European Commission

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

Valuation of regulating services of urban trees in Oslo

Urban Ecosystem Accounting Webinar

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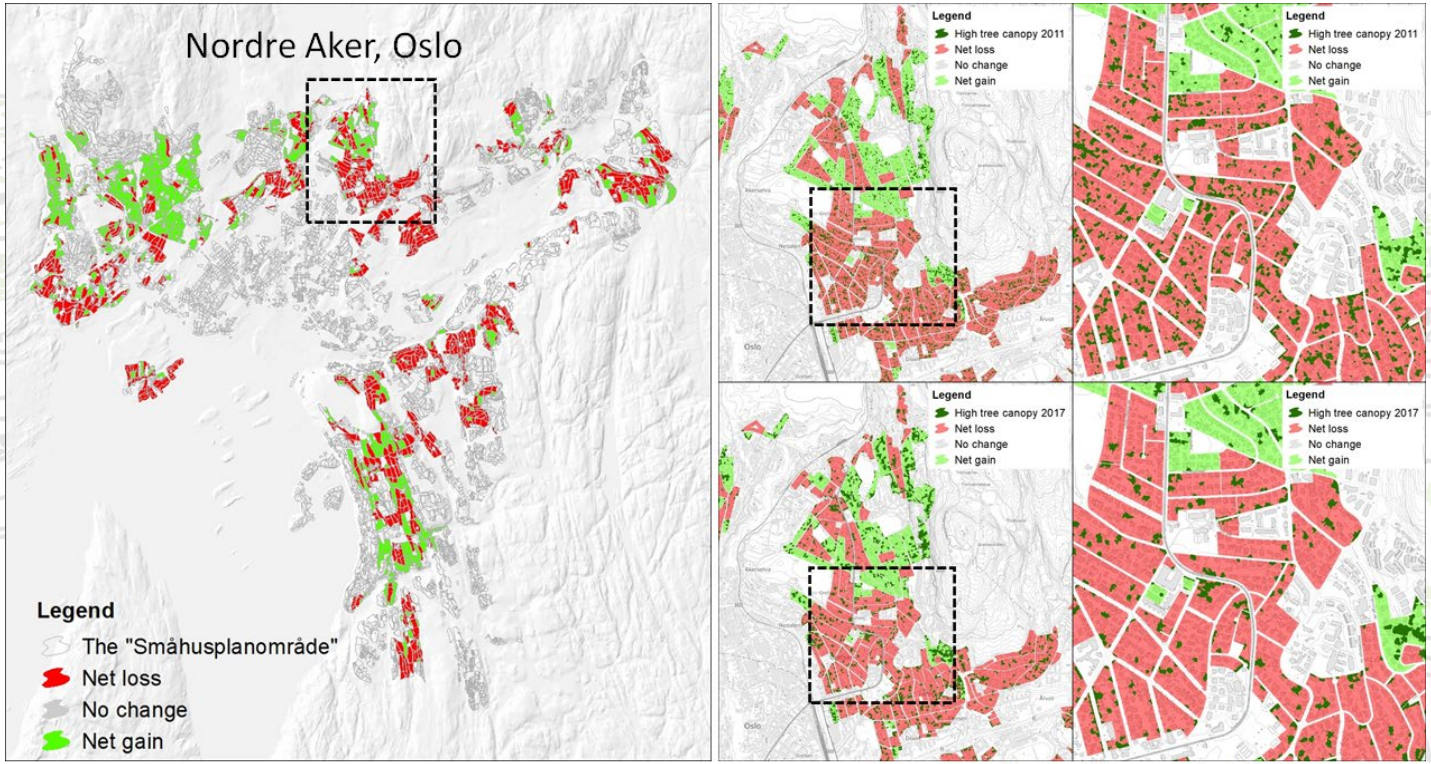
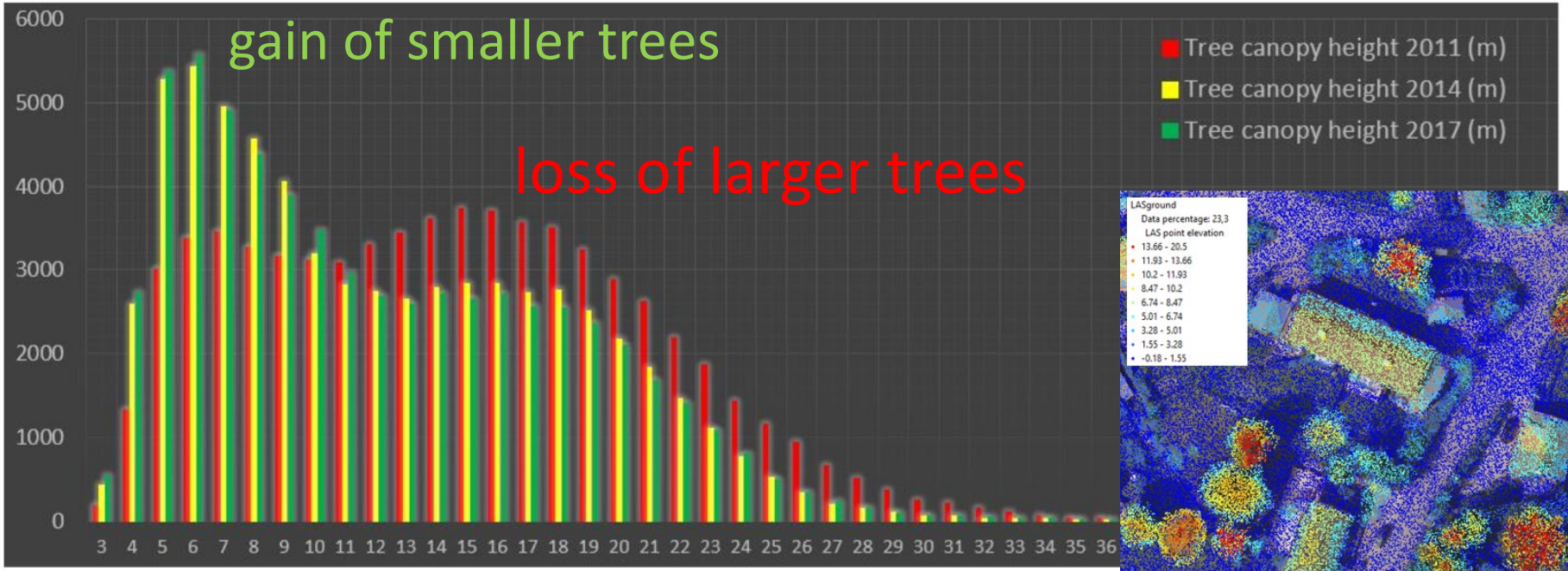
Case study : ecosystem accounting of Oslo suburbs' loss of large trees due to urban densification



Source: Hanssen et al. 2019

Planning question: net loss of regulating services from trees due to sub-urban densification?



Source: Hanssen et al. 2019
Note: differences in Lidar classification of vetegation between 2011-2014-2017

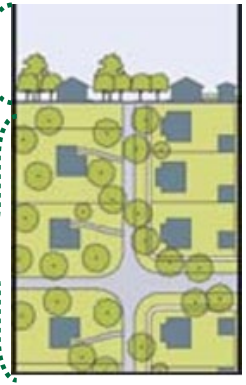
Relevance for municipal policy and planning (1/2) - extent-condition account

	EXTENT-CONDITION ACCOUNT			(SMÅHUSPLAN SUBURBS - TREES)					
	Tree height (elevation bands)								
Crown cover	2.5-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	Total
Total 2011 (daa)	65	1150	1822	2495	1884	661	123	15	8214
Additions (daa)	83	747	183	10	26	8	0	2	1059
Losses (daa)	0	0	0	-82	-224	-313	-71	-7	-698
Total 2017(daa)	148	1898	2005	2422	1685	356	52	9	8574
Change 2011-2017(daa)	83	747	183	-73	-199	-305	-71	-6	361

Source: based on Hanssen et al. 2019

Condition (height)

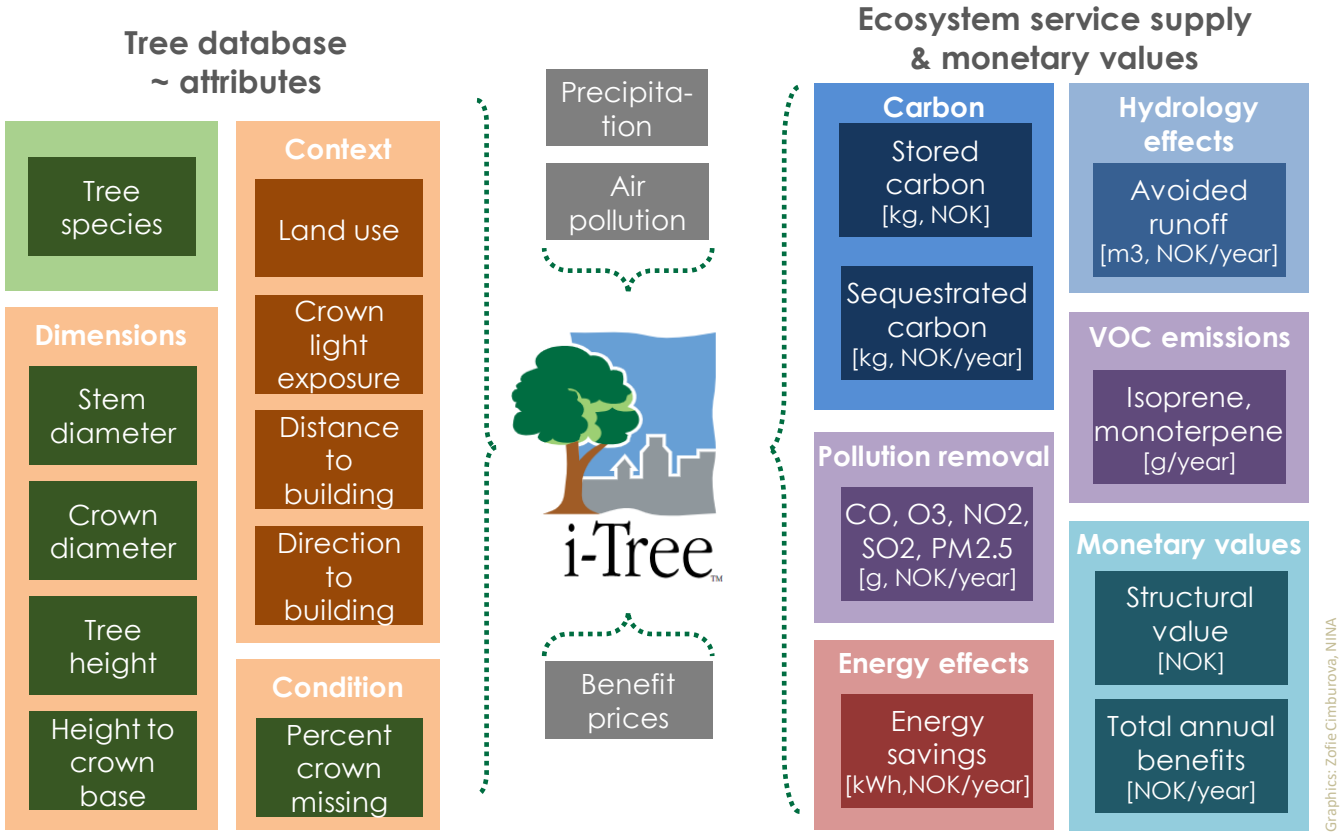
Extents (crown cover)



Source: https://transect.org/

Net gain in tree canopy extent in suburban area 2011-2017, despite loss of taller trees

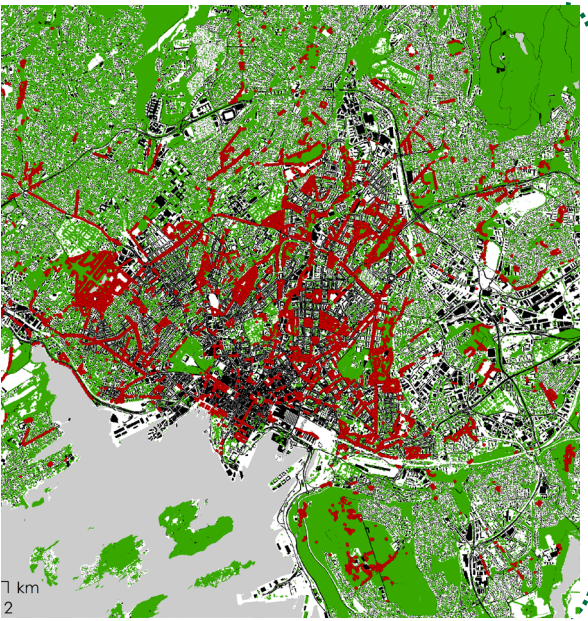
Methods: Quantification and valuation of **regulating ecosystem services** of urban trees using **i-Tree Eco**



Source illustration : Zofie Cimburova, NINA

Input data for i-Tree Eco

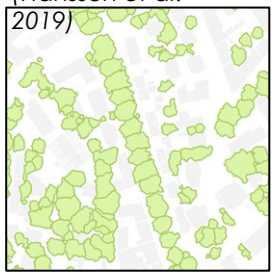
Municipal tree inventory



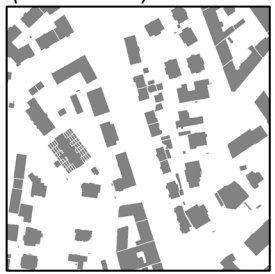
GIS & statistics

GIS analysis

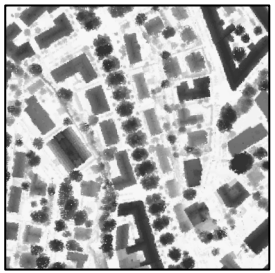
LiDAR detection of tree crowns *(Hanssen et al. 2019)*



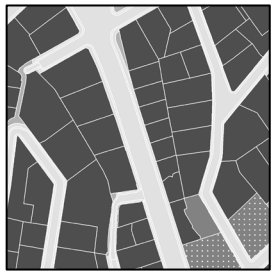
Building map *(Kartverket)*



Terrain map *(Høydedata)*



Land use map *(NIBIO, SSB)*



Statistical analysis

Allometric equations

BYM tree database (29 928 trees)	
Species	✓
Stem diameter	✓
Crown diameter	✓
Total height	✓
Height to crown base	✓
Crown light exposure	✓
Distance & direct. to building	✓
Land use	✓
Percent crown missing	

54 % suitable for i-Tree

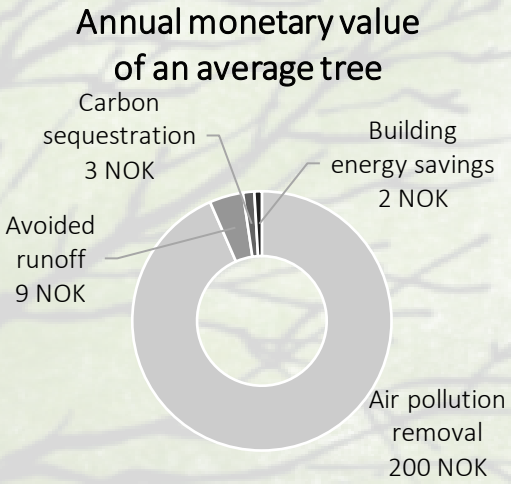
	✓
Air pollution removal	✓
Avoided runoff	✓
Carbon sequestration	✓
Building energy savings	

Source illustration : Zofie Cimburova, NINA

i-Tree Eco results for average municipal tree

- **For each tree (16 189 trees = 54 %)**

	Average ES supply per tree	Average monetary value per tree
Removed air pollution	0.8 kg/year	200 NOK/year
Avoided stormwater runoff	1 m3/year	9 NOK/year
Sequestrated carbon	8 kg/year	3 NOK/year
Stored carbon	385 kg	-
Building energy savings	1 (35) kWh/year	2 (45) NOK/year
Total annual mon. value	-	**220 NOK/year**
Mean asset value (NPV)	-	**12 414 NOK**



Source illustration : Zofie Cimburova, NINA

Conclusions

- Value of **air pollution removal** = 94% of annual value of an avg. tree (numerous accounting price assumptions…)

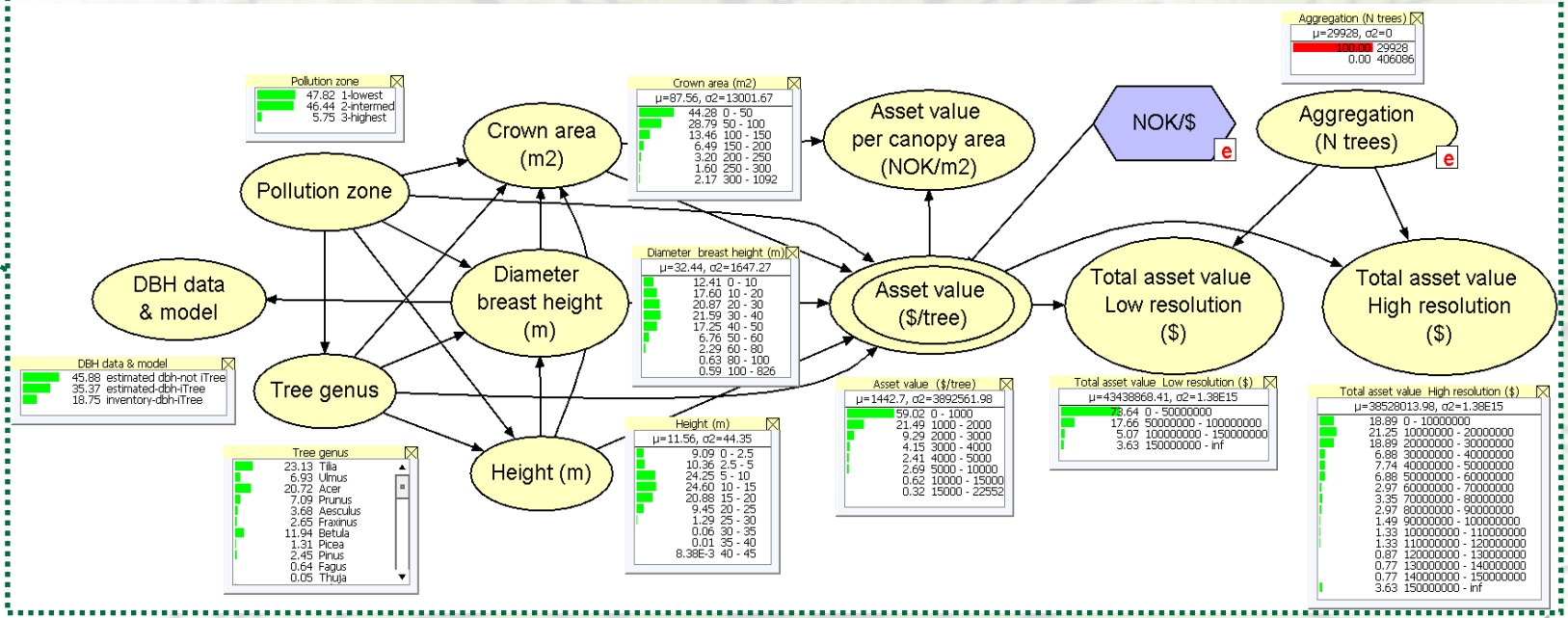
Accounting price corrections to iTree Eco US default values

- **Air pollution mitigation** - Norwegian PM2.5, NO2 health damage costs and SO2 building damage costs (not considering 100% future electric vehicles)
- **Carbon sequestration** – Norwegian cost/tonne CO2 of reaching national emissions reduction targets
- **Energy savings from building cooling** - 46% fossil fuel based electricity imports – Norwegian electricity price 2017
- **Stormwater runoff reduction** – current additional sewage treatment costs in Oslo from combined sewage overflow (not including future upgrade costs of sewage infrastructure due to climate change 5.5 times current costs to 2050)

- 2% risk free social discount rate for NPV asset calculations (not considering current near 0% interest rates)

Bayesian Belief Networks to generalize asset value to all trees in the built zone of Oslo

iTree Eco emulation model in a Bayesian Belief Network (BBN)

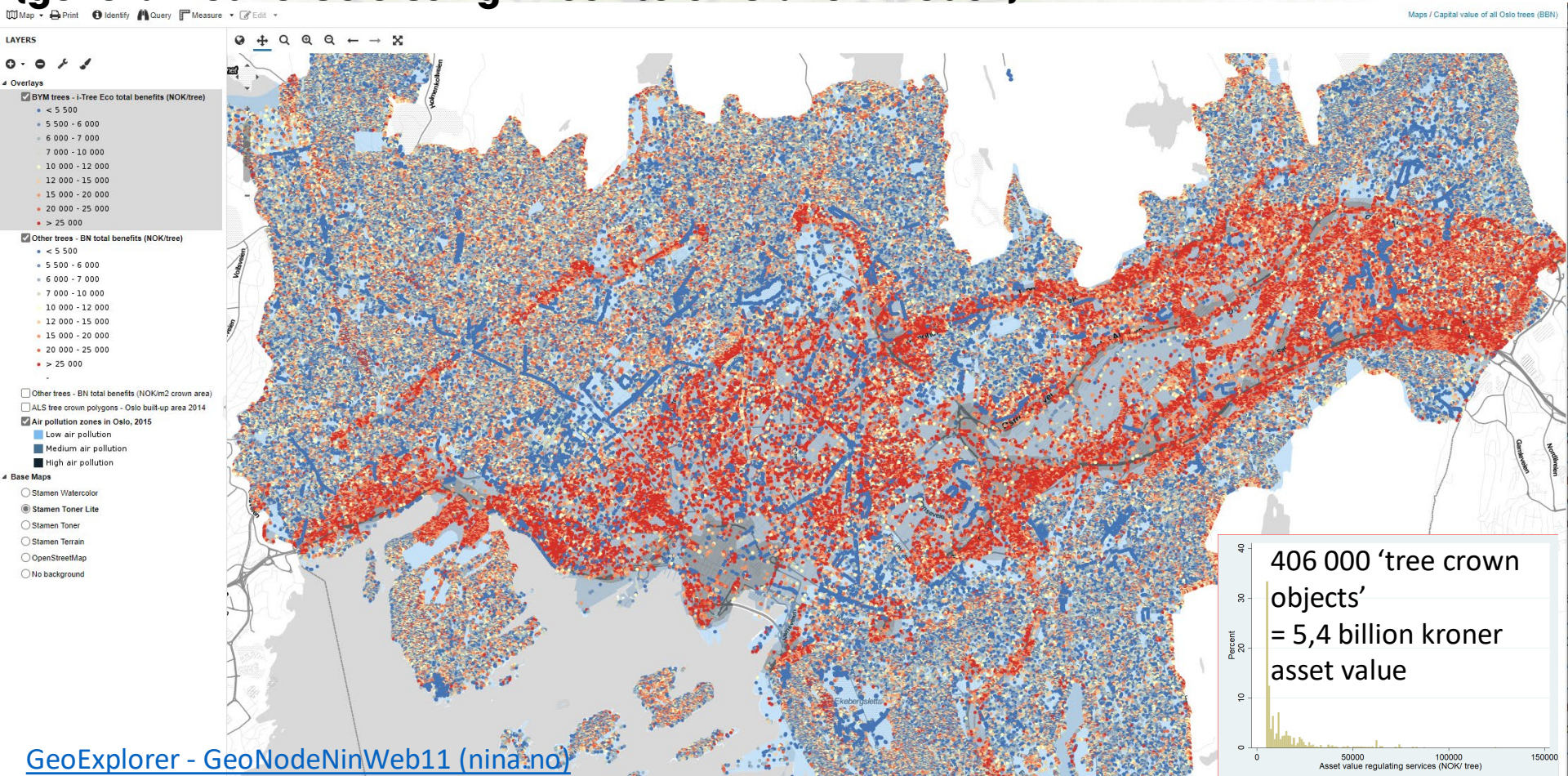


Source: Cimburova and Barton 2020

NINA

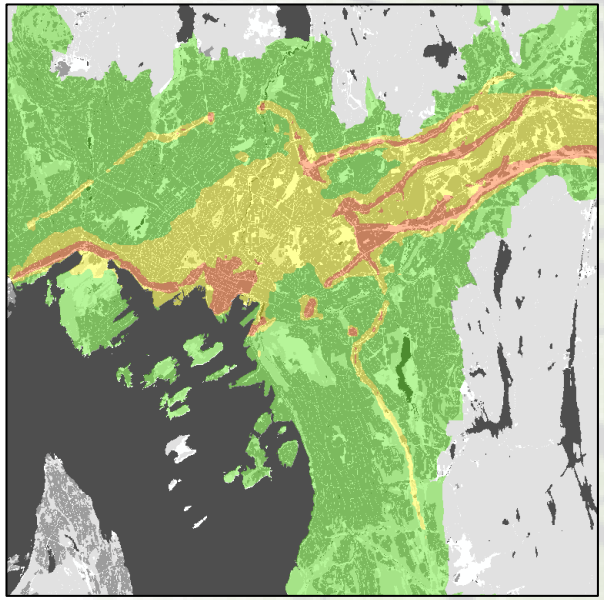
Asset values of urban trees due to regulating services

(generalized to Oslo using iTree Eco emulation model)



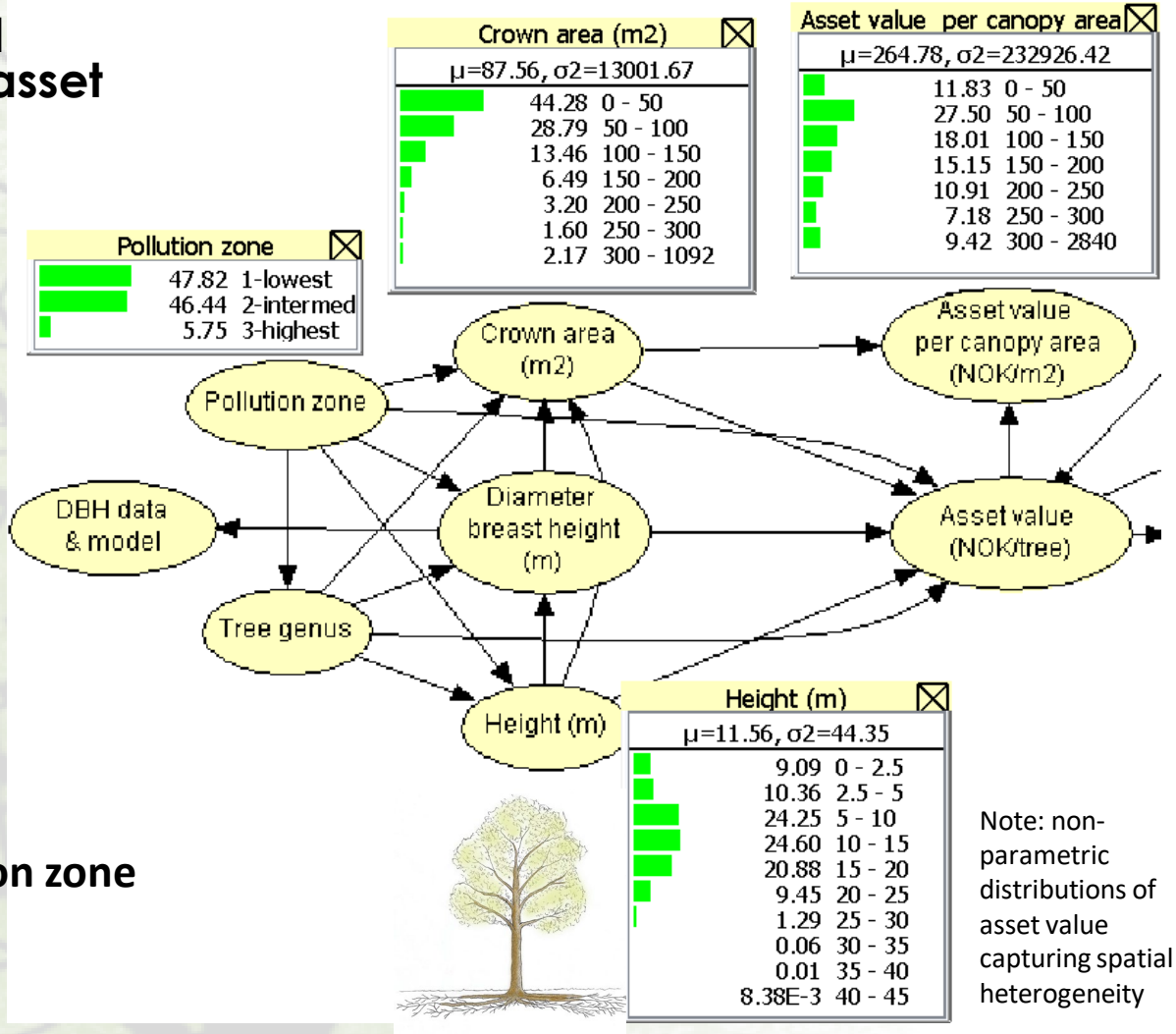
GeoExplorer - GeoNodeNinWeb11 (nina.no)

BBN asset valuation model used to generate per unit asset prices….



Source illustration : Zofie Cimburova, NINA

…conditional on air pollution zone and tree characteristics



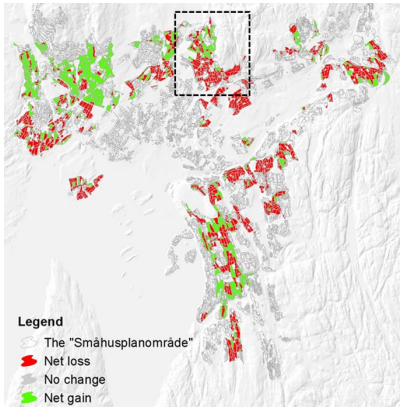
Note: non-parametric distributions of asset value capturing spatial heterogeneity

Relevance for municipal policy and planning (2/2) - monetary tree asset account

	MONETARY ASSET ACCOUNT (SMÅHUSPLAN SUBURBS - TREES - REGULATING SERVICES)								
	Tree height (elevation bands)								
	2.5-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	Total
E(Asset value)* (NOK/m2)	167	148	128	119	118	165	213	100	
Total 2011 (NOK)	10 887 326	170 469 304	233 351 800	297 903 938	221 465 342	109 002 315	26 122 118	1 478 261	1 070 680 404
Additions (NOK)	13 865 241	110 785 557	23 427 661	1 142 849	2 998 445	1 371 399	95 904	150 925	153 837 982
Losses (NOK)	-	-	-	- 9 805 576	- 26 386 555	- 51 692 347	- 15 176 275	- 732 634	- 103 793 386
Total 2017(NOK)	24 754 235	281 254 861	256 779 461	289 240 017	198 076 057	58 681 367	11 060 928	896 552	1 120 743 479
Change 2011-2017(NOK)	13 866 910	110 785 557	23 427 661	- 8 663 921	- 23 389 285	- 50 320 948	- 15 061 190	- 581 709	50 063 075

Source: own calculations (not peer reviewed) based on Hanssen et al. 2019

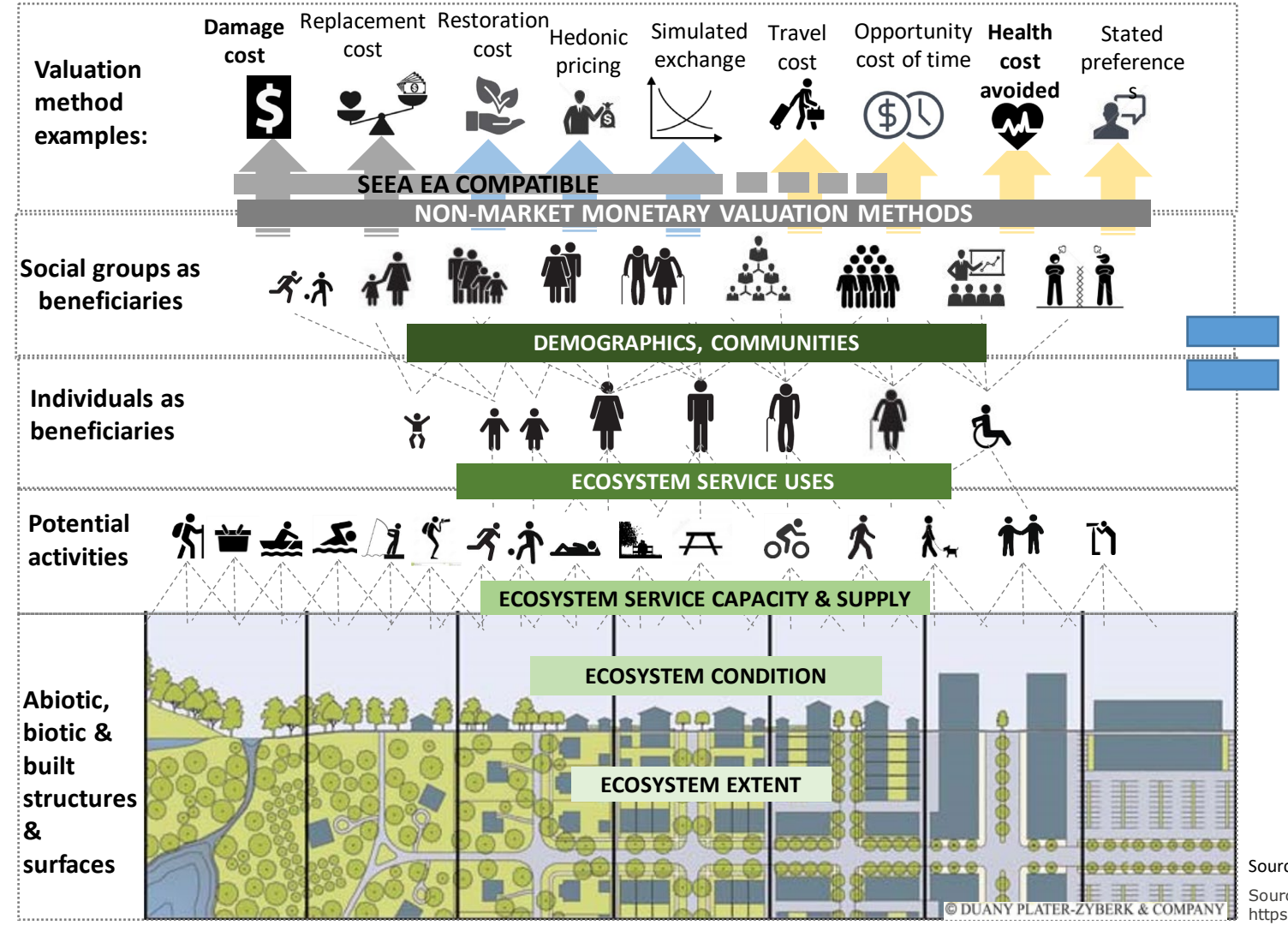
Note: *expected m2 tree crown asset values derived from BBN emulation model



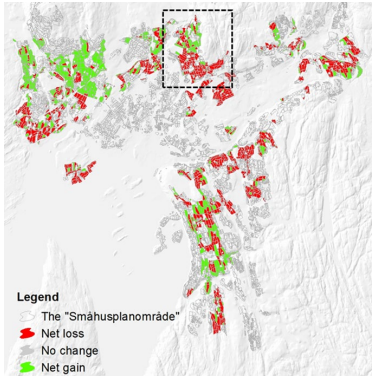
But the losses and gains are unevenly distributed. Some neighbourhoods experience a net loss, some a net gain.

Net gain in tree asset value due to regulating services of NOK 50 million in 2011-2017.

SPATIALLY SENSITIVE ACCOUNTING PRICES AND TABLES?



«Households?»



Source map : Hanssen et al. 2019

Source figure: adapted Barton D.N. et al. (2019).

Source transect illustration https://transect.org/

Thank you

Acknowledgement Zofie Cimburova and Frank Hanssen, NINA

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Mapping & Assessment for Integrated ecosystem Accounting
http://maiaportal.eu/

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References

i-Tree Eco: Cimburova, Z., Barton, D.N., 2020. The potential of geospatial analysis and Bayesian networks to enable i-Tree Eco assessment of existing tree inventories. Urban Forestry & Urban Greening 55, 126801. https://doi.org/10.1016/j.ufug.2020.126801

LiDAR tree detection: Hanssen, F., D.N. Barton, M. Nowell, Z. Cimburova 2019. Mapping urban tree canopy cover using airborne laser scanning – applications to urban ecosystem accounting for Oslo. NINA Report 1677. Norwegian Institute for Nature Research https://brage.nina.no/nina-xmlui/handle/11250/2598874

VAT: Nollet, A., Barton, D.N., Cimburova, Z., Often, A., 2021. Accounting for amenities and regulating ecosystem services of urban trees. Testing a combined field protocol for VAT19 and i-Tree Eco valuation methods. NINA report 1850. https://brage.nina.no/nina-xmlui/handle/11250/2725332

Barton D.N., Obst C., Day B., Caparrós A., Dadvand P., Fenichel E., Havinga I., Hein L., McPhearson T., Randrup T., Zulian G. (2019). Discussion paper 10: Recreation services from ecosystems. Paper submitted to the Expert Meeting on Advancing the Measurement of Ecosystem Services for Ecosystem Accounting, New York, 22-24 January 2019 and subsequently revised. Version of 25 March 2019. Available at: https://seea.un.org/events/expert-meeting-advancing-measurement-ecosystemservices-ecosystem-accounting