Sustainable Urban Environment: Role of Green Infrastructure

APSE Scotland Building & Housing and Renewables Seminar

R Emmanuel Glasgow Caledonian University 20 Feb 2014

Outline

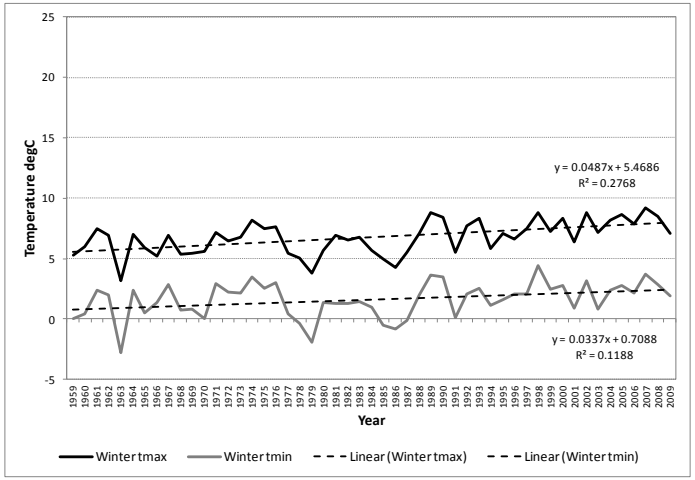
- Impact of URBAN climate change on buildings & cities
  - Urban Heat Island problem and overheating in GCV
- Role of Green infrastructure
  - Work in the Glasgow Clyde Valley Region
- Achieving Green Infrastructure
  - GAR in Planning guidelines

Local warming trends in Glasgow

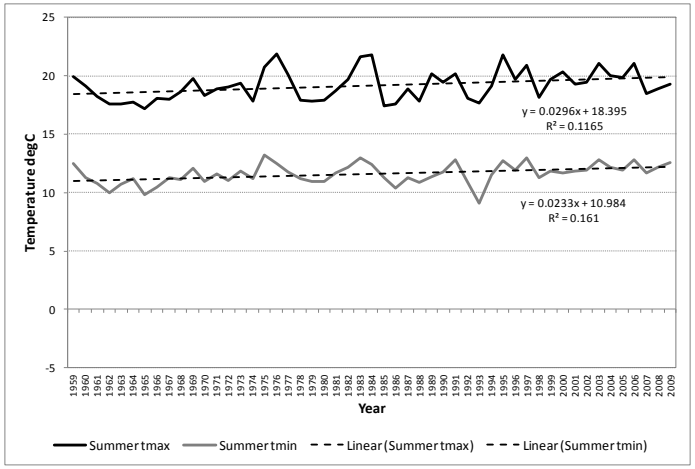
Source: MIDAS Data

Historic trends in local climate

- Although urban growth has slowed, local warming continues
- The magnitude of local warming is of the same order of predicted global warming
- Local land cover influences the rate of change



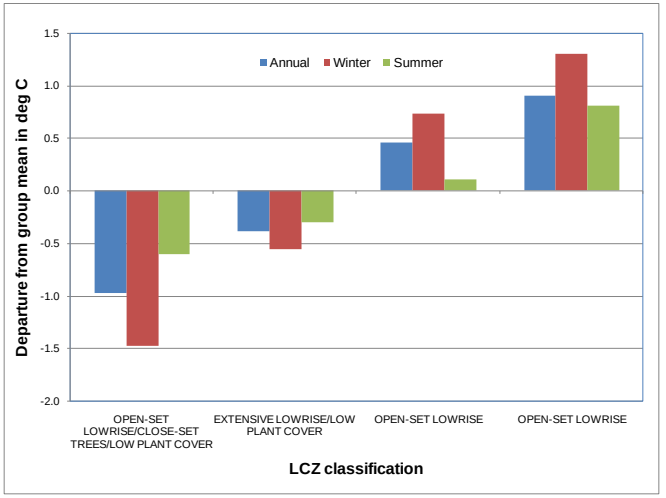
Day & Night trends - Winter

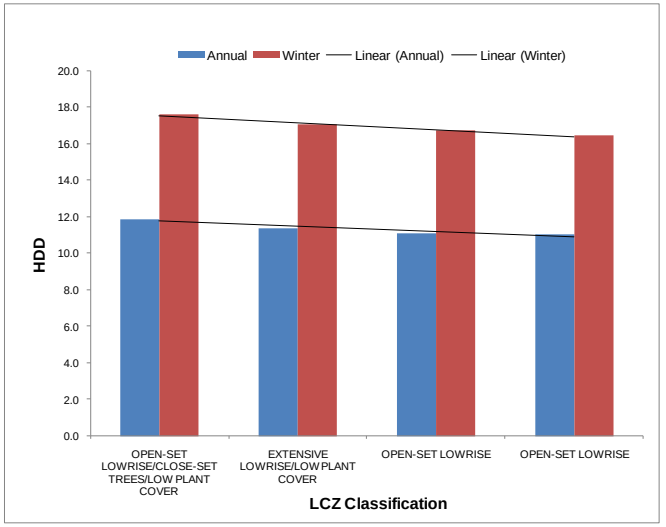


Day & Night trends - Summer

Historic trends in local climate

- Glasgow is warmer than its surroundings and the effect is more pronounced in the winter
- The effect is more pronounced in built up areas, even though they are far from city core
- A drop of nearly 12% in HDD in the city with less air frost days



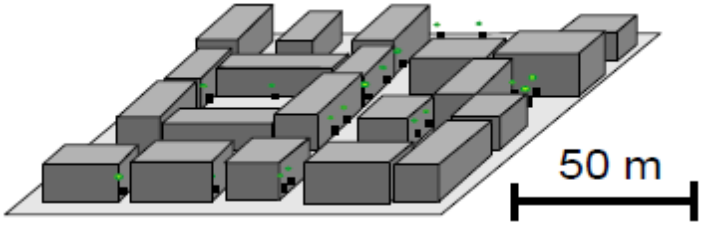


Heat Island in Glasgow City Centre

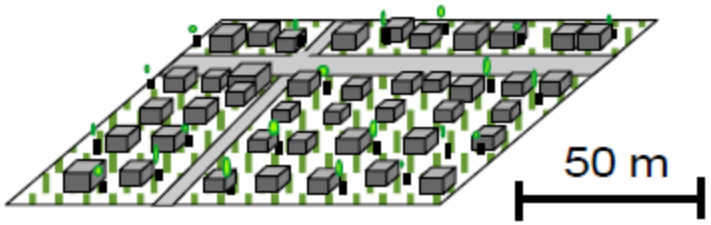
Role of green infrastructure

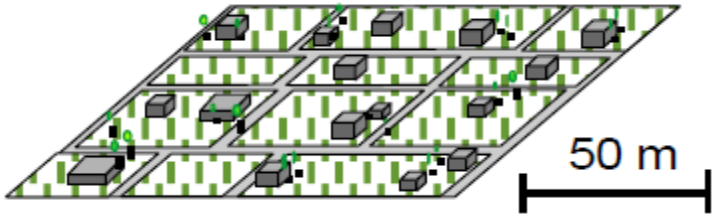
Source: Ordnance / LIDAR data

Local climate zones using landuse classes

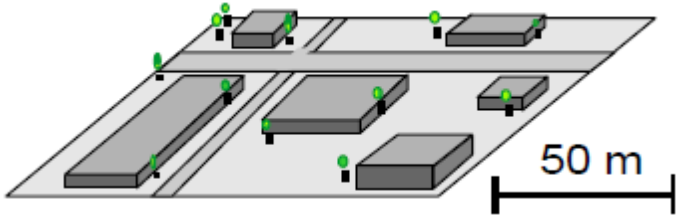


Compact midrise





Openset or Dispersed lowrise



Extensive midrise

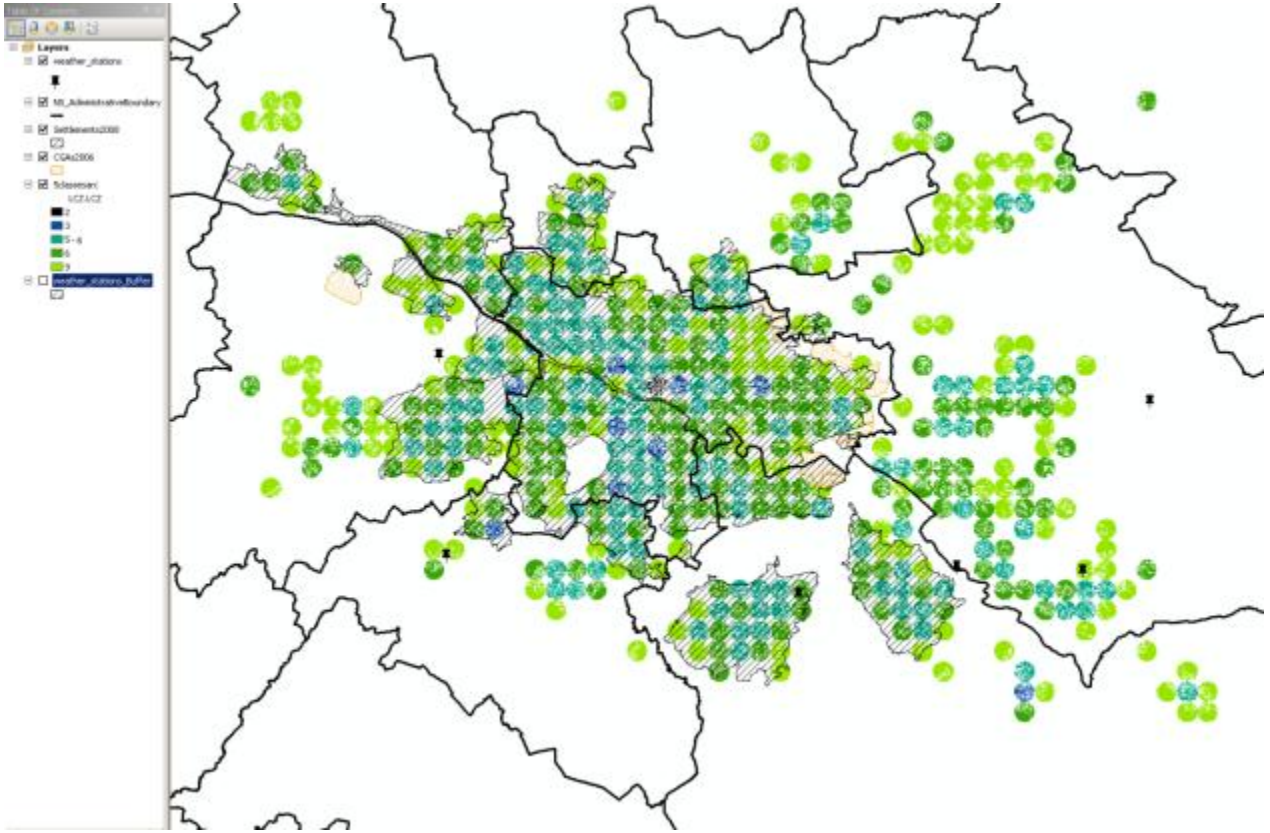
Detail of city centre land cover

Legend

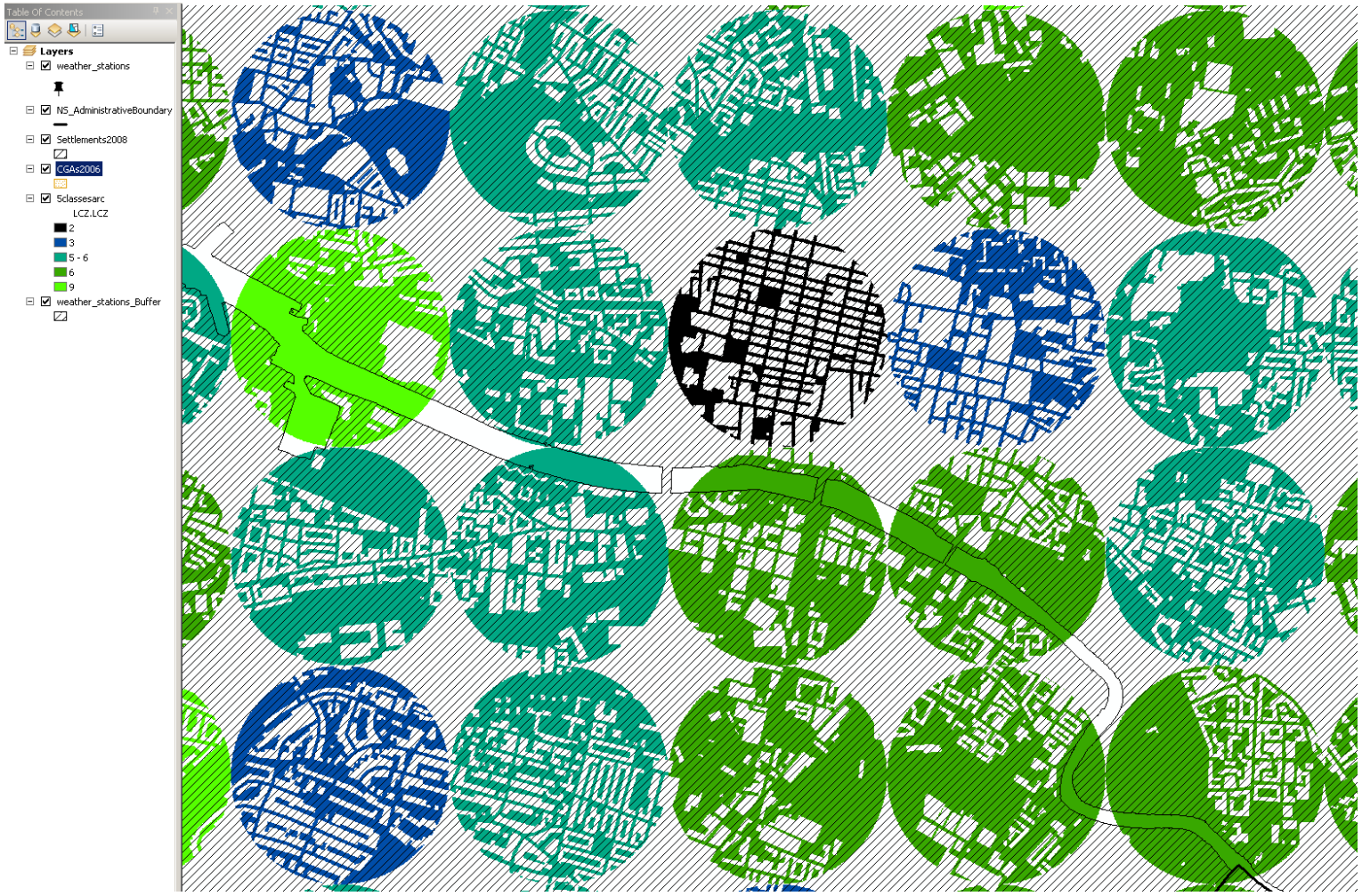
- Structure (path) 0.023%
- Glasshouse 0.025%
- Landform 0.045%
- Inland Water 0.168%
- Structure 0.307%
- Unclassified 0.481%
- Path 0.780%
- Rail 1.090%
- Natural Environment 1.463%
- Tidal Water 3.385%
- Roadside 10.709%
- Road or Track 20.704%
- General Surface 23.660%
- Building 37.160%

Built cover	**= 37.5%**
Roads	**= 33.3%**
Paved areas	**= 23.7%**
'Green' cover	**= 1.5%**
Water	**= 3.5%**
Unclassified	**= 0.5%**

Local climate zones within built up areas



Detail of city centre local climate zones

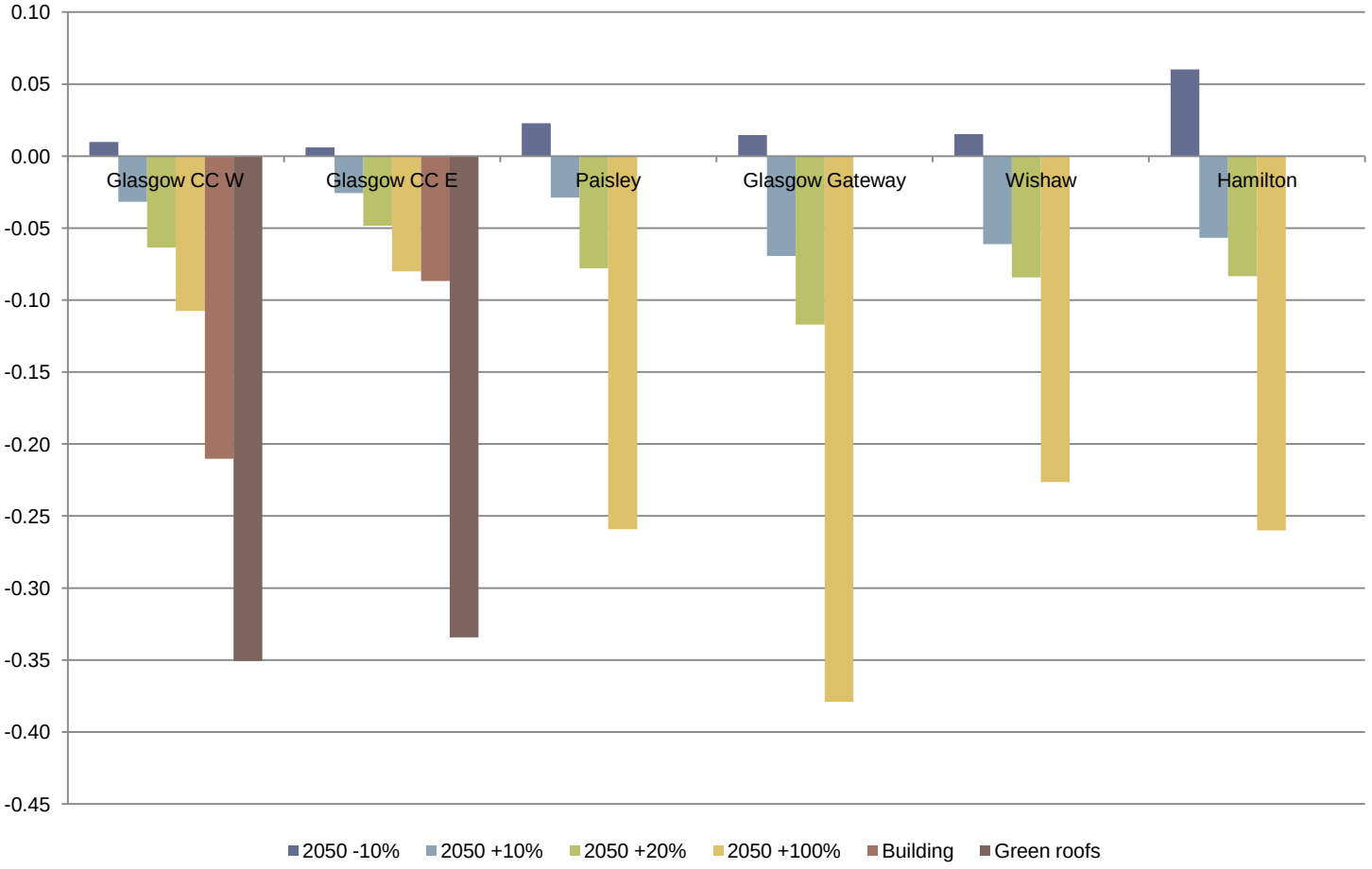


Selected sites & scenarios

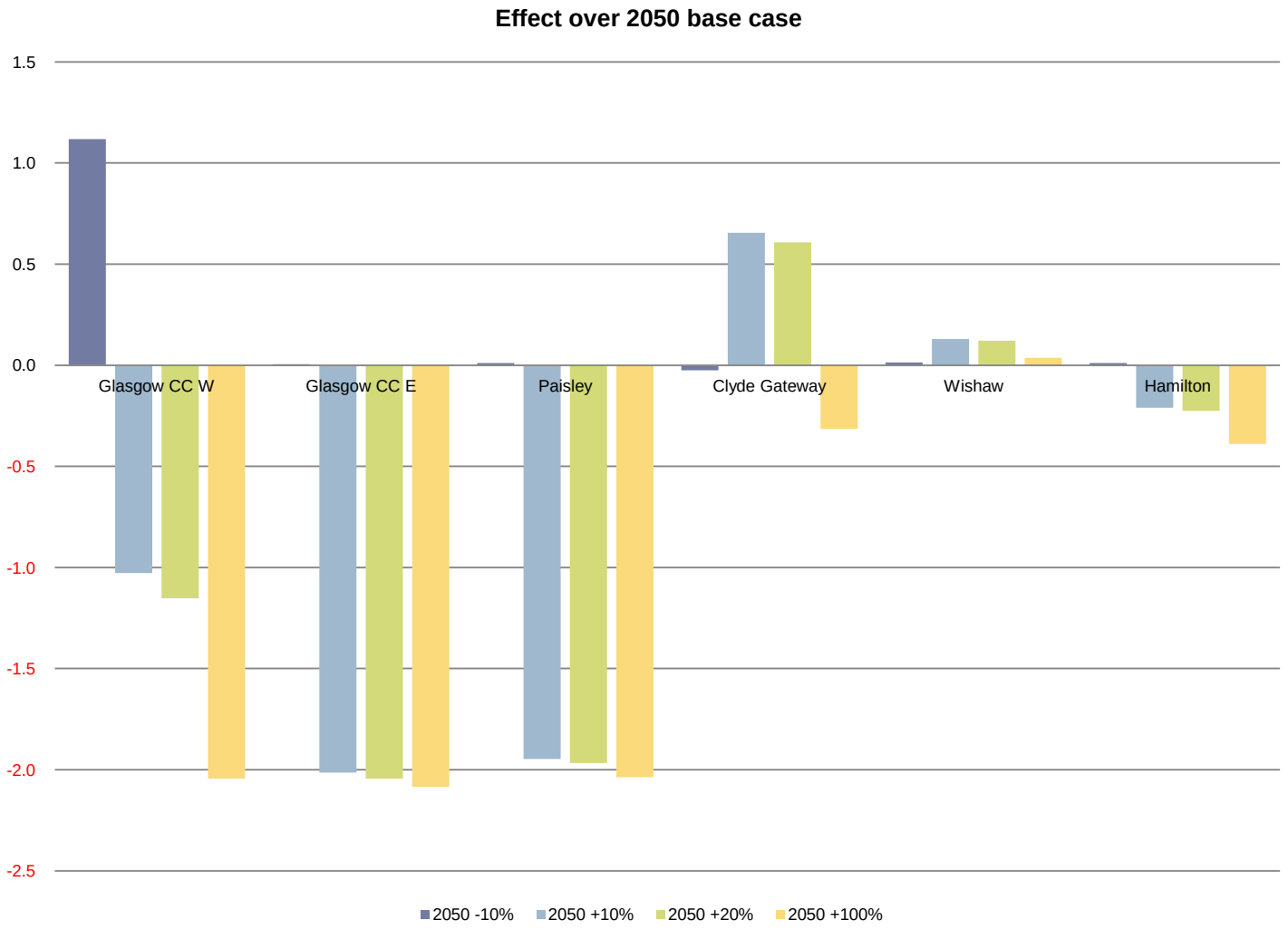
- Gla Centre West
  - Area surrounding Blythswood square
- Gla Centre East (Gla CCE)
  - Area surrounding the George Square area,
- Open lowrise: Clyde Gateway area
- Open midrise: Paisley area
- Sparsely built:
  - Wishaw
  - Hamilton

- 2012 current case
- 2050 UKCIP predicted temperature (Base case)
- Green infrastructure changes under 2050 climate
  - 10% less vegetation
  - 10% more vegetation
  - 20% more vegetation
  - 100% more vegetation
  - Additional strategies for city centre locations

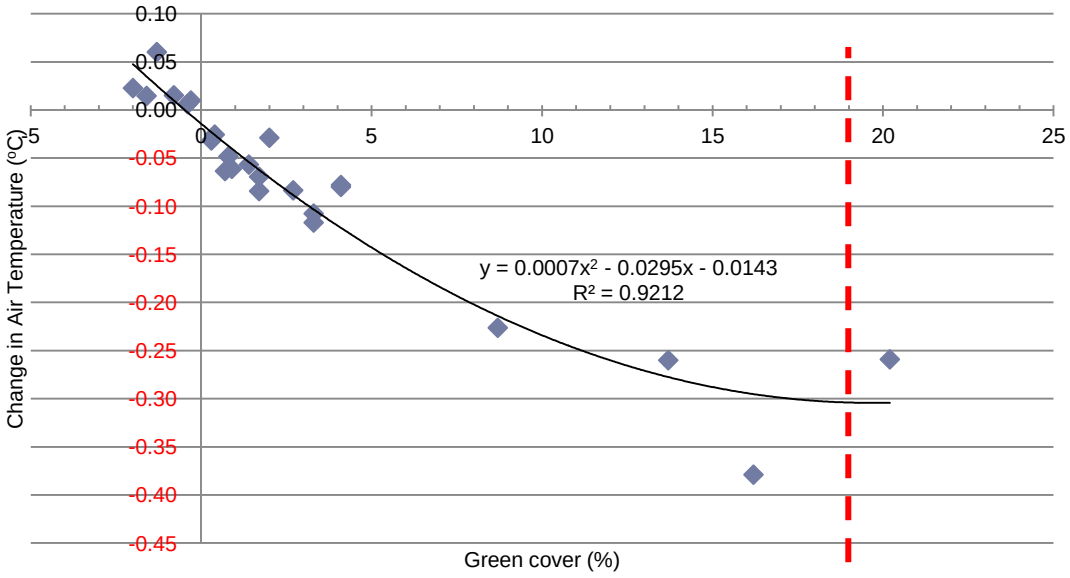
Effect of green infrastructure in 2050



Effect on surface temperature in 2050



Effect of green infrastructure in 2050



	Gla CC-W	Gla CC-E	Paisley	Clyde Gateway	Wishaw	Hamilton
< -1.00						
-1.00 to -0.75				0.2%		
-0.75 to -0.50				0.6%	0.1%	0.4%
-0.50 to -0.25	0.3%		1.8%	1.9%	3.2%	2.6%
-0.25 to 0.00	90.9%	81.0%	94.6%	93.3%	96.6%	95.9%
0.00 to +0.25	8.8%	19.0%	3.1%	4.1%	0.0%	1.1%
+0.25 to +0.50			0.5%			0.1%
+0.50 to +0.75			0.0%			
+0.75 to +1.00						
> +1.00						

Human comfort effect – 20% increase in green cover

		Gla CC - W	Gla CC - E	Paisley	Clyde Gateway	Wishaw	Hamilton
Cold	< -2.0						
	-2.0 to -1.5						
Cool	-1.5 to -1.0			0.7%			2.0%
	-1.0 to -0.5			**7.7%**	**1.0%**	**1.4%**	**8.9%**
	-0.5 to 0.0	**4.9%**	**3.6%**	**31.1%**	**20.4%**	**11.9%**	**19.1%**
Neutral	**0.0 to +0.5**	**31.8%**	**35.6%**	**12.5%**	**8.4%**	**9.2%**	**8.4%**
	+0.5 to 1.0	**15.8%**	**15.4%**	**5.8%**	**3.9%**	**2.1%**	**5.4%**
Warm	+1.0 to +1.5	0.6%	2.1%	15.3%	15.3%	9.6%	18.7%
	+1.5 to +2.0	7.0%	6.8%	24.6%	44.2%	57.6%	34.9%
Hot	> 2.0	40.0%	36.6%	2.5%	6.8%	8.2%	2.6%

Notes:
PMV classes cool to warm through 'neutral' conditions are highlighted

Achieving an increase in green cover

- How do we achieve a min. 20% green cover in city centre?
  - All greenery are NOT equal
  - Parks are the best
  - But large green spaces are impractical
  - Use the German approach (GAR)

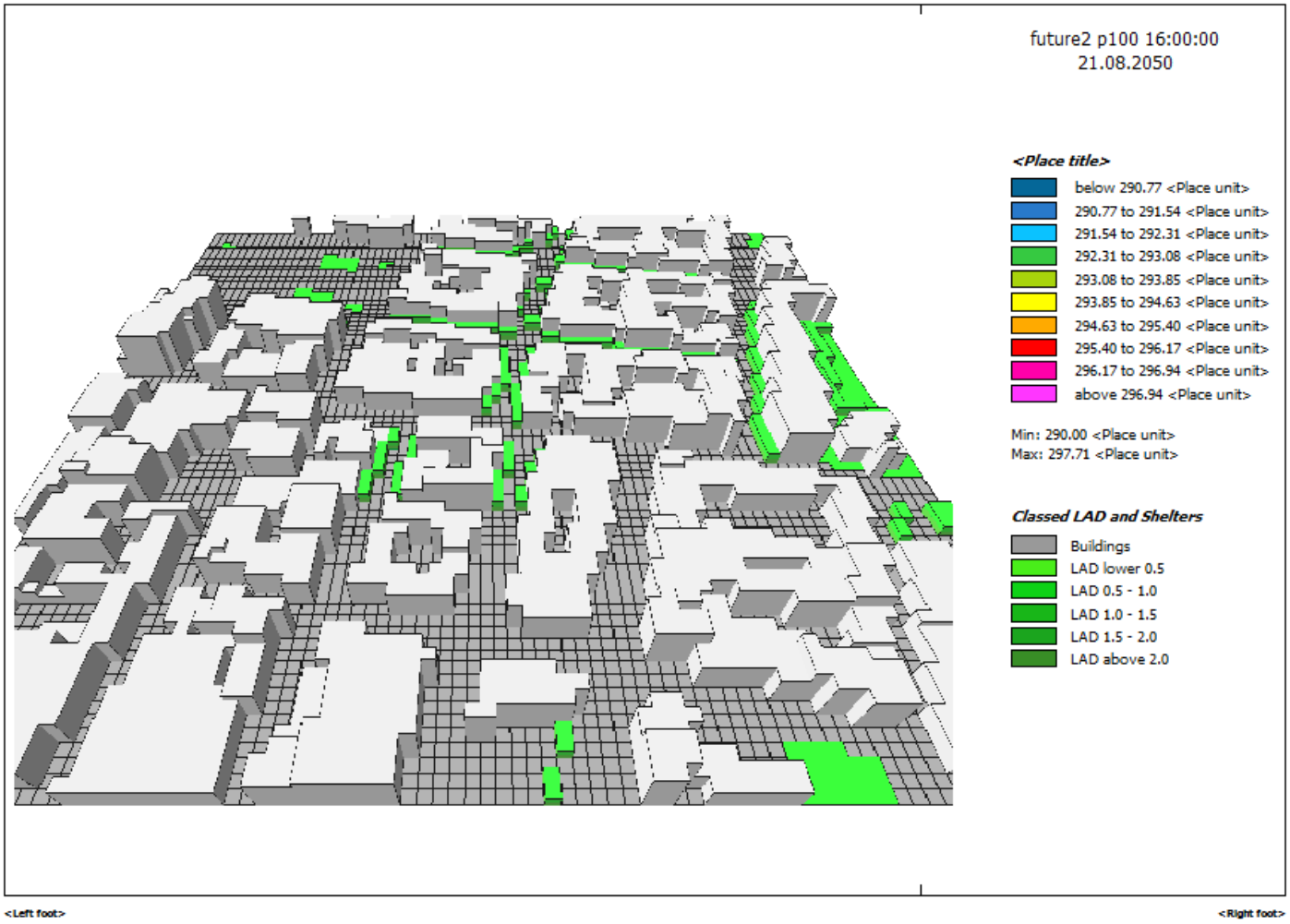
Technique / cover type	Rating	Description
Impermeable surfaces	0.0	Surfaces that do not allow the infiltration of water. Includes: roof surfaces, concrete, asphalt and pavers set upon impermeable surfaces or with sealed joints
Impermeable surfaces, from which all stormwater is infiltrated on property	0.2	Includes surfaces that are disconnected from the sewer system. Collected water is instead allowed to infiltrate on site in a swale or rain garden. Guidelines for preventing groundwater and soil contamination must be followed
Non-vegetated, semi-permeable surfaces	0.3	Cover types that allow water infiltration, but do not support plant growth. Example include: brick, pavers and crushed stone
Vegetated, semi-permeable surfaces	0.5	Cover types that allow water infiltration and integrate vegetation such as grass. Examples include: wide-set pavers with grass joints, grass pavers and gravel-reinforced grassy areas
Green façades	0.5	Vines or climbing plants growing (often from ground) on training structures such as trellises which are attached to a building. The façade's area is measured as the vertical area the selected species could cover after 10 years of growth up to a height of 10m; window areas are subtracted from the calculation
Extensive green roofs	0.5	Green roofs with substrate/soil depths of less than 80 cm. However, Berlin excludes green roofs constructed on high-rise buildings
Intensive green roofs and areas underlain by shallow subterranean structures	0.7	Green roofs with substrate/soil depths of greater than 80 cm. This category includes subterranean garages
Vegetated areas	1.0	Areas which allow unobstructed infiltration of water without evaluation of the quality or type of vegetation present. Examples range from lawn to gardens and naturalistic wooded areas

The German Green Area Ratio Method - SenStadt

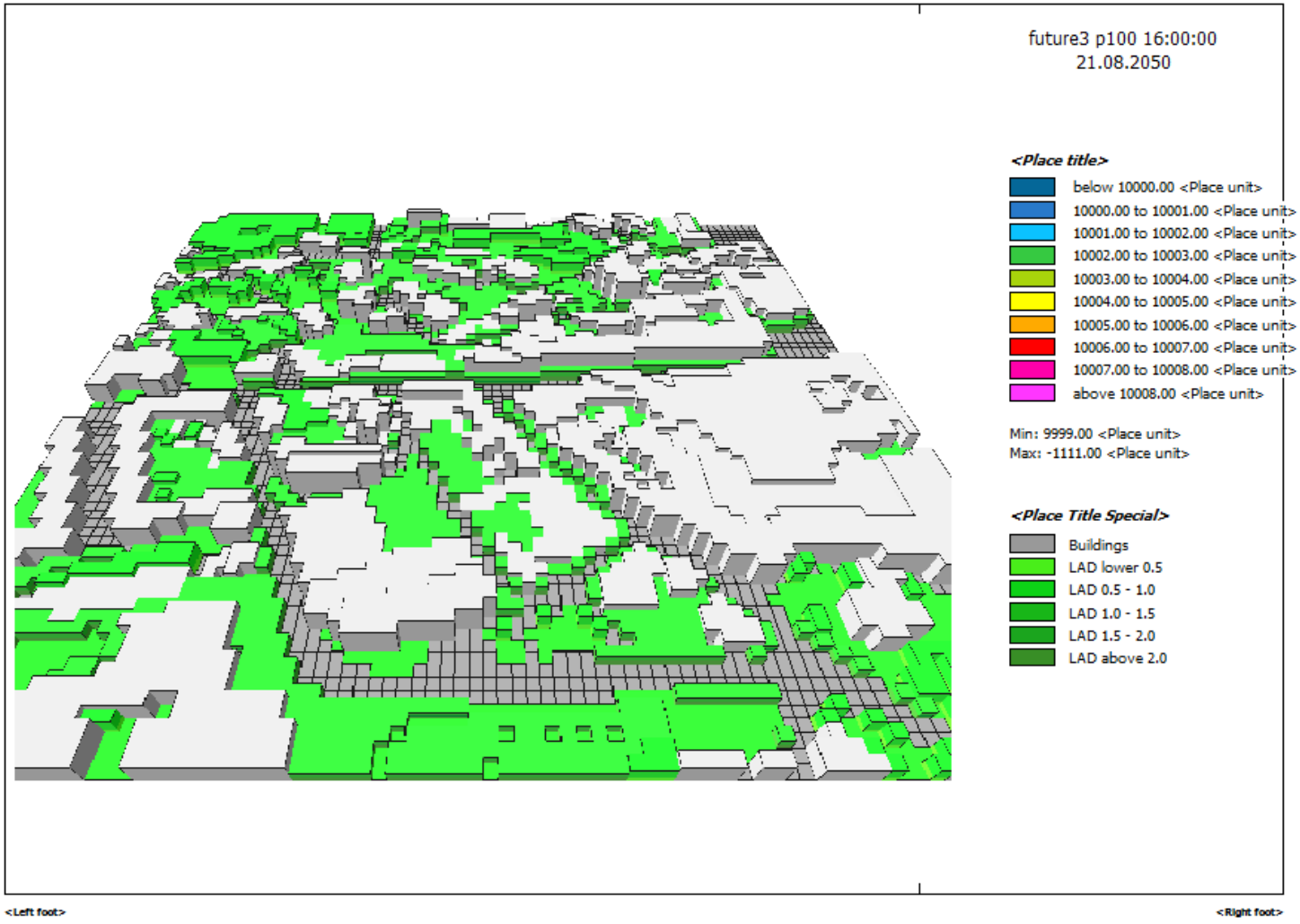
Scenarios for City Centre

Scenario	Permeable vegetated area (m^2)	Street trees (Nos.)	Intensive Roof Garden (m^2)	Extensive Roof Garden (m^2)	Green façade
1. A large park only	1,056				
2. Street trees only		528			
3. 50% of additional greenery in street tree, balance intensive roof garden		264	755		
4. 50% of additional greenery in street tree, balance extensive roof garden		264		1,056	
5. Mix of intensive (50%) and extensive (50%) roof garden			755	1,056	
6. 50% of all 'sun facing' (i.e. South & West) façade covered façade green					1,268

A possible view of +20% green in Glasgow City Centre



Other sites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Buildings
LAD lower 0.5
LAD 0.5 - 1.0
LAD 1.0 - 1.5
LAD 1.5 - 2.0
LAD above 2.0
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Summary

- Green cover increase in the GCV (especially Glasgow city centre) can have beneficial effect
- Such increase could eliminate most of the urban warming expected in the next 40 years
- A 20% increase in green cover appears the minimum needed
- A combination of parks/street trees/green roofs/façade green could achieve the same effect as street greening
- Technology is available to evaluate local climate effects of specific green infrastructure initiatives