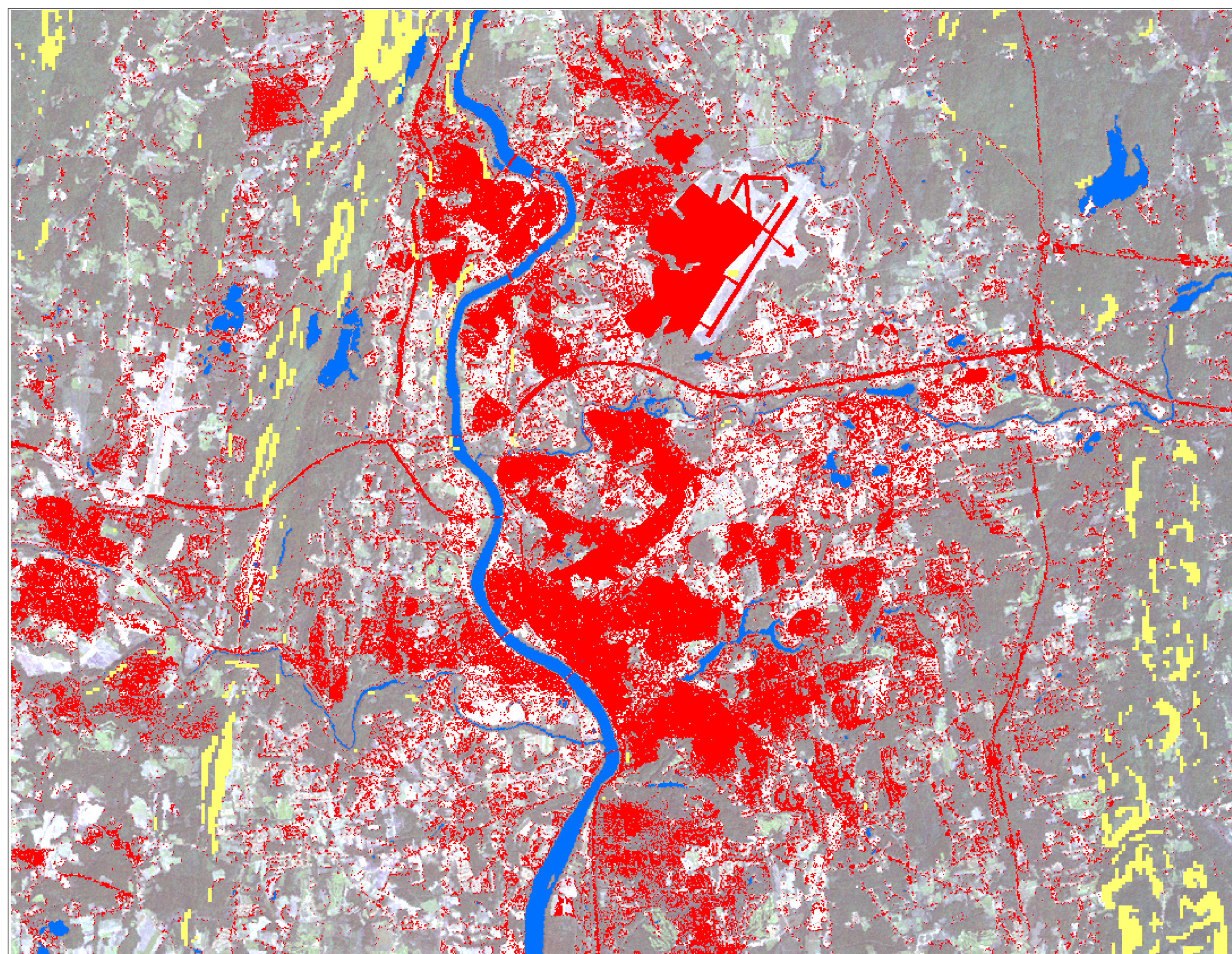


An Analysis of Change in the Spatial Structure of Springfield, MA

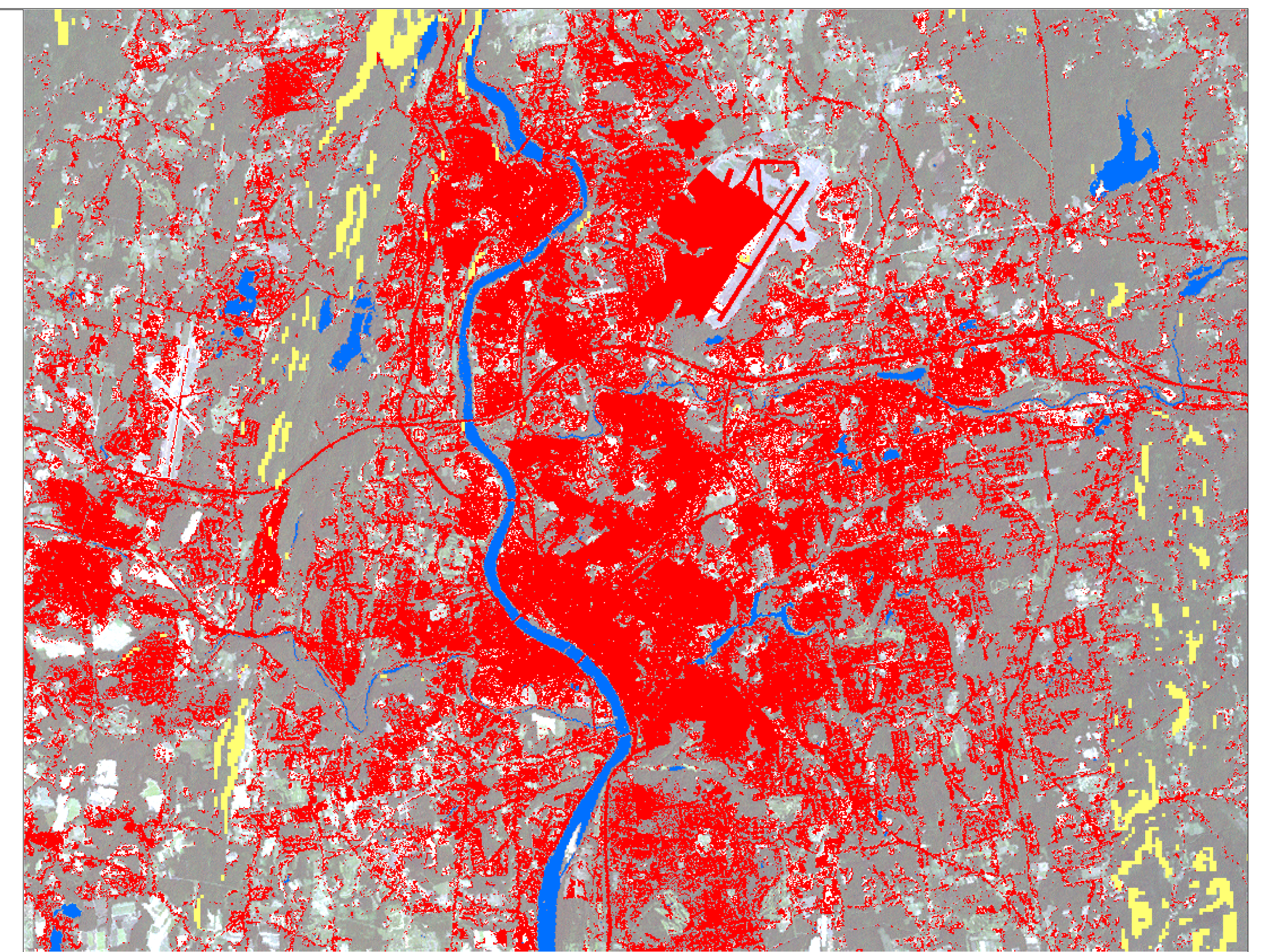
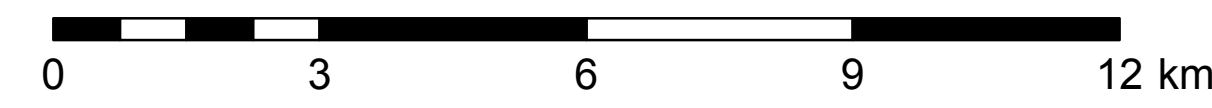


T₁: 28-Sep-89

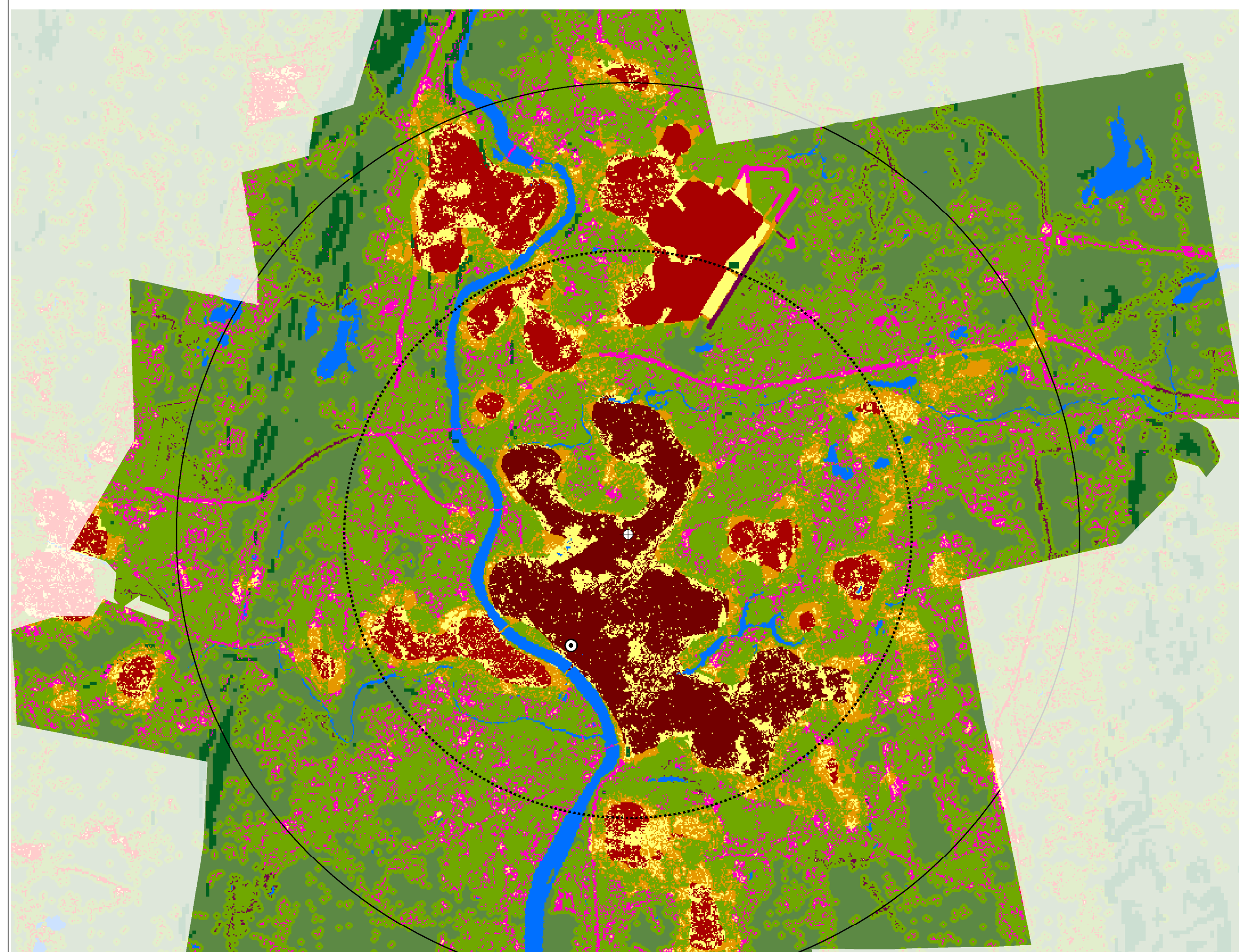
Land cover map derived from remote sensing

Urban and water land covers were derived from satellite (Landsat) imagery for two dates: T₁ and T₂. Unsupervised classification techniques and on-screen digitizing were used to derive urban land cover. Water was derived from level slicing water indices. Water indices were defined as the sum of reflectances in the visible bands divided by the sum of reflectances in the infrared bands. Water indices above a certain threshold corresponded to water. This threshold was determined by overlaying the water index map and the Landsat image to identify the minimum water index values that corresponded to water. Slope was derived from Shuttle Radar Topography Mission (SRTM) data. Excessive slope was defined as the percent slope below which 99% of the urban land cover exists.

- Urban
- Excessive Slope
- Water



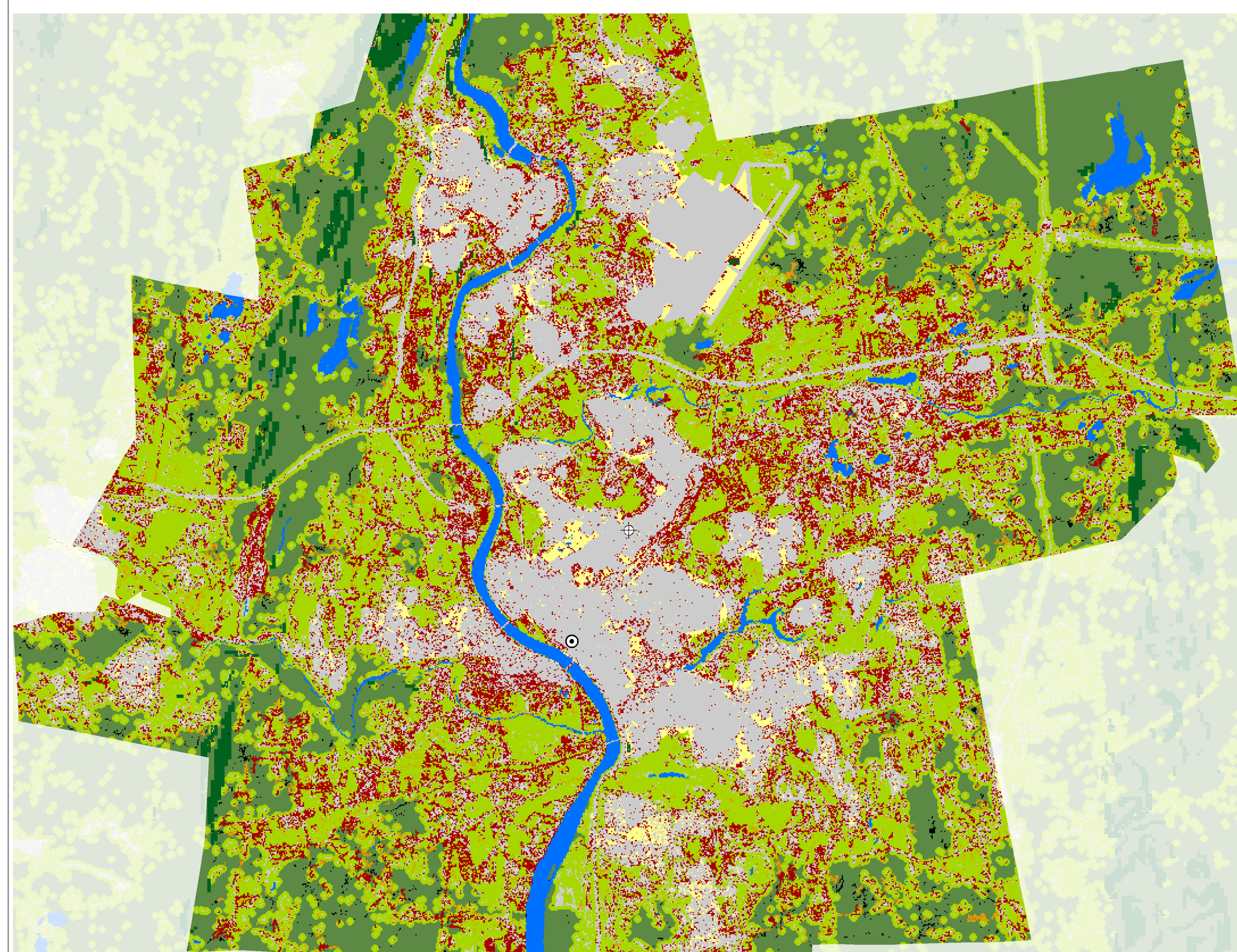
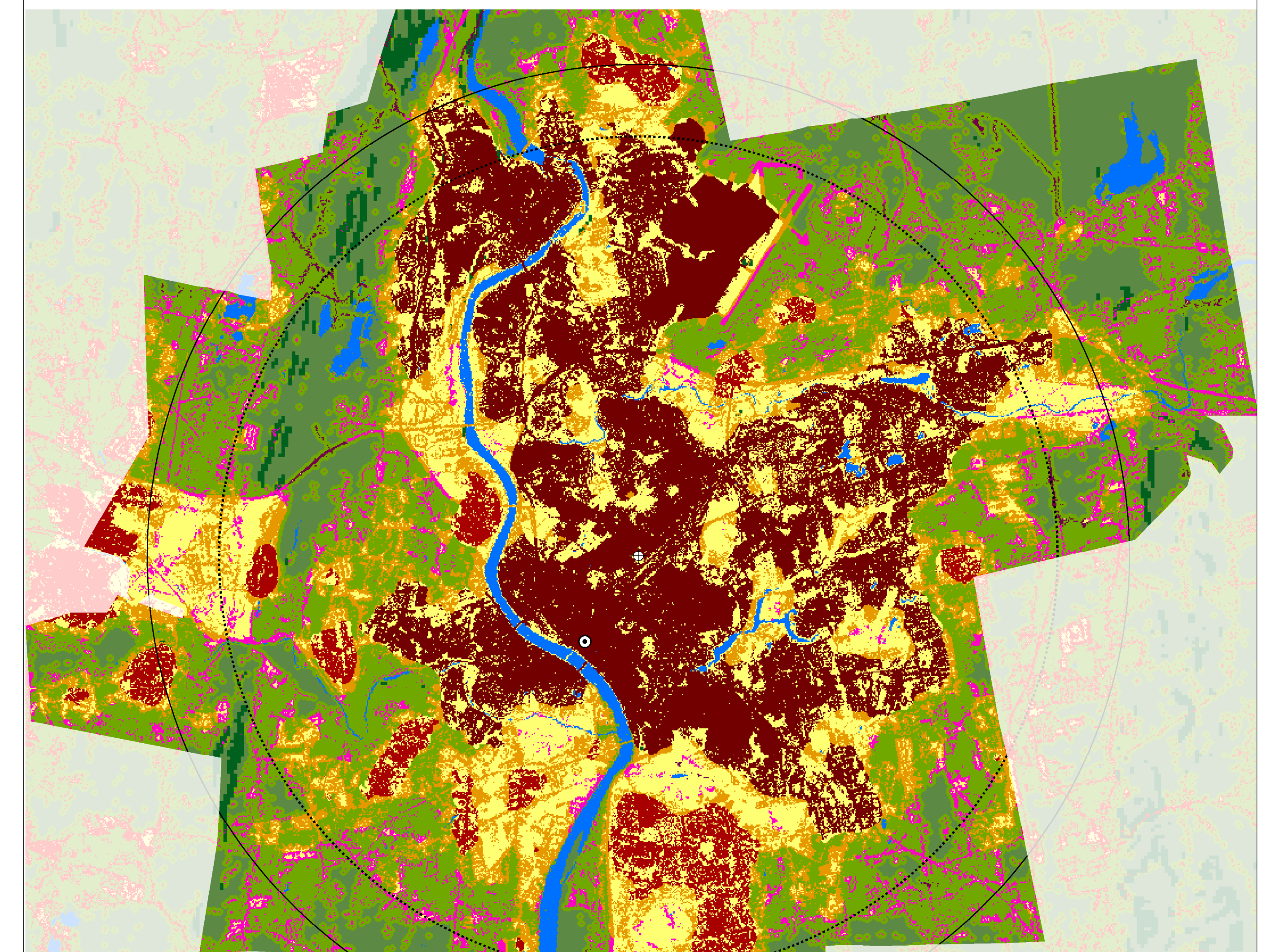
T₂: 8-Sep-02



Manifestations of urban sprawl

Urban sprawl may be manifested in the following growth forms: a polycentric structure, ribbon and scatter developments, and fragmented open space. These sprawl manifestations are depicted in the five urban categories. The urbanized open space and peripheral open space categories depict open space that is influenced by the city. At least 30% of the land within 550 meters of urbanized open space is impervious surface. Open spaces enclosed by impervious surfaces are also considered urbanized open space. Open space within 100 meters of impervious surface is considered peripheral open space. Two urban centers are depicted. The first is the point with the minimum average distance (MAD) to all urban areas. The second center is the central business district (CBD) determined in the field with GPS. The two circles are centered around the MAD center. The sprawl circle has the same average distance to the MAD center as the urban land. The equal area circle has the same area as the urban land.

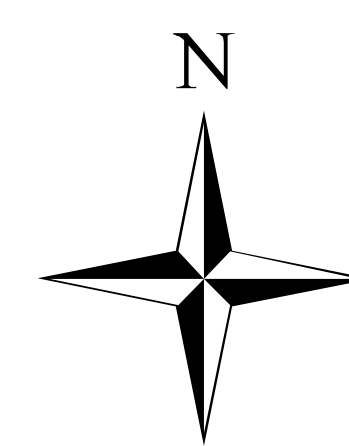
- + MAD Center
T₁: (42.13 N, 72.58 W)
T₂: (42.12 N, 72.58 W)
- ⊙ CBD
(42.10 N, 72.59 W)
- Sprawl Circle
- Equal-Area Circle
- Urban Main Core
- Urban Secondary Core
- Urban Fringe
- Ribbon Development
- Urban Scatter
- Urbanized Open Space
- Peripheral Open Space
- Open Space
- Excessive Slope
- Water



Classification of urban growth between T₁ and T₂

Land developed between T₁ and T₂ was classified into three categories: infill, extension, and leapfrog. Development within the urbanized open space was considered infill. Extension consisted of any development within 100 meters of T₁ development. Any development more than 100 meters from T₁ development was considered leapfrog.

- + MAD Center
- ⊙ CBD
- Extension
- Infill
- Leapfrog
- Built-Up Area (T₁)
- Urbanized Open Space
- Peripheral Open Space
- Open Space
- Excessive Slope
- Water



Land Use Category	T ₁		T ₂		Annual ΔT	
	km ²	%	km ²	%	km ²	% change
Built-Up Area	84.5	100.0%	193.9	100.0%	109.4	129.4%
Main Core	26.9	31.8%	105.6	54.5%	78.7	293.0%
Secondary Cores	27.6	32.6%	25.4	13.1%	-2.2	-7.9%
Urban Fringe	30.1	35.6%	62.9	32.4%	32.8	109.2%
Urban Ribbon	2.9	3.5%	2.0	1.0%	-1.0	-33.4%
Urban Scatter	48.4	57.3%	41.8	21.6%	-6.6	-13.6%
Open Space	342.5	405.2%	329.2	169.8%	-13.3	-3.9%
Urbanized Open Space	23.5	27.8%	105.6	54.5%	82.1	349.3%
Buildable	22.6	26.7%	99.3	51.2%	76.8	340.2%
Peripheral Open Space	319.0	377.4%	223.6	115.3%	-95.4	-29.9%
Buildable	306.9	363.1%	210.7	108.7%	-96.2	-31.3%
Urbanized Area	159.4	188.6%	343.3	177.0%	183.9	115.4%
Urban Footprint	427.0	505.2%	523.1	269.8%	96.1	22.5%
New Development					101.8	100.0%
Infill					85.3	83.8%
Extension					13.5	13.3%
Leapfrog					3.0	2.9%

Metrics	T	T	Annual ΔT
Population	523,949	576,321	0.74%
Slope of Built-Up Area			
Average	3.0%	3.6%	1.41%
Maximum (99th percentile)	18.8%	21.1%	0.91%
Density (persons / hectare)			
Built-Up Area Density	62	30	-5.52%
Urbanized Area Density	33	17	-5.06%
Restricted to Buildable Area	49	20	-6.80%
Urban Footprint Density	12	11	-0.83%
Restricted to Buildable Area	11	10	-0.59%
Sprawl Density	13	12	-0.55%
Compactness			
Average Distance to MAD Center (km)	7.52	8.17	0.64%
Average Interpoint Distance (km)	11.07 +/- 0.54	10.87 +/- 0.57	-0.14%
Openness Index	0.56	0.46	-1.45%
Compactness Index	0.40	0.73	4.75%
Distance from MAD Center to CBD (km)	3.12	2.53	

Three perceptions of urban land are presented in the metrics. The most conservative is the Built-Up Area which consists of impervious surfaces. The second and third metrics reflect the fact that Built-Up Area affects the open space around it. These metrics, the Urbanized Area and the Urban Footprint, encompass open space areas that are likely to have some degree of degradation due to their proximity to the impervious surfaces. The Urbanized Area consists of the Built-Up Area and Urbanized Open Space. The Urban Footprint encompasses the Built-Up Area, the Urbanized Open Space, and the Peripheral Open Space.

Population densities were based on three different perceptions of the urban area: impervious surface cover, urbanized area, and the urban footprint. The final density is based on the sprawl circle. The Openness Index indicates the average percentage of open space within 550 meters of the urban area. The Compactness Index is the ratio of the areas of the urbanized area and the sprawl circle.