Institute for Agri-Food Research and Innovation – Studentship Proposal Form

Please complete all sections. Information from this form will be used in the advertising process and on Newcastle and Fera websites to advertise your studentship idea. ALL studentships for IAFRI will be on a three year basis, please contact steven.hall@newcastle.ac.uk in the first instance if your proposal would require longer.

<table>
<thead>
<tr>
<th>Title of Studentship (please keep as concise as possible)</th>
<th>Integrated sensing technologies for rapid tree health assessment.</th>
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<tbody>
<tr>
<td>Value of Studentship (tick those that apply)</td>
<td>• Stipend at UKRC rate ☒</td>
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<td></td>
<td>• Full Payment of fees at Home/EU rate Band 1 or 2  ☒</td>
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<td>• Annual Direct Costs for project ☒</td>
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<td>Desired Start Date (if significantly different from call)</td>
<td>September 2019</td>
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<tr>
<td>Project Title and Summary (max 50 words)</td>
<td>Integrated sensing technologies for rapid tree health assessment.</td>
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<td>(this will be for advertising via postgradstudentship.p.co.uk, Jobs.ac.uk and others)</td>
<td>UK tree health is under pressure from invasive pests/diseases and climate change. Monitoring is required to understand ecological impacts and for public safety. This project will assess ground-based sensor technologies for their unique potential to provide flexible, rapid tree health data in urban areas and near key infrastructure.</td>
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<td>IAFRI Theme (please input the call theme to which this project best aligns)</td>
<td>This project closely aligns with the ‘Environment’ (tree health), theme of the call, although the developed monitoring approaches would have application in agriculture and tree crops (Agriculture).</td>
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<td>Full Project Description (min 1 side A4)</td>
<td>Background</td>
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<td>(please give a more detailed overview of project and provide details of candidate)</td>
<td>UK tree health is under pressure from invasive pests and diseases, climate change, land use change and pollution. The collection of data to provide evidence for tree health policy and management is one of the core requirements identified in both the UK Biosecurity Strategy [1] and the Defra’s Tree Health Resilience Strategy [2], which contributes to the 25 Year Environment Plan.</td>
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While the environmental and ecological aspects of tree health are becoming increasingly important, current tree health monitoring is driven by the requirement for stakeholders (including central government, local authorities, infrastructure organisations such as Network Rail, the Highways Agency and electricity companies, and large land owners such as the National Trust) to ensure that the trees that they are responsible for managing do not pose a safety hazard for the public. The majority of this work is done using a system of visual inspections. However, this means that only a small proportion of the trees that these organisations are responsible for can be assessed each year. The introduction of new tree diseases can often result in a large number of trees needing to be assessed rapidly, such as occurred with Chalara Ash Dieback, causing significant resource and funding challenges to the responsible organisations.

Remote sensing, from aircraft or satellites, is able to cover much larger areas but high-resolution imagery is expensive to obtain, and imagery may be obscured by cloud. In addition, there are many locations where flights by aircraft or drones are restricted, including urban population centres, major roads and rail lines, and around airports and airfields. An alternative for these areas would be to use ground-based sensors mounted on road vehicles or trains.

A variety of sensors have both the potential to detect signs of stress and disease in trees and to be deployed on ground-based mobile platforms. Thermal and multispectral or hyperspectral imaging cameras can allow detection of changes in plant biochemistry (e.g. water content [3] (Figure 1), or pigments [4]) related to disease or environmental stress, whilst photogrammetry methods using standard RGB cameras and mobile laser scanning systems can provide structural information that can be indicative of tree health (e.g. leaf area index, canopy volume [5]) or, potentially, of tree safety issues (e.g. trunk and branching angles). However, the accuracy, diagnostic capability, utility in operational scenarios and cost of such sensors varies significantly.
Aims and hypotheses
The project would investigate which ground-based sensor technologies would be suitable for monitoring and assessing tree health, identifying which of those technologies could be applied to support the organisations who are required to monitor and manage trees, and undertaking fieldwork on test case sites to assess the performance and develop the practical application of the technologies and processing methodologies. This will directly address Fera’s science strategy aims to deliver innovations in environmental monitoring including remote sensing, deliver risk management and decision support systems, and sustain capabilities to ensure UK biosecurity.

The hypotheses to be tested are:
1. That ground-based sensors will allow rapid assessment of tree health through providing information on tree canopy structure and/or spectral characteristics of the canopy.
2. That ground-based sensors are able to accurately replicate the results from established visual assessment methodologies.
3. That a system combining existing ground-based sensors with automated workflows could be developed as a proof-of-concept for automated mobile tree health mapping.

Methodology
The project will be split into the following phases:
1. Literature review of the state-of-the-art in ground-based remote sensing technologies, sensor technologies for tree health monitoring and associated geospatial data processing technologies
2. Identification of available technologies that address user needs for tree health assessment, including training on, and optimising the use of, the technologies identified with the highest potential. The cost-effectiveness of a sensor-based assessment approach, relative to visual inspection, will also be considered.
3. Field proof-of-concept tests of the technologies and comparison of results with visual inspection methods, with a focus on assessments for ash dieback and secondarily for oak health.

Figure 1: a) thermal imaging and b) terrestrial laser scanner data of drought-stressed trees.
4. Develop automated processing workflows to provide tree health information in a form useful to end-user stakeholders.

The first year of the studentship will focus on project proposal development, training and scoping of suitable technologies for testing, and the student will be based at Newcastle University with short periods spent at Fera. Identified technologies, which may include thermal cameras, multispectral imaging, photogrammetry and mobile laser scanning, will be fully calibrated, undergo preliminary testing in controlled conditions (e.g. to identify optimal indicators of stress / disease) and options for mobile deployment will be explored. The second half of the studentship will involve field campaigns to test the technologies abilities to assess tree health in comparison to existing visual inspection methods, as well as the development of automated processing workflows, based on machine learning methods and image processing. It is expected that the initial testing and development will be done at sites within the North-East (with support from Fera), while later, more extensive fieldwork will be done in Norfolk (in collaboration with Norfolk County Council).

The student will be expected to present (poster or oral) at two national conferences and at 1 international conference during the course of the studentship, as well as to prepare peer-reviewed publications in leading international journals. They would also be expected to present at School postgraduate seminars and the IAFRI science conference.

Training

The student would be based at Newcastle University, in the Geomatics research group within the School of Engineering, giving access to a range of ground-based sensing systems, including digital cameras, multispectral cameras, hyperspectral sensors and terrestrial laser scanning systems and expertise in remote sensing, mobile mapping and spatial data processing. The student would receive training in the operation of these systems, through in-house training, with attendance on external training courses, workshops or summer schools run by outside organisations, such as the distributors or developers of the technologies, as available. Skills will be developed in a variety of software packages (image processing and statistical) and data processing methods (e.g. Python programming) that allow the data collected by the sensors to be processed and analysed. The student would also be given opportunity to work with the GIS and Remote Sensing group at Fera, who have a number of projects related to spatial analysis and remote sensing of tree health and to visit collaborators at RAL Space working on hyperspectral systems for tree health monitoring. The student will meet regularly with all co-supervisors (Rachel Gaulton, Ankush Prashar, Andrew Crowe and Paul...
Brown), with the full team meeting in person at least 3 times per year and more regularly via video conferencing. The student will also be supported to develop a range of transferable skills, via participation in Faculty Postgraduate Researcher Development Programme and identification of additional training opportunities where required, including in effective communication and stakeholder engagement to facilitate effective working with stakeholders across a range of organisations. The student will engage with seminar programmes and postgraduate activities in both Geomatics and Agriculture research groups.

The project is supported by Norfolk County Council (NCC) who are willing to share data with the student on the assessments that they are making to support their responsibilities in managing trees in Norfolk. This includes a unique dataset that NCC have been collecting on the health of 225 stands of ash trees since 2016. NCC will provide feedback to the student to help target which technologies to focus on to meet stakeholder requirements. The student may also liaise with the tree officers at NCC to coordinate their fieldwork with ongoing assessments, allowing for a direct comparison between the existing visual inspection methodology and the outputs from the new technology.

References


https://doi.org/10.1371/journal.pone.0196004

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<th>Potential for Matched Funding (please give details of any potential ‘matched funding’ that may be available for this project)</th>
<th>No direct funding, but Norfolk County Council will provide logistical support for fieldwork and access to existing data sets with an in-kind value of approx. £20k.</th>
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| Costings  Please estimate annual costs for consumables etc. associated with this project | Laboratory / field trials costs and consumables for initial testing £3000  
Fieldwork / stakeholder collaboration travel and accommodation £5000  
High performance computer and external data storage £1000  
Sensor maintenance / calibration, costs of modifications for vehicle deployment £5000  
Attendance at 2 x national and 1 x international conference £2000  
Attendance on 2 summer schools (e.g. EARSeL / ISPRS summer school) / external training workshops £2000  
Travel to Fera for joint supervisory meetings £600  
Visits (x2) to RAL Space £1000  
Total funds requested: £19 600 (approx. £6500 per annum) |
| Name of Supervisors and Institution (min. 2 - supervision must be joint between Newcastle and Fera, Jointly Appointed academics will be classed as Fera) | Newcastle:  
Rachel Gaulton (School of Engineering (Geomatics) - remote sensing);  
Ankush Prashar (School of Natural and Environmental Science - agriculture, plant stress trait phenotyping).  
Fera:  
Andrew Crowe and Paul Brown (GIS/remote sensing) |
| To be Completed if Primary location of Student is at | Student will be based at Newcastle University in School of Engineering (Geomatics). |
**Fera Science Ltd:**

Please give details of facilities, resources and processes that are in place so that support is available to the student whilst located at Fera. These include:

- **i.** 10 meeting per year with academic supervisor
- **ii.** 3 meeting per year with full supervisor team
- **iii.** Systems in place for student to access NCL facilities E.G. Library
- **iv.** Plans for continued supervision if one or more current supervisors leaves their employment
- **v.** Plans for the student to engage in Newcastle activities that facilitate progression E.G. Postgraduate Conference

If possible provide a draft plan when these activities would take place.

Also include details of any risk assessment that have/will take place at Fera covering the PhD.

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**Person Specification**

(please specify qualifications and skills required for this studentship E.g.)

- **Discipline area**
- **English Language requirements**
- **Additional skills**

This project is likely to suit a student with a minimum of a first class or 2.1 BSc degree or equivalent and a background in remote sensing, geomatics, plant or pathogen biology, forestry or related subjects. Applicants may also hold, or be completing, a Masters degree in a related subject area. Candidates with a background in engineering, physical sciences or computer science and an interest in applying these skills to ecological challenges are also encouraged to apply. Applicants must be willing and able to carry out UK-based fieldwork. A full driving license is essential. Scientific programming (e.g. R / Python), image processing and ecological survey skills will also be viewed as advantageous.

All applicants must meet standard Newcastle University entry requirements for English language. See:

[https://www.ncl.ac.uk/international/language/#overview](https://www.ncl.ac.uk/international/language/#overview)
### Eligibility Criteria
- (Please state if you wish applications from outside UK/EU or any other eligibility criteria)

Candidates outside of the UK/EU are welcome to apply. However, evidence of ability to pay additional tuition (above home/EU levels) and visa fees for non-UK/EU students is required. Details of fee levels can be found at: [https://www.ncl.ac.uk/tuition-fees/costs/](https://www.ncl.ac.uk/tuition-fees/costs/)

### Further Information
(please list further sources of information relevant to the candidate, contact details or other potential advertising streams)

For further information regarding the studentship or project, please contact:

Dr Rachel Gaulton,
School of Engineering, Cassie Building, Newcastle University.
Tel: +44 (0) 191 208 6577
Email: rachel.gaulton@ncl.ac.uk

Dr Andrew Crowe
Fera Science Ltd.
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Email: andrew.crowe@fera.co.uk

Please see the [appendix](#) and select the relevant KEYWORDS for advertising

Upon completion please e-mail this form to steven.hall@newcastle.ac.uk or send printed copy to:

Steven Hall
Institute of Agri-Food Research and Innovation
2nd Floor Agriculture Building
Newcastle University
Newcastle upon Tyne
NE1 7RU