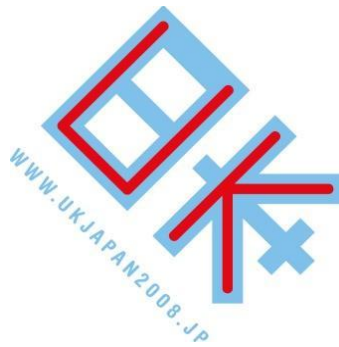


# **UK-JAPAN 2008 COLLABORATIVE PROJECT GRANT**

**Science and Innovation**

## **Installing a Phenological Camera**

### **Final Report**



**Project leader (UK): Dr John Grace, Professor**

**School of GeoSciences, The University of Edinburgh,  
Edinburgh, United Kingdom**

**Project partner (Japan): Dr Kenlo Nasahara, Associate Professor**

**Institute of Agricultural and Forest Engineering,  
University of Tsukuba, Tsukuba, Japan**

## **1. Introduction**

Surprisingly little is known about how the timing of spring leaf onset (known as ‘bud-break’) and autumn leaf senescence affect the balance between photosynthesis and respiration of forest ecosystems. This balance is crucial to understand how the biosphere is responding to, and is helping to ameliorate, the effects of global change. Eddy covariance sites are experimental sites, which aim to monitor surface-atmosphere exchanges of CO<sub>2</sub>, water and energy. The worldwide network of eddy covariance sites (FLUXNET) is monitoring the fluxes associated with the regional networks such as CarboEurope-IP, AmeriFlux and AsiaFlux. Phenology Eyes Network or PEN is the network of long-term ground observatories mostly located in AsiaFlux sites in Japan ([http://www.pheno-eye.org/index\\_e.html](http://www.pheno-eye.org/index_e.html), started in 2003). It aims for the continuous monitoring of terrestrial ecosystem for satellite validation using optical instruments on ground.

Mounting networked digital cameras is a simple method to observe the timing of canopy growth and senescence. The latest studies in webcam-based phenological monitoring (e.g. Richardson et al. 2007) indicated that webcams offer an inexpensive means to quantify the phenological changes. Although a recent FLUXNET survey has uncovered at least 26 cameras already ‘keeping on eye’ on canopies including the continent Europe (Wingate et al. 2008), no camera had been installed in such sites in UK prior to 2009. With the collaboration between the University of Tsukuba, the University of Edinburgh and the Forest Research, the installation of a digital camera system has now been carried out to monitor the deciduous broadleaf forest in Alice Holt, Surrey. This became the first canopy observation by a digital camera in a flux site in UK.

## **2. Activities**

With the Japanese partner’s help, a phenological camera was successfully installed in spring 2009 and the seasonal change of forests has been monitored for over a year. The project members in UK visited to Japan in autumn 2009 and Japanese partner visited to UK in 2010 to share the knowledge and methodology in the research field and present the current results.

### **2.1 Camera installation and monitoring**

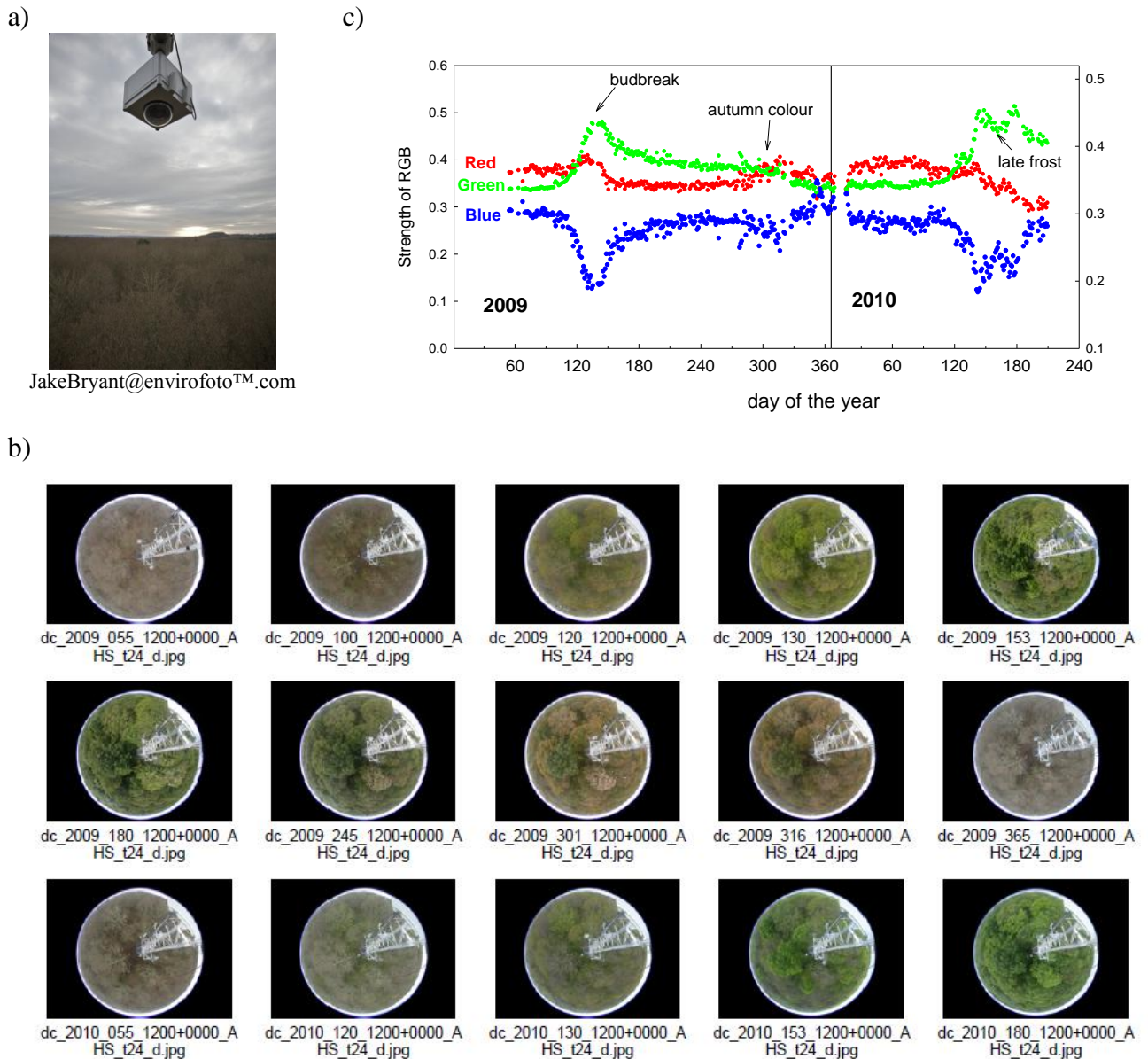
The automatic digital fish-eye camera system (ADFC) is the system to observe phenology and sky-condition developed by the Phenology Eyes Network (PEN). An ADFC system was loaned by the Japanese partner and installed on 24<sup>th</sup> February 2009 on a CO<sub>2</sub> flux

measurement tower in Alice Holt, Surrey (51° 10' N, 0° 51' W) with the assistance of staff in the Forest Research Alice Holt Research Station (Fig. 1a). At first, the system was unstable after the installation because of unforeseen technical difficulties. However, thanks for Japanese partner's advice the problem was resolved by the middle of March and the camera system became stable. The camera has captured the seasonal change of the deciduous forest dominated by pedunculate oak *Quercus robur* and some ash *Fraxinus excelsior* (Fig. 2b). The images have been uploaded on the website of our Japanese partner, Phenological Eyes Network (PEN, <http://pen.agbi.tsukuba.ac.jp>) to open the public.

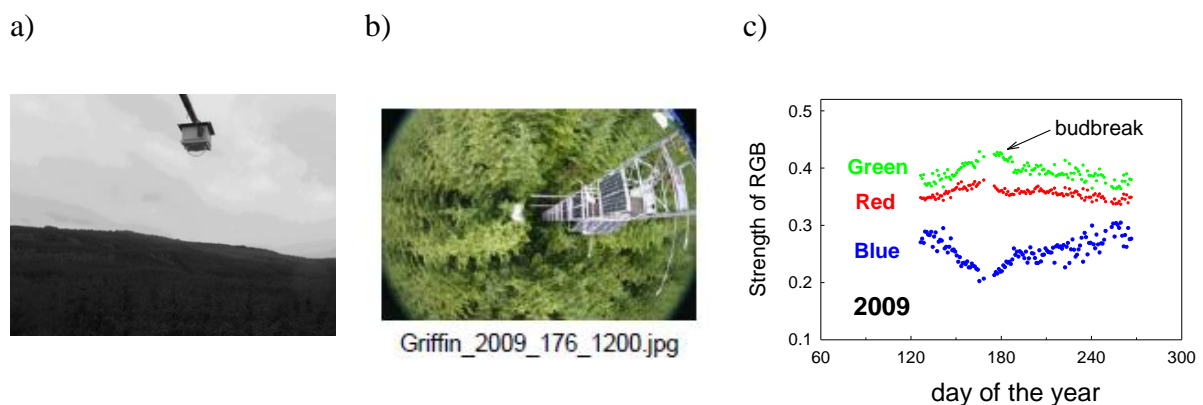
In spring, the appearance of new oak leaves was observed on the taken images on a daily basis followed by the budbreak of ash trees. Mildew disease on the oak trees was seen in summer and the progress of autumn colouring was monitored. Digital cameras store images using digital numbers in three colour signals, red, green and blue (RGB). We screened the images captured between 12 noon and 2pm to minimise the influence of the sunlight and analysed the strength of each colour. In 2009 the green signal dramatically increased in the spring onset season, while the red signal increased in the autumn colouring season (Fig. 2c). In spring 2010, the decline due to the damage of the late frost was seen. The results proved that the observation using a phenological camera is useful for the quantitative analysis as well as the qualitative monitoring.

In the spring 2009, Forest Research also installed a CCTV-type camera system on the same tower. Together with the research group in Forest Research, we did the same analysis to compare the images taken by the two cameras. Although the trends of seasonal transition in colour were similar, the values of RGB signals were different. In order to investigate the sensitivity of cameras to colour signals, we are going to conduct camera experiments using colour charts purchased with the remaining amount.

Meanwhile, we installed a similar system at Griffin, Aberfeldy Scotland, another CarboEurope IP flux site, managed by the University of Edinburgh (56° 36' N, 3° 47' W). This one is a coniferous forest. Two digital cameras failed during the test. We developed an alternative camera system which became operational on the 24m tower in the Sitka spruce plantation forest on 7<sup>th</sup> May 2009 (Fig. 2a). The camera clearly captured the budbreak of new shoots in the summer (Fig. 2b). This also detected by the increase of green signal (Fig. 2c). Unfortunately, a problem of power generator occurred in October has suspended the camera work. Electricity will soon be installed in the site, which will provide stable power supply. We hope the camera system re-start shortly.



**Fig. 1** The camera installed in Alice Holt, Surrey (a), the canopy phenology observed on images (b), and the results for the strength of extracted colour signals (red, green and blue) from the digital images (c). In 2010, the budbreak started later than the previous year and the effects of late frost were observed.



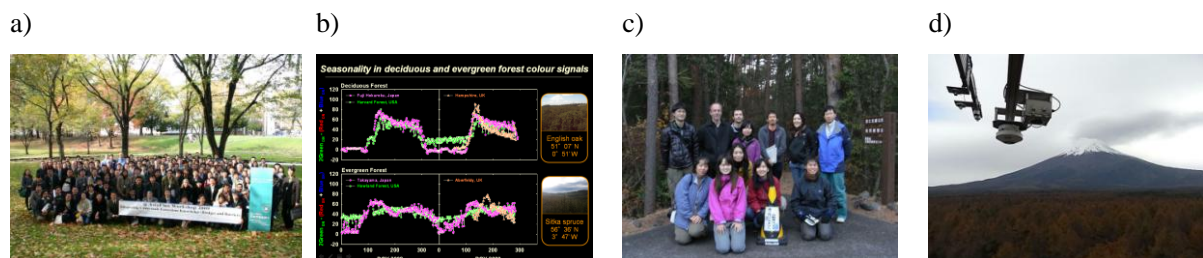
**Fig. 2** The camera installed in Griffin, Perthshire (a), the canopy image of Sitka spruce (b) and the strength of colour signals (c). Unfortunately, the observation has stopped due to power failure since October 2009.

## 2.2 Visit of British Partner to Japan (October 2009)

In October 2009, three project members in Britain went to Japan to attend an international conference in Sapporo and visit three observation sites.

FLUXNET is a global network of micrometeorological tower sites that use eddy covariance methods to measure the exchanges of carbon dioxide and the AsiaFlux network covers the South East Asia region. In the end of October, the 8<sup>th</sup> AsiaFlux workshop was held in Sapporo, Japan (<http://www.japanflux.org/asiafluxws2009/>, Fig. 3a). More than 180 scientists and students from 16 countries took part in the workshop entitled ‘Integrating Cross-scale Ecosystem Knowledge: Bridge and Barriers’. Dr Lisa Wingate had invited for an oral presentation and introduced our results of monitoring in Alice Holt and Griffin comparing with other sites (Fig. 3b). The PhD student, Toshie Mizunuma presented a poster about the colour analysis using a year-through images of a Japanese beech tree in Mt Tsukuba provided by the Japanese partner. Professor John Grace and Dr Kenlo Nasahara were also invited for the workshop as the key note speakers. This provided a great opportunity for the project members in both UK and Japan to meet face to face and discuss the further activities.

Wingate and Mizunuma also had two day fieldtrip to visit three PEN sites in Japan: Kiryu Experimental Watershed (KEW) site managed by Kyoto University, Fuji-Hokuroku (FHK) managed by National Institute for Environmental Studies (NIES) and National Institute of Advanced Industrial Science and Technology (AIST), and Fuji-Yoshida (FJY) flux sites Forestry and Forest Products Research Institute (FFPRI). The knowledge and experience about the camera systems in the three sites were discussed.



**Fig. 3** The photo in the 8<sup>th</sup> AsiaFlux Workshop in Sapporo (a) and a slide presented by Dr Wingate (b). Fieldtrip to two PEN sites in Fujiyoshida (c) and camera system on an observation tower in Fuji-Hokuroku site (d).

## 2.3 Visit of Japanese Partner to UK (April 2010, June 2010)

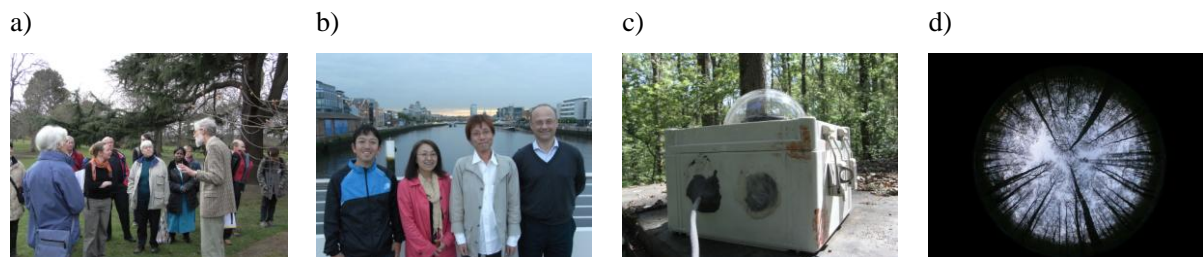
On behalf of Japanese partner, Dr Shin Nagai of Japan Agency for Marine-Earth Science and Technology (JAMSTEC) who is one of core members of PEN, visited UK in April 2010

and June 2010 to attend conferences and help to install another camera system.

The Botanical Society of Scotland held International conference on Phenology: Plant ecology and diversity on 7<sup>th</sup> – 9<sup>th</sup> April in Edinburgh (<http://www.botanical-society-scotland.org.uk/content/phenology-conference-2010>). Prominent academics in plant phenology from Europe and Australia were invited as key-note speakers. We had an opportunity to demonstrate our collaborative project. Nagai presented the activity of PEN and the recent achievements and Mizunuma introduced our installation project with the preliminary results. This has developed a new collaboration with a research group led by Professor Annette Menzel of Technical University of Munich, Germany.

The second visit co-incided with an international conference on 14<sup>th</sup> – 17<sup>th</sup> June in Dublin organised by Trinity College Dublin (<http://www.tcd.ie/Botany/phenology/2010/>). From 24 countries from Europe, North America, South America, Australia and Japan, 125 attendees gathered the conference titled ‘Phenology 2010 - Climate change impacts and adaptation’. Again, we presented the achievements of our collaborative project in front of the global phenological scientists. At the satellite workshop for land product validation subgroup coordinated by National Aeronautics and Space Administration (NASA), Nagai’s talk about the recent results using PEN’s ground observation data attracted the audience to lead the new collaboration between Europe, USA and Japan toward a new phenology product.

The two visits provided excellent opportunities for the project members of PEN, Forest Research and University of Edinburgh to discuss the future research. Nagai visited the Alice Holt Research Forest twice to help the installation of another camera system. The second fish-eye camera in Alice Holt was mounted upward on a caravan next to the flux tower (Fig.4c, d). The upward camera allows us to estimate leaf area index (LAI) which represents the vegetation growth. In addition to the colour signals from the downward camera, the index will tell us more about the phenology of forest canopy.



**Fig. 4** The photo at the Phenology Conference in Edinburgh (a) and Phenology 2010 in Dublin (b). A new camera system installed on a roof of caravan in Alice Holt Research Forest (c) and an image taken by the camera (d).

### 3. Financial details

The following is the expenditure covered by the Grant.

<b>Expenditure</b>	<b>Item</b>	<b>Amount</b>
1. Fieldwork at Alice Holt, Surrey, UK		<b>¥ 77,957</b>
• Installation of a phenology camera system	Transportation	¥ 56,914
• Monitoring images	Accommodation	¥ 21,043
2. Fieldwork at Griffin, Aberfeldy, UK		<b>¥ 141,140</b>
• Installation of a phenology camera system	Transportation (*)	N/A
• Monitoring images	Repair of equipment	¥ 141,140
	(*) Covered by another budget.	
3. Visit of UK Partner to Japan (October 2009)		<b>¥ 399,172</b>
• Asiaflux workshop at Sapporo	Transportation	¥ 276,489
• Project meeting	Accommodation	¥ 102,530
• Field tour to PEN sites	Conference	¥ 20,153
4. Visit of Japanese Partner to UK (April 2010)		<b>¥ 343,401</b>
• Phenology conference at Edinburgh	Transportation	¥ 151,302
• Project meeting	Accommodation	¥ 85,237
• Installation of a camera system in Alice Holt	Conference	¥ 69,432
	Communication	¥ 1,841
	Install equipment	¥ 35,589
5. Visit of Japanese Partner to UK (June 2010)		<b>¥ 485,402</b>
• Phenology 2010 in Trinity College Dublin	Transportation	¥ 277,977
• Project meeting	Accommodation	¥ 132,104
• Maintenance of camera system in Alice Holt	Conference	¥ 75,322
6. Misc		<b>¥ 54,067</b>
• Testing colour sensitivity of cameras	Test equipment	¥ 54,067
<b>Total cost of the project</b>		<b>¥ 1,501,139</b>

### 4. Presentations

The following is the list of presentations under the auspices of the UK-Japan collaborative project award.

Wingate, L., Richardson, A. D., Nasahara, K. N., Braswell, B., Jacobs, N, Mizunuma, T., Clement, R., Wilkinson, M., Morison, J., Grace, J. and FLUXNET webcam network (2009) Keeping an eye on the carbon balance linking canopy development and Net Ecosystem Exchange using an international webcam network. AsiaFlux 7<sup>th</sup> Workshop,

10/2009, Sapporo. (oral)

Mizunuma, T., Koyanagi, T., Nasahara, K.N., Mencuccini, M., and Grace, J. (2009) The optimal colour index for the photographic recording of leaf phenology. AsiaFlux 7<sup>th</sup> Workshop, 10/2009, Sapporo. (poster)

Nagai, S. (2010) Comprehensive ground observation network connecting satellite remote-sensing with in situ ecosystem observations: Phenological Eyes Network (PEN). International Conference on Phenology: Plant ecology and diversity. Edinburgh, 04/2010. (oral)

Mizunuma, T., Wilkinson, M., Mencuccini, M., Grace, J., Morison, J. L. (2009) The use of digital cameras for remote assessments of forest phenology; a modern approach to an old problem. International Conference on Phenology: Plant ecology and diversity. Edinburgh, 04/2010. (oral)

Nagai, S. (2010) Ecological examination of the phenology detection technique by using continuous digital camera images in a deciduous broad-leaved forest, Japan. Phenology 2010 - Climate change impacts and adaptation, 06/2010, Dublin. (poster)

Mizunuma, T., Koyanagi, T., Nasahara, K.N., Mencuccini, M., and Grace, J. (2010) The optimal colour index for the photographic recording of leaf phenology. Phenology 2010 - Climate change impacts and adaptation, 06/2010, Dublin. (poster)

Nagai, S (2010) Phenological Eyes Network (PEN). An International Workshop on the Validation of Satellite-based Land Surface Phenology Products. Dublin, 06/2010. (oral)



John Grace, Edinburgh, 19.8.10