Creative strategies for using i-Tree Eco data outputs in Switzerland

The vision for i-Tree's evolution is to become a management guidance system by using the collected local tree data and other local environmental data to:

- make recommendations as to the best species and locations to address local environmental issues within the built environment
- facilitate sustainable Urban Forest and traditional forest management strategies that encompass multiple Ecosystem Services deliverables.

Our hope for i-Tree is that Foresters globally – in the Urban Forest or traditional forested lands - will collect local forest data to make better and more informed decisions related to sustaining forest and community health, resulting in a more informed , ecosystem-oriented forest management strategy. Thus. the outcome could be healthier forests and healthier people.

(David Nowak, personal communication to Naomi Zürcher, 19.09.2021)

For the purpose of clarity, the Urban Forest is defined as an ecosystem characterized by the presence of trees and related flora, funga and fauna, the soils and landscapes they populate and the air and water resource they coexist with, all in a dynamic association with people and their human settlements. (Zürcher, N. 2022. Connecting Trees with People: Synergistic Strategies for Growing the Urban Forest. Springer Verlag ISBN 978-3-030-94533-6)

Unlike most other assets, trees generally appreciate in value over time. The understanding that it is the maturing canopy tree that is the beginning of the period of maximum ecosystem services benefits must be incorporated into our management thought process and resulting strategies. Maturing healthy canopy trees provide more carbon storage and sequestration, more air pollution reduction, more building energy savings, enhanced biodiversity, increased water resource management and avoided storm water runoff as well as improved public health and well-being.

So, how can we use i-Tree Eco output data to make more informed and consequential decisions that can facilitate long term adaptive strategies, especially at a time when the impacts of a changing climate are already a part of our daily management challenges.

i-Tree Eco data as an element in attaining the Grünstadt Schweiz / Villeverte Suisse award

The ecosystem services benefits trees are able to deliver are a barometer for their ability to sustain their structure and function within the built environment, especially with the added impact of a changing climate. Given the concern for sustainability and climate change adaptation expressed throughout the overview and Catalogue of Measures presented by Grünstadt Schweiz / Villeverte Suisse, i-Tree Eco data can make a substantial contribution to a municipality's ability to secure and retain the award.

In addition to i-Tree Eco's applicability to the Strategic Management Process (Strategische Führung / Direction stratégique SF1 and 3), as an instrument with which to measure quality and a basis for climate adaptation and (CC!) a communication tool with which to share the resulting data with varied stakeholders, the Measure criteria captured throughout the PPB Planning, Design and Construction section (Planung, Projektierung und Bau / Planification, conception et construction) as well as PU2 and 3 would be greatly enhanced with an i-Tree Eco assessment contribution.

(The authors thank David Risi, Stadtgärtnerei Luzern, for his inputs.)

Following are specific examples illustrating how i-Tree Eco could be incorporated into the Grünstadt Schweiz / Villeverte Suisse certification process and help to establish strategic planning and management initiatives that can GROW a healthy and sustainable Urban Forest.

Incorporating i-Tree Eco outputs into inventory results
i-Tree Eco field measurements can easily be incorporated into Urban Forest / Forest inventory data collection. Inventories, whether complete or based on samples, normally include species, DBH as well as structural elements such as height and crown width as well as condition information. Any additional i-Tree Eco field measurements related to tree crown structure and health could then be added to what is already being collected. Complete ground-based Urban Forest inventories as well as random sample-plot Forest inventories are usually not completed at one time which makes the incorporation of i-Tree Eco field measurements much easier.

What is important is to integrate i-Tree Eco field data into current inventory procedures. Attached is a table which identifies all the elements, including i-Tree Eco, that are essential to urban tree management and should be collected during a ground-based urban tree inventory.

Use of i-Tree Eco data to inform future ecosystem-oriented planting initiatives
i-Tree Eco's Ecosystem Analysis Urban Forest Effects and Values Written Report offers a summary of a project's structure, function and value. Within that assessment report, i-Tree Eco offers a Tree Characteristic analysis. In addition to tree species composition, i-Tree Eco's evaluation of the tree population by diameter class can provide valuable structural information to determine future planting needs and where shortfalls exist within diameter class distribution. Given the understanding that it is the healthy maturing canopy tree that is delivering the maximum ecosystem services benefits, it is essential that managers require an overview of the stocking continuity necessary to maintain those benefits in combination with the management criteria provided by an Urban Forest / Forest Inventory assessment. This overview would provide managers of all forest types from Urban Forest to traditional Forest with essential adaptive management data needed to maintain ecosystem-oriented diameter class distribution.

Regarding VSSG / BSB determined value of trees in relation to i-Tree Eco valuation
The current Swiss standard applied to tree loss due to negligence or planning and construction projects is the calculation of compensation according to VSSG and BSB. This value is currently higher than the equivalent value calculated by i-Tree Eco (column entitled Structural Value) which is based on the CTLA valuation used in the U.S. and accepted by U.S. courts. It is the "Amenity" value, similar to the VSSG and BSB thought process.

To address the need for a more complete assessment of the loss of trees and the true

value of that loss, a more inclusive determination is recommended, as follows:
• retain the VSSG/ BSB method currently accepted by Swiss law – this establishes the "investment" of yesterday – the planting of the tree up to and including the date of loss - today;

• combine the result of this methodology with the i-Tree Eco methodology which quantifies Ecosystem Services, establishing the value of the tree of today and into its contributing future – the tree of tomorrow - with the inclusion of Forecast Tool data.

The total i-Tree Eco supplement could be made at the municipal level (or also at the cantonal level). This supplement calculates the monetary value of the lost ecosystem services of today – what existed at the time of damage or felling - combined with the forecast for future years. This total ecosystem services value would then be added to the VSSG/ BSB compensation calculation.

The resulting value would then provide the total loss of services / benefits for what exists today combined with the tree's remaining productive years. To arrive at the correct additional value, the Structural Value calculation contained in the i-Tree Eco output reports must be removed so that the resulting calculated data contribution is for ecosystem services only.

To fully document and establish the totality of lost services and benefits from a comparative perspective, a new i-Tree Eco project can be created by submitting data for the replacement tree(s) consisting of species plus standard DBH planting size. i-Tree Eco would then calculate all the remaining field data based on its defaults. The Forecast Tool can be used to determine the number of years it would take the replacement(s) to equal the the damaged / felled tree of today and tomorrow. Documentation of the totality of loss when tree removal is caused by spatial development could and should provide an incentive to use an ecological design approach to building within the treed built environment.

Use of i-Tree Eco data to mitigate planned spatial development
Cities across Switzerland contain a very limited amount of precious green space. That existing space is often looked at as either vacant land in its entirety or magically, so that the tree is just standing there without any relation to that essential landscape underground – its root system. This understanding and the need to present the tree in its entirety might help to create categories as a point from which to begin.

In locations where existing trees and the landscapes they populate are threatened by planned spatial development, one can do an i-Tree Eco assessment to show the additional value that those existing trees are delivering and will continue to deliver to the local community. This information combined with documentation of that critical landscape underground could help to mitigate the existing development plan, reducing impact as well as tree loss. This additional data could be added into existing inventories to help monitor Urban Forest health and effects.

One can also be very creative by using the "Stratum" feature to make the resulting outputs more meaningful. For example, although one cannot assess the soil ecosystem using i-Tree Eco, one can create Strata that would distinguish between trees planted into an impervious environment as opposed to trees growing in an open, unsealed landscape.

A further distinction could be the extent of that impervious surface – either outside the Critical Root Zone or inside it. An even further consideration would be to define impervious surface according to an ecological Tree Protection Zone, which acknowledges the need to consider the functional ecological root footprint and uses the following formula from Dr. Kim Coder's extensive research:
• DBH 15cm or less: a minimum of 4.5 meters from the dripline
• DBH >15cm: a minimum of 7.6 meters from the dripline
• DBH >1 meter: may require a minimum that exceeds 9.1 meters

Given the experience with flooding and the likelihood of increased flooding caused by extreme weather events, the i-Tree Eco output data would be exceptionally helpful in providing comparisons in tree growth between same species located within varied sealed or impervious surfaces as compared to unsealed or pervious environments. These data comparisons can form the basis for an enhanced Best Management approach to cost-effective urban water resource management solutions:
• unsealing soil wherever possible
• where it is not possible, explore the full range of paving alternatives – dry-set / porous / pervious / permeable pavers - combined with structural soil substrates
• incorporation of bio-remediation as well as phytoremediation strategies to increase runoff retention capacity.

A reduction of impervious cover would also have the additional benefits of reducing the Urban Heat Island effect as well as the costly conflicts between paving and tree roots while greatly improving growing conditions for trees, further enabling the retention of healthy maturing trees.

Another approach to improve utilization of i-Tree Eco outputs could be to include i-Tree Eco field measurements for newly planted trees to help monitor these trees' ecosystem services deliverable from planting date. If varied techniques are being implemented to improve rooting space, an i-Tree Eco assessment could add to the body of knowledge regarding resulting tree health and survival rates. All the data for these newly planted trees could then be added to existing inventories to help keep them up-to-date.

If a City is doing any demonstrations, such as assessing varied structural soil recipes to determine how structural soil functions and which recipe supports the most stable and productive results, one can expand the evaluation to include the vitality of the trees that are included in those demonstration sites. An i-Tree Eco assessment could benchmark tree structure and function at the inception of the experiment as well as provide additional information as to how trees are responding to the structural soil installations under adjoining paved surfaces.

Use of i-Tree Eco data to enhance traditional forest management
In Switzerland, forest planning is the responsibility of the Cantons. Accordingly, there are many different planning, monitoring and control systems. A widespread approach is the so-called "Weiserflächen" Concept.

"Weiserflächen" are reference-areas, in which the development of the forest is specifically observed as a basis for forest management and as an object of knowledge transfer and learning.

This concept could be further developed: Municipalities could select specific areas (of different green space types) where they look very closely and document the experiences with i-Tree Eco.

• Water retention capacity is an important forest ecosystem service, especially in protection forests. i-Tree Eco quantifies the avoided runoff capacity of trees in m3 of retained water per year. In selected sub-areas - e.g. in Weiserflächen - the services could be quantified, for example before and after intervention or in a comparison of different management regimes.

• For many forest ecosystem services, the leaf surface area plays a decisive role. In order to gain a better understanding of the relationship between development stage and leaf surface, ideal-typical stands could be measured at different stages of development and thus a kind of ecosystem service coefficient could be determined as supplementary information on forest development.

• Forests and wood are currently of great importance for climate policy in connection with their carbon sink performance. In practice areas, such as the inventoried areas of Marteloscopes, the inventory data could be expanded to include an i-Tree Eco assessment. In this way, silvicultural test interventions could be supplemented with i-Tree Eco data as to the effect on the carbon sink performance of the remaining stand.

Use of i-Tree Eco data to communicate with local communities
Managing the Urban Forest cannot be a task that is just relegated to professionals. No government will ever have enough funding or an adequately trained staff to have essential eyes and ears throughout an entire municipality's Urban Forest ecosystem. Since the Urban Forest belongs to all its residents, it is critically important that we share our expertise in an understandable way so that residents and communities who are interested in learning can participate, where appropriate, in the management of the resource.

i-Tree Eco data outputs contain information which, when shared, can provide communities with a much better and more complete understanding of their trees –
• the trees they coexist with,
• the trees that, as they mature, provide a vast array of life's essentials to all the trees' associates including us,
• the realization that we cannot live without healthy mature trees sharing the spaces and places we occupy.

Examples of ways in which to share knowledge and engage with local communities are as follows:
• most villages, towns and cities throughout Switzerland have, within their centers, at least one specimen tree that is 100 years old or more. That tree has a story. It has lived through those years, bearing witness to all that has transpired. That story, combined with data from i-Tree Eco, can provide citizens with a much greater understanding of that tree's importance and thus, the importance of all their trees. This can be accomplished with simple signage or an article in the local paper as well as an "Our Trees" section on the municipality's web page.

• Swiss municipalities are often divided into Quartier. One way of engaging with these local communities is to ask them to select their favorite community tree. Once that tree has been selected, an i-Tree Eco field data collection day can be organized and announced so

interested residents can observe what we are doing and learn why. That data would then be made available to the Quartier with a tree tag for the measured tree.

• to further encourage residents to do their own assessments of trees they care about and are interested in, an announcement regarding the MyTree APP can be made in a local paper as well as the municipality's web page with all the necessary information on how to download onto a smartphone and what to do with the data that has been collected. MyTree is an excellent way of engaging adults as well as youth with their trees and sharing what they have learned with the entire world. More importantly, it facilitates and enhances the tree - people connection which can only contribute to quality-of-life. The anticipated release date for the MyTree APP for Switzerland is end of February 2022.

• as noted in the accompanying Inventory Data to Collect table, citizens can also assist with certain inventory elements including some of the i-Tree Eco field measurements. Swiss municipalities might consider engaging with Pro Natura groups or schools with gardens to encourage this aspect of participatory management. A simple training guideline can be developed and shared with the interested public. We always recommend that citizens are accompanied by an expert for support as well as the collection of inventory elements requiring professional expertise.

i-Tree Eco field data collection to inform and advance education
To expand existing curriculum that explores tree physiology and to integrate the Stadtgärtnerei into the value of the urban tree and treed landscapes, i-Tree Eco can add an understanding of tree structure and function and its contribution to the ecosystem services benefits afforded by healthy trees, essential to urban dwellers.

• i-Tree Eco as well as the MyTree desktop App can be incorporated into existing experiential curriculum for a range of student ages that explores trees, their physiology and the landscapes they populate. MyTree is now available for all locations throughout Switzerland and provides easy access to an individual tree's quantifiable eco-system services benefits. MyTree can be accessed at the following link: https://mytree.itreetools.org/#/

• i-Tree Eco can be used to benchmark trees' ecosystem services benefits for student projects that are recommending improvements to existing treed landscapes. Benchmarking current benefits establishes a baseline from which to compare landscape improvement results.

	A	B	C	D	E
2	**Inventory Data to be Collected**	**Basic Data**	**Additional Essential Data**	**Subsequent Management Data**	**Citizen Participation**
3	**Location**				
4	Physical - the address being surveyed	✔			★
5	GPS coordinates for GIS mapping	✔			★
6	**Spatial Resource: Site Characteristics Condition**				
7	Land use or site class [⌘]	✔			★
8	Planting area type		✔		
9	• tree lawn / grass strip		✔		
10	• curbside cutout		✔		
11	• street mall / median strip		✔		
12	• parking island		✔		
13	• urban park		✔		
14	• open field		✔		
15	• urban woodland		✔		
16	Planting area dimension		✔		★
17	• distance of trunk flare to infrastructure		✔		★
18	Planting area treatment		✔		★
19	• open accessible soil volume		✔		
20	• permeable or impermeable pavement / surface		✔		
21	• ground cover		✔		
22	• open landscape		✔		
23	Paved walkway width and condition		✔		★
24	Amount of street traffic		✔		★
25	Presence of overhead wires		✔		★
26	Presence of underground utilities		✔		
27	Adjacent use				★
28	• buildings including type and size e.g. one-family, multi-residence, business		✔		
29	• parking lot		✔		
30	• public or private greenspace		✔		
31	• vacant land		✔		
32	**Tree Resource: Current**				
33	General Tree Metrics				
34	• Genus and species [⌘] + cultivar or variety, if known	✔			✚
35	• DBH (diameter at breast height, specific or class) [⌘]	✔			★
36	• TFD - trunk flare diameter and shape		✔		★
37	• total tree height [⌘]		✔		★
38	• total live tree height [⌘]		✔		✚
39	• height to crown base [⌘]		✔		★
40	• crown width [⌘]		✔		★
41	• percent crown missing [⌘]		✔		✚
42	• crown light exposure [⌘]		✔		✚
43	• proximity to buildings within 60'/18.3m [⌘]: direction N>S, E>W; distance		✔		★
44	Condition				
45	• incremental annual growth		✔		
46	• percentage of dieback [⌘], foliage transparency, crown density, live crown ratio	✔			
47	• risk assessment and rating	✔			
48	• mechanical injury		✔		
49	• pathogens	✔			
50	• abiotic impacts		✔		
51	• condition notes e.g. specific observations affecting maintenance		✔		
52	Conflicts with Infrastructure				
53	• pavement [⌘]	✔			★
54	• buildings	✔			★
55	• overhead wires [⌘]	✔			★
56	• street / roadway signage	✔			★
57	• street / roadway lighting	✔			★
58	Actions recommended				
59	• maintenance, e.g. pruning	✔			
60	• removal	✔			
61	• risk mitigation	✔			
62	• site mitigation, e.g. increase tree pit size, bevel pavers	✔			
63	**Tree Resource: Subsequent**				
64	New Planting Data				
65	• GPS / GIS coordinates			✔	
66	• Genus, species, cultivar / variety			✔	
67	• Provenance, if known			✔	
68	• date planted			✔	
69	• caliper / height at planting			✔	
70	• production type e.g. field grown, container grown			✔	
71	• package type e.g. B&B, bare root, container specifics			✔	
72	Public Construction Inventory Data (to be submitted at Project's conclusion)				
73	• GPS / GIS coordinates			✔	
74	• Genus, species, cultivar / variety if known			✔	
75	• planned intervention e.g. clearance pruning, root pruning, transplanting, irrigation, removal, including dates of occurrence			✔	
76	• documented - dated construction impacts / mitigation e.g. soil compaction			✔	
264	[⌘] - i-Tree assessment parameter				
265	[★] - unassisted participation				
266	[✚] - assisted participation				
267					
268					