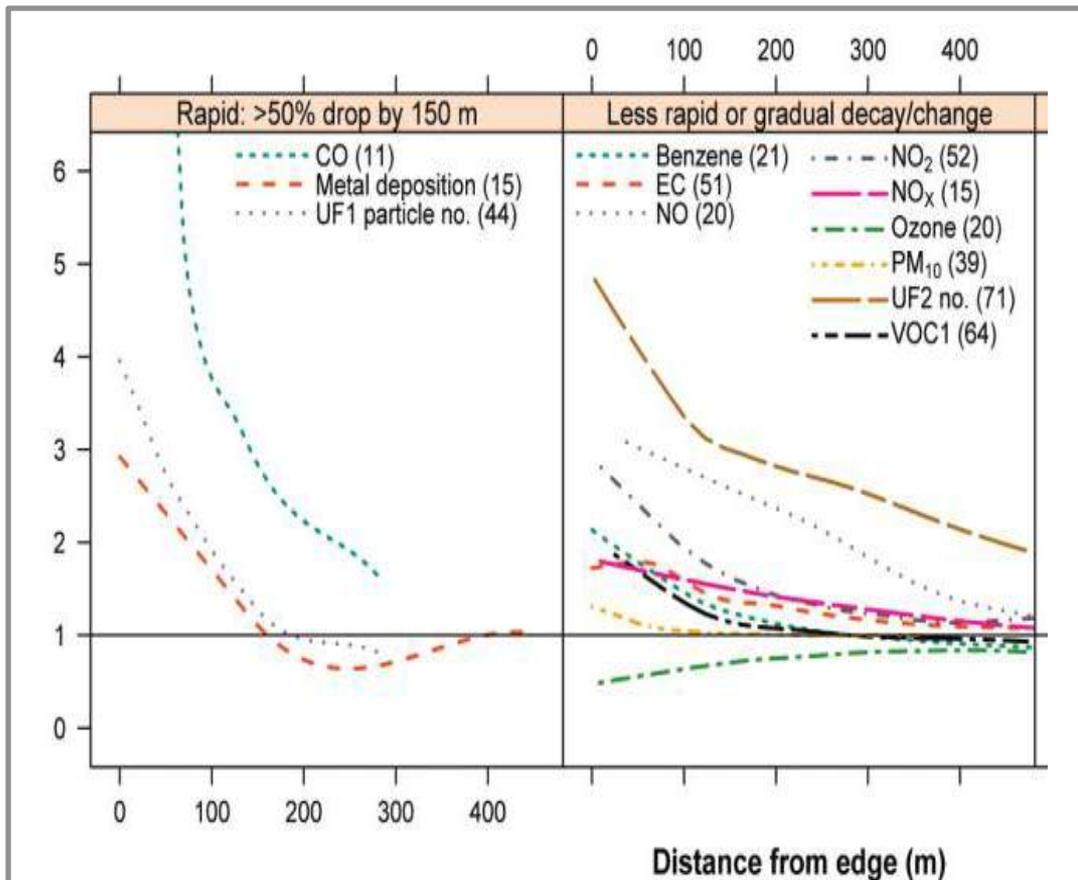# Assessing the potential of Portland's urban forest in mitigating air pollution

Meenakshi Rao
Dr. Linda A. George
Portland State University

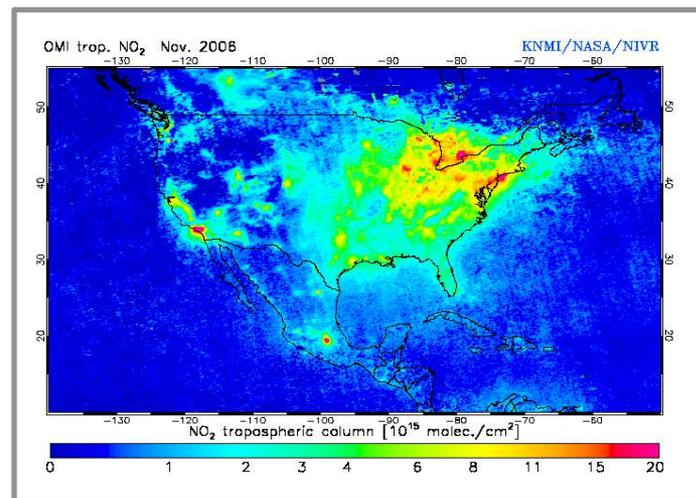# *Scale matters!*

Karner et al (2010) Near Roadway Air Quality: Synthesizing the findings from real world data *Environ. Sci. Technol.*
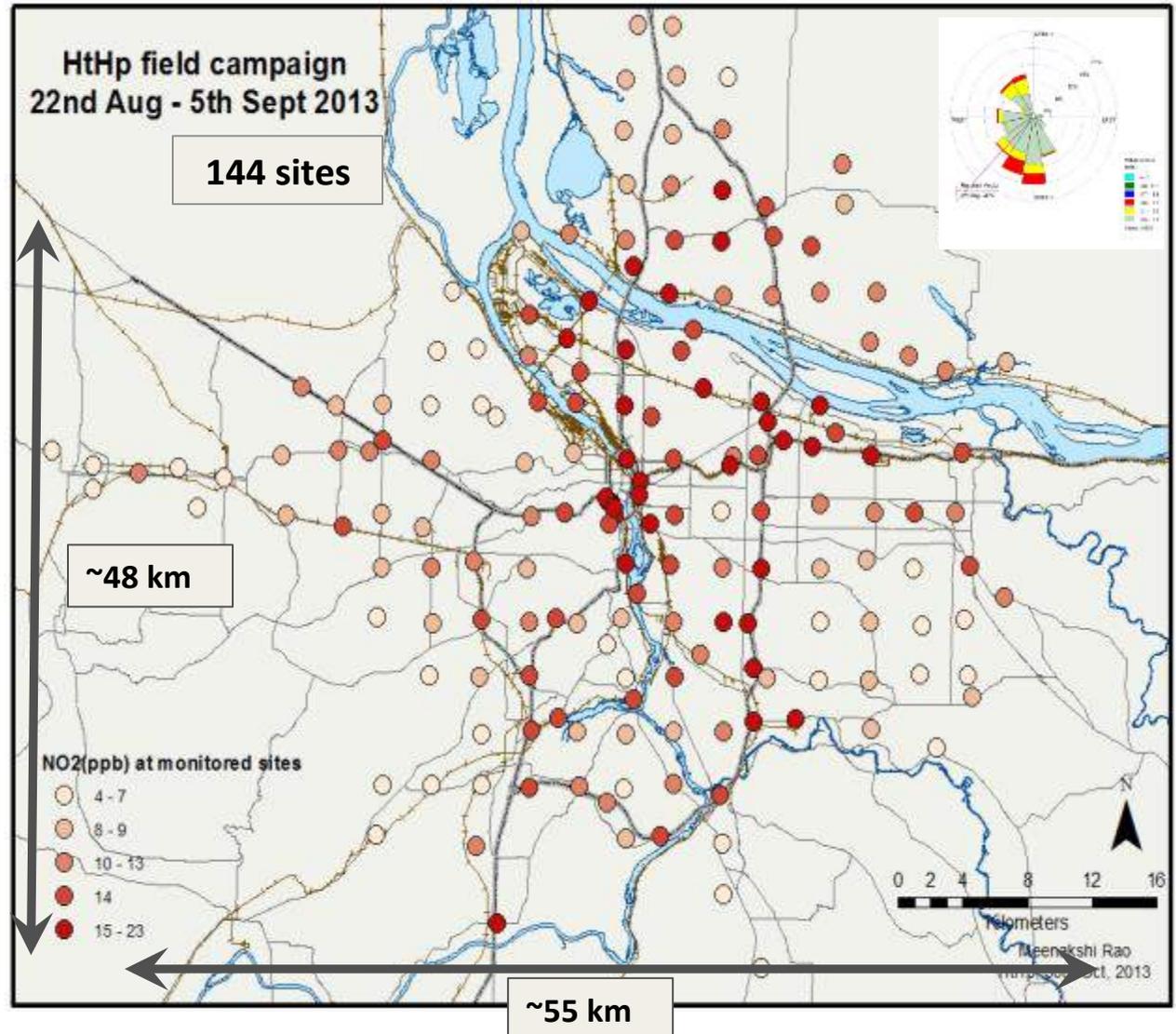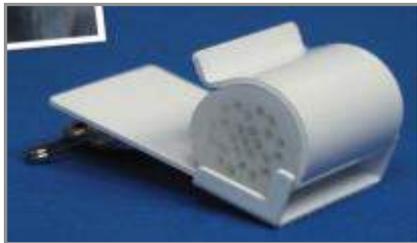

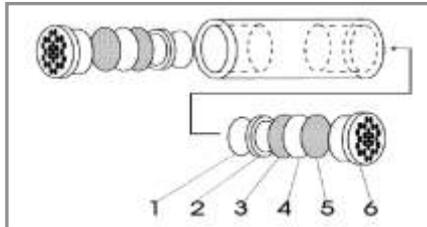EPA monitoring stations

Satellite data

3

Land-use & land-cover variables:

1. Roadways:
   - Freeways(AADT)$_{1200}$
   - Major Arteries$_{500}$
   - Arteries$_{350}$
   - Streets(POP)$_{800}$
2. Railroads$_{250}$
3. Industrial Area
4. Water
5. Area under tree canopy$_{400}$
6. Area under non-canopied veg
7. Population
8. Elevation
9. X (Longitude)
10. Y (Latitude)

24 circular buffers, 50m -1200m, (50 m increments)

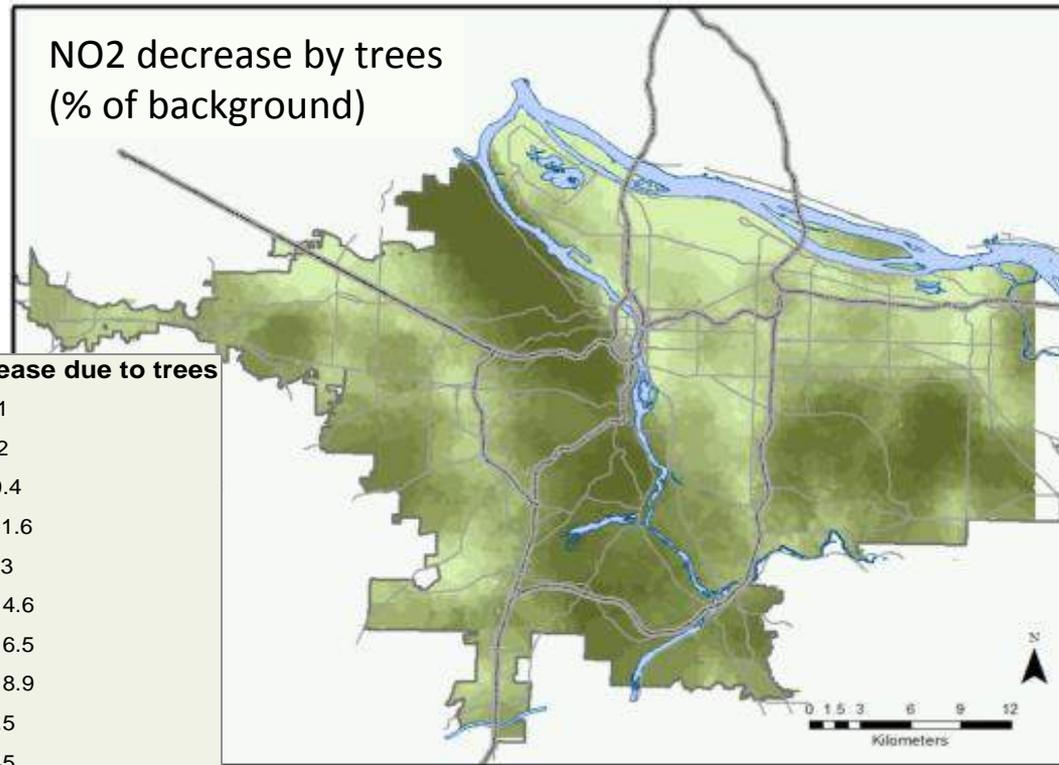Mavko et al *A sub-neighborhood scale land use regression model for predicting NO2* Sci Total Environ (2008)
Henderson et al *Application of land use regression to estimate long-term concentration of traffic-related nitrogen oxides and fine particulate matter* Environ Sci Technol (2007)

NO2 LUR Model

Average Adj R^2 = 0.80

NO2 (ppb) =

7.7

+	$1.1 \times 10^{-8} \cdot FWY\_AADT_{1200}$	freeway (m) in 1200m, weighted with AADT	19%
+	$6.5 \times 10^{-4} \cdot MAJ\_ART_{500}$	major arteries (m) in 500m	8%
+	$1.7 \times 10^{-3} \cdot ARTERIES_{350}$	arteries (m) in 350m	9%
+	$1.8 \times 10^{-8} \cdot STREETS(POP)_{800}$	streets (m) in 800m, weighted by the pop.	10%
+	$1.0 \times 10^{-3} \cdot RAILS_{250}$	railroads (m) in 250m	4%
−	$1.0 \times 10^{-2} \cdot ELEVATION$	elevation (ft)	
+	$1.4 \times 10^{-5} \cdot (ELEVATION)^2$	elevation (ft) squared	
−	$5.73 \times 10^{-6} \cdot TREES_{400}$	tree cover (m^2) in 400m	-12%
+	$1.1 \times 10^{-4} \cdot X\_DIST$	distance (m), along the E-W axis, from city center	

Rao, M., George, L.A., Rosenstiel, T.N., Shandas, V., Dinno, A., 2014. Assessing the relationship among urban trees, nitrogen dioxide, and respiratory health. Environ. Pollut. 96–104.
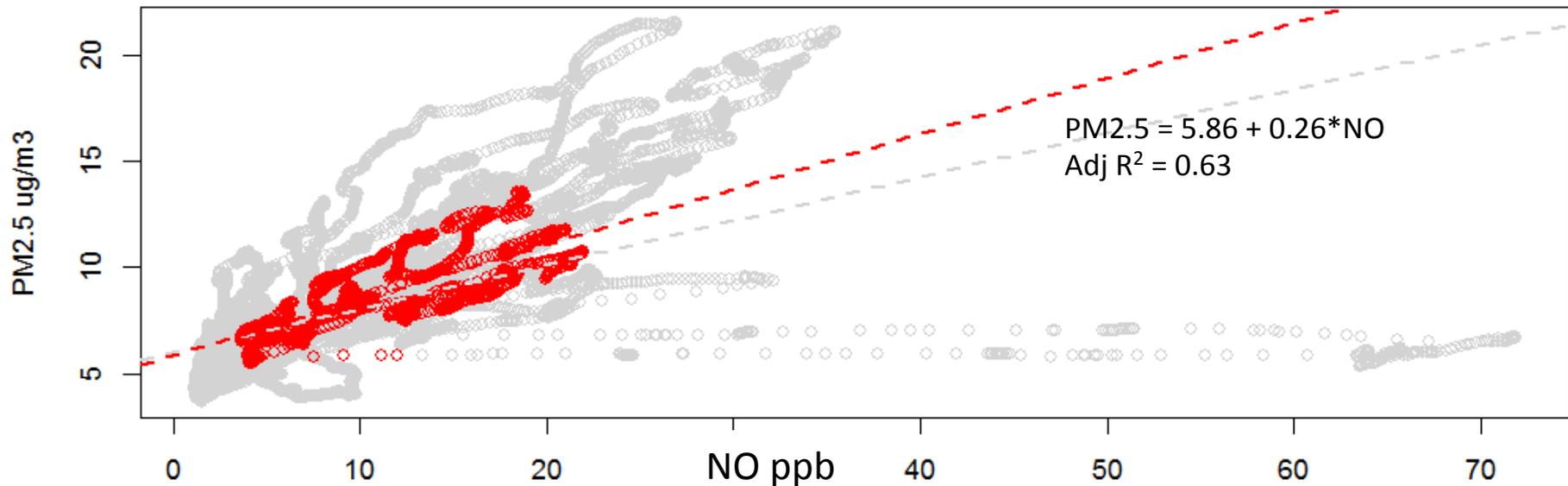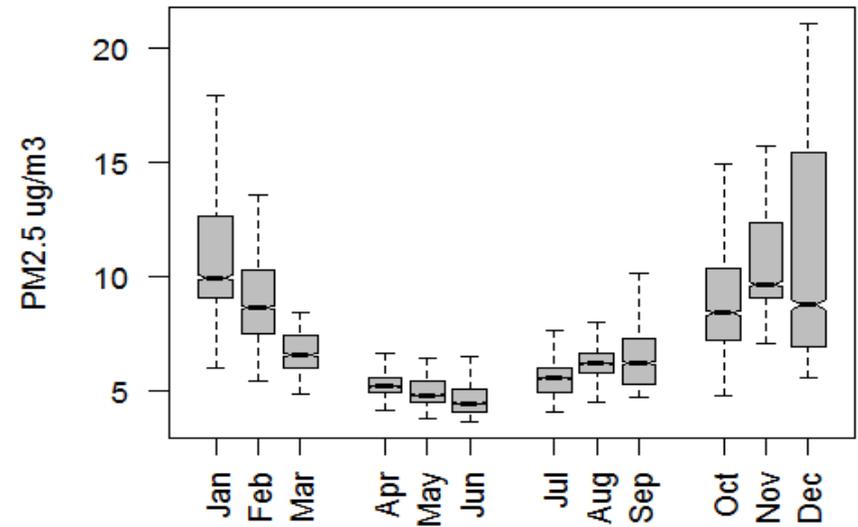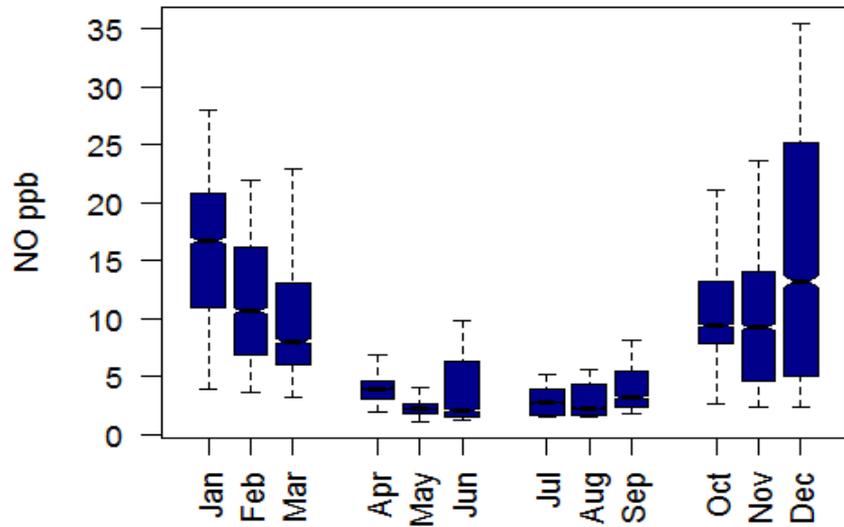
Modeled NO2 decrease due to trees

NO2 decrease by trees
(% of background)

%NO2 decrease due to trees

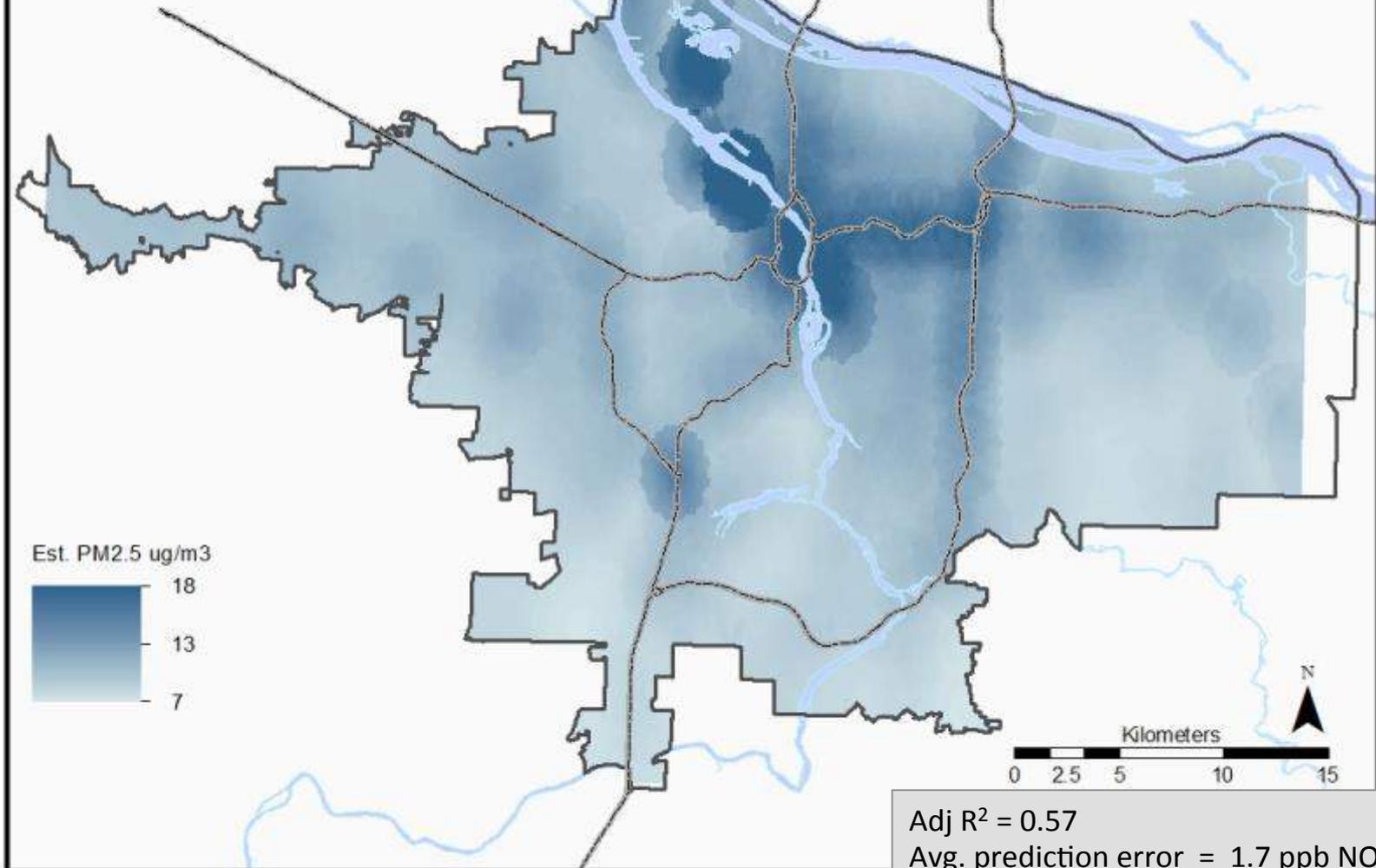- 0.9 - 7.1
- 7.2 - 9.2
- 9.3 - 10.4
- 10.5 - 11.6
- 11.7 - 13
- 13.1 - 14.6
- 14.7 - 16.5
- 16.6 - 18.9
- 19 - 22.5
- 22.6 - 45
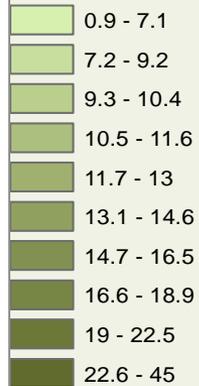
Health Impact	Reduced Incidence due to Trees	Valuation of Benefit (in $1,000,000)
Asthma Exacerbation, Missed school days (4-12 years)	6083	0.52
Asthma Exacerbation, One or More Symptoms (4-12 years)	17663	2.76
Emergency Room Visits, Asthma (all ages)	46	0.01
HA, All Respiratory (65 and older)	49	0.92
HA, Chronic Lung Disease (less Asthma) (65 and older)	24	0.33
Sum Value:		$4.54

Correlation between NO and PM2.5

PM2.5 = 5.86 + 0.26*NO

Adj R² = 0.63

$$PM2.5 = 5.86 + 0.26*NO$$

$$\text{Adj } R^2 = 0.63$$

Two-week moving averages for NO and PM2.5 based on Oregon DEQ air quality monitoring station, 11/2011 – 02/2015

Estimated PM2.5
13 - 27 Feb, 2014

Est. PM2.5 ug/m3
18
13
7

Kilometers
0   2.5   5   10   15

N

Adj R^2 = 0.57
Avg. prediction error = 1.7 ppb NO

$\mathbf{ln(NO)}$ = 1.84 + 4.8x10^{-9}*FWY_AADT$_{550}$ + 6.1x10^{-3}*MAJ_ART$_{50}$ + 2.3x10^{-4}*ARTERIES$_{500}$
+ 2.2x10^{-4}*RAIL$_{300}$ + 3.9x10^{-5}*POP$_{1200}$ + 2.2x10^{-5}*Y_DIST

PM$_{2.5}$ removed by trees was estimated using:

$$M = c*v_d*LA$$

where

    M: mass of PM$_{2.5}$ removed

    c : concentration of PM$_{2.5}$

    v$_d$: deposition velocity (depends on wind
        speed and tree species)

    LA: leaf area

Data sources

  c: PM$_{2.5}$ at 1km grid (1076 points)

 v$_d$: Nowak et al (2013)

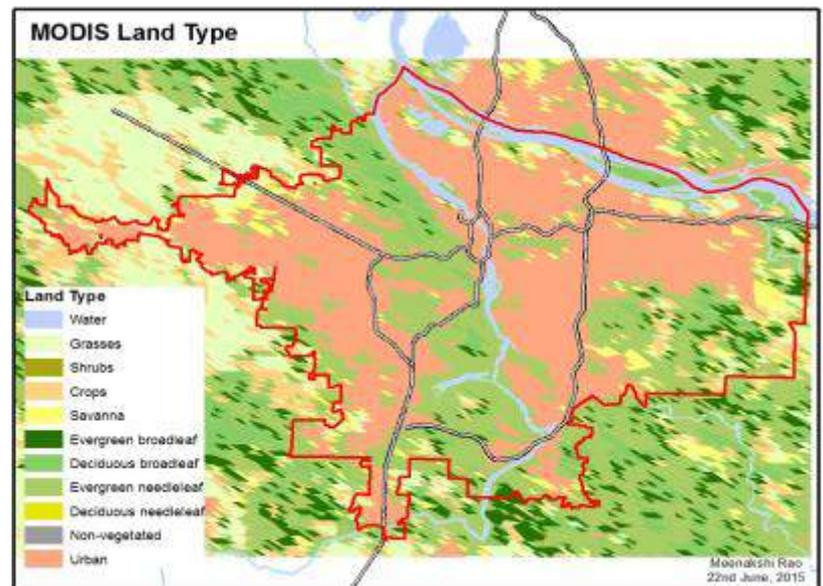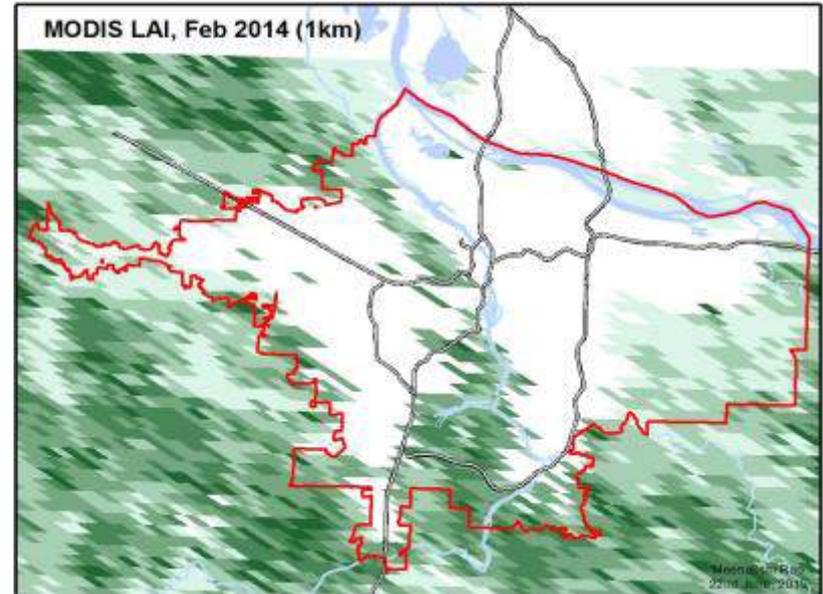 Wind speed: DEQ monitoring station

 Leaf area index (LAI) : MODIS (MCD15A2)
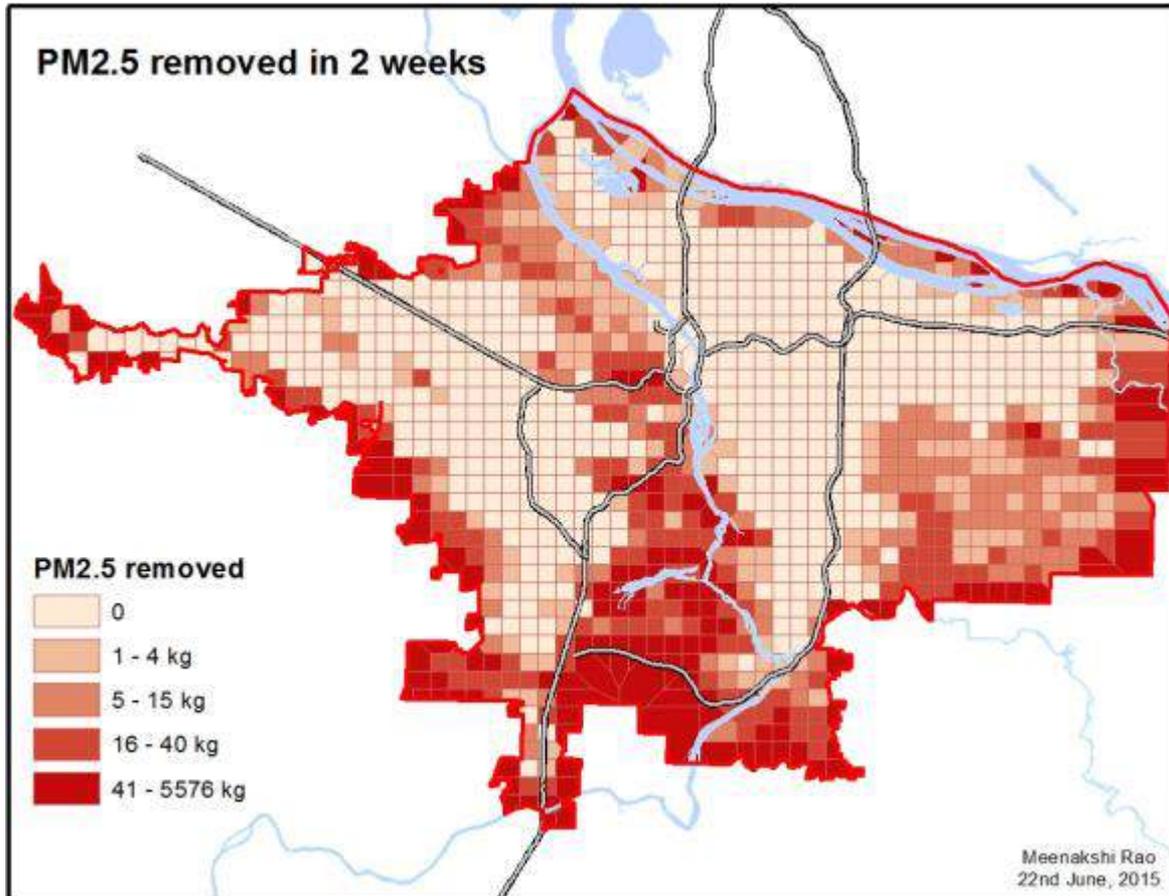
 Tree type: Land cover data, MODIS (MCD12Q1)

Also:

  resuspension: Nowak et al (2013)
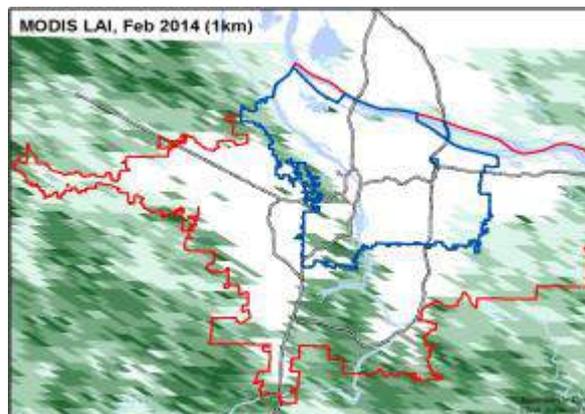
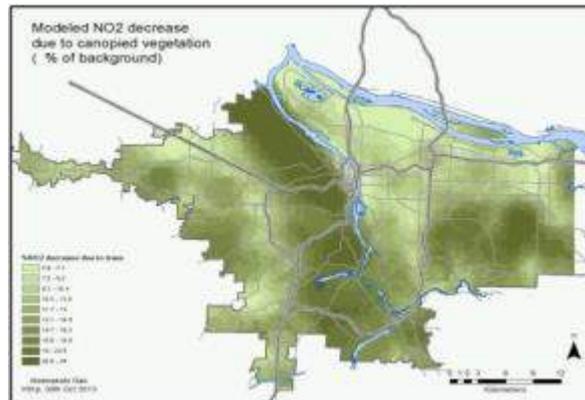 boudary layer height: WRF run

MODIS LAI, Feb 2014 (1km)

MODIS Land Type

Land Type
- Water
- Grasses
- Shrubs
- Crops
- Savanna
- Evergreen broadleaf
- Deciduous broadleaf
- Evergreen needleleaf
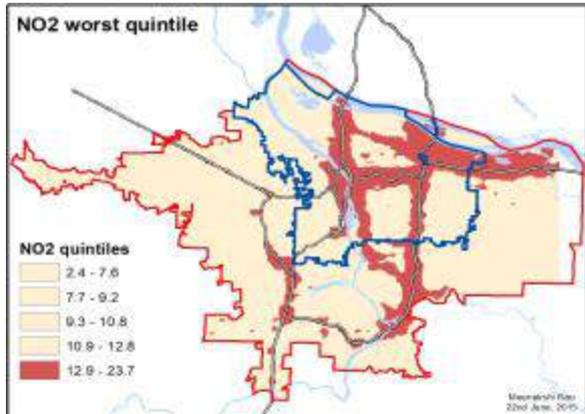- Deciduous needleleaf
- Non-vegetated
- Urban

PM2.5 removal by trees in Portland

- Trees are removing ~43 tons of PM2.5 in two weeks – or ~ 1050 tons/year in the PMA

- This results in ~2% lower PM2.5 concentrations

- This removal prevents ~12 deaths, providing an annualized benefit of ~ $88 million *(based on mortality)*

Trees and air pollution

NO2 worst quintile

NO2 quintiles
- 2.4 - 7.6
- 7.7 - 9.2
- 9.3 - 10.8
- 10.9 - 12.8
- 12.9 - 23.7

Modeled NO2 decrease
due to canopied vegetation
(% of background)

MODIS LAI, Feb 2014 (1km)

Implications:

➢ Trees can mitigate air pollution and provide a measurable health benefit

➢ Trees cannot neutralize air pollution

➢ However: trees can be used more effectively to reduce air pollution
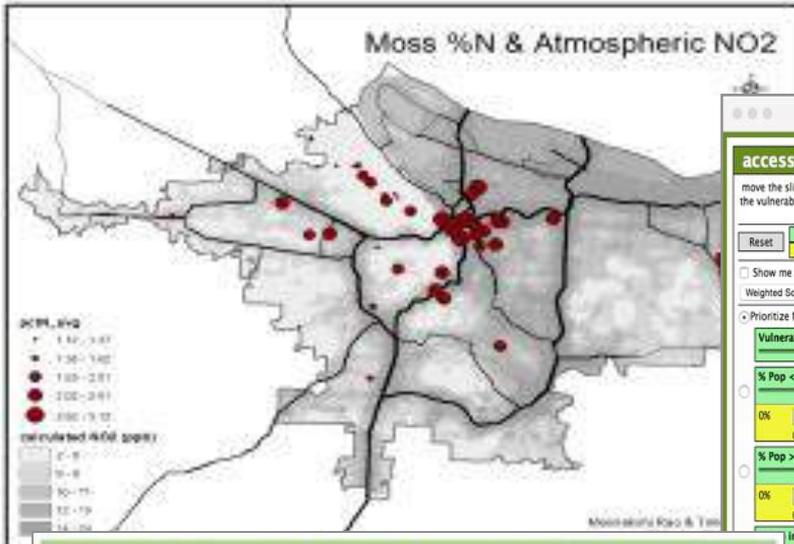
Next :

In collaboration with Rodrigo Gonzalez-Abraham

➢ Use validated 1km WRF/CMAQ model to determine $PM_{2.5}$

➢ Determine the role of trees in $PM_{2.5}$ removal

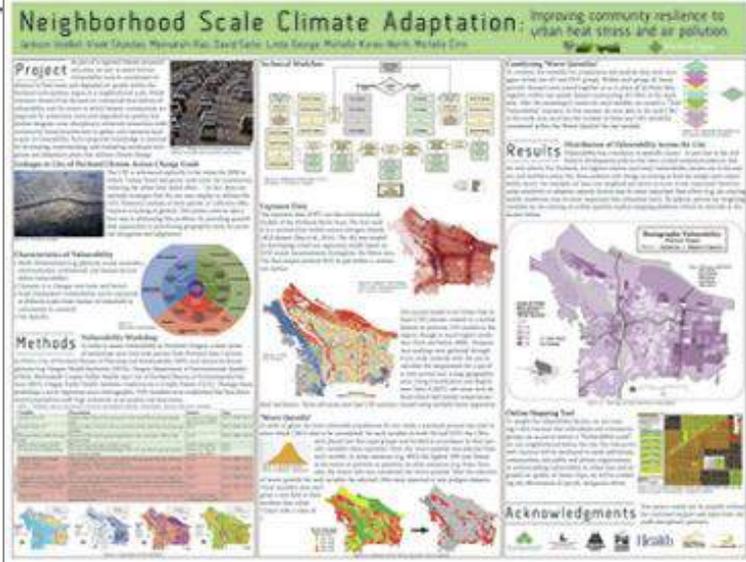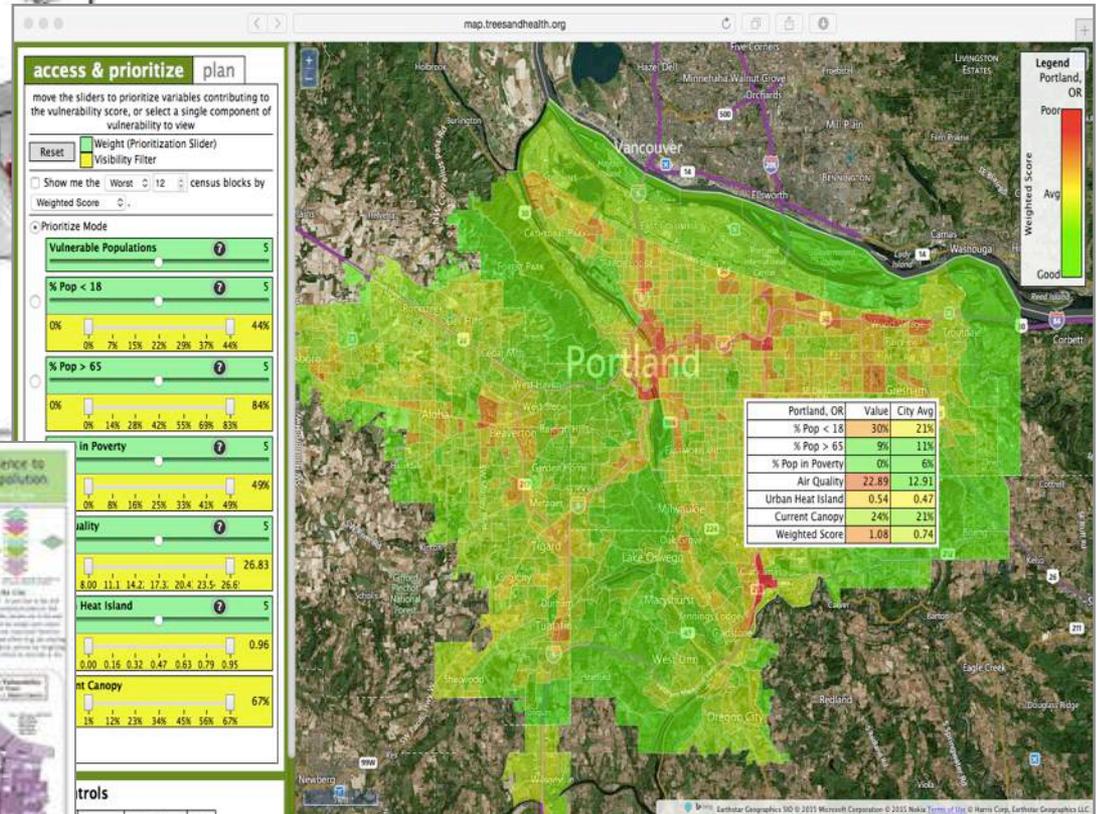➢ Determine the role of Portland's trees in production of ozone and secondary $PM_{2.5}$

Applications

Moss as bio-indicator of air pollution
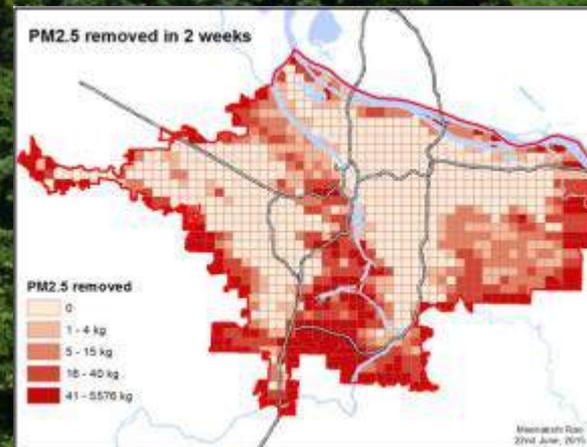*Timea Deakova & Dr. Rosenstiel*

Planting site prioritization tool for urban foresters
Healthy Trees, Healthy People Project

Climate adaptation planning for heat stress
Dr. Shandas, Jackson Voelkel & BPS

Questions?

mrao@pdx.edu

PM2.5 removed in 2 weeks

PM2.5 removed

- ☐ 0
- ☐ 1 - 4 kg
- ☐ 5 - 15 kg
- ☐ 16 - 40 kg
- ☐ 41 - 5576 kg

Acknowledgements

Silas Aho	Desiree Arcenaux	Bennett Battaile
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