The spatial footprint of the non ferrous metal industry in Lubumbashi
Different evidencing techniques

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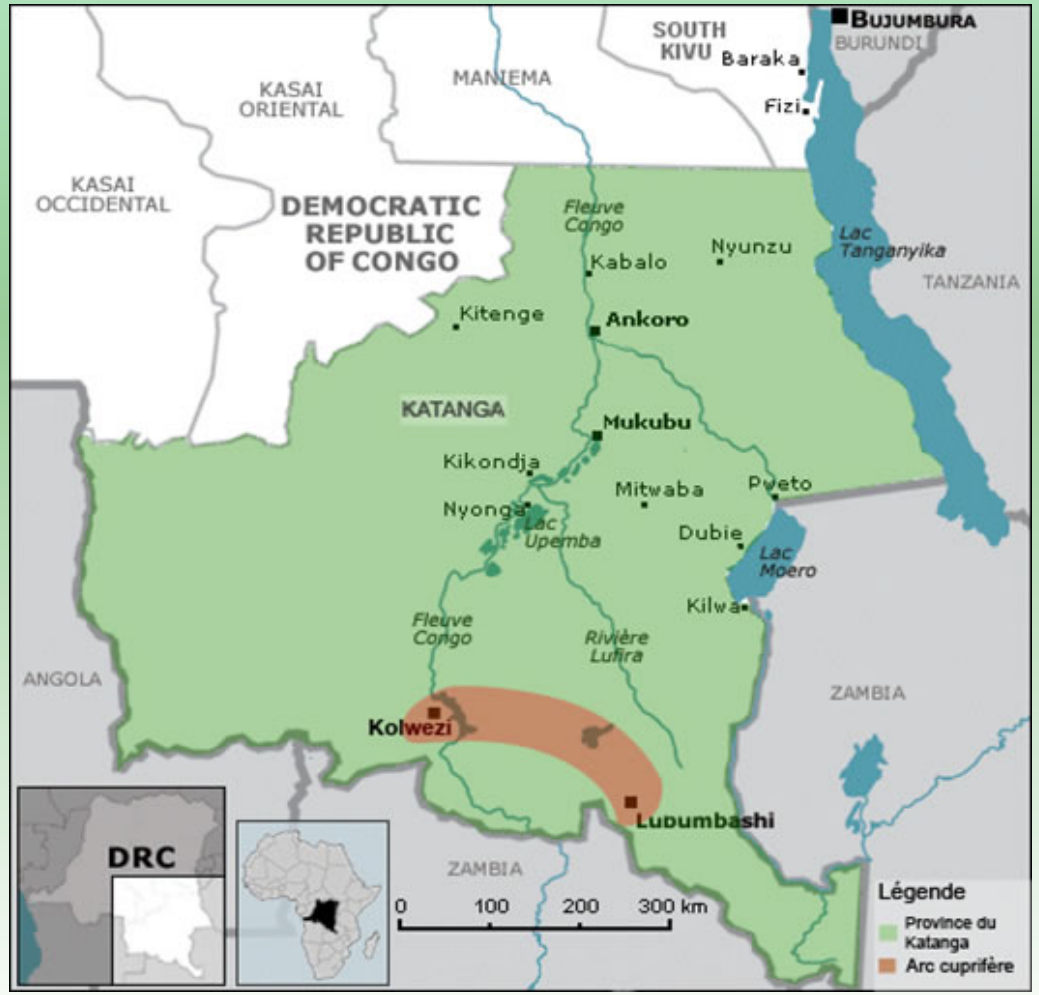
International Planning and History Society (IPHS)

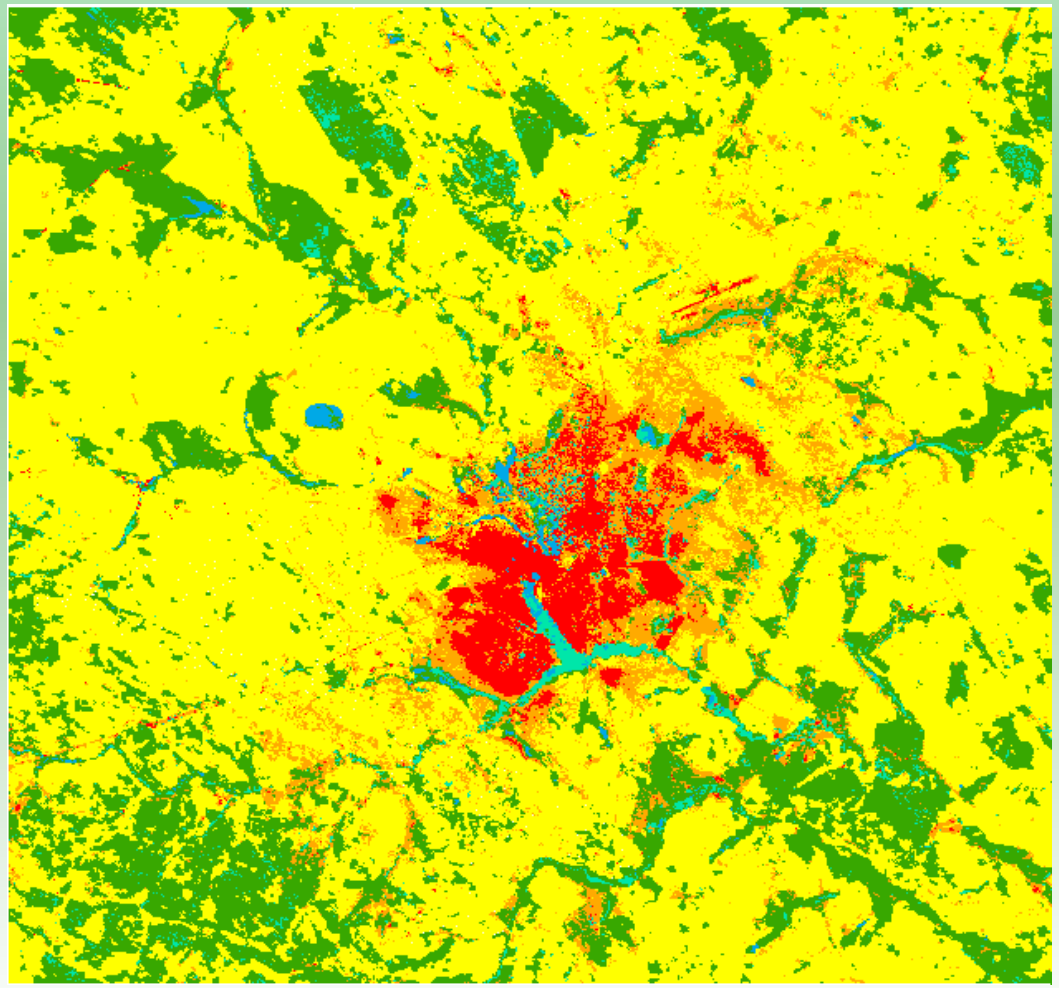
Institute of Geography and Spatial Planning, University of Lisbon, Portugal

Context

Study zone



Fast unplanned urban sprawl



Classified LANDSAT image of the area round Lubumbashi, 1984

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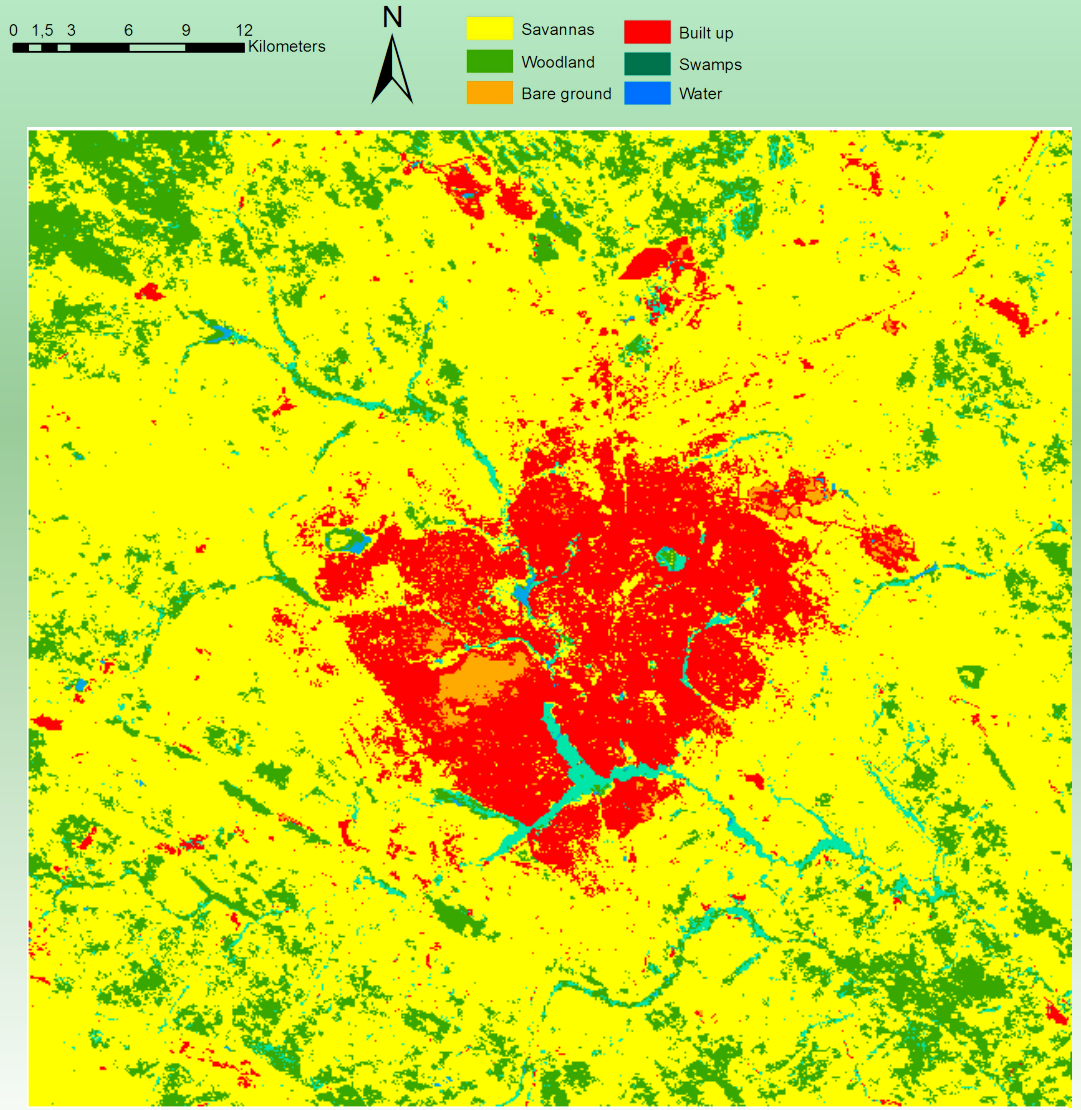

Classified LANDSAT image of the area round Lubumbashi, 2009

Heavy metal atmospheric deposits

Gécamines smelter during colonial period

Vegetation degradation

Bare soils in the pollution cone

Photograph : S. Boisson

Bare soils in the pollution cone

Photograph : G. Colinet

Vegetation degradation

Climax vegetation in the area : Miombo

Objectives

Research objectives

Confirming the presence of atmospheric **pollution** due to **heavy metal** deposits from metallurgy and mining **industry** in Lubumbashi

- Pollution cone from the Gécamines smelter (effect on the vegetation)
- Other traces mining / metallurgy activities

Material and methods

2 (very) different approaches

1. Spatial pattern metrics
   - Based on classified high resolution satellite image
   - Vegetation vs. bare ground spatial structure indexes on polluted and non polluted areas

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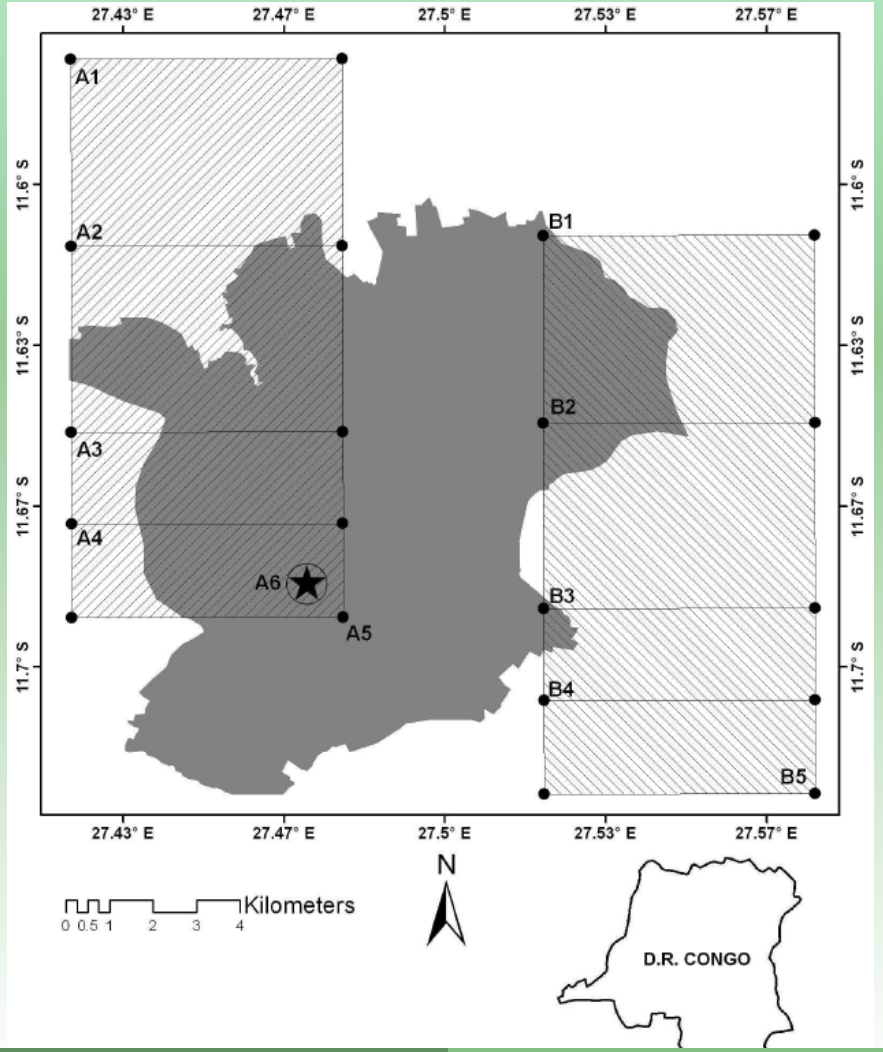
2. Perception analysis : picturesque vision of urban spaces
   - cf. Kevin Lynch perception theories
   - Adaptation to Dev. countries and pollution context

Spatial pattern metrics analysis

Images and zones

- classified 2005 Quickbird image
- Clips downwind of the Gecamines smelter + control zone outside
- Nested testzones to highlight the effect of the pollution cone
- Increasing remoteness from source



Spatial pattern metrics

n_v, n_s = number of vegetation / bare soil patches ; $a_{i,v}, a_{i,s}$ = area of the i^{th} vegetation / bare soil patch ; $a_{tot,v}, a_{tot,s}$ = total vegetation / bare soil area

- $$\text{General vegetation Area index}(G.V.A.) = \frac{a_{tot,v}}{a_{tot,s}} \quad (1)$$
- $$\text{Vegetation patch area index}(V.P.A.) = \frac{\sum_{i=1}^{n_v} a_{i,v}}{\sum_{i=1}^{n_s} a_{i,s}} \quad (2)$$

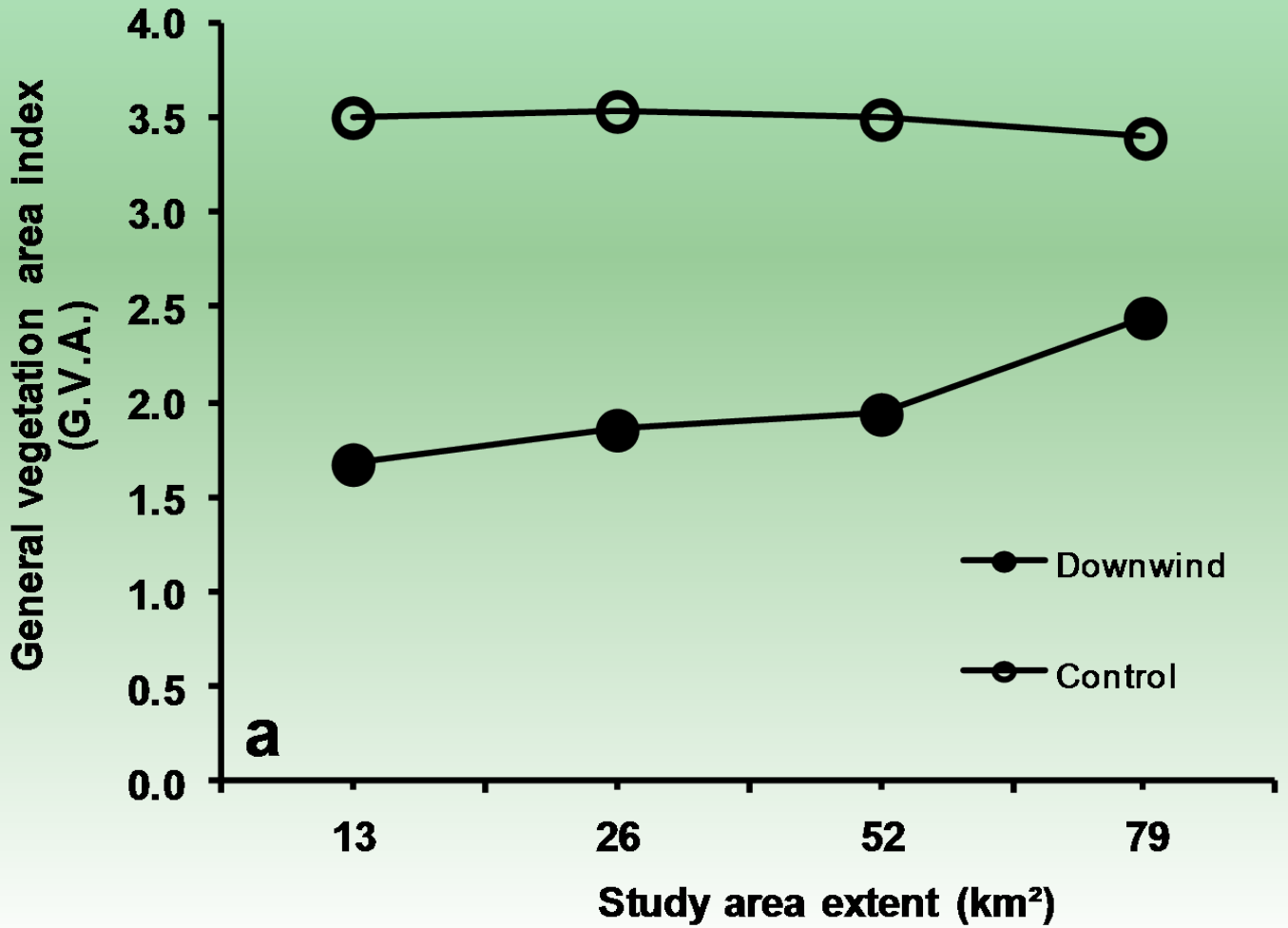
- If $\exists$ contamination effect,
  - $G.V.A.\text{downwind} < G.V.A.$ control
  - $V.P.A.\text{downwind} < V.P.A.$ control

Spatial pattern metrics

- $$Dominance_v = \frac{a_{max,v}}{a_v} \quad (3)$$
  - with $a_{max,v}$ = area of the largest vegetation patch ;
- For $Dominance_s$ (bare ground dominance), same principle with : $a_{max,s}$ = area of the largest bare soil patch ;
- LPI $\rightarrow$ measuring fragmentation
  - If $\exists$ contamination effect $\rightarrow$ bare soil fragmentation $<$ vegetation $\rightarrow$ $Dominance_s < Dominance_v$

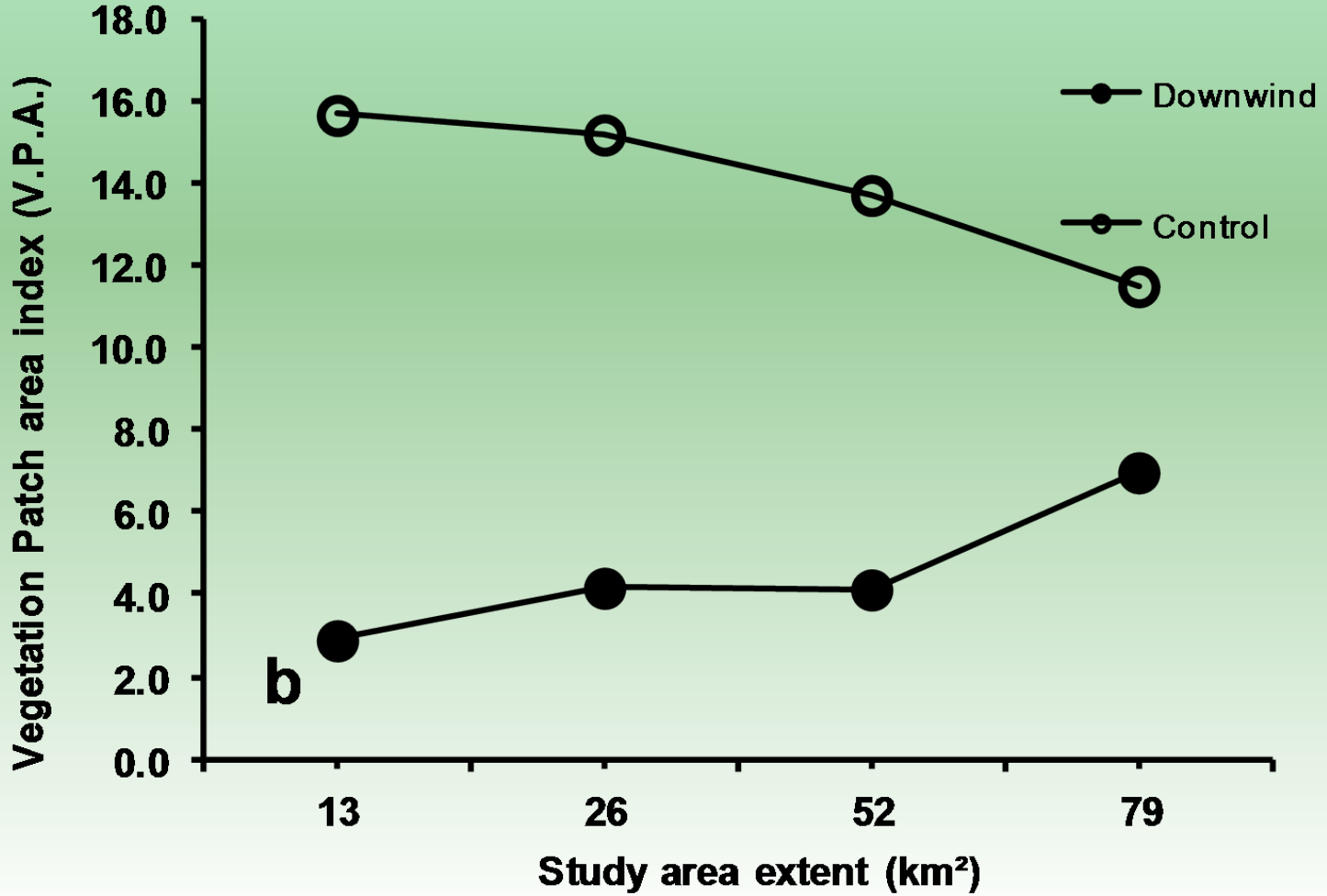
Spatial pattern metrics

Results



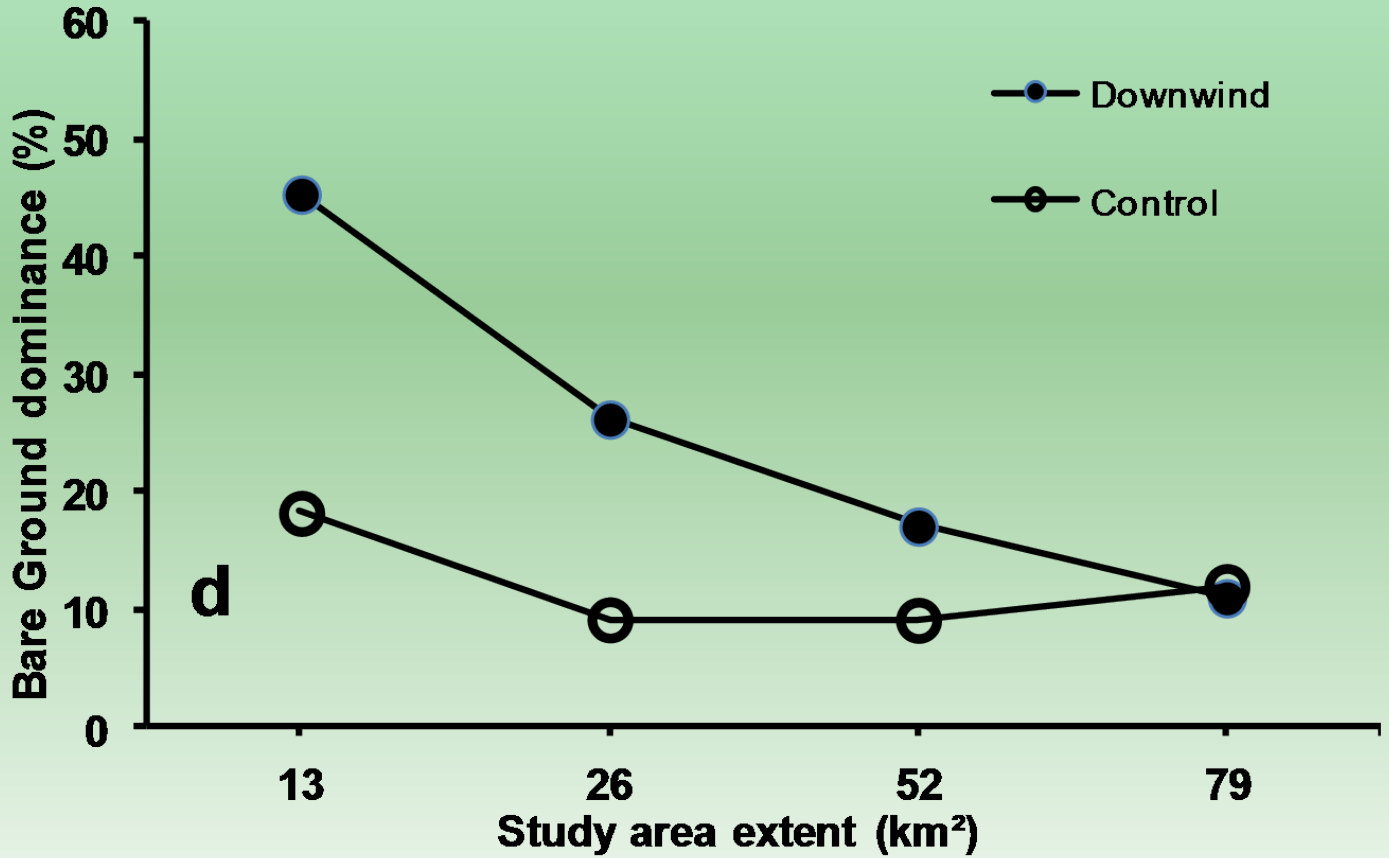
Spatial pattern metrics

Results



Spatial pattern metrics

Results



Picturesque approach : pollution perception

Kevin Lynch's theory

The *citizen* : observer and user of the city

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- Human, sensitive city stimuli, interacting with it
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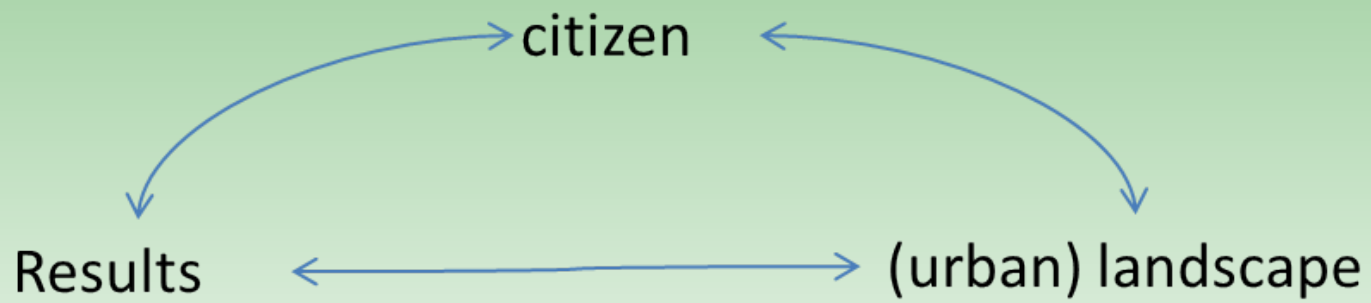
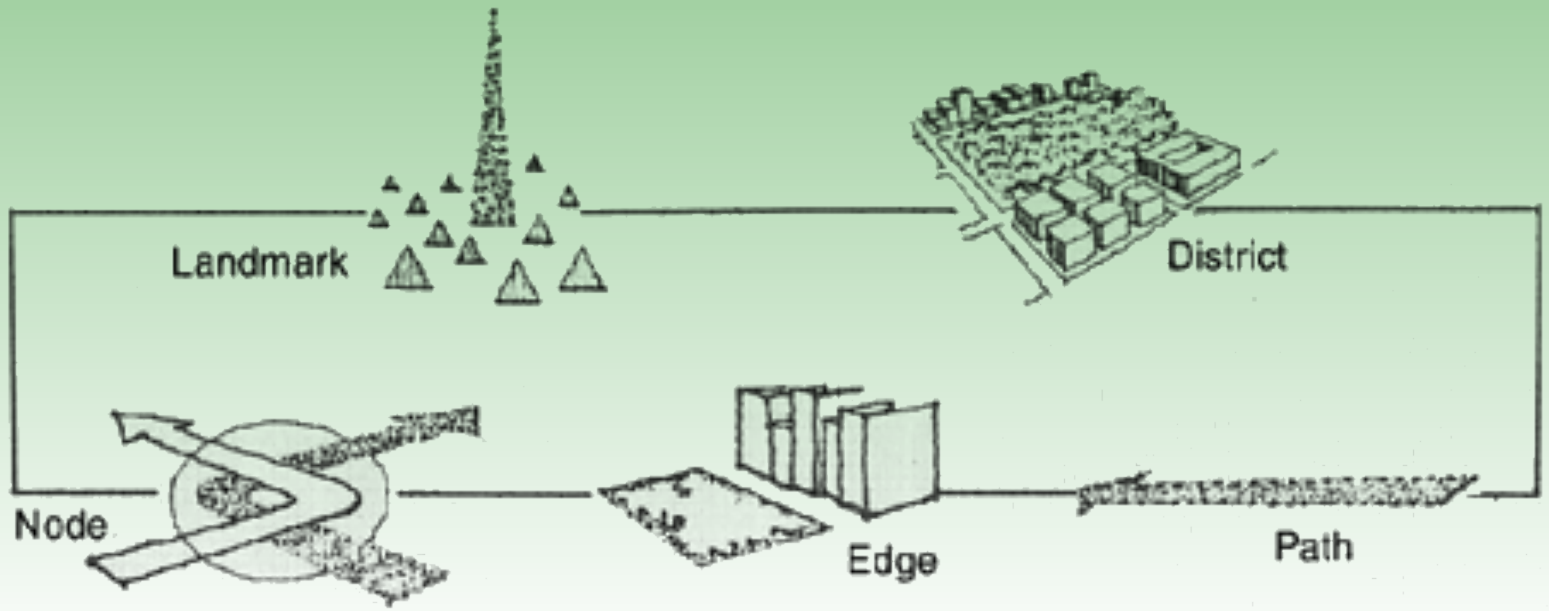


5 constituting elements of the image of the city

- Edges
- Paths
- Nodes
- Landmarks
- Districts



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- Complementary uses in urban studies
- Activities : elements listing, maps drawing, usual itineraries descriptions, qualitative feeling description

Comparison of expert and citizen paradigms

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- Sørensen similarity index :

$$S_{Similarity} = \frac{2a}{2a + b + c} \tag{4}$$

a = number of elements cited in both paradigms ; b = number of elements only present in the expert paradigm ; c = number of elements only in the citizen paradigm

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  - 1 element added : point-edges

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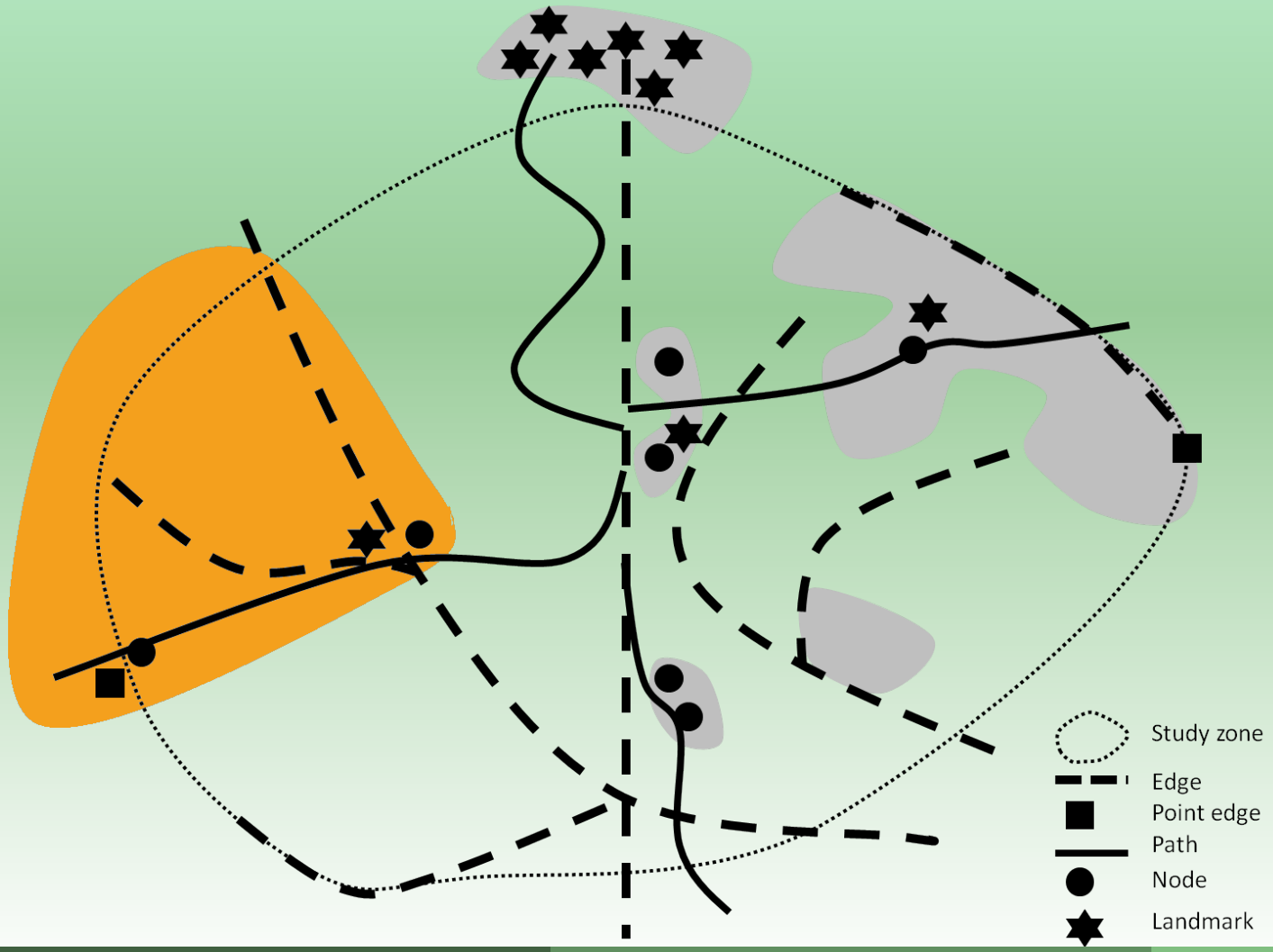
- To the context of developing countries
  - 1 element added : point-edges
- To the context of mining and metallurgy pollution : Adapted definition of the elements : induced by pollution
  - Districts = contaminated zones, *Pollution districts*
  - Paths = pollution transmission itineraries
  - Landmarks : mining and metallurgy flagships

Pollution perception map

Perception results



Expert and citizen comparisons

		Edges	Point edges	Paths	Nodes	Landmarks	Districts
Observers	elements	10	7	65	54	45	19
Collective	elements	8	5	63	52	49	19
Common	elements	7	5	59	44	40	19
$S_{similarity}$	(%)	77.8	83.3	91.5	83	84.9	91.5

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- High similarity
- Higher citizen sensitivity to landmarks only $\rightarrow$ most conscious element for city users ?

Discussion/conclusion

- Spatial structure
  - Cheaper technique than soil samples collection : confirms more accurate small-scale field surveys
  - Pollution effect on vegetation : bare soils
  - Effects weaken with remoteness from source
  - Existence of the pollution cone
  - Perspective : cone extension

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  - Existence of the pollution cone
  - Perspective : cone extension
- Perception
  - Pollution effect : bare grounds, metallophyte grass, water color, fume odor,...
  - Not only in the Gécamines pollution cone : transport + newly installed plants
  - Part of the image of the city

Discussion/Conclusion (2)

- Both approaches
  - Complementary
  - Confirm the existence of the pollution cone and vegetation degradation
  - Urban sprawl $\rightarrow$ peripheral plants soon included
  - Can spot areas of interest for further analyses at low cost
- Implications for urban planning ?
- Communication between planners and environmental scientists ?

References

I. Vranken, Y. M. Amisi, F. Munyemba Kankumbi, I. Bamba, F. Veroustraete, M. Visser & J. Bogaert (2013) The spatial footprint of the non-ferrous metal industry in Lubumbashi, TROPICULTURA, 31-1, pp. 22-29.
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Photograph : S. Boisson