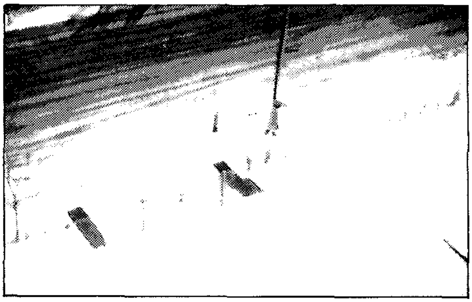


Figure 12.

Midtown Toronto, just south of Yonge and Bloor Street, December (Photo: Author).

Le centre de Toronto, au sud des rues Yonge et Bloor, en décembre (Photo: auteur).

In most cases the winter city urban environment turns the potentially beautiful experience of winter into a nuisance. The low winter sun cannot penetrate buildings, shadows are cast to fifteen times the height of buildings and any snow is quickly turned into slush with road de-icing chemicals and sand. The seasonal changes to winter become evident only through greater discomfort. The positive aspects of winter are best displayed where natural elements dominate, parks, street trees, landscaped areas. It is especially important to be exposed to the positive side of winter, since Olgyay has estimated that the indoor living period in northern latitudes is over seventy percent of total annual hours. With so much time spent indoors, it is particularly important to maximize the positive aspects of contact with the outdoor environment, by extending the outdoor season as long as possible, and optimizing the positive climatic effects during the long cold season.

Winter City Design Guidelines

1. Orientation

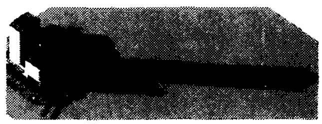


Fig 13.
October 21, 2:30 PM shadow cast from a high-rise building. Dynaperspective building, form Z shadow calculation.
21 octobre, 2h30 de l'après-midi: ombre projetée par un bâtiment élevé. Dynaperspective et calcul de l'ombre de type Z.

A. Building Orientation

For northern locations such as Edmonton, a direct southern orientation maximizes winter heat gain and minimizes summer heat gain. For more temperate winter cities such as Toronto, with greater summer cooling requirements, the ideal orientation is seventeen degrees east of south to also minimize summer heat gain, from the less desirable western orientation.

B. Open Space Orientation

The cold northern orientation should be avoided for outdoor use areas and north facing building elevations should contain the least window area. There is almost zero sun access on the north facing orientation. South facing sun pockets can extend the passive outdoor season during the early spring and late fall seasons. With shelter from the cold north winds the outdoor season can be extended even further.

C. Orientation preference:

north facing: Unacceptable

east facing: Acceptable

south facing: Ideal. This orientation should be maximized with building entrances and outdoor use areas.

west facing: Acceptable

2. Solar Access

In a cold winter climates access to sunlight is one of the most important winter comfort issues.

A. Minimum Sunshine Objectives

Given the long underheated winter period, access to sunshine is important for psychological well being. Worse condition winter shadows in Edmonton on December 21 are quite severe. The sun rises at 9:34 AM and sets at 3:34 PM. Shadows are cast to fifteen times the height of the object or structure. As a minimum sunshine access during the early Spring and Fall should be required of all development and public spaces.

* Urban sidewalks: North sidewalk 10:00 AM to 4:00 PM March 21 to September 21 (Stevens, 1982 p 24).

* Active outdoor spaces: 10:00 AM to 4:00 PM March 21 to September 21 (Stevens, 1982 p 24).

* Interior living spaces (excluding bedrooms and circulation spaces) should receive direct sunlight 10:00 AM to 4:00 PM (March 21 to September 21)

3. Wind Protection

A. Wind Chill

Generally canopy trees will reduce winter wind chill effects.

Dense (tree) vegetation and woodland environments in the urban environment will absorb winter winds, down drafts of buildings and improve the urban microclimate. (Hough Stansbury Woodland Limited, 1990). Where space and lack of surveillance needs for crime control permits, evergreen trees provide the best wind control.

Fig 14

Green Ash (Fraxius pennsylvanica) trees, twenty feet (6 M) on center. Riverdale Neighborhood, within the Saskatchewan River Valley (Photo: Author).

Arbres de type Fraxius pennsylvanica, ayant 6m de haut. Quartier de Riverdale, dans la vallée de la Saskatchewan River (Photo: auteur).

B. Fast Growing Canopy Trees

Large, treeless urban spaces are generally bio-climatically uncomfortable. Wherever possible canopy trees should be used to modify the microclimate. The slow growth rate of northern vegetation requires innovative approaches to achieve microclimatic modifying vegetation. Hough Stansbury et al advocate a fast/slow species plantings which mix fast growing pioneer trees with slower grower climax vegetation (Oak, Maple, walnut, Pine, Spruce) (Hough Stansbury Woodland, Ltd., 1990).

C. Structural Wind Barriers

Arcades, canopies, awnings, overhangs and buildings which step back can greatly reduce wind stress. Protection of pedestrian paths from winter winds with shade trees, large shrubs or garden architectural elements can greatly increase outdoor comfort. (trellis, greenhouse glass covering, pergola, brick walls, etc.)

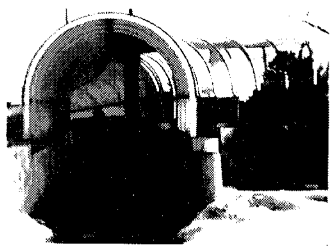


Fig. 15

Unheated covered sidewalk, Scarborough Town Centre, Metropolitan Toronto (Photo: Author).

Trottoir couvert mais non-chauffé, centre Scarboroug Town, banlieue de Toronto (Photo: auteur).

4. Materials

A. Albedo

Dark non-reflective colors for heat retention and build-up.

B. Thermal Mass

A maximum of heavy brick, stone and block construction in outdoor use areas to maximize heat storage and re-radiation. Wood construction for all outdoor construction to maximize insulating materials. Metal should be avoided for lack of insulating qualities.

C. Insulation

Heavy wood construction should be used outdoors wherever possible to maximize insulting materials for human touch. Metal should be avoided due to cold conducting qualities. In Downtown Edmonton the historic Warehouse District had wooden sidewalks which are appreciably warmer in the winter. (The life cycle costs of wood are much higher than concrete or unit pavers.)

5. Passive Heating:

A. Building overhangs, awnings covered/sheltered sidewalks

Sheltered sidewalks trap waste heat and re-radiate this heat back to passing pedestrians. Wherever possible these pedestrian coverings should maximize visibility with the maximum glazed area.

B. Protected entrances

Traditional/vernacular northern construction typically contained mud rooms, transitional unheated spaces for the removal of winter coats and snow boots. This concept can be extended into the outdoors with evergreen buffer planting, structural raised planters or six foot tall (m) hedges.

C. Greenhouse arcades

Sheltered pedestrian ways can be enlarged to accommodate passive seating and cafe areas. If these areas are unheated and have operable windows they can expand the apparent outdoor season well into the winter months. The design of these greenhouse arcade systems is complex. The Ottawa, Canada Transit mall has had problems of low use and excessive numbers of the homeless. Surrounding land uses and a critical mass of pedestrians are necessary to ensure success.

Fig. 16
High maintenance snow removal from the covered sidewalk, Ottawa Bus Transit Mall (Photo: Author).

Entretien du trottoir couvert, Ottawa Bus Transit Mall (Photo: auteur).

Outdoor Comfort

> "...we have built broad piazzas and boulevards which have no place in northern climates ... the design of northern cities should be rooted in the forms of the north, not the Mediterranean, for cities which have been well designed for the cold are often surpassingly lovely" (Gutheim, 1979, 111).

This quotation applies equally to the arid southwest. The cold Winter City and the hot Desert City are the climatic mirror images of the benign Mediterranean climate.

The Winter and Desert City are the flip side of the same coin. Their climates are harsh. Everyday outdoor activities are uncomfortable. Many people avoid the outdoors for long periods of time. The premise of this paper is that there are low technology site planning solutions which can increase outdoor comfort to a point where properly clothed individuals can go about their daily outdoor activities with greater comfort. The urban design solution is not to create a desert version of San Diego or a winter version of Nice, but to celebrate the deserts and the northern prairie's unique natural place qualities.

Improving the bioclimatic comfort of cities with stressful climates will create more useful, comfortable and energy efficient urban areas. The daily activities of all residents and visitors will be completed with more comfort and efficiency. The appropriate technology approach of sun control and wind modification, along with energy efficient site planning and design will create more functional and comfortable environments.

The arid southwest and the deserts in particular are difficult natural environments to understand and appreciate. Linking a functional shaded landscape design ethic with the natural landscape character of the entire arid region, including the deserts, could create a unique Desert City image for the Phoenix Centered Region and a more appropriate and ecologically sound or sustainable image for the other arid region cities.

Edmonton and other extreme winter cities are equally difficult natural places to appreciate. Living in a city of extreme climate requires an adaptation of our urban lifestyles. Yet the era of relatively cheap energy has allowed us to ignore the natural world and to retreat to a highly modified interior environment of high energy inputs. These interior environments create even greater separation from the natural environment. A re-introduction of climate sensitive site design will increase outdoor northern comfort.

Design and planning which respects a climatic sense of place will create more memorable and interesting cities. Desert Cities and Winter Cities share a similar lack of contact with their challenging climates. A functional concern for outdoor comfort can improve the image of both cities and lead to a more comfortable everyday environment.

APPENDIX

Climate Summary

Phoenix, AZ, USA (Latitude 33 26)

Natural Region	Lower Sonoran Desert
Height Above Sea Level	1,100 feet (335 m)
Climate	Subtropical Desert
Average Precipitation	varies 7-11 inches (17.5-279.5cm)
Average Evaporation	110(275 cm)
Yearly Mean Temperature	degrees Fahrenheit
Peak Minimum Temperature	19 degrees Fahrenheit(-7 C)
Peak Maximum Temperature	126 degrees Fahrenheit(52 C)
Annual Sunshine Average	86% of total daylight hours (The sunniest city in the USA)
Average Frost Free Period	302 days
Average annual degree days	1492 days
USDA Plant Hardiness Zone	9b (average annual minimum temperature of 30 to 25 Fahrenheit) (-1 to -3 Celsius)

Metropolitan Phoenix Street Trees

Evergreen Trees

ACACIA abyssinica, aneura, baileyan, farnesiana (sweet acacia), notabilis, minuta, pendula, pennatula-salicina (Willow Acacia), saligna, schaffneri, smallii, stenophylla (Shoestring acacia

BRACHYCHITON populneus

CALLISTEMON viminalis, phoenicus

CASUARINA equisetifolia

CERTONIA siliqua

EUCALYPTUS camaldulensis (Red gum), campaspe (Silver Topped Gimlet), cinerea (Ash gum) citriodora, erthrocorys, leucoxylon(White ironbark, microtheca (coolibah tree), nicholii, polyanthemos (Silver-dollar gum), polyanthemos '(Polydan'), populnea, sideroxylon, torquata, viminalis (Manna gum)

FRAXINUS uhdei (Evergreen ash)

GEIJERA parviflora

LYSILOMA thornberi (Feather bush)

OLEA europaea

PARKINSONIA aculeata (palo verde)

PHOENIX dactylifera (Date palm)

PINUS brutia eldarica, halepensis, roxburghii

PISTACIA atlantica, chinensis

PITHECELLOBIUM flexicaule (Texas ebony)

PITTOSPORUM phillyraeoides

PROSPIS alba (Argentine mesquite), chilensis

QUERCUS ilex, virginiana

RHUS lancea

SOPHORA secundiflora

THEVETIA peruviana (Yellow oleander)

ULMUS parvifolia (Chinese elm)

WASHINGTONIA filifera, robusta

Deciduous Trees

ACACIA wilardiana (Palo Blanco)

CARYA illinoinensis

CELTIS reticulata (Western Hackberry)

CERCIDIUM floridum(Blue palo verde), microphyllum, praecox (Sonoran Palo Verde)

FRAXINUS velutina

GLEDITSIA triacanthos

JACARANDA mimosifolia

MELIA azedarach (Chinaberry)

PROSOPIS hybrid, velutina

PYRUS kawakamii

ULMUS pumila

Climate Summary

Edmonton, Alberta, Canada (Latitude 53 35)

Natural Region	Northern Prairie
Height Above Sea Level	2,200 feet
Climate	Cold Temperate
Average Precipitation	17.58 inches (43.95 cm)
Yearly Mean Temperature	37.1 degrees Fahrenheit (2.8 C)
Peak Minimum Temperature	- 57 degrees Fahrenheit (
Peak Maximum Temperature	99 degrees Fahrenheit (37C)
Daily Sunshine Average	6.2 hours
Yearly Average Wind Speed	9.1 MPH (15K/H)
Average Frost Free Period	100 days (May 28 to Sept. 2)
Average annual degree days	10,278 degree days
USDA Plant Hardiness Zone	3a, average annual minimum temperature of -35 to -40 Fahrenheit (-37 to -40 Celsius)

Urban Trees for Micro-climate Modification

Acer ginnala (Amur Maple), negundo (Manitoba Maple)
Tilia americana (Basswood)
Sorbus decora (Mountain Ash)
Quercus Macrocarpa (Bur Oak)
Pinus sylvestris (Scotch pine), contorta latitolia(Lodgepole Pine)
Picea glauca (White Spruce)
Eleagnus angustifoia (Russian Olive)
Salis alba sericea (Siberian White Willow)
Betula papyrifera (White Birch), verrucosa (Weeping Birch)
Fraxius nigra (Black Ash), pennsylvanica (Green Ash)
Populus tremuloides (Trembling Aspen), balsamifera (Balsam Poplar)
Populus deltoides occidentatis
Larix Siberica (Siberian Larch)

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