

Uptake of Decision Support Systems in the Forestry Sector in Great Britain

Final Report



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Forest Research is the Research Agency of the Forestry Commission and is the leading UK organisation engaged in forestry and tree related research. The Agency aims to support and enhance forestry and its role in sustainable development by providing innovative, high quality scientific research, technical support and consultancy services.

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Executive summary

Introduction

- Over the last decade, researchers have developed numerous Decision Support Systems (DSS) for the forestry and land use sectors in Great Britain (GB) and Europe.
- The use of DSS differs markedly between the public forest estate and the private forest industry. Although different DSS are integrated to varying degrees into Forestry Commission (FC) decision-making processes, some are used on a mandatory basis. Within the private sector, however, the picture is much more diverse and there are no 'standard' or mandatory systems.
- Although many DSS are now integral to the systems of forest management planning and decision-making used in the GB forestry sector, for some DSS, the level of adoption has been lower than expected. This problem is unique neither to GB nor forestry and is not yet fully understood.
- Therefore, social research was carried out to understand the factors affecting forestry DSS uptake in GB, and to advise on the strategies and processes whereby they are conceived, commissioned, developed, implemented and maintained.
- The main methods used were: a) semi-structured interviews with 30 people involved in different aspects of DSS conception, commissioning, development, implementation, consolidation, maintenance and use, and b) an online survey of 81 members of the Institute of Chartered Foresters and/or FC staff.

Findings

- The perception among respondents was that the value of DSS appears to be increasing for a range of reasons, including perceptions that they can support a growing demand for evidence based policy, help policymakers and managers respond to climate change, and support certification.
- Many of the factors that influence the uptake of DSS can be expressed in terms of the level and quality of stakeholder engagement during DSS development and implementation. There is, therefore, a need to focus on the process and not just the product, to identify and understand end user needs, and work with them collaboratively to build trust and credibility.
- The barriers to uptake are diverse and improving levels of DSS use will rely on addressing a range of these, rather than concentrating on one of two factors. Barriers include cultural resistance among intended users, a lack of trust between foresters and scientists, and a sense that DSS may threaten professional judgement.
- Improved communications are required between developers and other key stakeholders on how DSS fit into decision-making processes and there is also a need to clarify roles and responsibilities regarding the delivery of DSS.
- Integration of DSS into corporate systems within the FC has been problematic in the past. However, things are now moving in a more positive direction and a newly

developed protocol on DSS commissioning should help to address this through requirements for early engagement between different corporate stakeholders, and through insistence on the need for an 'owner' for each DSS who takes responsibility for ensuring the sustainability of the DSS over the long-term and commits the necessary resources to this.

- DSS will only be adopted if they satisfy a business need and are easy to use. User groups can help ensure DSS are developed to meet customer needs, but they need to be able to communicate effectively with scientists, have a stable composition over the course of DSS development, and their membership also needs reflect the full range of users and stakeholders.
- A lack of training, support and guidance was identified as a barrier to uptake. Better delivery strategies are needed to help the industry absorb DSS.
- Making DSS use compulsory would increase uptake but the case for mandatory use needs to be accepted by users for it to work; it is only likely to happen and be effective if the DSS is perceived to respond successfully to business and users needs.

Conclusion

- Successful DSS uptake is dependent upon satisfying a range of criteria rather than addressing a single barrier.
- Nevertheless, a fundamental factor is whether the DSS is seen to improve upon existing decision-making practices. In some decision-making venues local stakeholder knowledge and judgement appear to be more useful than the outputs of science-based DSS.
- This suggests the need for new kinds of engagement at the interface between science and decision-making. Broadly speaking, we would argue for a shift from a knowledge-transfer model (a unidirectional process) towards knowledge-exchange (dialogue between collaborating partners) and knowledge-interaction (shared cultures and institutions).
- In this way, one of the underlying problems behind DSS uptake can be turned on its head: rather than developing a tool largely in isolation from its intended users, and then seeking a user and a problem that the tool can address (as has sometimes been the case), researchers begin with a better understanding of the actual problems faced by decision-makers in specific contexts – an approach which may, or may not, result in the creation of a new DSS as originally conceived.

1. Introduction

1.1 Background

Internationally, there has been increased attention placed upon the development of computer-based Decision Support Systems (DSS) to enhance the evidence-base for environmental decision-making (Reynolds et al., 2007). In response, over the last decade, Forest Research (FR) has been involved in numerous projects to develop DSS for the forestry and land use sectors in Great Britain and Europe. Many of these have been adopted by the Forestry Commission (FC) and other parts of the forestry sector, and are now integral to the systems of forest management planning and decision-making applied throughout Great Britain.

However, for some DSS, the level of adoption by potential end users has been lower than expected, which has raised questions about the factors impacting upon uptake and how it might be improved. These concerns have emerged often in spite of a shared perception among researchers and end users during commissioning and development of a tool that it would provide useful knowledge for decision support.

Such perceptions are not restricted to FC. A growing body of academic literature has identified and analysed reasons behind perceived gaps between DSS design and use, or between modellers and end users, across a range of software and tool applications within and beyond the environmental sectors (Diez and McIntosh, 2009; Edwards et al., 2013; Jakeman et al., 2006; McIntosh et al., 2005, 2009; Nilsson et al., 2008; Stephens and Middleton, 2002). The causes of the problem have often been explained primarily in terms of the quality of stakeholder engagement during DSS development and implementation, as opposed to issues of a more technical nature (Stephens & Middleton, 2002; Oxely et al., 2002, 2004; Diez and McIntosh, 2009).

Thus, for example, based on experiences of several projects and a literature review, McIntosh et al. (2009: 41-43) propose the following good practice guidelines for involving users in development:

1. know the capabilities and limitations of DSS;
2. focus on the process of DSS development rather than the product;
3. understand the identity, roles, responsibilities and requirements of end users;
4. work collaboratively with key stakeholders, and
5. build and maintain trust and credibility.

In February 2008, FC stakeholders met to prioritise needs (see Box 1). This led to:

- an expert working group to focus on strategy and process for commissioning DSS development, implementation and maintenance by the Forestry Commission. The

outcome was a new protocol for DSS commissioning within the FC, much of which is based around project management principles (see Box 2);

- a social research project to deepen understanding of the issues identified in the workshop.

This document is the final report of the social research project, and builds directly upon and supersedes an earlier scoping study which was published in 2010 (Stewart et al., 2010; cf. Stewart et al., in press). It is based on the analysis of interview transcripts and questionnaire survey responses, both of which provide an insight into the views and perceptions of a range of stakeholders with regards to the factors impacting upon the uptake of DSS. It is therefore complementary to the work of the expert working group and the new commissioning protocol. Although the commissioning protocol (see Box 2) should help to resolve many of the more procedural issues identified in this study, this social research adds value in helping to reveal the complex nature of some of the barriers to DSS adoption. In particular it sheds light on cultural barriers and barriers derived from the personal and institutional values and perceptions of potential users. It also highlights the need for stakeholder participation and engagement throughout the development process.

Box 1. Stakeholder meeting to discuss production and implementation of DSS

A meeting was hosted by Forest Research in 2008, with representatives from relevant sections of the Forestry Commission operating at GB level: FR; Corporate and Forestry Support, Operational Support Unit, GB Planners Group, the Forest Management Officers Group, and Learning and Development.

Key conclusions and research needs:

1. Clarity was sought regarding the **strategy and process** by which DSS are conceived, commissioned, developed, implemented and maintained, including the role of user groups, steering groups and champions.
2. Clarity was sought regarding **product type**, in particular whether the DSS was to be implemented as a stand-alone product, a product that could be embedded in existing corporate systems (e.g. Forester GIS), or retained by FR to run as a bespoke consultancy service.
3. The **potential new uses** for individual DSS needed to be explored in discussions with FR teams and users, perhaps by user/steering groups.
4. **Data dependencies** needed to be resolved, due to the mismatch between data availability and requirements to run assorted DSS.
5. While most DSS had been developed with input from a range of users (through formal user/steering groups and/or testing), and their use supported by training, **linkages between developers and the user community** needed to be maintained after development, not least because of staff transfers and organisational change.

6. There was a need to provide ongoing **maintenance** and **servicing** of products after they have been made widely available.
 7. A shared understanding of the **culture and terminology** of developers and users was required and could be achieved partly through greater frequency of contact.
- (Source: Forest Research, 2009).

Box 2. The DSS commissioning process

Vision:

DSS need to be **user-focused, soundly based, well designed and well executed** to ensure that they, and their outputs, will **transparently influence decisions** made by policy makers and forest managers. DSS will be **embedded in corporate decision-making** and will enable managers to practise **evidence-based decision-making** in a complex operating environment.

Commissioning:

1. Key questions to ask and topics to address before deciding to commission a DSS are:
 - What is the '**overall problem**' to be addressed and what are the **objectives**?
 - Who are the **users** of both outputs and software i.e. customers?
 - Is a DSS the most **effective and efficient** means of supporting objectives or transferring knowledge and what are the alternative solutions?
 - Who is the **developer/supplier** of choice?
 - What is the **governance** structure(s)?
 - Critical **success factors**.
 - **Data availability** and robustness of **model validation**.
 - **Risk** identification and mitigation.
 - **Resource requirements** and likely **timescales**.
2. For DSS intended for use on the FC estate it is essential:
 - That high level **business purpose** is explicit.
 - To take account of **business authority and business processes**.
 - To take account of **corporate IT architecture and strategy**.
 - To take account of **corporate inventory and forecasting strategy and systems** where relevant.
 - To take account of the **resources needed for implementation, maintenance and support**. This includes roll out, training, documentation, platform upgrades etc.
3. Commissioning authorities need to:
 - Consider the **costs and complexities** involved and whether both authority and budget should be delegated to a **bespoke project board**.

- Ensure that **standard purchasing processes** highlight or flag proposals to develop a DSS. A formal **Gateway Review** must be undertaken before deciding to convert models into tools that work with readily available input and non-expert users.

Development:

4. Development must be managed through **standard processes** with **clear gateway review points** (as per the project lifecycle).
5. No DSS should be developed without a **commitment from the 'owner'** to undertake the costs of **further development and ongoing future maintenance**.

Publication/dissemination:

6. The publication and dissemination of DSS should follow the same **quality assurance and governance procedures** as those that are in place for other technical outputs.

Monitoring and review:

7. A set of **key performance indicators** should be established for each DSS to provide a monitoring framework for its use and effectiveness.

(Source: Forestry Commission, Inventory, Forecasting and Operational Support Service Board, 2010)

1.2 Overview of the role of DSS in British forestry

The scoping study revealed four DSS to be priorities for further social research: ForestGALES, Ecological Site Classification (ESC), Establishment Management Information System (EMIS) and Hylobius Management Support System (HMSS). These were seen as broadly comparable in terms of their intended application since they had all been developed and released for use across the entire forestry sector (as opposed to being only for use by researchers, the public, or the private sectors). We also explored the use of Forester GIS and Production Forecast, two systems used directly by the FC. Appendix 1 gives a description of the DSS covered by the study.

Across different DSS, there is a continuum in the level of expertise required to operate them. Some tools can be rolled out to users with no or little need for training or specialist knowledge. Other tools such as ESC and HMSS require training. At the other end of the scale, some DSS like BEETLE (a DSS that was not identified as a priority for further social research in the scoping study) may only ever be operated by researchers as part of a bespoke consultancy service because of their complex nature or because it is deemed too difficult to embed them into existing systems. Another continuum is the scale at which different DSS are applied, from ForestGALES and EMIS which operate at the stand or site level, to BEETLE which operates at a landscape level.

The use of DSS differs markedly between the public forest estate and the private forest industry. For example, across the whole of Britain, the Forester GIS system is central to forest design planning and management processes within the FC. A single geo-database contains all spatially related data and separate modules of software within the Forester GIS system hold information which can be used for different purposes such as design planning, recreation management or production forecasting. Forester GIS is not known to be used directly by any private sector organisation (although several agencies make bespoke requests to FC for specific outputs from the Production Forecast module). The main reason is simply that it was designed primarily for FC needs, and hasn't been actively promoted for use outside FC, although in principle it is available for anyone to purchase.

FC Operational Guidance Booklets (OGBs) cover cross-GB operational policy and guidance for management of the public forest estate. Reflecting its centrality to FC forest management, the use of Forester GIS is promoted across a range of these OGBs. In some, such as *OGB 41 – Managing Conservation Data*, its use is recommended, while in others, such as *OGB 36 – Forest Design Planning*, *OGB 12 – Managing Forest Roads* and *OGB 32 – Production Forecasting*, its use is stated as mandatory.

Other DSS are integrated into FC operations and processes to varying degrees. For example, HMSS is used to a greater extent in Scotland than elsewhere in the UK. Their inclusion in OGBs is not as prominent as Forester GIS. Some DSS are mentioned or recommended (for example, use of part of ForestGALES is recommended in *OGB 9 – Thinning*) but, unlike Forester GIS, their use is not detailed as mandatory.

The role of DSS in the private sector is therefore much more diverse and there are no 'standard' DSS which are used across Britain for forest planning and management purposes in private woodlands. Members of the private forest sector are not subject to OGBs and have a greater freedom to adopt (or not) DSS as they see fit.

1.3 Research objectives

The specific objectives of the study were to:

- improve understanding of the factors affecting DSS uptake, especially those relating to the institutional context in which DSS are developed and applied;
- learn from both positive and less satisfactory experiences, to inform the future development and implementation of DSS;
- advise on the strategies and processes whereby DSS are conceived, commissioned, developed, implemented and maintained by FC and other forestry sector stakeholders.

1.4 Methods

1. Semi-structured interviews

Interviews were conducted with 30 people (including the nine interviewees from the scoping study), typically on an individual basis (face to face and over the telephone, with one or two social scientists and a single interviewee) or on three occasions on a group basis (one or two social scientists and a group of respondents). Interviews took place between August 2009 and July 2011.

Interviewees were selected to reflect respondents' roles in different aspects of DSS conception, commissioning, development, implementation, consolidation, maintenance and use; and on willingness to be interviewed for the project. The sample was not intended to be statistically representative, for example of different countries in GB, or across forestry sub-sectors, but instead aimed to include those who would help to identify the key issues affecting the uptake of DSS in the forestry sector. The respondents are summarised in table 1.

Table 1. Respondents in semi-structured interviews

| Stakeholder | Number of respondents |
|---|-----------------------|
| FR DSS developers | 6 |
| FC GB or country level DSS customers | 2 |
| FC GB staff from within Corporate and Forestry Support | 2 |
| FC planning and operations staff | 7 |
| FC staff working in the grants and regulations side of the business | 6 |
| Private sector representatives (including an independent consultant, industry bodies, and managers from a large estate and a sawmill) | 5 |
| Local authority planners | 2 |
| Total | 30 |

The interviews were structured around a common set of topics and a small number of base questions, the selection of which was informed by the scoping study. A copy of the interview schedule can be found in Appendix 2. The interviews were recorded on a digital recorder with the agreement of the participants that the interviewees would all be referenced anonymously, which helped to elicit more candid responses. The interviews were all transcribed and coded in both a deductive and iterative manner. Thus, the codes and themes identified during the scoping study were used as an initial basis, but these were adapted and developed, and a revised list of themes emerged during the analysis process.

2. Online survey

The survey was conducted during the second half of 2011 using the Internet tool Survey Monkey, to give the study more breadth than was possible through interviews alone and gather a wider range of views and experiences with a broader geographical spread. The survey questions are given in Appendix 3. They were informed through analysis of the data collected during the scoping study, awareness of the relevant literature, as well as through the piloting of the questionnaire with a small group of stakeholders. Survey respondents were also given free text boxes to allow them to provide any information they felt might be useful, in addition to the answers they provided to the quantitative questions.

In particular, the survey increased the contribution of views from the private sector. The Institute of Chartered Foresters (ICF) supported the survey by advertising it in their e-newsletter and sending invitations by email to individual ICF members. (The ICF is the Royal Chartered body for foresters and arboriculturalists in the UK and has around 1,300 members who practice forestry, arboriculture and related disciplines in the private sector, central and local government, research councils and universities and colleges.) The survey was also advertised in the weekly e-newsletter for staff of the FC 'Connect Bulletin'. In total 81 questionnaires were completed by ICF members, subscribers to the ICF eNews or FC staff.

2. The potential future value of DSS to the forestry sector

This section focuses on overarching issues raised by interviewees and survey respondents regarding the current and future role of DSS. Overall, they indicate that the potential for application of DSS is growing, as changing policy agendas incorporate multi-purpose forestry objectives, adaptive forest management strategies and climate change concerns. However, these same agendas may also pose threats to the applicability and value of DSS.

Increasing demand for DSS to support evidence-based policy and planning, and justify decision-making associated with the public forest estate and certification

Forest management decision-making has become increasingly complex since the Rio Earth Summit in 1992. The focus on sustainable, multi-purpose forest management requires integration of environmental, social and economic concerns, and incorporation of stakeholders' views and public participation (Lawrence and Stewart, 2010; Sheppard, 2005: 1515).

At the same time, there have been growing calls for evidence-based policy, and for DSS to help provide this evidence in a user-friendly format (Nilsson et al., 2008). A number of interview respondents felt that DSS could prove useful in this respect:

Just giving... people's best advice based on experience is no longer good enough... we need to have systems which use evidence-based science to provide the answers they need. DSS developer (Interviewee 1)

DSS can help at the strategic level when diverse groups are being consulted:

because it helps manage complexity... you've got really competing, conflicting, dynamic situations happening on a big estate and you need to be able to react... in a way that you can get as much evidence-based information [as possible]... the arguments move quickly but we don't make the changes on the ground quickly so what we need is the ability to sensibly start discussions and debates without feeling we are forced... you need tools that can respond to that dynamic so you can plug in scenarios... That's the kind of decision support tools that are really, really helpful. DSS country-level customer (Interviewee 2)

Similarly, an FC planner (Interviewee 17) explained:

I think we expect to get more [questions from stakeholders around decision-making and evidence] as the years go by, people obviously realise that they've got a voice and they can ask questions and we do things in a certain way but could we have done more?... And therefore, having more analysis to support our decisions probably would be more of the type of work we'll be doing in the future.

At the operational level, another interviewee (18) suggested that there was a need for DSS to assist with landscape level design planning and to identify optimal solutions based on multiple objectives, where stakeholders score recreation and/or aesthetic values and ultimately endorse the use of the DSS. He described how:

I'll come up with a solution and it wouldn't be wrong but someone could have an equally valid, better solution. So having some objective scoring, assessment, description would be useful and it would be useful for stakeholders as well if they endorse that approach. They'll be more reassured that if they're looking at a plan which includes that agreed method of design, then it's less likely to be challenged.

It was also noted that DSS can prove useful to provide an evidence basis for certification: 'It's there to back you up for an UKWAS [UK Woodland Assurance Scheme] audit' and help justify your decision-making (Interviewee 4). Similarly, a DSS developer stated that:

I think probably as we go towards certification and having carbon standards and these kinds of things, there is much less scope for what you might call a sort of intuitive forester... I think the climate is that there is going to be much more requirement to justify how you arrived at a decision. DSS developer (Interviewee 6).

Increasing demand from private sector for DSS to justify outcomes of decisions

The increasing need for evidence to support policy-making is also impacting upon the private sector, parts of which use DSS to justify their decisions to statutory consultees, the FC as the forest industry regulator, and the wider public. For example, one forest manager on a large estate in Scotland (Interviewee 13) explained that the government's ambitious targets for afforestation could lead to conflict between the forestry sector and 'the outside world', because consultees from other sectors and organisations (in particular 'NGOs who tend to have a very fixed agenda on one particular item – a single issue') may not agree with proposed land-use changes or tree species changes. Thus, the main reason his organisation uses a particular DSS is:

to justify our decisions to outside consultees because unfortunately being a forester doesn't seem to lend... any credence to the fact that you might know what you're talking about. Private forest manager (Interviewee 13).

Similarly, DSS could be very useful when Woodland Officers have to appraise applications for woodland creation:

[applications] which are marginal, for whatever reason, or are pushing at the edge of what we think of as best practice or acceptable practice. That's really when this sort of approach comes into its own... I would be quite rigorous and say, the onus is on the applicant to demonstrate – it's not for us to demonstrate that it's not possible... and you've got these [DSS] to back things up. Where your experience of judgement says, debateable, not sure about this, tell you what, why don't you give me an assessment based on X, Y, Z [DSS]. FC grants manager Scotland (Interviewee 14).

However, at the moment this is not standard practice and the Woodland Officers we interviewed rarely asked applicants to use DSS to support their proposals:

... we rarely refuse or make them change a [felling] application. I mean, it does happen, I don't know, I wouldn't like to put a figure on it. Maybe 90% of what comes through is fine and it tends to be fairly unimaginative, but it's not controversial anyway. [...] we're under pressure to meet targets... You know, we don't get the steer that it's our, that we've got any real power to oppose things like that I suppose. We just make recommendations and if people don't want to go along with that then at the end of the day we usually accept it I think'. Woodland Officer Wales (Interviewee 10).

DSS useful for justifying decision-making internally

One private sector interviewee noted that some DSS can also be usefully applied to help justify decisions already made internally within an organisation:

... we use it for justifying growth rates internally for economic appraisal'. Private sector interviewee (13).

DSS useful to target incentives

Some FC staff working in the grants and regulations side of the business (Interviewees 14 & 28) suggested that DSS could also be used demonstrate where operations are likely to deliver higher levels of public benefit so that additional incentives could be targeted, for example by offering locational premiums to supplement existing planting grants. In this way, DSS could support improved delivery of public benefits and government policy objectives.

DSS development may not keep up with rapid changes in policy and business

As mentioned above, sustainable, multi-purpose forestry operates in a dynamic context and policy agendas can change quickly. While DSS can help provide an evidence-base

for decisions, changes in policy can also render DSS redundant or out-of-date. For example:

Sometimes business practices overtake decision support tools... this is something that is going to become an issue with decision support systems and models in general... the business changes its mind quicker than we can respond .DSS developer (Interviewee 3).

One of the examples he gave was that:

We are just getting to grips with [modelling] homogenous, even-aged stands but demands are being made for modelling mixed species stands with different age structures. There is always a feeling that systems are slightly out of date... We are always on catch up. DSS developer (Interviewee 3)

There are new demands for DSS to help managers respond to climate change

One of the competing demands that foresters have to deal with is a result of the growing perception that forests need to play an essential role in climate change mitigation and adaptation (Lawrence and Stewart 2010). Ogden and Innes (2007: 728) argue that the uncertainties associated with climate change may have discouraged managers from incorporating climate change into forest management plans, but that DSS may be able to help with these efforts if they can help quantify uncertainty and integrate forest management models with climate change models.

Our research shows both increasing demand for such models, but also concerns that it is difficult to keep up to date with newly emerging climate data. Demand for tools tackling climate change issues was raised by those working on the ground. As one FC interviewee noted:

... we're being encouraged to make sure that we address the climate change issue in our design plans, but there are no tools I'm aware of that give much guidance on that at all ... That for me is a big gap. Forest Planner, Scotland (Interviewee 18).

More recently, as part of EU projects, FR incorporated climate change data into existing DSS to estimate tree species suitability and assess the impacts of planning scenarios on the provision of benefits under potential future climates. By 2012 these models were being piloted in FC forest districts in North Wales and across Scotland to support forest design planning and district level strategic planning with promising results.

Other DSS are becoming out of date in relation to climate data, so these models and tools are already becoming inappropriate (Interviewee 13). One developer (Interviewee

6) suggested that 'trying to climate proof' existing DSS was a challenge because 'they are based on field experiments in current or past climate scenarios' and would either have to be incorporated with 'very broad assumptions' about climate changes or be based on 'proper process based modelling' of which the capacity is low at present.

There are new demands for carbon-related DSS

Closely linked to this discussion of climate change is the issue of carbon. Respondents noted both increasing demand for DSS, and their role in demonstrating objectivity.

Those noting increased demand included two private sector interviewees (11 and 12) in relation to carbon costs of production and carbon markets, and a senior manager within the FC who suggested that:

... carbon budgeting is an obvious area where demand will increase and I think that just reflects the complex set of policies and demands that forest managers are expected to accommodate and it's very difficult to do that without some sort of support. Senior Manager, FC (Interviewee 21).

This was supported by an interviewee (13) working for a large estate, who noted that they are already using existing DSS to derive estimates for growth rates for the sale of carbon to help fund some forestation proposals 'because that's an independent and peer reviewed decision if you like, it's not us saying, "Oh yeah, we'll do this, give us the money because you'll get this amount of carbon off it"'.

Lack of DSS available which are relevant in the urban context

Two private sector consultants who responded to the survey also noted the lack of DSS available for use specifically in urban environments and for arboricultural purposes. One noted that:

DSS are useful tools, in addition to professional judgement, and it would be useful to develop ones relevant to arboricultural situations. More people see and experience urban trees than woodland trees and, because of this, research that improves/increases the urban tree stock and/or reduces its management costs, will be greatly appreciated. The benefits of urban trees are largely intangible...[But] Research indicates that urban trees will play an important role in climate change adaptation of urban areas where the majority of us live. Survey respondent.

However, at present, such tools are likely to be perceived by many as being beyond the remit of FR, and their development would be reliant on either external contracts or a refocusing of FC research commissioning resources towards urban arboricultural issues.

Some argue that the focus should now be on improving existing DSS rather than creating new ones

Some informants felt that, rather than develop new DSS, FR should 'focus on existing tools', 'refining and improving them' and should be 'fairly self-critical about doing anything more' (Independent consultant, Interviewee 22), especially taking into account the fact that uptake has not been as widespread as anticipated in some cases).

3. Barriers to uptake

The previous section showed that demand for DSS within the GB forestry sector may be on the increase. However, articulated demand for DSS does not necessarily equate to high uptake of existing DSS for a variety of reasons. This section explores the reasons for this. It investigates the multiple barriers to uptake, based on information from interviewees and survey participants. The barriers identified are not applicable to all DSS, or all parts of the forestry sector; instead they illustrate the range of factors that can influence DSS use and usefulness, and point to ways in which the gap between DSS supply and demand might be addressed.

3.1 Survey results

The online questionnaire survey elicited 81 responses from FC staff, ICF members and subscribers to the ICF eNews.

27% percent of respondents were FC staff. Of the respondents that were not FC staff, 58% were private sector consultants (42% of overall sample) and 29% were employees of private forest management companies (21% of overall sample). These groups of respondents (i.e. FC staff, consultants, and private forest management company employees) made up 90% of the overall sample; seven other categories of organisation were not well represented (Table 2 below).

Table 2. Number of survey respondents from each type of organisation

| Type of organisation (choose one of the following) | Number of respondents |
|--|-----------------------|
| Consultant | 34 |
| Forestry Commission | 22 |
| Private forest management company | 17 |
| Private woodland owner | 2 |
| Local authority | 2 |
| Other government department or public body | 0 |
| Community group | 0 |
| Non-governmental organisation | 1 |
| University or research body | 1 |
| Other | 1 |
| No response | 1 |
| Total | 81 |

In terms of geographical split, respondents were asked 'In which of the following countries do you personally undertake forestry-related work (please tick all that are applicable): England, Scotland, Wales?' The results are given in Table 3 below. Around 70% operated in either England or Scotland in roughly equal numbers. Only 6%

operated in Wales, with a similar number operating across all three countries, and in both England and Wales. Thus, Wales-based respondents were under-represented, although this can be accounted for partly by the low woodland cover in Wales which is around one quarter of that in either England or Scotland (Forestry Commission, 2011).

Table 3. Countries in which survey respondents operated

| Country | Number of respondents |
|-----------------------------|-----------------------|
| England | 30 |
| Scotland | 26 |
| Wales | 5 |
| England and Scotland | 3 |
| England and Wales | 5 |
| Scotland and Wales | 1 |
| England, Scotland and Wales | 6 |
| No response | 5 |
| Total | 81 |

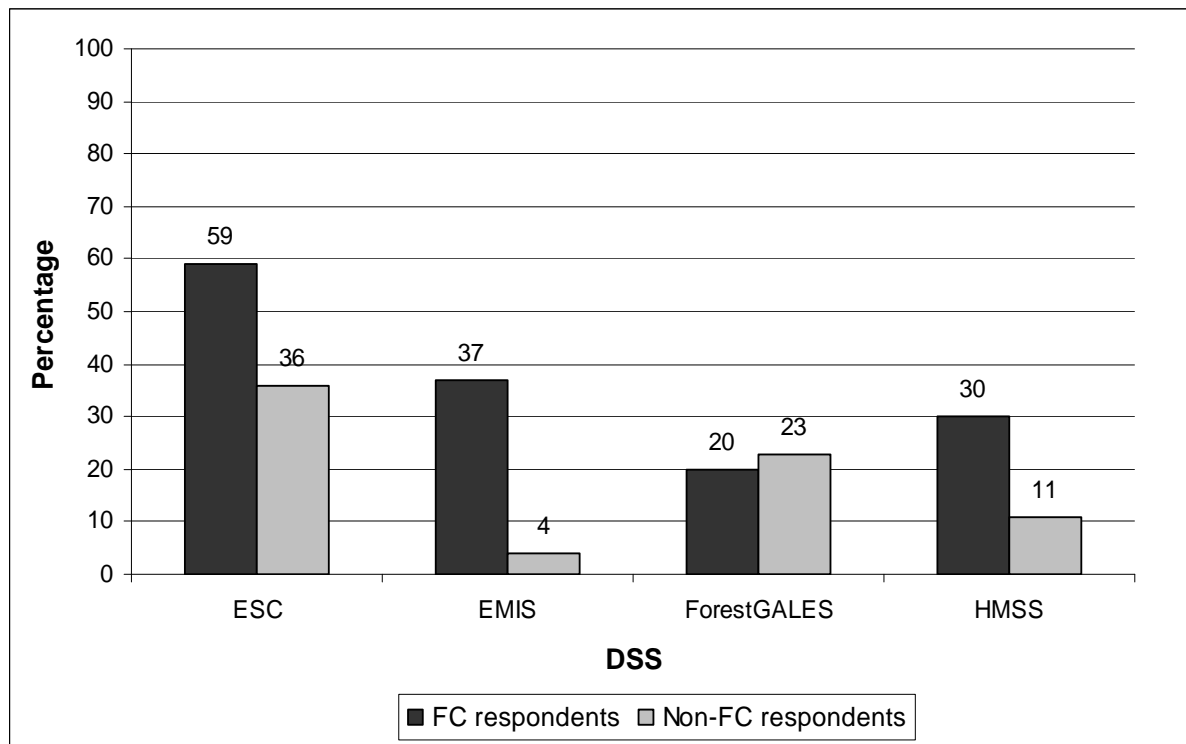
Levels of use among FC and non-FC respondents were assessed by asking: 'How often do you use computer-based versions of the following decision support systems (DSS)?

- Ecological Site Classification (ESC)
- Establishment Management Information System (EMIS)
- ForestGALES
- Hylobius Management Support System (HMSS)
- Forester GIS
- Production Forecast'.

In the survey results reported below, findings relating to Forester GIS and Production Forecast have been removed from the analysis, because in retrospect it was decided that their uptake and use within the private sector is not comparable with the other four DSS. They have not been promoted actively outside the Forestry Commission, although in principle they are available for anyone to purchase. It should also be noted here that some outputs from the four DSS are available in a range of non-computerised forms (although in the survey it was clearly stated that the questions referred to computerised versions), such as maps of species suitability and recommendations for alternative species found in some policy documents. Therefore, in some cases, individuals may use these outputs without being aware that they were produced using a DSS.

Overall, 53% of respondents reported that they did not use any of the four DSS. Broken down by the type of organisation the respondent worked for, 36% of FC respondents and 59% of non-FC respondents did not use any of the four DSS. Figure 1 indicates that, in three out of the four cases, the DSS were reported to be used more extensively within the FC (including FR) than within the wider forestry sector.

Figure 1. Percentage of FC and non-FC respondents who use four different DSS



Respondents were also asked to indicate the reasons for not using particular DSS, by selecting one or more factors from a list. Figures 2 and 3 (below) illustrate the findings from this question in relation to FC and non-FC respondents respectively (see also Appendix 4). Averaging these results across all DSS, Table 4 shows the top five reasons for non-use for both FC and non-FC respondents, not including the answer 'Not relevant to my job'. This response category was not included in the analysis because the study was concerned with better understanding the reasons for non-use where a DSS *was* potentially relevant to an individual's role. The top five reasons for non-use were arrived at by aggregating the percentage of respondents who selected the option for each DSS, as opposed to the actual number of respondents, since the total number of respondents who gave any reason for non-use of individual DSS varied.

Figure 2. Reasons for the non-use of four different DSS by FC staff respondents

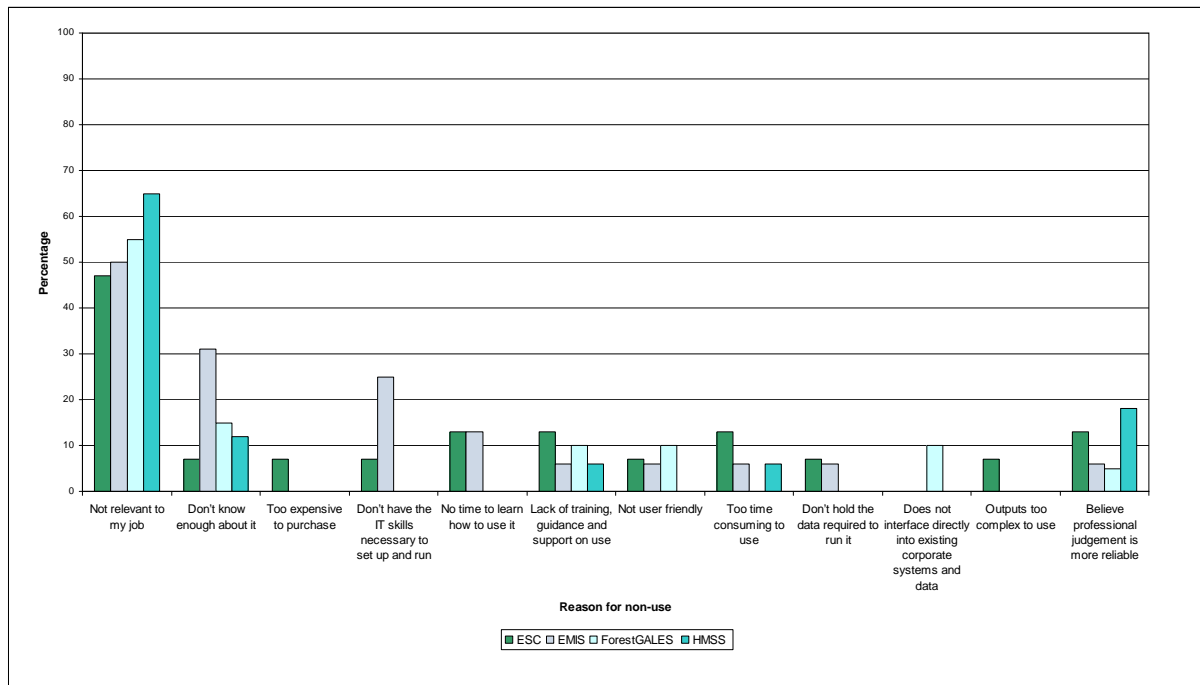


Figure 3. Reasons for the non-use of four different DSS by non-FC respondents

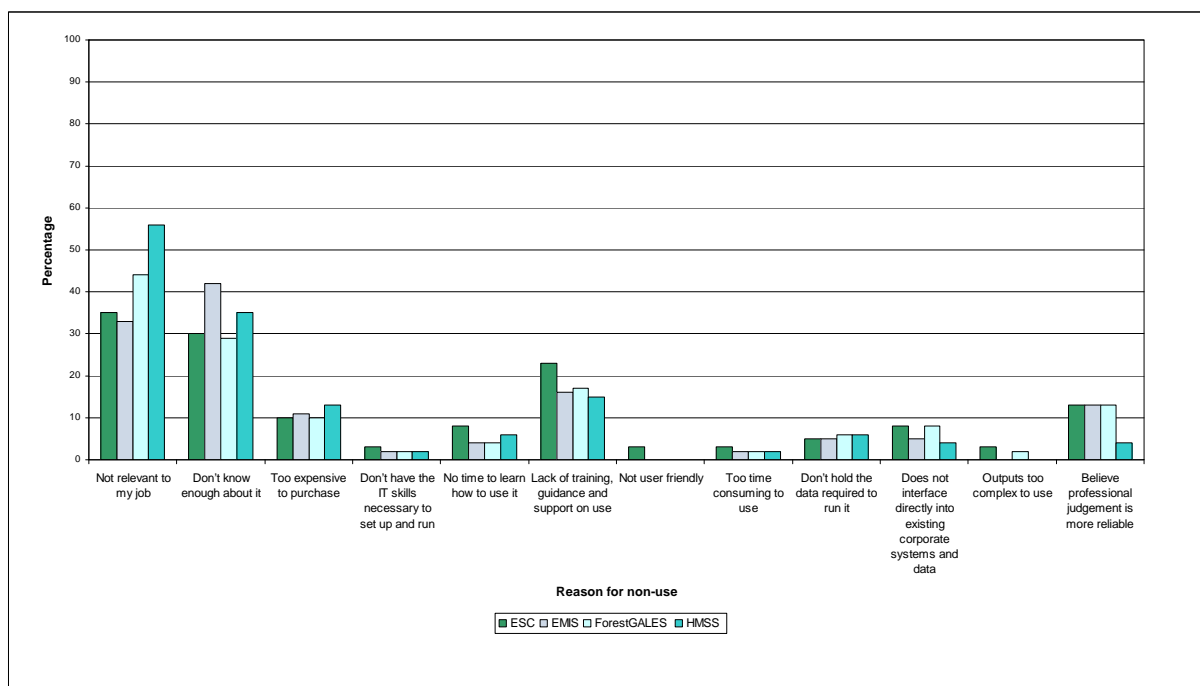


Table 4. Top five reasons for the non-use of DSS by FC and non-FC respondents

| FC respondents | Non-FC respondents |
|---|---|
| 1. Don't know enough about it | 1. Don't know enough about it |
| 2. Believe professional judgement is more reliable | 2. Lack of training, guidance and support on use |
| 3. Lack of training, guidance and support on use | 3. Too expensive to purchase |
| 4. Don't have the IT skills necessary to set up and run | 4. Believe professional judgement is more reliable |
| 5. No time to learn how to use it | 5. Does not interface directly into existing corporate systems and data |

Three of the top five reasons for non-use of DSS are common to both FC and non-FC respondents, as follows: i) Don't know enough about it; ii) Believe professional judgement is more reliable; and iii) Lack of training, guidance and support on use. For FC respondents, importance was also given to concerns around IT skills required and time: iv) Don't have the IT skills necessary to set up and run, and v) No time to learn how to use it. For non-FC respondents, more emphasis was placed on the following reasons: vi) Too expensive to purchase, and ii) Does not interface directly into existing corporate systems and data.

The remainder of this section of the report interprets and contextualises these results in more detail, using quotes taken from the qualitative responses in the questionnaire survey, as well as from the semi-structured interviews undertaken.

3.2 Cultural resistance to DSS: professional judgement versus scientific models

For many there is a perception that DSS do not add value beyond professional judgement

Within the private sector, where economic concerns are paramount, a perception exists that DSS do not necessarily add value beyond professional judgement. The survey results (Figure 3) demonstrate that although this is not the primary barrier to uptake of DSS by the private sector, a belief that 'professional judgement is more reliable' than the system is a contributing factor, especially in the cases of ESC, EMIS and ForestGALES.

One interviewee (13) explained that for many in the private sector, while DSS may ultimately produce more accurate outputs than those based on professional judgement, the differential is not significant enough to justify the time spent using the DSS. The comments of an industry body representative are also illuminating:

...one of the most frequent observations is we haven't got the time [to use DSS] and time is money. Who am I going to charge... Is it teaching grandmother to suck

eggs? Is it a waste of time? I know it all already. Do I need it? It looks complicated. It looks more designed for use on the national forest estate where people are expected to tick boxes and fill in forms and show what they've done or prove what they've done, whereas in the private world, if I own a woodland, I would go to consultant x because I've seen his work, I have confidence in his professional judgement, I don't expect him to have to pass some exam just to go and manage my woodland. Forest industry representative (Interviewee 16)

A similar point was made by a private sector survey respondent:

Professional judgement is not necessarily "more reliable", but may nevertheless be more cost effective [than using a DSS], when one includes the cost of the time involved for training, data gathering, inputting etc. Minor improvements in outcome do not necessarily justify these costs; more likely, these improvements are likely to be intangible and not readily appreciated by the clients who ultimately have to pay for them. Private sector survey respondent.

The same respondent noted however, that they do have a role in training less experienced staff:

My opinion is that in most forestry contexts (except maybe v. large upland plantations) there are too many variables for overly-prescriptive DSS to be practical - but they have a great benefit in helping to improve professional judgement. Which I suppose is the point!

Similarly, another survey respondent (private woodland owner) explained that:

Most of the forest area is managed under CCF [continuous cover forestry] and is an area that I have managed for over 20 years. I have found that my knowledge of the forest a more reliable and faster means of support than from a computerised system. Private woodland owner survey respondent.

Many FC staff also believed that sometimes DSS contribute little beyond what their professional judgement and a site visit can conclude. This is evident from the survey results (Figure 2) which show that, where the DSS was relevant to the respondent's job, a belief that professional judgement was more reliable than the DSS in question was the top reason leading to non-use, especially in the case of Forester GIS and HMSS and ESC. A Woodland Officer (Interviewee 10) explained that he and his colleagues did not use DSS:

...because when grant applications and forest design plans were submitted to his office 'if they were right then we could probably see just from local knowledge and

knowing the site... I've worked in this particular area for 20 years... I know the sites and the conditions very well. Woodland Officer Wales (Interviewee 10).

Similarly, an operational manager (Interviewee 20) stated that 'if you actually follow... [a specific DSS] to the letter... it's very labour intensive and it takes a while to do and two of the foresters that I've got are 50 plus and they're absolutely brilliant... they've been doing it for donkey's years and they can virtually walk on a site and say' what is needed without the need for a DSS. He added that where DSS can be useful is when staff are new and inexperienced as an introduction to a topic:

That may be something again that if a new entrant came in you would point them to for an overview of it. This may be right or may be wrong, what we tend to do here is that we tend to be quite practically based... We would tend to use them [DSS] as more reference. Operational manager (Interviewee 20)

Similarly, another member of operational staff in a different country (Interviewee 24) stated that some DSS require a lot of data to be input to begin with, which ultimately requires a site visit: 'by the time I've walked over the site to gather all that information, then I know that I already know the answer so why would I then type it into a computer to tell me something that I already know?'

Some respondents also suggested that some foresters believe DSS provide absolutes which threaten their professional judgement and local knowledge. For example, one Woodland Officer (Interviewee 10) stated his concern that there 'is the danger you get replaced by a system', 'but they don't work in every situation'. As a private sector respondent (Interviewee 13) noted, DSS 'can be too broad brush', and often 'our local knowledge is better' but DSS can still be 'used against you sometimes' by statutory bodies to challenge decisions.

However, a developer explained that:

... people do feel threatened by [decision] support, the number of times we've had to emphasise these are decision support, so it's helping you make the decision and not decision-making. DSS developer (Interviewee 5).

Similarly, a country-level customer maintained that:

I think perhaps there was a presentational issue in the past and maybe the decision part of the DSS is the bit that made some forest managers uncomfortable. People are very wary of computer systems that make a decision on the ground, but of course they are not designed to do that. DSS customer (Interviewee 2).

Other factors are taken into account which can't easily be modelled

Members of a forest district team suggested of one DSS that 'the model is very, very careful, they don't want to get anything wrong' (Interviewee 25) and while it might give 'technically right' (Interviewee 23) outputs, they are not the outputs that the district will be implementing because they have other factors to consider which the model does not take account of and therefore, ultimately, 'It's not adding value to what you know' already (Interviewee 23).

DSS may be seen to impose solutions, suppress creativity and deny personal choice

As a DSS user at the forest district level maintained that:

...foresters who have probably been in the job for a long time think that they know more than the system can tell them. Forest planner (Interviewee 4).

He added that a lot of planning foresters see design planning 'as being a creative process... and... they see themselves being pinned down by decision support systems'. The effect is that 'it's taking their creative edge off'. This 'creative edge' is similar to what another interviewee (6) described as a characteristic of 'the intuitive forester'.

Similarly, within the private sector there is a feeling that a drawback of DSS is that they cannot take into account personal choice which may not always be based on scientific reasoning:

...one of the key things that is involved in land ownership, is the owners choice prerogative and human beings if they have one thing, is they are not always logical. Private sector interviewee (13).

Likewise, an FC Woodland Officer noted that:

... people's decisions about how they manage the land, what trees to plant, etc., have got so many other influences... often the decisions are then much simpler than some of those [decision support] systems would suggest. Woodland Officer Wales (Interviewee 10).

DSS may challenge values that underpin decision-making

One interviewee suggested that some foresters may find it difficult to accept particular DSS because they encourage or force decision-makers to consider non-market aspects, whereas in reality forestry decision-making is primarily about financial returns:

... no matter what people say about multifunctional forestry and sustainable forestry, at the heart of what happens on the ground is how much money it's going to bring in, how much volume you're going to get, whether you're going to meet your volume targets, that drives everything. DSS developer (Interviewee 9).

Of relevance here, Borchers (2005) argued that 'infusion of a technological innovation into organisations is determined largely by a trade-off between its compatibility with existing values, past experiences and needs, and the relative advantage of the innovation over that which it replaces'. It appears that some DSS can challenge the values that underpin decision-making.

Lack of trust and understanding between forest managers and scientists

Another important barrier, raised by various interviewees, was the perception of a persistent state of distrust between different types of 'experts', in particular between scientists and foresters, brought about largely by a lack of understanding of mathematical models by foresters, and of user needs by modellers. One developer (Interviewee 1) argued that the problem was not specific to the Forestry Commission and that the wider public also 'mistrust' models and the DSS based on them because they have a 'lack of understanding... about what models are' and prefer to 'trust experience'.

There is uncertainty inherent in the design of and outputs from DSS, the models they are based on and the decisions which they may point the user towards. As one survey respondent noted:

The software we use suffers from trying to predict and interpret probabilities using a limited number of parameters from complex natural systems. At best they provide indicative results. Survey respondent.

Some foresters identified problems with inaccuracies in the outputs from DSS. For example, some models are seen as 'quite pessimistic' in their forecasts (Interviewee 18). According to a developer (interviewee 1) uncertainty causes 'a problem within FC because foresters... like to know exactly what to do, when and where and they don't like these sort of fuzzy edges around decisions... If you put uncertainty into there it makes it uncomfortable'. Put simply, he stated that 'Foresters... like absolutes', although this runs counter to the finding above that some foresters dislike DSS precisely because they feel that they do provide absolutes, which in turn challenge their professional judgement.

DSS can be seen as constituting a threat to the fundamental nature of forestry jobs as outdoor occupations

Some foresters view DSS as a threat to the outdoor nature of their jobs. For example, as a consultant (Interviewee 22) explained, 'there is a perception that forestry's too

computerised now and too much of the time is spent at the desk... rather than out in the field' which is where most foresters prefer to be. Similarly, a survey respondent, when asked about specific improvements to DSS that he would like to see, noted that an improvement would be, 'Foresters that use their judgement or learn from others without having to do their work office-based'.

Interviewee 22 suggested that 'a more paper-based approach' or 'something more rough and ready' might sometimes be more appropriate (which links to later discussion about ensuring that the needs of the DSS user are met to ensure successful uptake). Another way to address this concern might be to consider the utilisation of mobile technologies such as smartphones and tablet computers which could run slimmed down, simplified versions of DSS for use on-site.

3.3 Communication and FR/FC linkages

The issue of how DSS have been presented to potential users, raised above by interviewee 2 (in relation to the fear amongst some foresters that DSS provide absolutes and threaten their professional judgement), is part of a wider communication problem that cuts across the themes discussed in this report. The survey results shown in Figure 2 also suggest that, within the FC, communication around DSS is a factor influencing uptake. For example, when averaged across all DSS, 'Don't know enough about it' was the reason with second highest percentage of responses for FC respondents (Table 2). Indeed, in the case of EMIS, ForestGALES and Production Forecast, it was the most reported factor leading to non-use (jointly with 'Believe professional judgement is more reliable' in the case of Production Forecast). The survey results for non-FC respondents (Figure 3) suggest a greater communication problem, where lack of knowledge was the most frequently chosen factor explaining non-use across all DSS. This point was elaborated in different ways by several non-FC respondents' comments:

The models have probably not been adequately promoted to the private sector. Decision-making currently relies on professional judgement and experience but no doubt IT models could contribute significantly in that process if they were accessible and easily understood with basic training (cf. section 3.5 below). Non-FC survey respondent.

I would dearly like to know more about these systems. Non-FC survey respondent.

I currently do not use any DSS listed above. I know very little about how they work, how they may be accessed? Non-FC survey respondent.

Forester GIS and Production Forecast - I know nothing about these programs and did not know they existed. Being self employed I do not have the time to look

around the FC web site with the hope of stumbling across something useful - which indeed they may be. Non-FC survey respondent.

I would love copies but have no idea where to get them from' and; 'I would love ESC and ForestGALES but wouldn't like to pay that much for them and do not know where to obtain them regardless. I have never used any of the others but I would be interested in learning more about them. Non-FC survey respondent.

Lack of knowledge relates to the survey finding that all DSS were perceived by many non-FC respondents to be 'too expensive to purchase' (Figure 3). Three of the DSS covered by the study (ESC, EMIS, ForestGALES) are available to download for free via a DSS portal (<https://www.eforestry.gov.uk/forestdss/>), although this does not appear to be widely understood, and may be due to a lack of promotion and marketing to the forest industry. Copies of ESC and ForestGALES on disc cost around £150 each. Members of one FC district team (Interviewees 23, 24 & 25) noted that it is not always easy to find out what DSS are available or where, with one of them summarising: 'it's not well advertised and finding the link to the page they're on... I couldn't find it... it's like a secret (Interviewee 24). This may be because although the DSS portal has been live for over five years, it has never been widely promoted. Furthermore, it is currently password protected and requires users to register to gain access, which may add to its perceived inaccessibility.

There is uncertainty over who is responsible for DSS delivery

One barrier to better communication and to higher levels of DSS uptake appears to be an uncertainty over whose responsibility it is to make sure that DSS become embedded within FC and non-FC corporate structures and systems. As one developer reported:

Its always been one of the problems at FR that we have a bunch of scientists here developing systems to help forestry but scientists aren't very good at the next stage of how to embed their things in other people's systems and a lot of them don't really see it as being their job or something they know how to do or have the skills in. It's the next step, it's critical actually to getting things adopted but we don't always actually do that. DSS developer (Interviewee 1).

Likewise, another developer (Interviewee 7) stated that while he had driven the DSS through development, 'I have often felt that somebody else ought to be working with me to deliver that to the [forest] enterprise'. Similarly, another developer reported that:

Within my centre we have a kind of rule of thumb that FR's role is up to the point of doing a pilot project but it's not FR's role to do the operationalisation of a product, but that's not universally agreed, it's not written down. FR developer (Interviewee 6).

Since then, the protocol for DSS development issued by Inventory, Forecasting and Operational Support (IFOS) Service Board (Box 2) has helped to clarify respective roles to some degree.

Developers may not feel best placed to promote DSS

A related issue has been the perception that there is no clear system for communicating within the FC and beyond about new and existing DSS, and developers can find identifying and compiling a suitable means of communication difficult because it is not necessarily their area of expertise or something they feel comfortable with. For example, one developer (Interviewee 1) stated that 'publicity within FC I find quite difficult'. One case was reported where a scientist used what was seen to be an unnecessarily high level of detail when presenting a DSS to customers and discussing its capabilities. According to Interviewee (5) 'there was a key point where the whole programme nearly got closed down because that level of detail had entered into some people's perception and they just decided it was unworkable'.

Improved communication is needed on how DSS fit into decision-making

A DSS customer at the country level (Interviewee 2) argued that people need to be able to 'actually understand how it can help in their job' and perhaps 'an education process' is needed. Similarly, one developer (Interviewee 3) noted that people 'need to know how it fits into the business process' for uptake to be successful. These aspects relating to how the DSS would fit into the decision-making process may prove to be more important in discussions with potential end users than seeking to communicate every aspect of the science behind the models. Arguably, better dialogue early on in the design process with potential users around the question of how the tool will add value to, or change, existing decision-making procedures could lead to the delivery of more useful DSS.

Lack of effective channels for DSS communication

Upgrades of existing DSS are produced but there is no obvious or accepted best practice way to communicate this to potential users. Indeed one Woodland Officer in Scotland (Interviewee 29) stated that '[name] has got a copy of ESC on disc, the old style, which is all I'd ever seen, I've never had any training on it and I didn't know that it was available online until I started six months ago... this has not been communicated to us that it's available in that form.' Similarly, a private sector respondent (Interviewee 13) suggested that a 'little bit of communication wouldn't go amiss... Issue an email to someone like CONFOR who will then go, paste to all of their members and the ICF, it's there, it's done, everyone will have it'.

One option is to use the various electronic newsletters which exist. However, there is a problem of information overload and as one developer (Interviewee 1) put it, 'we don't want to inundate people with bits of information about our different decision support systems' within FR. As a solution, it was suggested to this developer that rather than use

electronic newsletters to communicate news about just the DSS he was working on, something should be compiled which described all the DSS available: 'At which point I just get stuck, I just can't do that so it doesn't necessarily happen... It would have to be regular as well because... a lot of people won't read [a one off article and]... the staff change is quite fast... somebody would actually have to think about this every year maybe.'

Informal communication links between FC and FR have declined in recent years

Respondents also raised concerns about the historical decline in linkages and communication between FC and FR which was seen to make it more difficult for FR to 'sell' DSS to the FC. In the past foresters undertook a five year 'tour of duty', in which they were encouraged to spend time in a specialism such as research. This helped to build connections between FR and FC. As one respondent (Interviewee 2) explained:

... you would basically have foresters going into FR for five years and coming out. So they would bring all that contact and all that knowledge of what was going on [in FR back into FC] but you don't get that same flow going anymore. So you have to work at the communication thing an awful lot more because it doesn't happen naturally in the way it once did. I still think there is the same willingness and I think there is the same desire for research. I just think... it used to communicate very naturally whereas now it has to be too much more formally done, but that means you have to then be clear about what it is you want the tools to do.

The last sentence in the quote above relates to the discussion below on the need to identify the full range of potential users and applications for a DSS to ensure uptake and use.

According to one interviewee (2) the impact of the decline in the tour of duty, and the links it engendered between FR and FC, was compounded by the historical decision to make FR a 'stand alone entity... encouraged to try and generate revenue', rather than a department within FC as it had previously been, a move which 'created this disconnect' between the FC which was traditionally the 'principal customer' and FR. From a different perspective, another interviewee (5) described the problem thus:

...we've had devolution, breaking up structures and prior to that it was also the agency construction where the Forestry Commission got split into FE, FA and FR... for a while that really was a case of "if it's not invented here, we're not interested" and definitely between FE and everybody else, so... some of that legacy is lurking.

While communication and linkages are reported by some respondents to be improving again, this discussion indicates that greater attention needs to be given to formal, structured communication between FR and the FC around DSS if they are to achieve

high uptake within FC, since the informal communication networks and methods of the past have changed and arguably no longer function as effectively (Interviewee 2).

Communication about DSS, to both the private sector and the parts of FC focusing on the wider industry, needs to be improved

As suggested by the survey results, while communication around DSS is seen as problematic internally within the FC, the problem is greater with regards to communication with non-FC bodies. Many interviewee respondents, from both within the private sector and sections of the FC that focus on grants and regulation, had not heard of some of the DSS available (e.g. Interviewee 13; Interviewee 29). One forest industry representative (Interviewee 16) had observed confusion around whether DSS could be accessed freely and 'whether or not some of these things were already linked irrevocably to Forester [GIS] and therefore you couldn't use them' (which on the whole they are not) since, to our knowledge, the private sector does not use the Forester GIS system.

Another respondent questioned 'If they are a tool for the use of the industry, how are they promoted...? Are there demonstration sessions or are people just pointed at a website?' (Interviewee 11) This interviewee suggested that the forest forums which exist across Scotland would be a good place to promote DSS to industry. One FC manager with responsibility for regulating and supporting the wider forest industry (Interviewee 14) suggested that FR 'won't necessarily know how best to target the private sector' but that this expertise does exist within the FC. Unfortunately, however, he argued, the part of the FC responsible for working with the private sector also broadly lacks up-to-date knowledge and technical expertise with regards to DSS because the focus of DSS promotion and training is usually on FC staff working to manage the public forest estate: 'We are not as competent as we would like or as aware is perhaps the better word, of all of this as we would like'. This interviewee also suggested that buy-in within the industry-focused side of the FC would probably also be needed at a national level if they were to do more to raise the profile of DSS.

DSS uptake can be enhanced through the activities of 'champions'

One mechanism that has been used in the past to communicate with the sector about DSS, and raised by some respondents as a potential means of improving DSS uptake, was the use of 'champions' whose role it is to promote a particular DSS within the forest industry. One developer (Interviewee 6) observed of one DSS, that developers had recently established dialogue with some of the 'influential cross-country groups, like GB planners [and]... the HMOs' which had helped establish 'a sort of champion who is taking ownership of rolling it out' which other DSS had not benefited from. A forest planner (Interviewee 23) agreed, stating that this DSS 'is one good example of something that's a really well embedded and well used tool, and that's partly because it was adopted at senior levels' within the FC.

Another developer (Interviewee 9) argued that a different DSS had had a high-level steering group on which ‘there were the kind of people who could take on the responsibility of directing the role of [the DSS]... within the business of the Forestry Commission’ as well as the private sector (the steering group included one senior director from one of the largest private forest management companies). In this case, the use of champions failed to increase uptake. One developer (interviewee 5) surmised that this was probably partly because some staff had moved into different roles. Another reason relates to the discussion above about devolution. The Steering Group included senior managers at GB level, yet, as one interviewee (5) reported, with devolution, ‘any structure that would allow [them] to say this is the tool we are going to use in Forest Enterprise across the country... and... we’ll embed it in the software, just disappeared’.

Another developer (Interviewee 7) maintained that champions were a good way to ensure that feedback from the industry to the developers could take place in a structured way: ‘There has to be feedback from the industry to those champions and a way to channel that information back to the people developing the system... it seems to me that a small group of champions that have links to organisations that are trying to develop the system would be very advantageous.’

3.4 Corporate delivery context

Another reported barrier to uptake is associated with tensions within the corporate delivery context in FC, in particular relating to the linkages between DSS developers and the FC’s centralised Information Services (IS), (previously known as Business Services Division (BSD)) and Inventory, Forecasting and Operational Support (IFOS).

3.4.1 Information Services

Integration of DSS into corporate systems is seen by some developers to be hindered by resistance, software incompatibility and lack of expertise within IS

In terms of the context in relation to IS, one developer (Interviewee 3) said that there were ‘a whole host of hoops to jump through’ for IS to consider integrating any DSS into corporate systems, even though the DSS were not usually ‘systems of significant scale’. A DSS commissioner (Interviewee 8) suggested that in one case there had been difficulties and time delays in development because IS had not been able to provide a platform for the DSS and were not able to support it.

Similarly, referring to a different DSS developed by FR, another developer (Interviewee 5) maintained that it had not been possible to integrate it into the corporate systems because of resistance from ‘the gatekeepers of those corporate systems’ and because ‘the software versions they were running’ were incompatible. Discussing the same DSS, another developer (Interviewee 9) felt that IS had not wanted to integrate it into the corporate system because they did not have the expertise to maintain it, fix any problems with it, and provide advice on its use ‘because it’s a very complex system, set

of programmes and routines'. Interviewee 5 summarised the situation by asserting that: 'there is definitely a tension between this drive to be innovative and package knowledge in new ways and then the ability of the corporate systems to then accommodate that knowledge'.

There has often been a failure to include those responsible for delivery in early stages of DSS development

Another developer (Interviewee 6) suggested that part of the practical solution should be to consult with IS earlier in the process of DSS development: 'where we have gone wrong in the past is... what I don't think we have done is include the people who would be responsible for delivering the products. So we haven't included information services like BSD... sufficiently early.' The respondent added that 'it's not just the users we need to engage with, it's the delivery mechanisms' because we need to understand the corporate context. In particular, survey respondents from within the FC highlighted that the fact that ForestGALES 'does not interface directly into existing corporate systems and data' was a barrier to uptake (Figure 2). However, the new protocol on commissioning DSS (see Box 2) has attempted to address these issues and includes provisions that instruct the commissioning board for any new DSS to ensure that the views of IS are understood and it maintains that it is essential that corporate IT architecture and strategy are taken account of in the commissioning process.

However, private sector survey respondents reported that the fact that DSS do not interface directly into their existing corporate systems and data was a problem across all DSS (Figure 3). This suggests that, where DSS are intended for sector wide use, more consultation is needed to better understand the systems and data requirements of different stakeholders.

3.4.2 Inventory, Forecasting and Operational Support (IFOS)

There is an argument for the integration of all DSS into Forester GIS to ease use and spatialise outputs

Another issue is whether or not DSS developed by FR should be integrated into 'Forester GIS', the main forest management information system used by the FC, and developed and supported by IFOS. It has frequently been suggested that inclusion of FR's DSS in Forester GIS could help to improve uptake within the FC, not least because if DSS rely on the data which sit within this system, ease of use would be enhanced if they were integrated into it, or were able to interface with it (Interviewee 21). For example, Interviewee 17 argued that 'having all the features coming together in Forester would be the ideal way of doing' large scale work covering 'large areas of ground' – 'ultimately the best way to manage things and get things from [a specific DSS]... is if it's GIS integrated'. Likewise, another planner (Interviewee 18) stated that:

really for it [a specific DSS] to be useful, it needs to be embedded within GIS because it's fine looking at [this particular DSS]... as part of a DSS package on another system but it's very cumbersome to take that data and transpose it into GIS, which then allows you to develop a design plan.

Furthermore, there is a preference amongst forest planners for DSS to show results spatially, using GIS (Interviewees 23, 24 & 25).

Reasons for not incorporating DSS into Forester GIS include retention of control by FR and minimal use of the system by the private sector

Most FR DSS developers would prefer DSS to remain under the control of FR and be delivered from within FR for various reasons; they recognised the need for their systems to be compatible with Forester (Interviewee 1) but not the need for their systems to be delivered through it. The reasons given for this include the fact that they do not want to lose control over making changes to the systems (Interviewee 7). It was also noted that, 'FR is here to support the whole forest industry and not just FC' and Forester GIS is 'not a system which is widely used in the private sector' so it would therefore not be appropriate for all DSS to be delivered solely in this way (Interviewee 1).

Separate governance structures for development of Forester and commissioning of DSS

There is also an organisational or structural barrier to the integration of DSS into Forester, because at the moment there are two separate governance structures for the management and development of Forester and the commissioning of DSS. On the one hand, most forestry-focused DSS are commissioned and funded through the FC's Corporate and Forestry Support department, and, on the other hand, IFOS and therefore Forester are governed by a Service Board. If FR were 'to design and implement a decision support system' that was integrated into Forester it 'would require those governance structures to in some way have some handover, handshake or some consistency of prioritisation' but 'it's not at all clear there's any mechanism in the countries for doing that' (Interviewee 5). Again, the recent protocol for DSS development issued by IFOS should help to address this problem.

The best approach is to ensure compatibility between Forester GIS and other DSS and discuss delivery mechanisms at an early stage

The most sensible way forward, it would appear therefore, would be to ensure the compatibility of DSS with Forester GIS. As one district planner (Interviewee 23) argues, 'I think the way to go is really with compatible systems... I don't think it's necessary to be a built in part of Forester... I wouldn't build anything more into Forester itself', 'I think it's already complex enough'. Another interviewee (19) suggested that, in the past often developers have not thought to go 'to IFOS and say "we've got this particular project, can we work with you to do it?"' She maintained that, much as early discussions need to

take place with IS, if FR develop new tools for use within the FC then there should be interaction between IFOS and FR about the best way to deliver them at a very early stage: 'it might be worth saying, [should we] migrate the data into this particular format [to be compatible or integrated within Forester]? Can we do that and can we work on it and do whatever we need to develop that way?' Indeed, where a new DSS will utilise inventory and forecasting data/systems, the new commissioning protocol (see Box 2) explicitly calls for DSS commissioning boards to engage with IFOS at an early stage.

Furthermore, a developer (Interviewee 3) confirmed that 'there are moves afoot' to remedy the situation somewhat and incorporate a spatial component into DSS, although the main problem lies with the availability of data: 'if they want spatial landscape scale analysis, it's not really a decision support system issue, it's a data collection and management issue [...] people have got to appreciate the costs, not only in software terms but in the fact of the amount of data that is going to have to be collected.' Furthermore, he suggested that further down the line, 'there will be a revolution and a lot of these tools that we are using at the moment like Forester... will become more web-based, and my question is, is it worth investing now for something that in two or three years time we will do again?' At the time of writing, Forester GIS is indeed being migrated from the desktop to a set of web based solutions and services and one of the drivers behind this move is to make it easier to link DSS developed in FR to the data managed through Forester GIS.

Moreover, recent developments have led to the inclusion of a slimmed-down version of ESC within the current desktop version of Forester GIS. FR have also been working on the development of spatial versions of ESC and ForestGALES at forest district level that can be provided on request as GIS layers for use within Forester GIS. A planner (Interviewee 18) from one of the districts trialling this development stated that 'I think the data will have a big impact both strategically and also at a design plan level... I can see a tremendous asset to us now and now that it's sort of within GIS, we're able to use it a lot more easily which was a bit of a stumbling block in the past'.

3.5 Meeting business demands and user requirements

Uptake of DSS depends upon the extent to which they satisfy a business need, and are easy to use

Alongside concerns regarding the corporate context through which DSS may be delivered, one of the obvious factors behind DSS uptake is the extent to which there is a business demand for them and they meet business and user requirements. As one developer (Interviewee 5) noted, 'decision support tools and expert systems and decision support systems were in a way the rage' at one stage and 'if you looked at what the EU were asking for in their projects, decision support was one of the kind of buzz-words of the era.'

Another interviewee (11) suggested that the aim of some European funded projects 'might be creating a tool in the first place and that's, as far as they're concerned, that's where it ends. So it becomes, it's basically about just ticking off a target somewhere, you're just chasing an outcome because it's there' but it doesn't mean the tool is ever really used or that there is a demand for it and it takes away from producing more meaningful outputs from projects. The same respondent (Interviewee 11) also made the point that FR probably needs to seek external views 'at an early point', and ask, 'is this relevant? How would you use it in practice?' before deciding that the development of a DSS is appropriate.

A DSS customer and commissioner at GB-level (Interviewee 8) suggested that 'the critical thing is there has to be a demand for them'. This interviewee added that sometimes meeting business needs can be about ensuring a DSS is delivered in a timely manner when the industry needs it most. Furthermore, there has to be an 'ease of understanding' when using them and they must not become 'too complex' or 'over-developed and therefore unwieldy'. Similarly, a developer (Interviewee 7) suggested that 'the most important thing is the practicality of the system in terms of its importance to the industry in general'. Some interviewees found certain DSS clumsy and cumbersome to use. For example, one respondent (interviewee 24) described how in using one DSS they were required to email or call the developer to delete an entry from it or extend the amount of entries you can include. He also suggested that it would be useful if it was linked to GIS so that you could see the locations of where the entries related to because otherwise, once a lot of entries are built up, navigating the system and finding the entry you require becomes difficult. Another interviewee (17) suggested that 'we don't get as much use out of them [DSS] or as much application of them as really should be done because they're not really as robust as they need to be for a working environment'.

Another interviewee (21) made the argument that, 'historically FR has tried to create a one size fits all for a number of its applications and that's exceptionally difficult... creating or trying to create DSS which will be used by a wide range of customers for what is essentially quite a large... organisation [the FC], down to individual estate owners... [is] a very big ask'.

3.5.1 Technical delivery requirements

Developers may find it difficult to keep up with the latest demands from users

As noted earlier, technology moves on quickly and sometimes DSS developers struggle to keep up. One developer (Interviewee 1) noted that when a specific DSS was first developed, they had established through the user group that 'the user interface that people wanted was a simple Windows screen' but with the introduction of Forester 'almost immediately we found that... people started working on GIS systems... so immediately we are battling against change'. He continued: 'the industry moved on fast

and the FC moved on fast' and the developers were left 'trying to catch-up'. Indeed, as noted previously, there has been an increased desire for spatialised or visual outputs from DSS over the recent years as the comments of one survey respondent highlight: 'it would be useful to see the... data for each site shown graphically so that you can see at a glance which sites will be the problematic ones'. However, developers also have the problem of meeting conflicting demands, with one interviewee (20) saying of the same DSS, and the suggestion that it should be linked directly with GIS: 'I'm a great believer in keeping things simple because if you make things complicated people won't use them'. For him, a simple list of 'practical applications, what can we do, where' is enough.

Survey respondents also noted that the outputs of some DSS do not meet their needs presentationally: 'Outputs from the system we use are not easily presented in reports, and are usually summarised as text. Outputs provided have poor GUI [graphical user interface] for presentation and are too technical for use other than as appendices in documents'; 'the results are not easy to present or interpret from the software outputs'.

Do not discard older delivery formats too soon

Somewhat conversely, an important issue raised in interviews with members of the private sector was the need to meet a range of technical delivery requirements for different users and not move towards new technologies and abandon old ones too quickly. For example, private sector respondents working in rural areas of Scotland reported that there was still a need to produce disc-based versions of DSS rather than just deliver them via the web because of issues with internet connection speeds (Interviewees 13 & 22).

Automatic updates when new operating systems are released could help maintain user levels

A consultant (Interviewee 22) also suggested that providing automatic DSS version updates (either via the web or by posting a disc) would be a good idea, citing the example of the introduction of the new operating system, Windows 7: 'the migration to Windows 7... has knocked out quite a number of software tools including certainly the version of ESC that I had. I appreciate you can probably get more updated ones, but when there's a major change in software like that I think there is a risk that people stop using the tool because it appears to stop working.' This links to the previous discussion around communications and relationships between IS and FR. If these relationships were improved it is likely that concerns such as these could be addressed more effectively, because IS would be more likely to know when such events were due to occur and how to prepare for them.

3.5.2 User groups

User groups can help ensure DSS are developed to meet customer needs

As one interviewee (17) maintained, 'The user support aspect is absolutely critical to making any package work, and of course ultimately it's the only way that packages will be properly adopted'. An FC planner (Interviewee 18) suggested that:

the problem that I've noticed in the past... is that the end user is very rarely involved in the development of the system and we end up producing a lot of very good DSS from a scientific point of view but when it comes to the practitioner at the end of the day, they find it's quite difficult in practice to roll it out, it's unreliable, it's not really giving us the answer we want in the way we want it.

He continued,

You need a practitioner involved... just to keep the developers' feet on the ground. I think it's all too easy for scientists and developers to develop something in a direction that they might see as being very worthwhile and it gives you all the bells and whistles, but we've got to keep a clear idea of what it is we're trying to achieve and we might not need all the bells and whistles, we might just need a fairly mundane output for the practitioner to be able to use.

One of the main mechanisms that has been employed to help integrate DSS into the FC business, be adopted by the private sector, and ensure they meet user requirements has been the establishment of user groups. All the DSS developed within FR appear to have involved the establishment of user groups in some form. This is encouraging from the perspective of ensuring the product is fit for purpose, meets customer needs, is applicable to the real-world jobs being undertaken in the industry, is easy to use and provides 'champions' to take the DSS back into the business and explain its benefits, and show others how to use it. However, some criticisms and concerns were levelled at these groups.

User groups need to be able to communicate effectively with scientists, and have a stable composition

One such criticism was that users may not always feel able to openly criticise or discuss perceived flaws in the DSS because they feel intimidated by the scientists who are developing the tools (Interviewee 3). Another concern was that if the user groups are relied upon as a fundamental vehicle for embedding the DSS in the forestry sector, and in particular within the FC, then this may prove unsuccessful because of staff turnover and the fact that members of user groups will often change posts (Interviewee 3).

User group membership needs to reflect the full range of users and stakeholders

Another issue raised was their representativeness in terms of the potential user base and 'that user groups in the past might not have had the right people' in them (Interviewee 3). For example, while user groups have to remain limited in size to some degree or they become unwieldy, one interviewee (3) suggested that perhaps user groups in the past had been 'overly skewed to the FC' with usually only one private sector participant on the user group for each DSS. A DSS user at the district level (Interviewee 4) also noted the differences between districts and their needs: 'if you take Scotland quite simply as a country and look at the districts there are very big variations in the challenges that each district faces'.

One respondent (Interviewee 3) argued that the way in which user group members were chosen was also often problematic with not enough consideration being given to who should be involved. Rather than having 'a certain specification of user' identified for involvement, the process was often far more abstract and left to certain individuals within the FC to suggest possible candidates. This respondent (Interviewee 3) also suggested that perhaps there were four groups of users which should be represented on DSS user groups: 'FE planners, the FC [operational] staff on the ground, academia and [the] private sector'.

This matter is up for debate but it is significant in that DSS developers have sometimes not initially foreseen the full range of applications for their DSS and therefore not included all potential users in their user groups. For example, one developer reported that, in the case of one DSS, 'initially we probably had quite a simple view that it would be forest district managers' using it but 'different roles have developed in district offices so... perhaps now it can do a variety of things for a variety of people' and forest district managers are 'probably sitting at too high a level' to use it much (Interviewee 6). Indeed, as this developer (Interviewee 6) further explained, a member of the user group for a specific DSS identified that it could be used as a useful 'means of auditing the decision-making process for the purposes of certification' and 'Planners are now using it as a means of, or beginning to think of using it as a means of defining species choice and plant type' (Interviewee 6).

Identity of end users is not always clear, and needs to be explored carefully

One respondent (Interviewee 3) also argued that forest planners 'were neglected in a lot of things', including user groups because developers often saw their tool's application as being purely at the operational level but they were later revealed to also have application at the strategic level (although not all tools have a strategic element): 'part of the problem we've had is that a lot of the representatives tend to come from the tactical user base as opposed to the strategic'.

Indeed, one developer (Interviewee 7) admitted that when the user group was formed for the DSS he worked on it only had operational staff on it, but ‘over time it has become more and more apparent that it’s actually [also] a planning tool rather than just an operational tool because the planners, when they can see that kind of spatial information, have the opportunity to alter the way the forest is felled’. Similarly, a DSS customer at the country-level (Interviewee 2) explained that in his experience with this same DSS:

[It] was rolled out to operational staff because it’s an operational problem, but the operational staff realised that planners were controlling a lot of what they were doing so there wasn’t great uptake. There needs to be more done to understand where one person starts using it and another picks it up.

This respondent (Interviewee 2) maintained that DSS need to be presented as being applicable from the strategic policy making level right down to the implementation level: ‘if we can cascade right through to the guys on the ground so that the policy has been set using good evidence-based science then the guys on the ground can use the same tools to actually get the best result at that level’.

Developers need to understand how use of DSS may affect operations on the ground

One DSS developer (Interviewee 3) raised a related concern, claiming that DSS may be used at a strategic or forest planning level to formulate policy and plans but that there can be a problem if operational staff then follow these plans without refining them based on site specific knowledge. As the interviewee (3) put it, ‘operational staff do as they are told even if they know from experience that what they are doing is far from optimal’. A DSS customer (Interviewee, 2) at the country-level described the situation thus: ‘you have got ops [operational] people saying well you just give me the plan and I’ll implement it... culturally you can’t afford that to happen because... decisions that are made at a strategic level can get interpreted literally without being refined at micro-level’. This further emphasises the need for clarity over how a specific DSS can be used at different levels.

3.5.3 Volume testing and feedback

Volume testing and feedback mechanisms from users are often not put in place

Respondents also suggested that in the GB context there has often been a DSS development stage that has failed to be implemented or which has remained too informal, namely volume testing and feedback after the launch of a DSS. One country-level customer (Interviewee 2) argued that, even when a user group is employed, when a DSS ‘goes en masse, all the problems come out’ and there needs to be a clearer process for feedback from the whole industry which should be seen as part of the development process. He added that feedback and volume testing ‘plays a role in terms

of strategic direction but [also] in terms of practicality, applicability and in terms of just testing it properly' and that the majority of dialogue should 'be at the user level' with 'more field-based communications' and 'a lighter touch at the top'. Likewise, a developer (Interviewee 6) admitted that 'there needs to be some kind of mechanism for feeding comments back and improving the system and maintaining the system and to be honest I am not sure we have actually addressed that yet'.

3.6 Training, ongoing support and consolidation

There is a need for greater training, guidance and support

Results from the survey indicate that a 'Lack of training, guidance and support on use' of DSS is a major factor contributing to lack of uptake. In the survey, this was identified as being in the top five reasons for non-use of DSS for both FC and non-FC respondents (Table 4). One non-FC survey respondent also made the point that sometimes training and guidance associated with a specific DSS can actually be of more use than the DSS itself: 'I found the course and guidance material more use than the computerised DSS'.

Better delivery strategies may help the industry absorb new and improved DSS

Another issue that was raised and which reportedly acts as a barrier to uptake is the limits of 'the industry to absorb' new DSS developments (Interviewee 3). As another interviewee (6) put it, the industry needs time 'for consolidation before the next one is delivered' and it should fit 'in to a process of delivery so that it doesn't matter whether the tool is being delivered from FE [Forest Enterprise] itself or FR' because it is 'being rolled out to a user community according to a time table', something which has perhaps not happened in the past with DSS being launched in a more haphazard manner. Similarly, another respondent (Interviewee 23) commented that 'staffing is going down... they're not going to be replaced in the short-term, you don't have the luxury of time to learn and absorb and build these new things into your daily routines, so this is a major stumbling block' and essentially, if a new DSS is very complicated and deals with complex uncertainties such as climate change 'it's just easier to put it to one side and say it isn't the core bit of work' and not use it. Another interviewee (17), an FC planner, noted that some DSS appear to be 'in a fairly advanced but not fully complete stage' [and] there's a very strong disincentive to roll your sleeves up and have a look at them. It's not like people have a lot of free time on their hands.... to dabble'.

There may be long-term training needs, partly because of staff turnover

Consolidation takes time because individuals have to learn how to use new systems and how to apply them to their job. Some things that can aid this process are training and support but a criticism that has been levelled against some existing DSS is that training and support for users have been lacking or have not been maintained. For example, one developer (Interviewee 9) noted that, in the case of one DSS, a series of training courses were run initially for perhaps five years but for some reason 'the whole thing collapsed and, because there's a big turnover of staff at the operational level in the

organisation, the skill-base... suddenly disappeared, so there was nobody on the ground to run the thing’.

Another developer (Interviewee 1) reported a similar story with a different DSS whereby training was provided to accompany the initial roll-out, but no subsequent training was provided. A private sector consultant (Interviewee 22) noted that ‘they do tend to go cold after you’ve done the launch seminars... I suspect you need to continue with these efforts beyond the initial period after the launch of the tool, a refresher type approach, and updates’. Another private sector respondent (Interviewee 13) stated that he would like to know how to use certain DSS such as HMSS ‘but where’s the training sessions, when, how do you get on?’ Likewise, regarding another DSS, one DSS customer at the country-level (Interviewee 2) maintained that, along with a minor technical issue, the problems which had hindered the uptake of the DSS were to do with a ‘lack or training’.

A developer (Interviewee 3) also conceded that FR ‘have been very poor at developing any supporting documentation’ such as user manuals for the DSS it has developed. However, this same respondent also reported that, with a DSS he had been involved with, there had been training courses but that these ‘didn’t help uptake much because people went away from the training course knowing [the DSS]... existed’ but there was no compulsion to use it.

The new protocol on commissioning DSS (Box 2) should potentially help with these issues in the fact that it emphasises the importance of ‘ownership’ of the DSS (which should be determined during the commissioning process) in terms of ensuring that the DSS itself and its associated training and support mechanisms are sufficiently resourced in a sustainable manner over the long-term.

A hub of expertise could be created within FR to offer services on a consultancy basis and provide training on DSS

Some interviewees suggested that there could be potential for FR to offer training services and expert advice, perhaps on a consultancy basis. As one private sector consultant (Interviewee 22) articulated, ‘you need a touring core... that would go round in person to the districts and provide a combined expert advice and training role’. Another interviewee from a private estate (Interviewee 13) explained that they already contracted such services from FR to some degree. Speaking of a specific individual from FR who is an expert on soils he said:

I actually get all our managers with him for two days... he’s a wealth of knowledge... absolutely brilliant, and a very good way of putting it across, a real enthusiast for his subject, but very helpful. When you’re doing these surveys, everybody went with him, so they learnt exactly about it, so effectively that gives you the nuts and bolts to be able to do your ESC – so I did it [got training in how

to use ESC] but not through a formal training method... Like always in the private sector we do it short code.

A FC forest planner (Interviewee 23) added that 'I've always seen that [consultancy services run on specific DSS] as being a service that FR should really get into'. For example, the same interviewee observed:

BEETLE [see Appendix 1] is a case where it's a deceptively simple thing but once you start getting into it and thinking about what it's actually telling you, it's quite complex and it's very difficult to use then for a forester who's sitting here and whose main job is planning and he's got a full work schedule. He's not going to have time to go out and get that knowledge.

However, regardless of the strategies that may be developed to improve upon the ways in which DSS are developed, implemented and used, there are those who believe that general uptake will only improve if DSS use is made obligatory and imposed in some way from above.

3.7 High-level directives on DSS use: the only way to ensure high uptake?

Some argue that the only way to ensure high uptake of DSS is to make their use compulsory

Making the use of certain DSS mandatory, for example to meet requirements for certification or official operational guidance, has increased uptake. As one Forestry Commission survey respondent in England noted, he uses certain DSS simply because 'I'm told I have to'.

Examples where high-level edict ensured high uptake

An example which backs up this argument is HMSS. When this was originally designed and rolled-out there was a slow rate of uptake, but as explained by one interviewee:

... then the FSC [Forest Stewardship Council]... picked up on the system and its potential to reduce the amount of insecticide that is being used in the industry and [they]... put out a derogation essentially saying that the industry, not just the FE but the industry as a whole, needed to be seen to be reducing its chemical usage and essentially saying that they should use the Management Support System.
DSS developer (Interviewee 7).

As a result, representatives from the Forestry Commission Scotland Planning Team held meetings with the developers and decided to roll the system out across Scotland, requiring district-level staff to use it where appropriate. Now it is argued that the HMSS

is 'one good example of something that's really well embedded and well used' and it is 'now the corporate way of doing things' (Interviewee 23).

Making DSS use mandatory, e.g. to support certification, would certainly increase uptake, but there are risks that this would lead to inappropriate use

The HMSS example led one developer (Interviewee 3) to conclude that 'the biggest element in the model to decide usage would be FSC [certification standard] compliance or some sort of mandatory element' to usage and 'being more engaged with UKWAS and FSC to let them know what we have got' would help with uptake. However, he also suggested that making DSS use mandatory may not ultimately serve the DSS cause well: in some cases it would mean certain DSS could end up being used inappropriately with a lack of cost-benefit return, and ultimately forcing people to use them 'will just get people's backs up'.

The case for mandatory directives needs to be accepted by users for it to work

A DSS user at the district-level agreed with this assertion when he stated that:

Some of them [the DSS] are getting used because we are told we must use them... I think a lot of the planning foresters... are probably quite set in their ways so they don't like being told to use these systems... there are probably certain things that are pushed down from above without properly consulting the people that are doing the job. It just gets rolled out and you get told you are doing it this way and that's it... sometimes the communication between senior management and district-level staff needs to be improved. Forest Planner (Interviewee 4).

This statement suggests that once again communication is an issue, this time in relation to senior management and district-level staff within the FC. Interviewee 4's statement above also perhaps points to a cultural resistance to change which may possibly be related to the mistrust many foresters have of science and mathematical models, which was discussed previously.

It should also be noted that DSS are tools intended to *support* decision-making, not to provide absolutes, and thus even if their use was mandatory, this should not mean that the adoption of their outputs should be; users should always be free to make the decision that they think is the most appropriate on their forest site.

Mandatory use for grant applications would also need acceptance by users and backing at a senior level within the FC

It has also been suggested that if the use of DSS was made mandatory for grant applications then this would substantially increase their use by the private sector (Interviewee 30) and could help Woodland Officers in some situations, as it would ease

the burden of 'having to push people to provide evidence all the time' (Interviewee 28). One local authority interviewee in Scotland described the situation at present:

There is no mechanism... that requires use of these systems to assess and analyse. SRDP [Scottish Rural Development Programme] doesn't require any of that, the Forestry Commission don't require it, even under their own guidelines they don't require it. So there is no emphasis on a land owner or a land manager to adopt any of these systems and put them in place because they don't have to and it's considered to be... just another layer of bureaucracy, more time wasted, so if they don't have to go down that route, then they won't do it. (Interviewee 27).

However, it was also noted by interviewees that, at the very least, making DSS use mandatory would need the buy-in of senior managers at a country-level within the FC (Interviewee 14). Their use would also need to be accepted as appropriate by users and not be too resource intensive because, as one interviewee (28) explained, at the moment in Scotland grant applicants are required to have a forest plan. The plan process has just been simplified and 'slimmed down' 'because it's perceived to be too complicated' so it is possible that if the use of DSS were also made mandatory, unless there was some level of recognition by grant applicants that this was necessary, there would be a backlash against them (Interviewee 28). Indeed, a survey respondent from a private forest management company noted that, 'Many are useful tools but there is a danger that we are "bullied" into using them for grant applications etc. (specifically ESC) and it becoming a requirement'.

Nonetheless, survey responses suggested that in Scotland at least, some DSS such as ForestGALES and ESC are already being used by some individuals and organisations to support their SRDP grant applications. Whether this is because they are specifically asked to or not by grant application assessors is unclear.

Inclusion of DSS within operational guidance or professional standards would enhance uptake

It has been argued that DSS need to be accepted as the professional 'standard approach' through the Institute of Chartered Forestry and through Continuing Professional Development (CPD) to ensure their acceptance across the industry (Interviewee 14). Similarly, another developer (Interviewee 5) argued that 'there is no attempt to build in the professional standard' to forest design planning that 'would force people to make use of' a DSS.

There is also debate over the extent to which inclusion of DSS in Forestry Commission Operational Guidance Booklets (OGBs) would enhance their uptake. Interviewees

revealed very mixed opinions over this matter with one district forest planner (Interviewee 23) suggesting that for DSS to achieve high levels of use within the FC they must be 'adopted corporately', 'right the way through from senior levels' and accepted as being 'part of the system' and 'the way we do things', which requires their inclusion in OGBs. Likewise, a developer declared that:

... unless you tell people to use a tool or decision support system in one of the OGBs, they won't use it because foresters follow the OGBs, or are supposed to follow the OGBs. So if they are doing anything which isn't in the OGBs they are kind of going off their job a little bit so it's hard for them to justify doing that (Interviewee 7).

It is argued that uptake depends primarily on its ability to meet demands

Conversely, a customer at the country-level argued that a DSS will appear in an OGB only once its business relevance and application has been established:

I think it [inclusion in OGBs] would come naturally but it comes back to specking out what you are wanting, why you want it, where you see the use might be... and then properly embedding that... through training [and] senior management support to make it work. The one thing it has to do is that it has to be practical and you have to be prepared to change things that annoy people... (Interviewee 2).

Thus, while making DSS mandatory will undoubtedly improve uptake, the only way this is likely to happen is if the DSS meet business and user requirements and needs, they add value (not least financial value, as for some users of HMSS (Interviewee 23, 24 & 25), their implementation and consolidation are adequately supported, and feedback about required improvements to DSS design are responded to adequately.

4. Discussion and conclusions

4.1 Key findings

The research presented in this report explores a range of factors that influence the uptake of DSS. The main findings are summarised below. To a large extent, they show that many of the factors can be expressed in terms of the quality of stakeholder engagement during DSS development. They point to a need to focus on the process rather than the product, to identify and understand end user needs, and work with them collaboratively to build trust and credibility.

‘High uptake’ or ‘successful uptake’ cannot simply be defined by the number of people using a DSS because, as one interviewee put it, ‘it could be a specialist thing that is helping a few people out with a very real problem’ (Interviewee 8). Also, as demonstrated in the discussion around high-level directives, the successful uptake of DSS relies on numerous factors or criteria (whether compulsion is one of these or not) and it is not a simple matter of meeting one or two of these; uptake will only be successful if a DSS meets a range of criteria.

The potential future value of DSS to the forestry sector

The perception among respondents was that the value of DSS appears to be increasing, partly because they are seen to support the growing demand for evidence based policy, and also as a means to help policymakers and managers respond to climate change, and demonstrate that they are doing so with the latest evidence and tools. The role of DSS may also increase in the future if they can assess carbon balance or support certification. The private sector is seen to have a demand for DSS, although our survey results suggest that uptake is hindered through lack of knowledge of what has been developed by FR/FC. Some argue that efforts should focus on improvements to existing DSS rather than developing new ones. Others argue that there is a need for new DSS, such as tools which support urban woodlands and trees, especially since their importance is increasingly being recognised in policy circles.

Cultural resistance to DSS

The barriers to uptake are diverse, and as mentioned above may need to be addressed together for significant impact to be made. Barriers include cultural resistance among intended users, and a lack of trust and understanding between foresters and scientists. There is also a sense that DSS may challenge values that underpin the practice of decision-making, impose solutions, suppress creativity, or threaten professional judgement. Some users did not welcome the uncertainty associated with use of DSS while others felt DSS provided users with misleadingly accurate results that were stripped of uncertainty.

Communication and FR/FC linkages

Improved discussion and communication is needed between developers and other key stakeholders on how new DSS would fit into decision-making processes, and this is arguably more important than detailed discussions around the science that underpins models. There is also a need for discussion to clarify roles and responsibilities regarding DSS delivery, a role that developers may not feel comfortable with. Part of the problem with uptake within FC is seen to lie in a reduction in tours of duty whereby foresters spent periods in research, which has helped to reduce informal links between FC and FR. It was noted that champions within and beyond FC can be particularly valuable in enhancing uptake.

Corporate delivery context

Within the FC, integration of DSS into corporate systems is seen by some developers to be hindered by resistance, software incompatibility and lack of expertise within Information Services. Part of the problem lies with developers where there has been a failure to include those responsible for delivery in early stages of DSS development. Regarding the role of IFOS (Inventory, Forecasting and Operational Support) there has been disagreement and uncertainty over whether DSS should be incorporated into Forester GIS. Reasons for not incorporating DSS into Forester GIS include the fact that some developers fear a loss of control over the DSS they have developed, and because Forester GIS has not been actively promoted to the private sector. It can be hard for DSS developers to keep up with latest demands from users, partly due to insufficient resources, for example the recent shift towards DSS that are spatially explicit. One barrier to dialogue and clarity over roles within FC has been the separate governance structures for development of Forester GIS and the commissioning of DSS.

However, the new commissioning protocol which has been developed should help to address many of these issues since it calls for DSS commissioning boards to engage at an early stage with both IS and IFOS, and it also highlights the importance of clearly addressing the issue of 'ownership' of individual DSS during the commissioning phase to ensure that an 'owner' takes responsibility for ensuring the sustainability of the DSS over the long-term and commits the necessary resources to this. Furthermore, Forester GIS is currently being migrated to a set of web based solutions which will allow FR developed DSS to link more easily to Forester GIS and the data it holds. Moreover, one DSS, ESC, has now been integrated into the current desktop version of Forester GIS. This demonstrates that things are moving in the right direction in terms of enhancing the usefulness and uptake of DSS.

Meeting business demands and user requirements

Uptake of DSS depends largely upon the extent to which they satisfy a business need, and are easy to use. Developers may find it difficult to keep up with the latest demands from users, e.g. for tools to become spatially-explicit. Meanwhile, there may still be a

demand for older technologies, such as disc-based versions of DSS. User levels could be maintained for some DSS if they are automatically updated when new operating systems are released. User groups can help ensure DSS are developed to meet customer needs, but they need to be able to communicate effectively with scientists, and have a stable composition over the course of DSS development. User group membership also needs reflect the full range of users and stakeholders, but this is hindered by the difficulties in identifying all potential end users. Use of DSS, for example by planners, may affect operations on the ground in unforeseen ways. Another concern is that volume testing and feedback mechanisms from users are often not put in place, with negative consequences on the usefulness of DSS being delivered.

Training, ongoing support and consolidation

A lack of training, support and guidance has been identified as a barrier to uptake, especially for the private sector. Better delivery strategies may help the industry absorb new and improved DSS, including attention to training, which needs to be sufficiently long-term to address problems with staff turnover and loss of expertise among intended users. The new protocol on DSS commissioning may help address training and support issues in part, at least in terms of emphasising the need for the DSS 'owner' to consider long-term resourcing. Consideration could also be given to whether the creation of a hub of expertise on DSS could be created within FR to offer services on a consultancy basis and provide training.

High-level directives on DSS use: the only way to ensure high uptake?

It is clear that making DSS use compulsory, e.g. to support certification, would certainly increase uptake, but, despite the fact that DSS are only intended to support decision-making processes rather than make the decisions themselves, there are risks this could still lead to inappropriate use. The case for mandatory use needs to be accepted by users for it to work. Inclusion of DSS within operational guidance would enhance uptake. However, it is argued that uptake depends primarily on its ability to meet demands: use of a DSS is only likely to be made compulsory, and even if its use is compulsory it is only likely to be used, if it is perceived on several levels to respond effectively to a business need.

4.2 Beyond Knowledge Transfer

The research has shown how successful uptake of DSS is dependent upon satisfying a range of criteria rather than addressing a single barrier. Nevertheless, the findings suggest that perhaps the most important factor is whether the DSS is seen to improve upon existing decision-making practices. Many forest planners and operational staff routinely make decisions on the basis of practical local knowledge and expert judgement, built up over many years, taking into account multiple, subjective, context-specific factors that cannot easily be quantified and modelled. Likewise, policymakers supplement available scientific evidence with the divergent opinions of multiple

stakeholders, while the interviewee respondents reported above referred to forest planning as a 'creative process' that often needs to take into account the unpredictable personal preferences of individual land managers. Evidently, in some cases, it may be difficult for a DSS, driven by incomplete or inaccurate datasets that cover a limited number of variables, to offer a better alternative. Such a DSS may still prove to be valuable, but at a more strategic level of decision-making where analyses conducted at a lower resolution may be sufficient. Of relevance here, Davenport and Glaser (2002) conclude that DSS may be suited best to decision-making venues with low levels of ambiguity, a relatively low number of possible choices facing decision-makers, and where there is an organisational culture of measurement.

Conversely, in some cases DSS may indeed offer a better alternative to local knowledge and professional judgement, precisely because they were developed to deal with complex scenarios, influenced by multiple, interlinked factors, and help to avoid the pitfalls of reliance on short-term experience when developing long-term plans. In such cases, and where these DSS are not used as extensively as they could be, developers will need to address the perception that local knowledge and professional judgement are more effective, and offer evidence to the contrary.

The conclusion that in some decision-making venues local stakeholder knowledge and judgement is seen to be more useful than the outputs of science-based DSS, and conversely that the outputs of some DSS are more accurate than local knowledge, suggests the need for new kinds of engagement at the interface between science and decision-making. Researchers addressing related issues in the health sector have identified three generations of 'knowledge-to-action thinking', which apply equally to the context of forestry: a) knowledge transfer (KT), and other linear models, dominant between the 1960s to 1990s, whereby uptake of knowledge is seen as a function of effective packaging and use of appropriate communication channels; b) knowledge exchange (KE), which emerged in the late 1990s, whereby knowledge is the result of social and political processes, and uptake is a function of effective relationships and interaction, and most recently c) knowledge interaction (KI), whereby knowledge is embedded in systems and cultures, and uptake is a function of effective integration with organisations and systems (Nutley et al., 2007; cf. Best et al., 2008).

It can be tempting to conclude from this literature that DSS development projects should abandon 'outdated' KT models of dissemination in favour of approaches grounded in the latest KI paradigm. However, the specific factors influencing DSS uptake identified in our study demonstrate the relevance of all three of these models. Thus, relatively straightforward improvements to uptake and use can be achieved through a traditional KT approach to address factors such as:

- the need to clarify roles and responsibilities regarding DSS delivery;
- the use of champions to promote DSS use;

- demand for older technologies, and for automatic updates of DSS when new operating systems are released;
- the need for volume testing and feedback mechanisms, and for better delivery strategies including long-term commitment to training, support and guidance especially for the private sector;
- the scope for developing a hub of expertise within the research agency, and
- the possibility that DSS use is made compulsory through high-level directives within an organisation.

It is likely that some of these factors could be tackled more effectively through the interactive approaches inherent in KE and KI. More importantly, improved KT alone, with its focus on uni-directional communication, will not address more fundamental factors that require deeper dialogue with stakeholders such as:

- a lack of trust and understanding between foresters and scientists;
- cultural resistance among intended users;
- challenges to the values that underpin the practice of decision-making, e.g. the perception that solutions are being imposed, creativity is being suppressed and professional judgement is being threatened;
- the need to ground DSS development in better knowledge of how DSS could add value to existing decision-making processes;
- integration into corporate systems;
- involvement of stakeholders responsible for DSS delivery in early stages of development;
- the need for developers to keep up with rapidly-evolving user demands, and
- barriers to dialogue that result from a separation of governance structures for the development and commissioning of DSS within an organisation.

At times, these latter factors suggest that the intended contribution of a DSS to decision-making procedures may have been misconceived.

Thus, in conclusion, we would argue for the DSS development community to supplement its current focus on traditional forms of KT with interventions that facilitate better interaction between: a) individual stakeholders (KE) and b) organisational systems and cultures (KI). Broadly speaking, this represents a shift towards a more participatory approach to modelling. As stated by McIntosh et al. (2009: 45) "One of the greatest, and frequently overlooked, benefits of projects is the insight gained by model developers, practitioners and stakeholders through a participatory development process. Such processes can make clear the contradictory objectives, expectations and perceptions between science and practice and play a fundamental role in mediating compromises from both sides" (cf. Díez & McIntosh, 2009: 599). These concerns are being addressed within other areas of software development with the emergence during the 1990s of 'lightweight' methods, such as 'agile', as an alternative to traditional

'heavyweight' methods grounded in a rigid 'waterfall' model of development. Agile projects are implemented by small, self-organising, cross-functional teams working on short-term iterations of the software development cycle (Dingsøyr et al., 2010). Meanwhile greater attention is being placed upon users' perceptions through more sophisticated approaches to user experience design (UXD).

A common criticism of any methodology that is dependent on substantial input from potential end users is the time and expense it is likely to involve. However, lessons learned from recent DSS development projects led by FR, which have employed some of the principles of agile, suggest that such a shift in emphasis does not necessarily imply the need for exhaustive stakeholder involvement: targeted interaction with one or two users may be sufficient if it involves genuine commitment, dialogue and learning (Edwards et al., 2013). In this way, one of the underlying problems behind DSS uptake can be turned on its head: rather than developing a tool largely in isolation from its intended users, and then seeking a user and a problem that the tool can address (as has sometimes been the case), researchers begin with a better understanding of the actual problems faced by decision-makers in specific contexts. Such an approach may, or may not, result in the creation of a new DSS as originally conceived.

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Appendix 1: DSS mentioned in the study

Biological Environmental Evaluation Tools for Landscape Ecology (BEETLE)

A suite of tools developed to model and analyse fragmentation and connectivity using GIS. BEETLE analyses land cover habitat requirement and species movement data.

<http://www.forestry.gov.uk/fr/infd-69pla5/>

Ecological Site Classification (ESC)

This tool determines species and woodland suitability based on site location (which thereby defines climatic factors) and optional assessments of indicator plants, soil and humus form. ESC has had a patchy history of uptake (Ray, 2001). In some locations the old version of ESC is being used, which has problems associated with it, but because of communication difficulties and a lack of training many people in the sector are not aware of newer versions of the system where these problems have been resolved.

<http://www.forestry.gov.uk/esc>

<https://www.eforestry.gov.uk/forestdss/>

Establishment Management Information System (EMIS)

EMIS comprises simplified tools to assist with species selection, site/species management options, and planting guidance. Its use requires the OS six figure grid reference of the site and knowledge of site conditions (e.g. soil type) (Perks et al., 2007). EMIS was developed with a user group but it has been suggested that there has not yet been much buy-in from the industry at large. EMIS has never been officially launched but some forest districts have found it useful and, although originally not developed with this type of use in mind, it has been adopted at a strategic level within European research projects such as ForeStClim (Transnational Forestry Management Strategies in Response to Climate Change Impacts) and MOTIVE (Models for adaptive forest management in a changing climate).

<http://www.forestry.gov.uk/fr/HCOU-4U4JE4>

<https://www.eforestry.gov.uk/forestdss/>

ForestGALES

Provides wind hazard assessments for GB conifer plantations based on stand (soil, drainage, location) and species (top height, average dbh) information (Dunham et al., 2000). ForestGALES is targeted at both foresters and planners and was developed with a user group. However, uptake across the industry has been patchy. Initially there was training to accompany the product but this has now ceased. The system works at the stand level and was developed before GIS became a major tool in the forest industry in GB. To try and meet the demand for spatial systems, FR are now providing wind risk

maps in GIS for requested areas since ForestGALES cannot provide this function.

<http://www.forestry.gov.uk/fr/INFD-5V8JC8>

<https://www.eforestry.gov.uk/forestdss/>

Forester GIS

Forester GIS has been developed by the FC with ESRI UK. It is designed for use by the FC and is the primary source of management information on the FC estate across GB. It comprises a database of spatially related information and a collection of bespoke application components (built on top of ArcGIS) for different uses such as design planning or recreation management.

Hylobius Management Support System (HMSS)

Assists with site-specific monitoring of pine weevil (*Hylobius abietis*) populations in advance of conifer clearfell restocking to predict and reduce transplant damage, insecticide use and costs of establishment. A user group was involved in the later stages of the development process which largely involved people in operational roles. However, it was later realised that it is essentially a planning tool because planners drive what happens on the ground. The system is now being used by many within the private sector and Forestry Commission Scotland and this is in large part because in June 2009 the Forest Stewardship Council put out a derogation which stated that the forest industry needed to reduce its chemical usage and that HMSS should be used to support moves towards this.

<http://www.forestry.gov.uk/fr/INFD-6T6LP4>

<https://www.eforestry.gov.uk/forestdss/>

Production Forecast

Production Forecast is a tool which can run within Forester GIS to produce reports that estimate felling volumes, product breakdowns according to top diameter class and the range of species according to user specified information. FC Foresters use Production Forecast to model their individual forest design plans and test them against different objectives. They also use Production Forecast as a first stage in building their operational (harvesting) work plans. Senior managers and policy makers use the aggregate facility which combines all the forest design plans in order to define strategic direction over the short to medium term and model policy decisions at a country level. It is also used within the context of the National Forest Inventory to provide estimates of current and future standing volume, stocked area, increment and production under various management scenarios. It has recently been extended to provide estimates of biomass and standing carbon. A GB Production Forecast is produced every five years for use across the industry utilising data from within the FC and externally from the private sector.

<http://www.forestry.gov.uk/forestry/hcou-4u8n8y>

Appendix 2: Interview schedule

A generic interview schedule is given below, comprising the full list of questions. Not all of these were relevant to all interviewees. Subheadings are used to indicate sets of questions that were anticipated to be appropriate for different groups of interviewee. The list is not exhaustive and additional questions, or modifications to questions, were needed for specific groups. Interviews began by providing background information on the project, and its objectives, tailored for different interviewee groups. In line with the Ethical Statement of FR's Social and Economic Research Group (SERG), interviewees were informed that their identity will remain confidential, and how the data was to be analysed, stored and used, before they were asked to give their consent to participate.

A. Introduction

1. How are DSS important to the forest industry?
2. How are DSS important to your job?
3. How would you define a successful DSS?
4. Can you tell me about the DSS that you are aware of in your role and your experience with them?

Ask relevant questions from B-F about specific DSS they have knowledge of:

B. Conception and development

5. What's the background to it?
6. How was it conceived?
7. Was it commissioned or developed out of a research project?
8. Is it an 'on-the-ground' tool or a strategic tool?
9. How was it developed? – what was the process?
10. Who was consulted through the conception and development phase?
11. Were users or potential users involved in any way in its development? [*probe in what ways, did they test it? etc.*]
12. Who was it targeted at?
13. Do you think it was targeted at the right level? [*probe –i.e. should it have been targeted at planner not forester?*]
14. Was there a user group to oversee its development? [*If so, ask additional questions below*]

Additional questions if there was a user group

15. Do you think this mechanism worked effectively?
16. Are there any ways you think the user group process could have been improved?

17. Do you think members of the user group also acted as a communication method to tell the industry about the DSS and champion it?
18. Do you think there was good representation of all potential users on the group? [*probe – not only in terms of from across the three countries and industry but also whether they were the 'right' people, e.g. planners and foresters*]

Additional questions if the interviewee was a member of the user group

19. Can you give me a bit of background of how you came to be involved in the user group? [*probe – how were they selected to join?*]
20. How often did you meet? [*probe - was this enough, too much etc.*]
21. Who else was on the group?
22. Do you think there was a good representation of all potential users on the group? [*probe - not only in terms of from across the three countries and industry but also whether they were the 'right' people e.g. planners and foresters*]
23. How did you feedback your views?
24. Did you feel able to openly say what you thought about the system, even if it was negative?
25. Did you feel that your views were taken on board?
26. Do you think members also acted as a communication method to tell the industry about the DSS and champion it?
27. Do you think the user group mechanism worked effectively?
28. Are there any ways you think the user group process could have been improved?
29. At what stage was the group disbanded and was this the right time?

C. Implementation and consolidation

30. Once it was launched was there a process of feedback for users to comment on it and if so was it effective?
31. If not, do you think this would have been useful?
32. Do you think it has met user requirements? [*prompt – i.e. easy to use, does the job they need it to? etc.*]
33. Do you think the DSS fits easily into existing planning or decision-making procedures? Does its adoption depend upon significant changes to these procedures?
34. Is there any training offered on its use? [*probe – has training ceased, been sufficient or not been effective?*]
35. Does it have effective supporting documentation such as a user manual?
36. Was there buy-in from the industry and potential users?

- 37. Were there high level champions in the FC and industry? If so were they effective?
- 38. Is it included in official guidance such as an OGB?
- 39. If not, do you think it should be? [*probe – would this help with uptake?*]

D. Maintenance and corporate delivery systems

- 40. Is it supported by BSD and delivered through the corporate information system?
- 41. How is it maintained?
- 42. Are there any issues/problems around maintenance?
- 43. Should it be delivered centrally, through Forester for example, or by FR?
- 44. Are there any drawbacks to this approach from your perspective?

E. Uptake and usefulness

- 45. What do you think are the factors that have affected whether the DSS is adopted or not?
- 46. Do you think that it has met a business need? / How useful do you think it has been to the business?
- 47. How well used is it and why?
- 48. Who uses it?
- 49. Are there other potential users – if so why aren't they using it?
- 50. What could make it better?
- 51. Do you think a DSS was the right way of communicating the information?
- 52. Was it cost effective?
- 53. Do you think that there is cause for concern that it is used in such a manner as to make decisions rather than to inform decisions?

F. Specific questions for IFOS and BSD

- 54. Why do you think that many of the DSS produced by FR have not been as successful in terms of uptake as anticipated? [*probe*]
- 55. What do you think needs to change to improve uptake?
- 56. Why aren't FR DSS delivered to the FC through the standard corporate delivery platforms?
- 57. Should DSS be delivered centrally, through Forester for example, or by FR?
- 58. Are there any drawbacks to this approach from your perspective?
- 59. Would this even be possible?
- 60. If you do think they should be delivered through Forester who should pick up the cost of this?
- 61. Do you think that we are likely to see tools like Forester becoming more web-based in the future?
- 62. Do you think FR DSS should be built on web-based platforms in the future?

G. General questions

63. What areas of forestry do you think will see the greatest demand for DSS in the future and why? [*probe – where will they add most value?*]
64. What are the biggest challenges to their potential and this demand being met?
65. Do you think that in the future their role will diminish, that they will be as important as they are now or that they will become more important, and why?
66. Do you think that shifting demands on forest management arising from issues like climate change will change the demands on DSSs?
67. Do you think that forestry is going to have to become more adaptive and therefore will require different kinds of decision-making, meaning that new kinds of DSS will be needed or that new ways of developing them will be needed?
68. Do you think that the forestry sector has the capacity to absorb and consolidate new DSS?
69. What are the key factors you think affect whether a DSS is adopted or not?

H. Concluding questions

70. Is there anything you think is important that I should have asked you about?
71. Is there anybody else you think I should talk to about this?
72. Is there anything else you would like to add or that you want to ask me about?

Thank you for participating.

Appendix 3: Survey questions

The survey

The survey is part of a research project conducted by Forest Research (the research agency of the Forestry Commission). The research aims to help improve the uptake and usefulness of forestry decision support systems (DSS) developed within the Forestry Commission.

DSS are defined as computer-based tools which use mathematical models and are aimed at supporting decision-making. Examples of forestry DSS include, Ecological Site Classification, Establishment Management Information System, ForestGALES, Hylobius Management Support System, Forester GIS and Production Forecast.

The survey is aimed at anyone for whom DSS could potentially be useful, so please do fill it in even if you do not currently use any of the DSS developed by the Forestry Commission. There are ten questions and the survey should only take a few minutes to complete so please share your views, knowledge and experience with us and help us to try and ensure that forestry DSS meet your needs in the future.

FOR MORE DETAILS:

Go to: <http://www.forestry.gov.uk/fr/dssuptake>

Email: Amy.stewart@forestry.gsi.gov.uk

1. How often do you use computer-based versions of the following decision support systems (DSS)?

| | Ecological Site Classification (ESC) | Establishment Management Information System (EMIS) | ForestGALES | Hylobius Management Support System | Forester GIS | Production Forecast |
|-----------------------|--------------------------------------|--|-------------|------------------------------------|--------------|---------------------|
| Weekly | | | | | | |
| Monthly | | | | | | |
| Every few months | | | | | | |
| Once a year | | | | | | |
| Less than once a year | | | | | | |
| Never | | | | | | |

Any comments:

2. If you DO use any of the DSS mentioned in this survey, please tell us what you use them for, which parts of them you use, and how they benefit you.
3. Are there any specific improvements you would like to see to any of the DSS discussed above and if so what are they?
4. Have you received any silvicultural / forest management training which has promoted or explained specific DSS? Yes/No.
If yes, please tell us the name and year of the course/s, the DSS mentioned and whether the course influenced your use of the DSS mentioned.
5. For those DSS that you do NOT use, please tell us why.
Please tick more than one reason where applicable.

| | Ecological Site Classification (ESC) | Establishment Management Information System (EMIS) | ForestGALES | Hylobius Management Support System | Forester GIS | Production Forecast |
|---|--------------------------------------|--|-------------|------------------------------------|--------------|---------------------|
| Not relevant to my job | | | | | | |
| Don't know enough about it | | | | | | |
| Too expensive to purchase | | | | | | |
| Don't have the IT skills necessary to set up and run it | | | | | | |
| No time to learn how to use it | | | | | | |
| Lack of training, guidance and support on use | | | | | | |
| Not user friendly | | | | | | |
| Too time consuming to | | | | | | |

| | | | | | | |
|--|--|--|--|--|--|--|
| use | | | | | | |
| Don't hold data required to run it | | | | | | |
| Does not interface directly into existing corporate systems and data | | | | | | |
| Outputs too complex to use | | | | | | |
| Believe professional judgment is more reliable | | | | | | |

Please explain your answers in more detail or to tell us anything else you think might be relevant.

6. Are there any DSS you use which have not already been mentioned in this survey? If so please tell us about them here, including how often you use them and what you use them for.
7. Which of the following best describes the kind of organisation you work for or represent:

Private woodland owner
 Private forest management company
 Consultant
 Forestry Commission
 Local authority
 Other government department or public body
 Community group
 Non-governmental organisation
 University or research body

Job title or role:

8. Do you have a direct role in planning or managing woodlands? Yes/No

If yes, roughly how many hectares are you personally responsible for?

9. In which of the following countries do you personally undertake forestry-related work? (Please tick all that are applicable).

England
Scotland
Wales

10. Would you be happy for us to contact you to discuss DSS further? Yes/No
If you are happy for us to contact you then please provide us with your contact info (name, organisation, address, telephone number, email address).

Appendix 4: Survey data

Table 1: Factors which lead to non-use of DSS by FC staff respondents (n=22)

| Factors | ESC | EMIS | ForestGALES | HMSS | Forester GIS | Production Forecast |
|--|-----|------|-------------|------|--------------|---------------------|
| Not relevant to my job | 7 | 8 | 11 | 11 | 1 | 9 |
| Don't know enough about it | 1 | 5 | 3 | 2 | 0 | 1 |
| Too expensive to purchase | 1 | 0 | 0 | 0 | 0 | 0 |
| Don't have the IT skills necessary to set up and run | 1 | 1 | 0 | 0 | 0 | 0 |
| No time to learn how to use it | 2 | 2 | 0 | 0 | 1 | 0 |
| Lack of training, guidance and support on use | 2 | 1 | 2 | 1 | 1 | 0 |
| Not user friendly | 1 | 1 | 2 | 0 | 1 | 0 |
| Too time consuming to use | 2 | 1 | 0 | 1 | 1 | 0 |
| Don't hold the data required to run it | 1 | 1 | 0 | 0 | 0 | 0 |
| Does not interface directly into existing corporate systems and data | 0 | 0 | 2 | 0 | 0 | 0 |
| Outputs too complex to use | 1 | 0 | 0 | 0 | 0 | 0 |
| Believe professional judgement is more reliable | 4 | 1 | 1 | 3 | 1 | 1 |
| No response | 7 | 6 | 2 | 5 | 19 | 11 |

Table 2: Factors which lead to non-use of DSS by non-FC respondents (n=58)

| Factors | ESC | EMIS | ForestGALES | HMSS | Forester GIS | Production Forecast |
|--|-----|------|-------------|------|--------------|---------------------|
| Not relevant to my job | 14 | 18 | 21 | 29 | 18 | 20 |
| Don't know enough about it | 12 | 23 | 14 | 18 | 22 | 19 |
| Too expensive to purchase | 4 | 6 | 5 | 7 | 5 | 6 |
| Don't have the IT skills necessary to set up and run | 1 | 1 | 1 | 1 | 3 | 1 |
| No time to learn how to use it | 3 | 2 | 2 | 3 | 2 | 2 |
| Lack of training, guidance and support on use | 9 | 9 | 8 | 8 | 6 | 7 |
| Not user friendly | 1 | 0 | 0 | 0 | 0 | 0 |
| Too time consuming to use | 1 | 1 | 1 | 1 | 1 | 1 |
| Don't hold the data required to run it | 2 | 3 | 3 | 3 | 3 | 4 |
| Does not interface directly into existing corporate systems and data | 3 | 3 | 4 | 2 | 4 | 3 |
| Outputs too complex to use | 1 | 0 | 1 | 0 | 1 | 1 |
| Believe professional judgement is more reliable | 5 | 7 | 6 | 2 | 0 | 3 |
| No response | 19 | 4 | 11 | 7 | 7 | 9 |