Protocol for inventory of Tiny Forests

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Method

Tiny Forests are urban forests with a relatively small area. The area varies, but is usually around 200-250 m^2. Due to the small area and the path that often crosses the Tiny Forest, a transect inventory is the best method to gather the data that is required to determine the standing volume of wood and CO_2-sequestration. In the transect method, two transects are plotted in the Tiny Forest: transect A and transect B. Transect A is plotted along the longest axis possible in the Tiny Forest. Transect B is plotted perpendicular to transect A, crossing transect A at transect A's halfway point. The path in the Tiny Forest must be covered by the transect in a representative manner in terms of area.

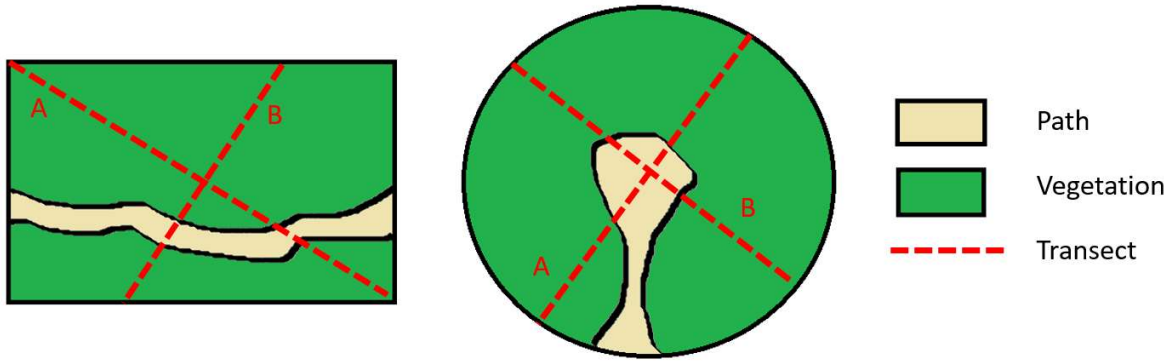

Figure 1 Plotting transects A and B in two different Tiny Forest designs

A transect is one meter wide and is measured in quadrants with a length of one meter, see figure 2. The transect is plotted by means of a measuring tape. The first quadrant is plotted over the first meter of the measuring tape. The area is measured of quadrants that cannot be fully plotted on the transects due to the borders of the Tiny Forest. In each quadrant, the diameter at breast height (1,30 m) and the height of each tree area measured. Trees smaller than 1,30 m are not measured. The species of each tree is noted as well. Of the trees with multiple stems (e.g. willows), the stem with the largest diameter is measured and the number of stems is noted. Trees that are dead or in bad condition receive a different vitality code. There is a field work form for this protocol in the annex.

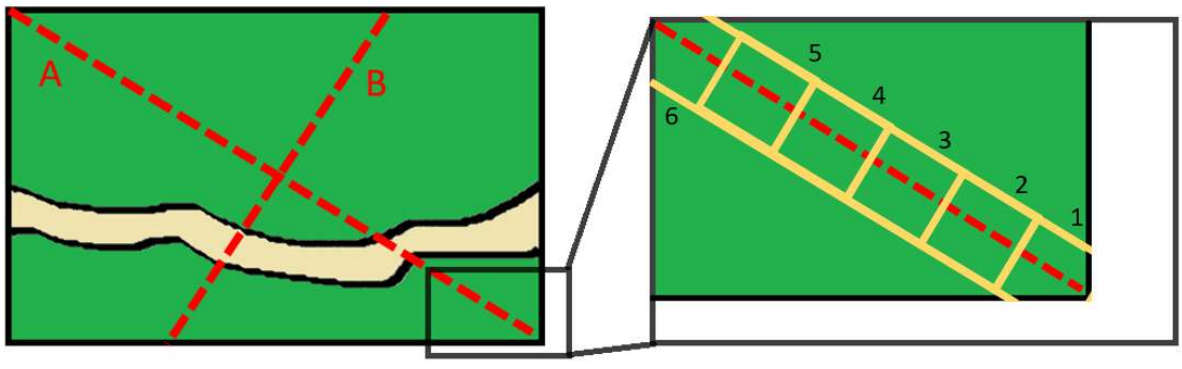

Figure 2 Position of the quadrants over a transect in a Tiny Forest

Materials

Several materials are needed for the measurements. Measuring of tree diameters can be done with a caliper. Tree height can be measured with an extendable rod, or a laser when the trees are taller than 5

meter. The transect is plotted with a measuring tape, that can be secured at a pole of the fence. To determine whether a tree is within a quadrant, it might come in handy to bring a rod of exactly one meter. Also to determine breast height, a rod of 1,30 m can be of use. The field form in the annex can be used for noting down data. The field form can be secured to a clipbord with a protective plastic cover.

Figure 3 Left to right: plotting a transect, tree height measurement and noting down data

Analysis

Based on the diameter of each tree, the area of the transects and the area of the Tiny Forest, the basal area can be determined. The basal area (m^2/ha) is the sum of the areas of the cross-sections of the tree stems at breast height. The basal area can be calculated based on the measured diameters. Furthermore the dominant height (m) is determined by averaging the height of the 10 trees with the largest diameter at breast height within the transects. Using the stand form factor[1] and the area of the Tiny Forest (ha), the standing volume of stemwood[2] can be determined [Jansen et al., 1996]. Due to the diversity of the Tiny Forests, it is not possible to directly extract a stand form factor from Jansen et al. [1996], but an estimation is made based on the most common tree species in the specific Tiny Forest. The formula that can be used for calculating the standing stemwood volume is:

$$Standing\ stemwood\ volume = basal\ area * dom.height * stand\ form\ factor * area\ \ Tiny\ Forest$$

To determine the total mass of aboveground and underground woody biomass, the stemwood volume is multiplied with an expansion factor[3]. For Tiny Forests, the expansion factor of decidious trees can be used (0.908) [Arets et al., 2019].

$$Above\ and\ below\ ground\ woody\ biomass = stem\ wood\ volume * expansion\ factor$$

The total sequestered mass of carbon can then be calculated based on the carbon content of the biomass. Most of the Tiny Forests will primarily consist of deciduous trees, so the average carbon content of deciduous woody biomass can be used (48%) [Arets et al., 2019]. To convert the mass of carbon to CO_2-equivalent (CO_2-eq), the mass is multiplied with the molecular mass of CO_2 divided by the mass of a carbon atom (3,67).

$$Mass\ CO_2 - eq = (biomass * carbon\ content)/(\frac{CO_2}{C})$$

To determine the average yearly CO_2-sequestration in biomass, the sequestered mass of CO_2-eq is divided by the age of the Tiny Forest.

[1] Factor to convert basal area and dominant height to stemwood volume.
[2] This excludes roots and branches.
[3] Factor to convert stemwood volume to above and below ground biomass.

$$average\ yearly\ CO_2 - sequestration = \frac{mass\ CO_2 - eq}{age\ Tiny\ Forest}$$

Reference

Jansen, J.J., Sevenster, J., Faber, P.J. (1996). Opbrengsttabellen voor belangrijke boomsoorten in Nederland. Hinkeloord rapport nr. 17. Landbouwuniversiteit Wageningen, 202p.

Arets, E.J.M.M., J.W.H van der Kolk, G.M. Hengeveld, J.P. Lesschen, H. Kramer, P.J. Kuikman & M.J. Schelhaas (2019). Greenhouse gas reporting of the LULUCF sector in the Netherlands. Methodological background, update 2019. Wettelijke Onderzoekstaken Natuur & Milieu, WOt-technical report 146. 113 p.

FIELD FORM

Tiny Forest: Transect:

Quadrant: Date:

Sample code	TREE					Comments
	Species	Number of stems	Vitality*	Height (m)	DBH (cm)	

* 1=vital, 2= weakened, 3=dead