

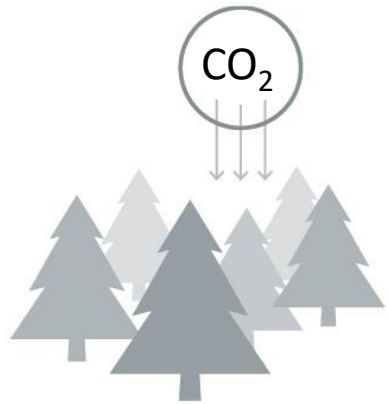
Managing urban trees for biodiversity and ecosystem service provision: Monitoring of tree-related structure variables

Hanna Fors

Dept. of Landscape architecture, planning and management, SLU

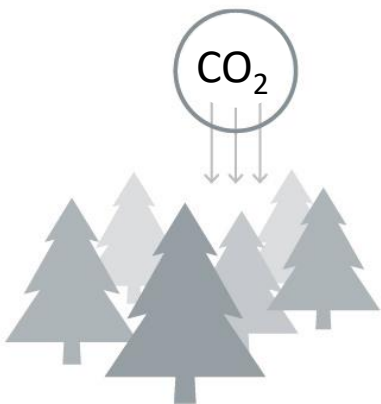


The rural forest



Ecosystem services

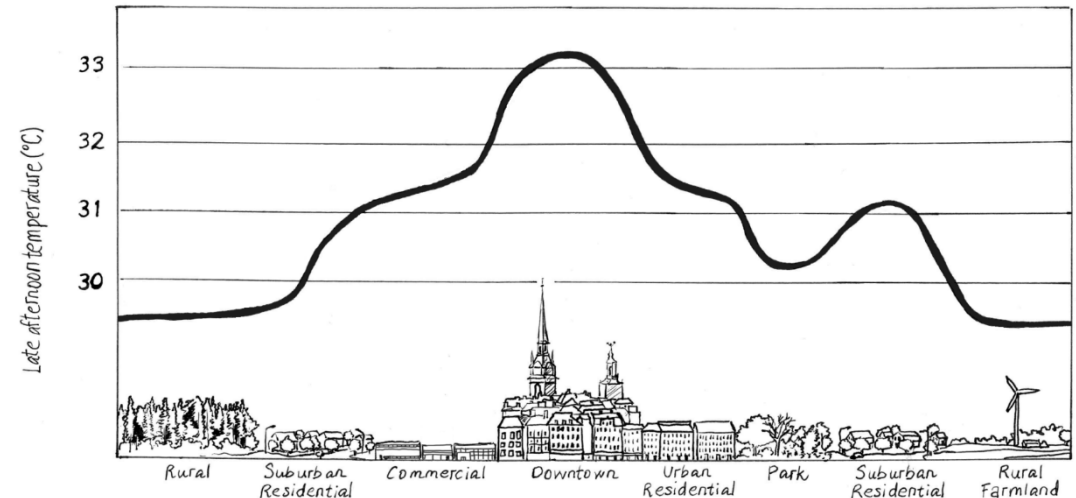
Supporting ecosystem services	Soil formation
	Photosynthesis
	Nutrient cycling
	Pollination and seed dispersal
Provisioning ecosystem services	Food, berries, fruits, herbs
	Bioenergy
	Natural medicines
	Fresh water
Regulating ecosystem services	Air purification
	Carbon sequestration and storage
	Water purification and flood regulation
	Thermal climate regulation
Cultural ecosystem services	Human health and well-being
	Recreation
	Knowledge and information
	Aesthetic values
	Social relations
Ecosystem disservices	Economic values
	Air quality problems (due to BVOC emissions)
	Allergic reactions (due to pollen)
	Poisonous species (of mushrooms, berries, fruits or plants)
	Thermal discomfort
	Vector-borne diseases
	Private property damage (e.g. falling branches)
Low perceived safety	



The urban forest

Air purification

Urban heat island mitigation



How to manage?

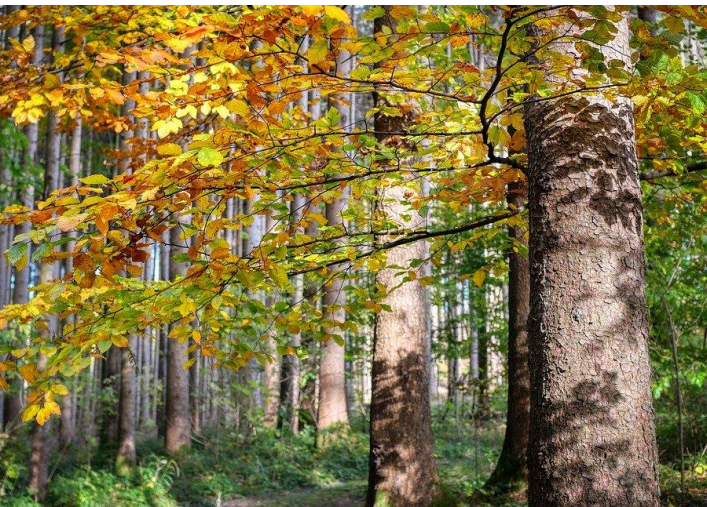
- No obvious answer to how to manage rural and urban forests in a way that balances between all these different values and aspects.
- Most earlier studies are limited to *either* rural or urban forests and only deal with a single or few ecosystem services or a single aspect of biodiversity. Such as:
 - How do native tree species affect species diversity of birds?
 - How does dead wood in cities support fungi and beetles that are dependent on decaying wood?
 - How does vegetation density affect noise reduction?
 - How should trees and vegetation be placed for increased perceived safety?
 - How does green space size affect local thermal climate?
 - How does the age of a tree affect people's attachment to a place?
 - Which urban tree species composition causes air quality problems?



The urban forest

Let's include all the trees in the Northern hemisphere and all the ecosystem services and biodiversity support they provide in the same study!

The rural forest



Main research question

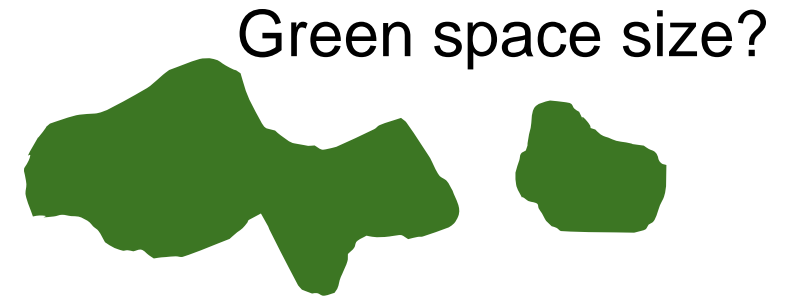
Which tree-related structure variables are considered important for biodiversity and the provisioning of specific ecosystem services and ecosystem disservices in urban and rural forested landscapes respectively?



Broadleaf or conifer trees?



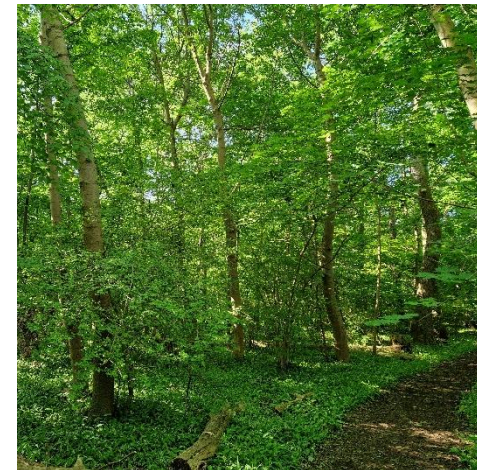
Dead wood?



Tree size
/age ?



Multi-storey
vegetation?



Literature review

- **Search terms:** (forest* OR tree* OR woodland* OR "green space*" OR "greenspace*" OR garden* OR "green infrastructure" OR urban) AND ("ecosystem service*" OR biodiversity OR "ecosystem disservice*")
in Scopus and Web of Science Core Collection
- **Limited to:** Review articles in English
- The search yielded 5,727 articles for title/abstract screening.
- **Inclusion criteria:** Review articles describing studies of urban and rural boreal and temperate forests in the Northern hemisphere
- Studies included in the review: **344 articles**.
- 224 of these were on rural forests and 115 on urban forests. 5 articles covered both urban and rural forests.
- 27 co-authors with joint expertise in urban and rural forest management and ecology

Structure variables	Biodiversity	Supporting ES	Provisioning ES	Regulating ES	Cultural ES	Ecosystem disservices	Total sum
Urban green space	19	7	8	60	89	18	201
Urban green infrastructure	6	3	4	47	21	11	92
Urban forest	4	1	8	34	14	10	71
Gardens & neighbourhood green space	18	1	5	17	29	11	81
Nature	4	1	1	5	19	9	39
Tree species composition	9	4	3	25	6	33	80
Tree species diversity	32	1	1	8	12	3	57
Native tree species	36				1	1	38
Non-native tree species	14	3	5	4	5	17	48
Broadleaved and deciduous trees				15		1	16
Conifers and evergreen tree species	2			15		3	20
Trees	12	1	13	82	46	45	199
Vegetation	9			32	7	10	58
Tree size and shape	16	3	1	38	10	25	93
Density of tree populations & vegetation	7			10	7	7	31
Tree age	13			4	5	3	25
Dead wood	16	1				2	19
Urban green space size	72	1	2	15	26	2	118
Tree canopy cover	26	1		10	9	4	50
Tree placement	5	1		25	10	22	63
Connectivity	29			2	1	1	33
Fragmentation	12	1					13
Variation within urban green spaces	12	1		2	6		21
Complexity	15			1	1	1	18
Heterogeneity	3				3		6
Forest edge	3						3
Multi-storey vegetation	2			3	1		6
Understorey and shrub layer	14	1	1	13	6	4	39
Total sum	410	32	52	467	334	243	1538

Structure variables	Biodiversity	Supporting ES	Provisioning ES	Regulating ES	Cultural ES	Ecosystem disservices	Total sum
Urban green space	19	7	8	60	89	18	201
Urban green infrastructure	6	3	4	47	21	11	92
Urban forest	4	1	8	34	14	10	71
Gardens & neighbourhood green space	18	1	5	17	29	11	81
Nature	4	1	1	5	19	9	39
Tree species composition	9	4	3	25	6	33	80
Tree species diversity	32	1	1	8	12	3	57
Native tree species	36				1	1	38
Non-native tree species	14	3	5	4	5	17	48
Broadleaved and deciduous trees				15		1	16
Conifers and evergreen tree species	2			15		3	20
Trees	12	1	13	82	46	45	199
Vegetation	9			32	7	10	58
Tree size and shape	16	3	1	38	10	25	93
Density of tree populations & vegetation	7			10	7	7	31
Tree age	13			4	5	3	25
Dead wood	16	1				2	19
Urban green space size	72	1	2	15	26	2	118
Tree canopy cover	26	1		10	9	4	50
Tree placement	5	1		25	10	22	63
Connectivity	29			2	1	1	33
Fragmentation	12	1					13
Variation within urban green spaces	12	1		2	6		21
Complexity	15			1	1	1	18
Heterogeneity	3				3		6
Forest edge	3						3
Multi-storey vegetation	2			3	1		6
Understorey and shrub layer	14	1	1	13	6	4	39
Total sum	410	32	52	467	334	243	1538

Structure variables	Biodiversity	Supporting ES	Provisioning ES	Regulating ES	Cultural ES	Ecosystem disservices	Total sum		
Urban green space	19	7	8	60	89	18	201		
Urban green infrastructure	6	3	4	47	21	11	92		
Urban forest	4	1	8	34	14	10	71		
Gardens & neighbourhood green space	18	1	5	17	29	11	81		
Nature	4	1	1	5	19	9	39		
Tree species composition	9	4	3	25	6	33	80		
Tree species diversity	32	1	1	8	12	3	57		
Native tree species	36				1	1	38		
Non-native tree species	14	3	5	4	5	17	48		
Broadleaved and deciduous trees				15			1	16	
Conifers and evergreen tree species	2				15			20	
Trees	12	1	13	82	46	45	199		
Vegetation	9				32	7	10	58	
Tree size and shape	16	3	1	38	10	25	93		
Density of tree populations & vegetation	7				10	7	7	31	
Tree age	13				4	5	3	25	
Dead wood	16	1						2	19
Urban green space size	72	1	2	15	26	2	118		
Tree canopy cover	26	1			10	9	4	50	
Tree placement	5	1			25	10	22	63	
Connectivity	29				2	1	1	33	
Fragmentation	12	1						13	
Variation within urban green spaces	12	1			2	6			21
Complexity	15				1	1	1	18	
Heterogeneity	3						3	6	
Forest edge	3								3
Multi-storey vegetation	2				3	1			6
Understorey and shrub layer	14	1	1	13	6	4	39		
Total sum	410	32	52	467	334	243	1538		

Structure variables	Biodiversity	Supporting ES	Provisioning ES	Regulating ES	Cultural ES	Ecosystem disservices	Total sum
Urban green space	19	7	8	60	89	18	201
Urban green infrastructure	6	3	4	47	21	11	92
Urban forest	4	1	8	34	14	10	71
Gardens & neighbourhood green space	18	1	5	17	29	11	81
Nature	4	1	1	5	19	9	39
Tree species composition	9	4	3	25	6	33	80
Tree species diversity	32	1	1	8	12	3	57
Native tree species	36				1	1	38
Non-native tree species	14	3	5	4	5	17	48
Broadleaved and deciduous trees				15		1	16
Conifers and evergreen tree species	2			15		3	20
Trees	12	1	13	82	46	45	199
Vegetation	9			32	7	10	58
Tree size and shape	16	3	1	38	10	25	93
Density of tree populations & vegetation	7			10	7	7	31
Tree age	13			4	5	3	25
Dead wood	16	1				2	19
Urban green space size	72	1	2	15	26	2	118
Tree canopy cover	26	1		10	9	4	50
Tree placement	5	1		25	10	22	63
Connectivity	29			2	1	1	33
Fragmentation	12	1					13
Variation within urban green spaces	12	1		2	6		21
Complexity	15			1	1	1	18
Heterogeneity	3				3		6
Forest edge	3						3
Multi-storey vegetation	2			3	1		6
Understorey and shrub layer	14	1	1	13	6	4	39
Total sum	410	32	52	467	334	243	1538

Results – urban forests

Reviewed studies mainly described the following tree-related structure variables that affect biodiversity and ecosystem service provision (*tentative list, analysis ongoing*):

- Tree species composition, native or non-native tree species, tree size and shape, vegetation density, dead wood, urban green space size, connectivity, horizontal and vertical variation with urban green spaces, and tree placement.

Then what?

- How much do we need of each tree-related structure variable?
- Few urban studies quantified structure variables.
→ We could learn from studies of rural forests, with more quantification of structure variables + Future studies should quantify the central structure variables identified in this study.

It is time for an urban national forest inventory!

- In Sweden, we have the Swedish national forest inventory – 100 years of monitoring data for the rural forest.
- An urban equivalent is lacking.
- The central tree-related structure variables for a broad provision of ecosystem services and support of biodiversity identified in this study could constitute the foundation of an urban national forest inventory.
- Long-term monitoring data of urban trees is important to be able to identify changes over time (e.g. decreasing number of old, large trees or amount of dead wood in the city) as a basis for strategic management of the urban forest.