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Jack Kimmel International Grant Application

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Applicant

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Degrees

2003 - BSc in Vegetation Construction and Plant Knowledge (Landscape Engineering). Swedish University of Agriculture Sciences, Alnarp, Sweden.

2006 - MSc in Vegetation Construction and Plant Knowledge. Swedish University of Agriculture Science, Alnarp, Sweden.

2012 - PhD with thesis “Trees for tough urban sites – learning from nature”.

2013-2015 - Post-doc at Cornell University, NY, USA, with the project ‘Planning for a future city “treescape” – adjusting ecological models exclusively for a sustainable tree use in urban environments’

Relevant citations authored

PUBLICATIONS: Henrik Sjöman

Thesis

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Scientific peer-reviewed publications

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Has this investigator previously received funding from the TREE Fund?	No
If yes, was the funding for this project?	
Previous TREE Fund awards	

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Relevant citations authored	PUBLICATIONS: Nina Bassuk Scientific articles (Selected) Sjöman, H., Hirons, A. & Bassuk, N. (2015, accepted) Urban forest resilience through tree selection – Variation in drought tolerance in Acer. Urban Forestry & Urban Greening.

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Has this investigator previously received funding from the TREE Fund?	No
If yes, was the funding for this project?	
Previous TREE Fund awards	

Students/Interns (if applicable)

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Name

Department or major

Status

Student/Intern 2

Name

Department or major

Status

Student/Intern 3

Name

Department or major

Status

Project

Project title	The role of tree species in cooling the urban climate - application in tree planting adn landscape architecture
Research area	Urban forestry
Project summary	The urban tree canopy is generally known to reduce the adverse influence of e.g. the urban heat island effect. Less known is how different species in solitaire plantings (i.e. in residential areas, pocket parks, parking spaces and along streets, etc.) differs with regards to shading and cooling due their architectural make-up. The aim of this project is thus to study how different species of solitaire trees may influence the mean radiant temperature and physiological equivalent temperature in complex urban environments depending summer or wintertime. This will also elucidate any contrasting qualities/benefits in summer vs. winter due to individual characteristics of each tree. Leaf and branch area index of 22 different species and 38 cultivars will be retrieved from solitaire individuals. The different indexes will subsequently be incorporated to the microclimate model ENVI-met, a software program building upon a three-dimensional interface designed to simulate the surface-air interaction in complex urban environments. The results will provide a tangible understanding in how different tree species, with regards to architectural make up, differs in significance to mitigating urban temperatures and thermal stress. The results will be discussed from a practice-orientated perspective in order to delineate the applicability of the results and the methods used. This is of significance to e.g. ‘Million Trees Programs’ initiated in a number of cities across America, and the ‘Green Streets Programs’ in Europe, as it will increase the technical vocabulary much needed in the planning and building process to justify why and where that particular tree is needed.
Statement of problem	Up to date, a general acknowledge exists that the urban tree canopy

will help us to mitigate adverse temperatures in towns and cities thus alleviating e.g. the urban heat island effect. However, in terms of using trees in the urban landscape for the purpose of climate regulation and mitigation, avoiding a generalization between tree species is imperative. This has been the subject of related studies where focus has been directed to how different species will perform in urban situations depending on indigenous background and ecological strategies. However, this project aims to provide a tangible understanding in how different tree species with regards to architectural make up differs in significance to mitigating urban temperatures and subsequent thermal stress on the human body (physiological equivalent temperature) – factors not only affected by incoming solar radiation but also the radiant temperatures from surrounding built up environment. Key to temperature mitigation is that different species may vary in this respect, but that such studies need to incorporate the context of which the tree is planted. By increasing the understanding that trees – just like any other building material – have different architectural properties depending species and season, and that this in turn influence the technical performance and capacity to regulating ecosystem services is important. It is important because depending on species and site based context, both adverse and beneficial effects may occur. It is also important for the tree planning profession and associated professional fields to justify their decision in why that particular species should be planted in a specific location and for which purpose.

Currently the vast majority of climate simulations of trees in the urban landscape rely on a generalization of canopy cover. Leaf area indexes tend to be gathered from stands of several trees or woodland plantings. An appropriate data set of leaf and branch area indexes for solitaire trees – especially winter time indexes – are lacking. This is most valuable for e.g. climate modelling in the urban context. Whilst the architect and building engineer have assembled a robust technical dataset over time and relies on U-factors for windows, R-values for building envelopes, and specifications for ventilation systems etc., the tree planner and landscape architect struggles for an equivalent abstract which will help him or her to justify why “that particular tree” should be incorporated in tandem to built structure. This applies in the early stages of planning as well as throughout the building process. The aim of this project is thus to contribute with a clearer picture of how different species in solitaire planting influence temperature mitigation and how this subsequently relates to the tree planning profession and landscape architecture in the urban matrix.

Significance of your proposed project as it relates to the profession of arboriculture or urban forestry

The reason for focusing on solitaire tree planting is that they make up a distinguished part of both the urban forest and of the urban built up matrix. In the latter respect, solitaire trees will influence both thermal comfort and energy use in buildings. A study of this kind therefore needs to incorporate the context of not only incoming solar radiation but radiant temperatures from the surrounding built up environment. Solitaire trees constitute much of the focus in the ‘Million Trees Programs’ initiated in a number of cities across America, and the ‘Green Streets Programs’ in Europe. Increasing the understanding that trees – just like any other building material – have

different architectural properties depending species and season, and how this influence the technical performance and capacity to regulating ecosystem services is important. It is important because depending on species and site based context (surrounding built up environment), both adverse and beneficial effects may occur. In using the microclimate simulation tool of ENVI-met, a three dimensional model of the tree's characteristics in tandem with surrounding buildings and surface covers will provide not only quantitative results but visually and graphically tangible imagery. This can provide the profession with a blueprint to better justify why and where "that particular tree is needed" and thus help in the haggle with other professional groups and of political incentives throughout the planning and building process. Part of the project is thus to discuss the probability in using ENVI-met and the subsequent results in a practice-orientated.

Description of what is currently known about proposed project area

Recent years have seen a number of research studies on how the urban tree canopy help mitigate the adverse effects of urban runoff (storm water), the urban heat island effect, and high uncomfortable temperatures during hot summer days (Akbari, et al. 2001; Xiao and McPherson, 2002; Gill et al., 2007; Nowak et al. 2012). Trees are as such considered important to reduce the impacts and extent of urban runoff and pluvial flooding, heat exhaustion (illness and mortality) and increased energy use in buildings due to air conditioning (Simpson and McPherson, 1998; Nikoofard et al., 2011; Deak Sjöman and Gill, 2014).

Studies carried out recently with regards to individual trees and possible effects on building energy use include e.g. Nikoofard et al., (2011) and Sawka et al., (2013), and with regards to species and transmissivity of solar radiation see Konarska et al. (2013). The study by Nikoofard et al. (2011) made an average estimate of deciduous and coniferous trees respectively and no distinguish between species were made. A much more comprehensive observation was made by Sawka et al (2013) using the SMUD's estimation tool where 8 different species and consequent age, DBH, height etc. were included. The study by Konarska and colleauges (2013) concentrated on 5 no of species and characteristics for summer as well as winter were studied.

Our project will contribute to this existing knowledge bank by increasing the number of species investigated to 22 species and 38 cultivars. The study will as such include a compilation of leaf and branch area indexes which in turn will be translated into leaf and branch area densities (of ten layers) to capture the three dimensional quality of each tree. A full three dimensional assessment with consideration to surrounding thermal properties of buildings and surface covers, climate variables ranging from cloud cover, air humidity, wind direction and speed, solar angles, etc., will be simulated from early morning hours to late evening. ENVI-met, which is a CFD (Computational Fluid Dynamics) program, is regarded to be one of the most sophisticated microclimate modelling tools when it comes to the interaction of vegetation and urban microclimate (Thorsson, 2007; Bruse, 2009). ENVI-met constitute a more detailed

input data base on vegetation when compared to the microclimate models of e.g. RayMan and SOLWEIG models (Lindberg et al., 2008; Matzarakis and Rutz, 2010). The study of Konarska et al., (2013) was made for the application in SOLWEIG (Konarska, et al., 2013).

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Summary of project goals

1. To compile a full documentation of leaf and branch area indexes of 22 tree species and 38 cultivars (i.e. summer and winter), followed by a conversion to leaf and branch area densities.
2. Study how each tree species correspond to mitigations of mean radiant temperature and subsequent physiological equivalent temperature (indicator of thermal stress to the human body) considering the surrounding context of a complex urban setting.
3. Discuss the results from the perspective of practice orientated applicability – i.e. how the results but also methodology used can be of value to the tree planning profession and landscape architects.

Description of measurable outcomes expected

The project focuses on both quantitative and qualitative approaches – the compilation of leaf and branch area indexes, subsequent leaf and branch area densities, and output data in ENVI-met is numerical. Since the ENVI-met tool is a CFD (Computational Fluid Dynamics) program, the outcome from the microclimate simulation will also be three dimensional and tangible in terms of imagery and visual interpretation of results. Clear and comparative results of how different tree species on solitaire planting affect mean radiant temperatures and physiological equivalent temperatures will be achieved. The following discussion of results with regards to its applicability for landscape professionals will be pragmatically structured due to the experience in the field of tree planning and landscape architecture by the project members.

Project plan including design, hypotheses, methodology and analyses

HYPOTHESES

The hypotheses to verify are:
1) Different tree species in solitaire plantings will affect the mean radiant temperature and physiological equivalent temperature in a complex urban setting, and 2) the use of ENVI-met simulations could be of value in the practice of tree planners and landscape architects.

DESIGN

The design of the research project is empirically orientated and consists of field studies (in retrieving accurate and place specific data) and modelling work in the ENVI-met software program. Due to the unique compilation of solitaire trees in the landscape laboratory of Hørsholm Arboretum, Denmark, the project has over 20 species and 30 cultivars of a consistent age to its disposal. Parts of the project will thus be carried out in Denmark. The compilation of indexes and input in ENVI-met is quantitative albeit a qualitative estimation of density values and architectural characteristics will interlace the study. The design of the project should be pragmatic and quantitative where applicable, but hold a qualitative stance to its subsequent application to professionals within tree planning and landscape architecture.

The research project is based on an international collaboration between the Swedish University of Agricultural Sciences/Gothenburg

Botanic Garden, Sweden (Henrik Sjöman) and Cornell University, USA (Prof. Nina Bassuk). At Cornell University research on urban trees in multifarious situations has been of tradition since the early 1980's. With the long experience of Professor Bassuk in field studies and through his practice in urban forestry, the analysis of the results from this project will be at cutting edge.

METHODOLOGY AND ANALYSES

1) The initial step is to retrieve leaf and branch area indexes of 22 tree species and 38 cultivars at the Hørsholm Arboretum outside Copenhagen, Denmark. All trees are planted 30 years ago and give a consistent data base with regards to age and environmental preconditions. The indexes will be measured using a CID Digital Plant Canopy Imager (CID, 2013). These measurements are carried out in winter and in summer, and captures wide angle canopy images with a subsequent estimate of indexes. We propose to take four digital scans of each tree species at three separate field visits in summer and three separate field visits in winter (within the same week). Scans need to be taken on days with full cloud cover and light conditions need establishing using an exposure meter prior to each scan. Each tree will then be scanned four times (south, west, north, and east) 0.5 meter away from tree trunk and 0.5 meter above ground level. A mean value of leaf and branch area index will thus be drawn from each of the four scans. The digital scans will be analyzed using the image processing tool provided with the Digital Plant Canopy Imager. All collected leaf and branch area index values will also be compared to the plant index compilation of Breuer et al., (2003) as well as to Nowak, (1996) and Nock et al., (2008).

2) Based on field visits and photographs taken of the vertical projection of each tree assessment of the architectural characteristics of each individual will carried out. This in turn constitutes the framework for the leaf and branch density layers which make up the plant input data of ENVI-met.

3) The following step is to implement all density indices to the microclimate model ENVI-met, a software program building upon a three-dimensional interface designed to simulate the vegetation-surface-air interaction in urban environments (Bruse, 2007). The area and climate of interest is the northern hemisphere in a temperate climate, and the urban context in this application will be in the geographical area of south Scandinavia. Each tree species will be placed in a strategic setting compatible to a semi-open urban space with nearby buildings. The same setting will apply to all simulations and each tree species will be consistently alternated whilst the built up environment remains the same.

ENVI-met is regarded to be one of the most sophisticated urban climate models with regards to possibilities to adjust the input data for specific vegetation. It is a tree dimensional model which means that the studied area is built on an interface with three dimensional

elements – in this case buildings and tree. A numerical input data of the buildings' albedo and indoor temperature is given. This will be for 0.3 for roofs and 0.7 for walls, and an indoor temperature of 21°C in summer and in winter. Input data of tree species consists of the leaf and branch density indices (as mentioned), where ten layers of density values make up each tree. In the winter, soil temperature will be set to 0°C in the upper soil layer descending to 6°C at 0.5 meters below surface level. Relative humidity values will be set to 50% and 60% respectively (for summer and winter). The surface cover will indicate to bare soil underneath each tree but constitute of asphalt in remaining surface covers.

Meteorological input data will consist of information on initial temperature and humidity, wind speed, wind direction, cloud cover etc. The initial air temperature will be set to approx. 300 Kelvin (~26°C) and specific humidity in 2500 m [g Water/kg air] 5.00. Wind speed will be set to 4 m/sec. Cloud cover is set to three separate fractions of low, medium and high (1, 2, 2) and indicate to a relatively cloud free day. Shortwave adjustment will have a factor of 0.8.

4) Simulations of each tree species will be carried out from early morning hours (03.00 hrs) to evening (21.00 hrs) – thus covering a simulation of 18hrs. Both winter and summertime simulations will be carried out.

5) The output data consists of numerical and three dimensional (Computational Fluid Dynamics) results where tangible imagery is possible through the additional program of Leonardo. It will be possible to examine a wide range of microclimate data from each simulation but for this study mean radiant temperature (Tmrt) will be of initial focus. Mean radiant temperature constitute a key parameter in calculating physiological equivalent temperatures (PET) together will parameters of air temperature, air humidity, and wind speed. Physiological equivalent temperatures can be described as the actual temperature which the human body physically perceives and for this study the RayMan model developed by Matzarakis and colleagues will be used (Matzarakis et al., 2010).

6) The ENVI-met results will be compiled into a document describing how each tree species will contribute to mitigating mean radiant temperature and influence physiological equivalent temperatures. This document will thus consist of both quantitative and tangible information with illustrative imagery from the simulations. The methodology used and the results will also be discussed with regards to its practice-orientated applicability, i.e. how the results can be of use to the tree planning profession and to landscape architects.

The project should be seen as a pilot study preparing to a longer post-doc stay of principal investigator at Cornell University. The financial aid from the TREE Fund will thus make an important contribution to this international collaboration.

BUDGET

The total budget cost is estimated to 19 492 USD. Total budget covers expenditure in Scandinavia and in the U.S for both applicants (7 485 USD for Principal Investigator and 3 207 USD for Co-principal Investigator). Additional costs include the purchase of a CID Canopy Imager equipment of 6 950 USD. Further costs in need of funding are travels to Hørsholm Arboretum in Denmark (800 USD) and one return flight to the U.S. (1 050 USD). No funding required for the ENVI-met software.

We apply for 10 000 USD in funding aid from the TREE Fund to cover the collaborative partnership between the Swedish University of Agricultural Sciences/Gothenburg Botanic Garden (Principal Investigator) and Cornell University (Co-principal Investigator).

Additional funding is made available from a partnership grant between the Swedish University of Agricultural Sciences and the Swedish Tree Nursery Industry of 9 492 USD.

References

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Bruse, M. (2007). Simulating human thermal comfort and resulting usage patterns of urban open spaces with Multi Agent System. Proceedings of the 24th International Conference on Passive and Low Energy Architecture PLEA, 699-706.

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Description of plan for disseminating the results of this project

The results will be disseminated through a couple of articles, one in a more popular scientific fashion, and in one scientific research paper. The former is to address the profession of tree planners and landscape architects in practice orientated journals (e.g. Arboriculture & Urban Forestry, ISA Today, JoLA), Proposed journals for the latter scientific paper is Urban Forestry and Urban Greening. Important dissemination is to participate and spread the result through conferences and symposium, in Scandinavia and the U.S.

	but also in an internationally wider scope. Example of events includes ISA symposiums, conferences held by e.g. ASLA (American Society of Landscape Architects), and ECLAS (The European Council of Landscape Architecture Schools). An established contact network in Great Britain through the TDAG group (Trees and Design Action Group) will further help disseminate the results to a practice orientated audience with implication to sustainable urban development.
Project start date	03/01/2016
Project completion date	12/01/2017
Geographic range of project	USA & Canada Europe & North Eurasia Asia & Pacific

Budget

Compensation/Stipend

Proposed project budget	0
Requesting from TREE Fund	0
Funding from other sources	0
Value of in-kind support from other sources	0

Employee Benefits

Proposed project budget	10692
Requesting from TREE Fund	5692
Funding from other sources	5000
Value of in-kind support from other sources	0

Travel (> 50 miles)

Proposed project budget	1050
Requesting from TREE Fund	1050
Funding from other sources	0
Value of in-kind support from other sources	0

Local Transportation (< 50 miles)

Proposed project budget	800
Requesting from TREE Fund	800
Funding from other sources	0
Value of in-kind support from other sources	0

Equipment (vehicles, growth chambers, etc.)

Proposed project budget	6950
Requesting from TREE Fund	2458
Funding from other sources	4492
Value of in-kind support from other sources	0

Supplies (paper, ink, toner, etc.)

Proposed project budget	0
Requesting from TREE Fund	0
Funding from other sources	0
Value of in-kind support from other sources	0

Contract Labor (contractor, speaker, etc.)

Proposed project budget	0
Requesting from TREE Fund	0
Funding from other sources	0
Value of in-kind support from other sources	0

Other/Misc.

Proposed project budget	0
Requesting from TREE Fund	0
Funding from other sources	0
Value of in-kind support from other sources	0
Description of other/misc. expenses	None

Total

Proposed project budget	19492
Requesting from TREE Fund	10000
Funding from other sources	9492
Value of in-kind support from other sources	0
Funds already received from other sources	0
Funds pending from other sources	0
Value of in-kind support already received from other sources	0
Value of in-kind support pending from other sources	0

How did you hear about this grant?	TREE Fund website TREE Fund conference booth University/organization financial aid department Word of mouth

Applications will be scored on the following scale:

- Applicant is qualified (0-10)
- Applicant has experience (0-10)
- Project directly meets one or all TREE Fund priorities (0-10)
- Project has clearly stated need (0-10)
- Project is clearly linked to arboriculture and/or urban forestry (0-10)
- Research has practical application (0-10)
- Methods are clear (0-10)
- Objectives are achievable within proposed time frame (0-10)
- Objectives are achievable within proposed budget (0-10)
- Requested funds are matched cash or in-kind (0-10)

Your application will not be available for editing after it has been submitted.
Please review your application for completion before submission.