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Do interventions to mobilize wood lead to wood mobilization? A critical review of the links between policy aims and private forest owners' behaviour

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Forests are expected to contribute towards an increase in supply of sustainable renewable materials and energy, which is commonly referred to as 'wood mobilization'. In Europe, much attention has focused on the gap between wood potentially and actually harvested. This paper assesses the evidence for successful interventions, based on a critical review of evidence conducted through the EU-funded project SIMWOOD (Sustainable Innovative Mobilisation of Wood). Few evaluations are able to report the impact of interventions on the amount of wood harvested in a way that can be attributed unambiguously to the intervention. The review concludes that (1) there is a need to focus less on surveys of constraints and more on real-life interventions and their success or otherwise; (2) more could be learnt from the experience of such interventions, if evaluations were published in the scientific literature, and if qualitative methods were included, to help understand why stakeholders do or do not change behaviours and increase wood harvests; (3) successful interventions are multifaceted (often combining incentives and advice, or farming and forestry, or production and markets) and (4) although experience can be shared effectively between regions, interventions must be tailored to local social, biophysical and political conditions and developed in context.

Introduction

The need for increased forest harvest

Forests cover 33 per cent of Europe's land area (FOREST EUROPE, 2015) and provide for diverse human needs, as the source of wood and other products, as well as services and values including biodiversity, landscape and climate change mitigation. Current policy and social expectations are increasing the pressure on forests and the solid biomass they provide (as both timber and energy raw material). In particular, while demand for timber is forecast to rise, new regulations on bioenergy also place demands on wood (Gronalt and Rauch, 2007). As a result, forest policy in many countries aims to harvest more while also protecting the forest (e.g. Tissot and Kohler, 2013; Levers *et al.*, 2014).

Forest-based bioenergy plays a critical role in Europe's future renewable energy supply and the achievement of climate protection objectives. EU Climate and Energy legislation announced in 2007 set a new obligatory target for renewable energy to constitute 20 per cent of overall energy consumption by 2020 and required member states to include measures in their National Renewable Energy Action Plans to promote new biomass mobilization (Stupak *et al.*, 2007; Lindahl and Westholm, 2011). The policy reflects the expectation that the amount of timber and biomass harvested from Europe's forests can increase substantially over current levels (FOREST EUROPE, 2010).

Scientific assessments of this expectation are mixed. A spatial analysis across Europe finds that harvested timber volumes are well below the increment in most regions; explains variations through biophysical variables such as the share of plantation species, growing stock, and site condition; and concludes that there is scope to intensify production (Levers *et al.*, 2014). Another study models the spatial distribution of future supply of wood from European forests until 2060, taking into account increased nature-oriented management and demand for bioenergy, and predicts a significant increase in wood availability (Nabuurs *et al.*, 2006). Others propose changes such as coppicing which would permit wood production in protected areas (Maesano *et al.*, 2014).

However, analysts have questioned the real availability of these estimated wood potentials, on technical, social and environmental grounds (Blennow *et al.*, 2014; Sikkema *et al.*, 2014; Verkerk *et al.*, 2014). Taking a broad view across Europe, Verkerk *et al.* (2011) conclude that increasing the availability of forest

biomass would require 'quite drastic changes' in forest management, which would be implemented by forest owners and managers. Nearly half of Europe's forests are publicly owned, and in these forests change in management can be achieved through change in planning and resource structures. However, it is in the privately owned forests that the greater challenge lies, because in most countries the level of harvesting is dependent on the interest and commitment of the owner, and his or her links with forest management services, harvesting contractors and markets.

This means we need to move beyond the calculation of wood availability and beyond technologies to increase that availability, to understand the realities of private owners and wood harvesting. Much research has studied owners, their stated predisposition to manage their forests (whether for conservation or production objectives) and constraints to harvesting. Especially important for the present challenge, however, is to examine the evidence for change: can the constraints be addressed in ways that lead to increases in harvesting wood from privately owned forest land? That is the issue examined by this paper.

Private forest owners and behaviour change

Over 50 per cent of Europe's forests are privately owned, and the total area and proportion of forest in private ownership is increasing (FAO, 2015; data are for Europe not including Russia). The numbers of owners are also increasing, and types of forest owners are changing in Europe, through restitution, privatization, sale/purchase, afforestation and changing lifestyles of owners (Živojinović *et al*., 2015; Weiss *et al*., 2017). Furthermore, across Europe there are great differences in context. For example, the Austrian Forest Inventory shows that approximately 54 per cent of Austria's forest area is accounted for by 'small forests', which are defined as smaller than 200 ha (Kooperationsabkommen Forst Holz Papier, 2011). In contrast, in France forests larger than 25 ha are described as 'large' (Elyakime and Cabanettes, 2009). In Scotland, policy advisors describe a cultural split between farming and forestry (WEAG, 2012), while in Sweden many owners are farmers resident in their forests (Nordlund and Westin, 2011), although this proportion is declining. The increase in 'non-resident' or 'absentee' owners is a concern in many European countries (Grubbström, 2011; Hokajärvi *et al*., 2011). Conversely, there may be some benefits to less management: some studies find that private forests have a particular contribution to biodiversity and carbon storage capacity, due to less intensive and more diverse forest management than in public forests (Schaich and Plieninger, 2013).

Size, integration with other land uses, lifestyles and traditions of ownership: all these factors affect 'willingness to harvest', competing values and relationships with other stakeholders. Because these factors vary between (and within) countries, we must beware of generalizations. Some factors are found to be relatively consistent. For example, a recent review of evidence in the USA and Europe found that parcel size, harvest price and distance from residence were the most common significant predictors of harvesting intention (Silver *et al*., 2015). An earlier study, which looks in more detail at the decisions underlying harvesting behaviours in the USA, concludes that research offers much information about harvesting but not about the other factors which influence owners' decisions, such as hunting and recreation, and/or an intention to bequeath their forest to future generations (Conway *et al*., 2003).

A further complication comes from the methods and questions addressed in research with owners. Many focus on values, attitudes and stated intentions. But none of these variables necessarily correlate with actual (current or future) behaviours. An important area of social research is built on understanding this gap and modelling the stages between intention and action (Rossi and Armstrong, 1999; Karppinen and Berghall, 2015). Several reviews have concluded that most studies which claim to study behaviour are in fact measuring stated attitudes without observing the harvesting behaviours (Lawrence and Dandy, 2014; Silver et al., 2015). To understand how forest owners move from current attitudes, intentions and behaviours, to new attitudes, intentions and ultimately behaviours, we must examine the effect of interventions.

Forest policy (whether government or non-government) attempts to influence private forest owners through a range of policy tools, typically classified as regulation, financial incentives and advice (also known as 'sticks, carrots and sermon'). These approaches, particularly financial incentive programmes, are notoriously variable in their success (Serbruyns and Luyssaert, 2006). Owners' attitudes to management are context-specific and a number of studies suggest that private owners' behaviour is more influenced by local socio-economic and cultural factors than by the forest economy or by policy programmes (Blennow *et al*., 2014; Canadas and Novais, 2014; Lawrence and Dandy, 2014). A study on 'market participation' finds that bioenergy market participation means different things for biomass producers, energy producers, and brokers, processers and other intermediaries, and that although 'market participation' can lead to behaviour change, the new behaviour may not be 'increased harvesting' (Galik, 2015). In Finland, a move towards small-scale biomass industries requires the renewal of existing forest industry and management processes (Åkerman *et al*., 2010), while in Slovakia, the focus is on developing new markets (Halaj and Brodrechtova, 2014). Even where there is willingness to change patterns of forest management and exploitation, it may not yet be obvious how to do so.

Objectives of this paper

This paper addresses the effectiveness of interventions intended to encourage private owners to increase wood harvest. It is based on a study conducted for SIMWOOD, an EU-funded project which aims to increase the mobilization of wood from European forests. The paper aims to use the available evidence (scientific and consultancy literature) to understand the potential or demonstrated contribution of interventions to increase wood mobilization. It focuses on two questions:

- How effective are different types of interventions which are intended to increase the harvest of timber and biomass from privately owned forests?
- What factors contribute to success of such interventions?

Methods

To address these objectives, a three-step approach was developed: first, to produce a framework to analyse relevant literature; second, to understand the extent to which literature helps to answer the objectives of this study and third, to validate the findings with stakeholders.

Method step 1: developing a conceptual framework for analysis

As described in the introduction, successful adoption of an intervention requires several stages of a logical process. The basic logical process underpinning this study builds on two methodological tools: the policy cycle and the evaluation methods.

The policy cycle is now a widely accepted way to conceptualize the steps of agenda-setting, policy formulation, decision making, implementation and evaluation (Jann and Wegrich, 2006). The decision-making step includes appraisal of options to overcome constraints, followed by design and implementation of an intervention to achieve that (Collier *et al.*, 2010). In modern evidence-based policy processes, such interventions are evaluated to understand whether they achieved their intended goal (Burton, 2006; Donaldson *et al.*, 2009; H M Treasury, 2011). Furthermore, the 'evaluation' step can be expanded to distinguish between measures of activities delivered, outputs, intermediate outcomes and impacts (H M Treasury, 2011).

This review uses such a framework based on the logical process underlying successful interventions to mobilize wood, as the basis for an assessment of the evidence available at each stage of the logical process. An early version of the logical process was tested against a sample of the literature, and modifications were made to accommodate interventions based on changes in either technology or governance. The final tested version of this framework, with examples relevant to wood mobilization, is shown in Figure 1.

This framework was operationalized as a set of questions to be applied to the literature (Table 1). Each item of the literature was coded, in order to analyse it in the second part of the methodology. By separating out these questions, we are able to understand where we have most evidence, what that evidence tells us and the extent to which different types of innovations and interventions have contributed to wood mobilization.

Method step 2: assembling and analysing literature

The search for and analysis of literature were conducted using rapid evidence assessment methods developed for use in public policy research and evaluation. This approach provides a systematic way to review and synthesize existing evidence to answer a research question (Government Social Research, 2010). The more rigorously quantitative approach of a systematic review is not appropriate (e.g. Haddaway *et al.*, 2015) because the literature is widely dispersed across many sectors and because there is an element of interpretation involved in assessing whether the work reported has explicitly or implicitly led to adoption and/or increased harvest. Instead, a mixed quantitative and qualitative approach is taken.

The collection of appropriate literature was based on two methods:

- a core knowledge network, consisting of project partners in SIMWOOD, provided evaluation reports in local languages and clarified local context;
- a search of academic literature used both academic online databases (Web of Science, Science Direct) and the internet search engines (Google Scholar). Because of the multiple steps identified in the

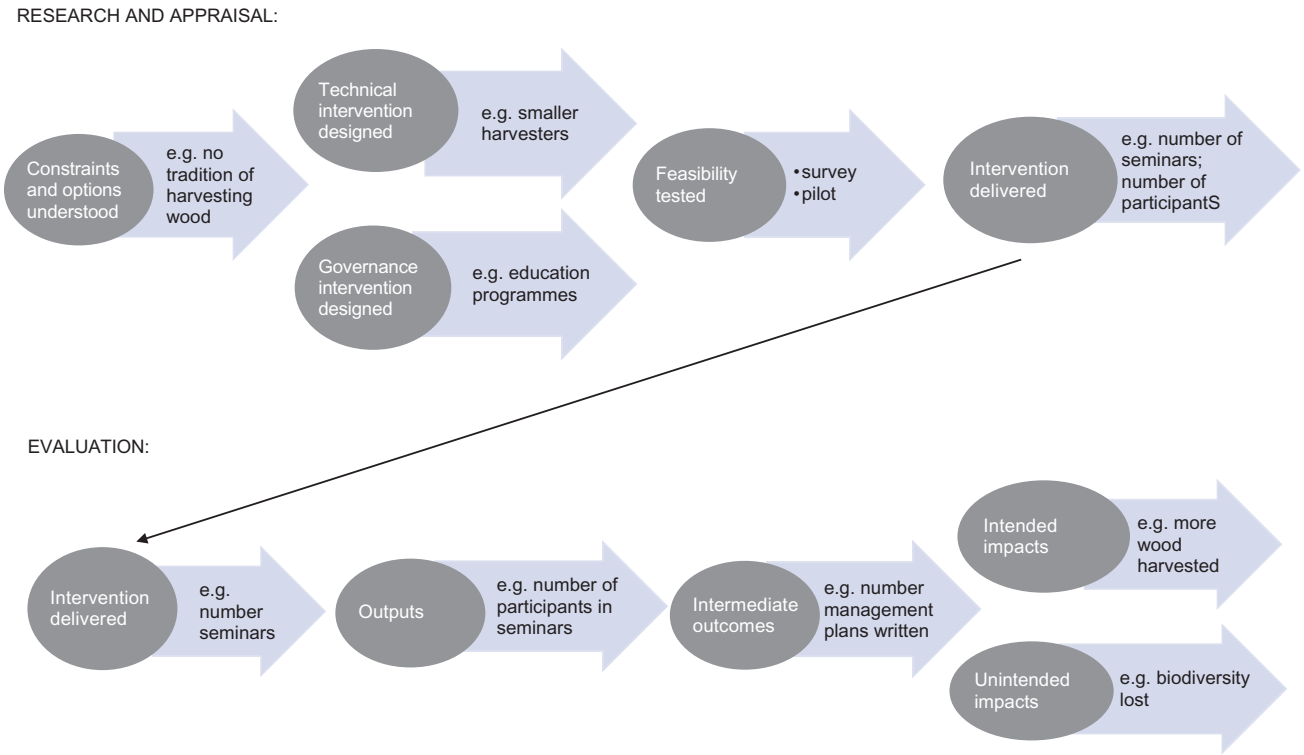

Figure 1 A diagrammatic representation of the process from problem identification to intervention to impact of intervention. Useful research can take place at each step, but evaluation can only be conducted after intervention.

Table 1 Framework used to analyse literature.

Code	Question	Examples
	Research	
1	Are stakeholders likely to harvest?	Data on owners' willingness to harvest or stated intention to harvest
2	Would they be likely to harvest if conditions changed?	Research on stated constraints or 'barriers' to harvesting. If described as a 'constraint', the implication is that removing this constraint would lead to more harvesting
3	What are stakeholders currently doing and why?	Factors *observed* to influence behaviour positively or negatively (in contrast to *stated* intentions). Includes studies that use hindsight to understand why different owners are currently managing forest in different ways
	Appraisal	
4	Is there a tested technology that would sustainably increase harvest?	Papers describing tools which could help owners or practitioners to harvest more; the term 'technology' includes management practices, and decision support tools and systems
5	Are stakeholders likely to adopt the proposed technology?	Papers assessing the suitability of technical changes in practice
6	Are there governance tools to encourage owners to increase harvest?	Papers describing governance interventions intended to motivate either adoption of technologies such as those described under (4), or other behaviour change
7	Are stakeholders likely to adopt the governance tool(s)?	Appraisals of governance interventions which assess the likelihood that they will influence the behaviour of owners and practitioners
	Evaluation	
A	Do stakeholders adopt the interventions?	An empirical assessment of how an intervention has been taken up; e.g. numbers attending trainings, or writing management plans or accepting financial incentives
B	Do stakeholders change willingness-to-harvest or stated intention to harvest?	Comparisons of owners' or managers' intentions before and after, or with and without the intervention
C	Do they change their harvesting behaviour?	Before-and-after or with-and-without comparisons which compare owners' or managers' actual harvesting actions
D	Is there a net increase in wood mobilized as a result?	Before-and-after or with-and-without comparisons which compare the amount of wood product harvested

analytical framework (Figure 1), it was necessary to 'cast a wide net'. The search began with an algorithm including combinations such as '(roundwood* AND harvest*) OR (timber AND mobilis*)' and 'timber AND incentive*', following trails to citations and similar papers, until no new relevant papers were identified. In effect almost all of the academic papers identified were published in English; a few were published in German or French, with English abstracts.

To keep the study focused and within manageable limits, eligibility criteria were applied to both academic papers and project reports. Only studies meeting the following criteria were included:

- the focus was on identifying and/or addressing constraints to increase mobilization of existing growth increment (i.e. the review excluded studies which aim to increase forest growth, for example by fertilization);
- the geographical focus was in temperate regions (in effect, Europe or North America);
- the document was published after 1999.

Method step 3: expert consultation and validation

Steps 1 and 2 were supported by the expert network that constituted the SIMWOOD project. Interviews with 12 SIMWOOD researchers helped to identify policies, programmes and reports, develop themes and check interpretation. Some of the reports are in German, French and Spanish and were assessed with a combination of online translation software, the author's partial knowledge of the languages and cross-checking with SIMWOOD colleagues who are native speakers. The issues summarized in the discussion also benefitted from the critical review by colleagues from other disciplines and national contexts.

Analysis

All eligible papers and reports were entered into an excel spreadsheet, which included relevant points from the abstract and conclusions of the paper, as well as methods used, sample size and region where the research was conducted. Each item was coded according to the framework (Table 1), as well as for country, type of publication and whether the harvest (where stated) referred to timber or biomass. Coding could include more than one code from Table 1; for example, a study which examined owners' attitudes to harvesting (coded 1) and also explored whether they would be like to adopt a particular intervention (such as incentives to prepare management plans) (coded 7) would be coded 17.

The coding allowed quantitative analysis based on overall distribution of documents and the themes addressed, and qualitative analysis based on the interpretation of themes identified within subsets of the literature. For example, the spreadsheet could be sorted on the coding to identify all of the papers that propose technical changes to allow increased harvest. The number of such papers was counted, and the papers themselves accessed to conduct thematic analysis. Thematic analysis is the most basic qualitative social research technique, which is independent of theory, and organizes qualitative and detailed data in a way that permits identification, analysing and reporting patterns; these in turn form the basis for discussing implications and further needs (Braun and Clarke, 2006).

Results

Overview of literature

Applying the criteria and framework set out above, from an initial list of more than 300 papers and 35 project reports, the final list included 115 peer-reviewed papers and 16 project evaluation reports as relevant and addressing at least one of the questions listed in Table 1. Of the 74 papers and reports, which specified a timber or biomass focus, 32 examined biomass – none before 2009; 36 examined timber and 6 examined both. This shift in focus is shown in Figure 2.

Overview of questions addressed by literature

Peer-reviewed papers and evaluation reports were coded and analysed separately, to compare the ways in which they contribute to each question in Table 1. The counts of papers and reports in each category are presented in Figure 3 as the proportion of each type of the literature addressing each type of question. This shows that the published scientific literature focuses to a large degree on description of forest owners' attitudes and current behaviour. While these also often provide suggestions about possible interventions, academically rigorous studies of interventions and their outcomes are generally lacking.

One-third of papers focused on 'willingness-to-harvest', while one-fifth looked at the influences on the current behaviour ('what are owners currently doing and why?'); a quarter examined potential technical interventions, but very few looked at their acceptability or adoptability, while one-fifth considered the likelihood that governance interventions such as grants or management plans would be adopted. Moving from appraisal to evaluation, only 3 per cent of peer-reviewed papers examined actual adoption, its effect on attitudes and behaviour; and none reported the effect on harvested volume.

Project evaluation reports, on the other hand, tend to focus more on the outcomes and less on the constraints being addressed. All of the reports assessed outcomes, although only half reported on whether those outcomes led eventually to wood mobilization.

Technical proposals

Twenty-nine papers and reports assessed technical changes which have the potential to increase harvesting (codes 4a and/or 4b); 27 were scientific papers and 2 were published post-project evaluations. Papers on technical options did not, on the whole, explicitly address a constraint but rather aimed to increase the harvest or reduce the cost. Table 2 summarizes these technical solutions and measures that were applied to assess their success.

Governance proposals

Twenty-five papers and reports considered governance tools (regulation, incentives and advisory services) which have the potential to increase harvesting (codes 6 and/or 7). These approaches were treated in a different way from technical interventions, by most papers. Usually, they were proposed as a result of considering the constraints to mobilization, and this is reflected in Table 3, which groups studies according to the type of governance intervention under consideration.

Factors associated with harvesting behaviour

Seventeen papers (coded 3) used a range of methods to understand which factors are associated with current patterns of harvesting behaviour. Many of these were based on large datasets collected through national surveys and explored correlations between behaviour or intention, and owner characteristics as well as

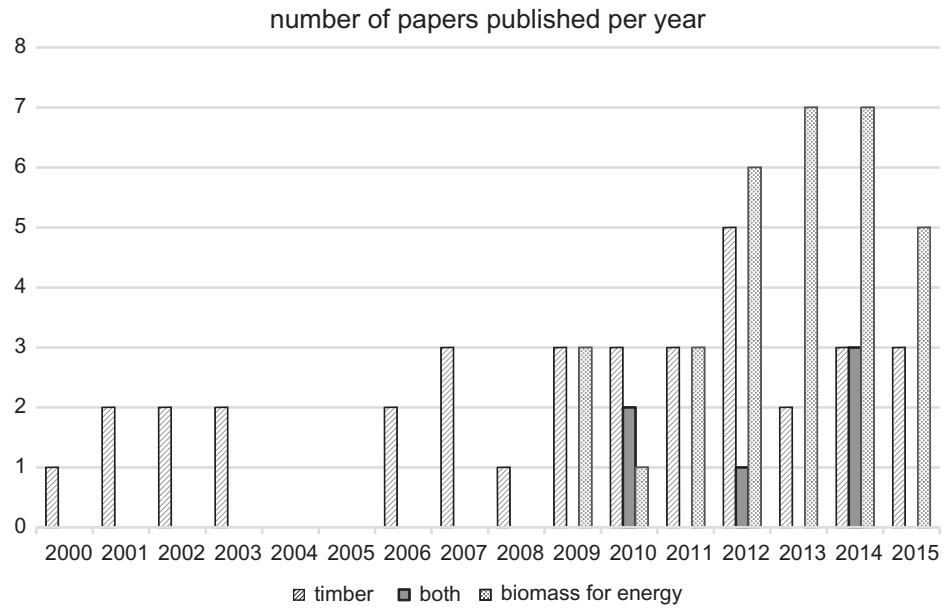

Figure 2 Number of selected relevant scientific publications per year focusing on mobilization of timber or biomass (energy) harvest (based on total dataset of 115 peer-reviewed papers).

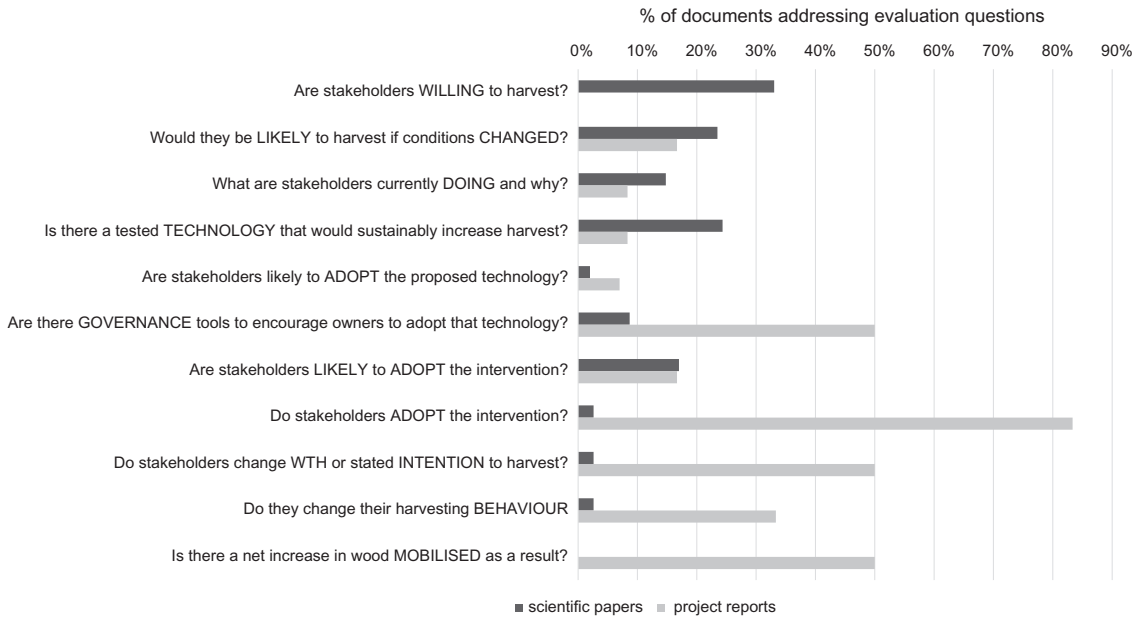

Figure 3 Share of papers and reports for each addressed question in the literature survey. Note each paper could be coded as answering more than one question. Data expressed as per cent of 115 papers addressing the question; or per cent of 12 reports addressing the question.

Table 2 Technical interventions proposed to increase volume of wood harvested.

Technical measure	Measures of success (sometimes implicit rather than described in paper)	Study
Improved harvest recovery through utilising more of the tree	• Volume removed or potentially removed • Nutrient removal	Mansuy *et al.* (2015), FOREST EUROPE (2010), Helmisaari *et al.* (2014), Chesnel and Hincelin (2011), Bergseng *et al.* (2013), Egnell and Ulvcrona (2015) and Eisenbies *et al.* (2009)
Improved harvest recovery through different harvesting methods	• Volume of residues remaining • Additional volume removed	Hytönen and Moilanen (2014), Egnell and Ulvcrona (2015) and Danilović *et al.* (2014)
Silvicultural treatments, e.g. thinning, regeneration cut, coppicing	• Ergonomics: working times, productivity • Energy balance: inputs, greenhouse gas emissions • Economics: costs and sales • Volume potentially removed	Vusić *et al.* (2013), FOREST EUROPE (2010), Petty and Kärhä (2011), Chesnel and Hincelin (2011) and Schweier *et al.* (2015)
Chipping/biomass harvesting	• Economics: costs and sales • Additional volume harvested (over existing timber harvest)	Jylhä *et al.* (2015), PROFORBIOMED (2014) and Kärkkäinen *et al.* (2014)
Tree planting	• Volume potentially removed	Chesnel and Hincelin (2011)
Accessing formerly inaccessible sites (cable logging; road construction)	• Unit costs; comparison with other products • Volume • Potential uptake	Devlin and Klvač (2014), Spinelli *et al.* (2014b) and Department of Agriculture Fisheries and Food (2010)
Improved safety (harvesters *vs* motor manual)	• Interest level of contractors • Costs	Ferrari *et al.* (2012)
Reducing costs of harvesting (mechanized small-scale feller bunchers; harvesters)	• Costs, productivity; comparison between countries • Damage • Acceptability of the technology	Schweier *et al.* (2015), Spinelli and Magagnotti (2011) and Valente *et al.* (2014)
Decision support	• Accuracy of volume assessment	Zambelli *et al.* (2012) and Rørstad *et al.* (2010)
Location of technology (e.g. chipper in forest or at roadside)	• Cost • Fuel consumption	Spinelli *et al.* (2014a)

inputs such as advice and markets. These studies are summarized in Table 4. All the studies have analysed indicators of current harvesting or management behaviour based on either owners' reported decisions or measured volumes of harvested wood or standing volume.

Table 4 aggregates findings, based on a wide range of indicators, at a high level of generalisation, so caution should be used in interpretation. For example, no distinction is made in the table between studies based on frequency of harvest, and those

Table 3 Governance interventions proposed to increase volume of wood harvested.

Governance instrument	Proposed measures of success (sometimes implicit – not always described in paper)	Study
Incentives		
Financial incentives for particular silvicultural systems	• Stated preference for harvesting scenario	Gruchy *et al.* (2012)
Subsidies for forest road construction	• Area harvested • Value of thinnings • Value of clearfell	Department of Agriculture Fisheries and Food (2010)
Transport subsidies	• Cost of energy transport	Devlin and Talbot (2014)
Subsidies for wood-chipping	• Profitability of whole-tree chip production	Petty and Kärhä (2011)
Information		
Information especially through social media	• Active forest management by small scale owners	Huber *et al.* (2013)
Extension services	• Stated intention to harvest • Stated intention to market timber • Stated intention to thin • Correct silvicultural decisions	Ní Dhubháin *et al.* (2010)
Awareness raising	• Awareness of market opportunities • Volume of residue available after wood processing • Willingness to adopt certification schemes • Willingness to harvest and sell energy wood	Joshi *et al.* (2014), Halder *et al.* (2012)
Advisory programmes tailored to specific groups	• Participation in bioenergy markets	Galik (2015)
Voluntary forest management programmes	• Stated interest in participating in programme • Enrolment/participation in programme • Obtaining and using a forest management plan • Trust in experts and organizations	Kilgore *et al.* (2008), Lind-Riehl *et al.* (2015)
Linking national and EU rural development schemes	• Adoption of silvicultural system	Elyakime and Cabanettes (2013)
Organizations and structures		
Stakeholder engagement with policymakers (e.g. intersectoral panel)	• Stakeholder buy-in and approval • Political support	Junta de Castilla y León (2014), Sergent (2014)
Organization of private forest owners	• Establishment of private forest owner associations • Stated interest in membership of forest owner association • Membership of forest owner association • Diversity of membership	Milijic *et al.* (2010), Põllumäe *et al.* (2014), Rauch (2007)
Support to machinery rings	• Cooperation between forest owners and machinery rings	Pezdevšek *et al.* (2012)
Cooperation among individuals and groups	• Supply of wood to energy markets • Adoption of forest management programs • Willingness to enter into cooperative behaviour with adjacent landowners	Plieninger *et al.* (2009), Stevens *et al.* (1999), Vokoun *et al.* (2010)
Organization of contractors	• Cost of harvesting • Costs paid by owner	Spinelli and Magagnotti (2011)
Regulation		
Regulation; financial incentives	• Public support for policy tools • Public support for timber harvesting	Schaaf and Broussard (2006)
Certification	• Costs of forest management and harvesting	Sikkema *et al.* (2014)

Table 4 Factors associated with current harvesting behaviour.

Factor	Relationship between factor and harvesting behaviour (summarized)	Study
Characteristics of land tenure		
Size of holding	Owners of smaller holdings are less likely to harvest	Conway *et al.* (2003), Elyakime and Cabanettes (2009), Bolkesjø *et al.* (2007), Kuuluvainen *et al.* (2014), Rodríguez-Vicente and Marey-Pérez (2009), Munn *et al.* (2002), Størdal *et al.* (2008), Young *et al.* (2015) and Poje *et al.* (2016)
	Owners of larger holdings are less likely to harvest	Vokoun *et al.* (2006)
	Smaller holdings harvested more seasonally	Koch *et al.* (2013)
Length of ownership	Hereditary landowner less likely to harvest than first time (new) landowner	Favada *et al.* (2007)
	Longer term owners more likely to harvest than new owners	Vokoun *et al.* (2006)
	First-time (new) landowner more likely to harvest than hereditary landowner	Kuuluvainen *et al.* (2014)
	Longer term residents more likely to harvest than more recent residents	Young *et al.* (2015)
Number of co-owners	Lower harvest associated with higher numbers of co-owners	Poje *et al.* (2016)
Absenteeism	Absentee owners are less likely to harvest	Conway *et al.* (2003) and Vokoun *et al.* (2006)
Characteristics of forest owner		
Owner's age	Older owners less likely to harvest	Bolkesjo and Baardsen (2002), Favada *et al.* (2007), Shigematsu and Sato (2013) and Poje *et al.* (2016)
	Older owners more likely to harvest	Conway *et al.* (2003)
	Middle-aged owners more likely to harvest than younger or older owners	Rodríguez-Vicente and Marey-Pérez (2009)
	No effect of age	Kuuluvainen *et al.* (2014)
Owner's gender	Women forest owners harvest less than men	Kuuluvainen *et al.* (2014)
	No effect of gender	Brough *et al.* (2013)
Owner's occupation	Farmers more likely to harvest than non-farmers	Favada *et al.* (2007) and Rodríguez-Vicente and Marey-Pérez (2009)
	Retired more likely to harvest than self-employed	Rodríguez-Vicente and Marey-Pérez (2009)
Owners' non-timber activities	Owners interested in non-timber activities are less likely to harvest	Conway *et al.* (2003)
Owners' finances (income and debt)	Owners with more (non-forestry or non-agricultural) income are less likely to harvest	Conway *et al.* (2003), Kuuluvainen *et al.* (2014), Størdal *et al.* (2008) and Shigematsu and Sato (2013)
	Owners with higher income are more likely to harvest	Favada *et al.* (2007)
	Owners with higher *agricultural* income are more likely to harvest	Størdal *et al.* (2008)
	Owners with greater need for income are more likely to harvest	Young *et al.* (2015)
	Owners with higher debt: income ratio are more likely to harvest	Conway *et al.* (2003), Størdal *et al.* (2008) and Shigematsu and Sato (2013)
Economics of harvesting		
Price	More harvest when prices increase	Bolkesjo and Baardsen (2002), Conway *et al.* (2003) and Susaeta *et al.* (2012)
	Diminishing response to price in larger properties	Bolkesjø *et al.* (2007)
	Higher prices result in shorter rotations, lower total volume harvested	Favada *et al.* (2007)
	Price had little influence on decision to sell firewood	Favada *et al.* (2007) and Bohlin and Roos (2002)

Continued

Table 4 *Continued*

Factor	Relationship between factor and harvesting behaviour (summarized)	Study
Perceptions of the timber harvest cost	Less harvest with higher or replanting harvesting costs	Bolkesjo and Baardsen (2002) and Knoot and Rickenbach (2011)
Tax rates	Less harvest with higher taxes on timber revenue	Bolkesjo and Baardsen (2002)
Site characteristics		
Access	Higher harvests are associated with areas with less steep terrain	Shigematsu and Sato (2013) and Poje *et al.* (2016)
	Higher harvests are associated with denser forest road network	Shigematsu and Sato (2013)
	More accessible areas more likely to be harvested	Poje *et al.* (2016)
Standing stock	Higher harvests associated with higher standing stock	Bolkesjo and Baardsen (2002) and Favada *et al.* (2007)
	Forest with higher proportion of conifers more likely to be harvested; areas with more growing stock more likely to be harvested	Poje *et al.* (2016)
Urbanization	Forests closer to cities, and those in areas of highest population density, are less likely to be harvested	Munn *et al.* (2002) and Vokoun *et al.* (2006)
Engagement		
Existence of forest management plan	Owners with a management plan are more likely to harvest	Størdal *et al.* (2008) and Young *et al.* (2015)
Landowner networks	Those with social networks which include forestry professionals are 'less' likely to harvest	Knoot and Rickenbach (2014)
	Those with social networks which include forest management are 'more' likely to harvest	Ruseva *et al.* (2014)
	Members of forestry associations are more likely to harvest	Rodríguez-Vicente and Marey-Pérez (2009)
	Those with more social contacts are more likely to harvest; but number of professional contacts has no association with harvesting behaviour	Brough *et al.* (2013)

based on harvested volume, unless the source indicated that the two indicators are associated with different factors. Several of the studies indicate that factors are interrelated; for example age is linked to need (or otherwise) for income. Context is also important; some results are linked to particular extension or incentive programmes, and in some countries size of holding is correlated with lifestyle choices whereas in others it is an outcome of recent history (Weiss *et al.*, 2018).

With these provisos, the analysis in Table 4 highlights some important points. First, characteristics of the owner and land tenure are often associated with harvest levels: in particular age, income, length of ownership and area owned. In contrast, price and fiscal incentives are less often found to influence harvest. Second, some of the most common factors contribute to harvesting decisions in different ways in different contexts. For example, in most cases, older owners are found to be less likely to harvest, but in one study from the US, older owners were more likely to harvest (Conway *et al.*, 2003), while in northern Spain, middle-aged owners were found to be more likely to harvest than younger or older owners (Rodríguez-Vicente and Marey-Pérez, 2009).

Interventions where outcomes are evaluated

The aim of this review was to examine approaches to evaluating wood mobilization projects. The previous sections analyse steps along this pathway, but only 25 papers and reports, representing 17 projects and programmes, described and evaluated the outcomes and/or impacts of interventions (codes A, B, C or D).

Most of these interventions are analysed in reports (published and otherwise) rather than scientific literature. The interventions are more complex than those proposed in models or analyses of factors contributing to harvesting behaviour. Most of them combine technical innovations with advice, financial incentives or support for organization. Some combine woodland management with wider rural development objectives. Furthermore, not all explicitly aim to increase wood harvests; many aim to bring more woodland into management, with an implicit impact on wood harvest.

In order to summarize this diversity, the projects were analysed according to aims and outcomes or impacts. Five main groups of (desired) outcomes were identified and related to the process summarized in Figure 1. Of these, four are intermediary

goals (organization; outreach or engagement; forest management and market stimulation) and only one group of goals includes indicators of increased harvesting.

These 25 reports were analysed qualitatively to summarize their approach to (1) measuring and reporting outcomes, and (2) factors contributing to those outcomes. A synthesis across projects is presented below, under two key themes – the way in which outcomes are measured and reported and the factors contributing to those outcomes.

A more detailed analysis of the 17 projects, separated according to the goals of the project or programmes (e.g. advice and engagement; forest management; harvest and markets) can be found in Supplementary data Table S1. This Supplementary data table provides the core findings of this review, and the reader who is interested in practical improvements to wood mobilization, and impact assessment, will find examples of interventions, outcomes and indicators.

Measuring and reporting outcomes

- In most of the evaluation reports, the project goals were reached, but often to a lesser degree than had been initially planned.
- Many of the project goals, and outcomes achieved, included direct or indirect indicators of wood mobilization. Descriptions of quantitative impact of interventions on wood harvest volume were elusive; however, no academic paper reported this, and only half of the evaluation reports did so. Three projects report no change in wood volume harvest (Wippel and Becker, 2008; Department of Agriculture Fisheries and Food, 2010; Chabé-Ferret and Sergent, 2012). Some studies do not compare the harvested volume with a baseline, making it difficult to attribute the harvest to the intervention. Others implied but did not demonstrate an increase in mobilization, through indirect indicators such as number of felling licences or the stated intention to harvest (Butler *et al.*, 2014; Raitila *et al.*, 2012).
- Goals and outcomes more typically consist of intermediate steps, such as the development of management plans, or building links between producers and markets. Six projects reported an increase in forest area or number of owners with management plans, or receiving forest management grants. Three reported an increase in bioenergy capacity or plants in construction.
- These intermediate steps were supported in most projects by outcomes and indicators related to outreach and engagement. Eight of the 17 projects supported organization of owners and included indicators such as number of clusters, collaboration groups, platforms, forestry clubs, 'chartes forestières de territoire' (regional forestry charters) formed; increased membership of existing owner associations and area of land consolidated. Only four reported levels of engagement with advisory services or extension; these were mainly treated as project outputs, with indicators which included hours of consultancy; and numbers of workshops delivered.
- A range of 'other' indicators demonstrated wider impacts. For example, the Forest Futures Project evaluation provided evidence that quality of life had improved for rural families, farm businesses had diversified, and environmentally undesirable outcomes had been avoided (PACEC, 2006a).

Factors contributing to outcomes

The most common issues identified by a qualitative analysis of the evaluation reports are as follows:

- Context: solutions must be tailored to contextual conditions (Wippel, 2006; Selter *et al.*, 2013; Raitila *et al.*, 2014). In Germany, different approaches were developed according to the preferences of forest owners in different regions (Wippel and Becker, 2008). To achieve increased wood harvesting, new organizational structures were required. In former West Germany, this was achieved through completely new structures, described as 'forestry clubs' which took over control of use and marketing of wood from the private forest. In contrast, in former East Germany, a less structured, voluntary organization (the more traditional 'forest enterprise community') was preferred (Wippel and Becker, 2008).
- Role of technology: interventions are not based on technology alone. Some include programmes to communicate and incentivize adoption of technology (e.g. Department of Agriculture Fisheries and Food, 2010; Raitila *et al.*, 2012). In other cases, no technical innovation was involved; instead, the programme promoted access to existing technology and changing practices such as management plans and marketing procedures (e.g. Hamilton, 2016; Butler *et al.*, 2014).
- Rural development: several successful projects treated wood mobilization as one strand in rural development projects or bioenergy sector support programmes (PACEC, 2006a; 2006b; ElPlieninger *et al.*, 2009; yakime and Cabanettes, 2013), particularly in countries with lower forest cover (England, Ireland, parts of France). These projects see wood mobilization as one (eventual) outcome of support for business development, bioenergy market development and networking amongst stakeholders (Raitila *et al.*, 2014; Ní Dhubháin and Greene, 2009; Howley, 2013).
- Forestry culture: a number of evaluations reported that the professional culture of forestry can inhibit success. A wide-ranging study in Germany reported lack of direct engagement and contracts between owners and local forest authorities, and also that gender stereotypes among foresters can hamper effective engagement because many small woodland owners are women (Wippel, 2011). While experts recommended joint forest management in parts of Germany, progress was stalled because the foresters were unhappy with the impact on their roles (Wippel and Becker, 2008). Ways to bridge culture gaps between professionals, government and owners included supporting local NGOs or forest owners' associations to provide advice and technical support and to mediate across different cultures (Raitila *et al.*, 2012).
- Involvement of a wider range of stakeholders: Two French evaluations found that [logging] contractors were seldom included, and that owner cooperatives were also sometimes left out of local mobilization partnerships (Chabé-Ferret and Sergent, 2012; DRAAF *et al.*, 2015). A German evaluation

highlighted the need to address concerns of the public, foresters, officials, and private and municipal forest owners, in relation to increased wood harvest (Becker Borchers Wippel, 2006). Another French project concluded that political support is more important than financial support in empowering regional forestry plans (Contrechamp, 2009).

- Organizations, clusters and platforms: these are widely seen as factors helping to reduce transaction costs as well as bridge culture gaps. In Central Europe, traditional models are being revisited, for example properties are being 'bundled' to provide advice more efficiently (Wippel, 2011). In Germany 'thousands of small local groups' are being encouraged to form associations of groups (U.Kies,pers.comm). An EU-funded project supported the formation of 'clusters' of forest owners and entrepreneurs, and concluded that they could 'effectively reduce overhead costs, open new markets and allow forestry works to be undertaken cost effectively' (Raitila *et al.*, 2012). In Scotland a pre-existing machinery ring was able to use strong existing levels of trust to group farmers who owned small woodlands in the same area, to reduce the costs of harvesting (Hamilton, 2016). In England, some regional projects described the use of intermediary NGOs as 'Excellent outreach into a section that we don't usually engage with' (Resources for Change, 2013).
- Processes of engagement: In addition to the choice of actors and organizational modes for bringing them together, success depends on the way in which a project is delivered. Project evaluations highlighted difficulties when roles and relationships were unclear, and goals were not communicated (Selter *et al.*, 2009). Strong professional interactions, and a strong continuous process, supported the exchange visits which led to profound change in Castille and Leon's forest policy (Junta de Castilla y León, 2014). A review of interventions in England found that success relies on plenty of one-to-one interaction between agent and forest owner, good local knowledge of conditions and contacts, and medium-to-long-term continuity (Molteno and Lawrence, 2013). And a review from Germany highlights the importance of repeated participation, information management, and inclusive networking (Schmid *et al.*, 2016). An evaluation of a pilot project in Auvergne, France concluded that the facilitation and animation processes were the most significant factor contributing to success (DRAAF *et al.*, 2015).
- Study tours and demonstrations: several evaluations highlighted the value of regional study tours, and 'seeing is believing' (Raitila *et al.*, 2012, 2014).
- Funding: funds are needed to support change, to set up new ways of working (Hart, 2013), for piloting new organizations (Wippel and Becker, 2008) and for financial incentives to the forest owners. 'Generous grant rates' were considered to contribute to success in the Irish Forest Road Scheme (Department of Agriculture Fisheries and Food, 2010). A pilot project in Austria concluded that further expansion would require 'high financial support' to increase harvesting by small owners (waldwissen.net, 2016). In England, allocation of grants (for woodland management) were seen as the successful outcome of programmes, and often treated as an integral part of projects including advisory services and other outreach tools (Hart, 2013). Tax incentives are commonly included in the suite of forest management tools in the US but are accompanied by advice and educational materials, so it is not always easy to separate the influence of the different components (see e.g. Butler *et al.*, 2014).
- Time and flexibility: some noted the need for time to build trust, momentum and confidence (Wippel, 2011; Raitila *et al.*, 2014). Others noted that time allowed the project to adapt to circumstances. For example, a project in south-west England initially focused on increasing woodland cover to stimulate the forest industry but later shifted to promote wider rural development aims, such as promotion of recreation, tourism and associated small businesses. This shift was considered to be the key to success by its evaluators (PACEC, 2006b).

Discussion

This study aimed to assess the effectiveness of interventions intended to increase wood harvests from private forests, and the factors contributing to success. It has shown that there is little evidence which demonstrates conclusively that a particular intervention has successfully increased wood mobilization. This is for a number of reasons: the pronounced focus of the published literature on studies of constraints rather than evaluations of real interventions; the complexity and context specificity of real interventions; the scarcity of evaluations which provide direct evidence of increased timber or biomass harvests and the lack of such evidence in the peer-reviewed scientific literature. Nevertheless, the evidence does show that increased wood harvests are possible. This section discusses what the evidence tells us about the design, content and evaluation of wood mobilization interventions, under six key themes.

Logical steps involved in changing behaviour to increase wood harvests

As set out in the Methods section, the analysis presented in this paper is based on a deconstruction of the logical process underlying successful wood mobilization. It proposes that interventions are linked to an identified constraint and the adoption of measures which lead to behaviour change which in turn lead to increased wood harvesting. This logic is set out in the steps shown in Figure 1. The review shows great differences in the amount and findings of research at each step and missing links between the stages. This has implications for both practice and research.

An implication for practical design of programmes to increase wood harvesting is that each needs to follow the logic of its context and therefore be designed in a local and participatory way. As discussed in the following, forest harvesting is a personally and culturally shaped practice, which leads to difficulties around transferring solutions from one context to another (Rauch *et al.*, 2015; Valente *et al.*, 2014; Wippel and Becker, 2008).

A bottom-up approach to design programmes together with stakeholders (public, foresters, official and owners) to address problems specific to the local environment is a characteristic of

every one of the 17 projects which evaluate outcomes. The Forest Product Mobilisation Programme of Castile and León in Spain is a good example (Junta de Castilla y León, 2014). The programme, and the measures contained in the programme, are based on a careful and inclusive process, where the experience of stakeholders helped to choose the interventions that could really make a change.

An implication for research is that more needs to be done to test the assumptions made in the model. In particular,

- Is there a link between 'willingness-to-harvest' and actual harvest? A rigorous test would require close collaboration with policy departments and the formulation of new policy programmes.
- Is there a link between improved technology and adoption of technology? The language of 'adoption' is more familiar in the discourse of development agendas in economically poorer countries (Lee, 2005), but the same principles apply everywhere: when technology is developed without consideration of its acceptability to users, or usability in a given context, it may well fail. More participatory approaches to technology development, which build in stakeholder involvement, are more likely to produce solutions that will be adopted by forest owners (Sharma and Henriques, 2005; Klenk and Wyatt, 2015; Koukios *et al.*, 2018).
- Is there a link between having a management plan and taking management actions? This link has been tested in a few cases (e.g. Germain *et al.*, 2014), mostly in the US. Programmes to support forest owners to prepare management plans can sometimes, but not always, increase the number of management activities implemented but this area needs more exploration.
- Is there a link between forest owners joining programmes offering coordinated management, or forest owners' associations, and change in behaviour leading to wood mobilization? Some studies show that membership of owner organizations is associated with more engagement in forest management activities (e.g. Rickenbach, 2009) but this could simply reflect a tendency for more active owners join owner organizations (Rauch, 2007).

Defining success

Evaluation requires a clear definition of 'success'. The questions raised in the previous section highlight the need to separate indicators of adoption of measures, from indicators of wood mobilization. Adoption of a measure is not the same as changed harvesting behaviour, but it is an essential step on the way and can be an indicator of potential harvest increase.

The review shows a marked contrast between indicators of success, in appraisals of technology and in evaluations of real interventions. Many assessments of the suitability of technical interventions propose timber volume (or similar) as an indicator of impact (see Table 2). In contrast, those which propose governance interventions focus more on intermediary outcomes (adoption of management plans, changed levels of interest in harvesting or managing) (see Table 3), while few evaluations of actual interventions have measured effect on wood harvest.

In designing evaluation of interventions, the choice of indicators, and the assumptions made about the links between indicators and the desired impact in natural resource management, is challenging (Conley and Moote, 2003). One meta-study of 123 cases found limited association between the stated objective of an intervention and its success (Agrawal *et al.*, 2014). Another, which looked at the relationship between innovation networks (resulting from policy interventions) and climate change adaptation, found that practitioners' satisfaction was higher than success in terms of learning effects, in turn higher than success in terms of implementation capacity (Schmid *et al.*, 2016). Another study found that past harvesting behaviour is not a guide to future harvesting behaviour (Kuipers *et al.*, 2013). Thus, we can infer that projects reporting high levels of participation and satisfaction do not necessarily provide evidence of implementation.

In addition to considering outcomes as intermediate stepping stones towards wood mobilization, evaluations show additional outcomes. Some of these are considered desirable, others not. There are tensions between different objectives of harvesting; the increase in attention to biomass can conflict with timber production (Kärkkäinen *et al.*, 2014). Several examples could not demonstrate net increase in wood mobilization, as it was not clear that increased biomass supply was not to the detriment of timber supply (Plieninger *et al.*, 2009; Devlin and Talbot, 2014). And there are trade-offs between harvesting and ecosystem services such as carbon sequestration, landscape aesthetics or soil protection through return of residues (Depro *et al.*, 2008; Peters *et al.*, 2015; Frank et al., 2015; Barrett *et al.*, 2016).

Features of successful approaches

The 17 intervention programmes which had been evaluated, together with some of the studies included in Table 4, provide insights into approaches which can bring about change in attitude and intentions, engagement, forest management and ultimately wood harvesting.

These interventions have a number of features in common. They all combine multiple approaches, in that they offer more than a single incentive, or a single technology. Instead, they combine technical and governance measures; and they often have a wider, more integrated focus than just 'wood mobilization'. The appropriate mix of features will depend on the situation and must be designed with an understanding of the particular constraints, regulatory environment and cultural setting.

For example, they may be rural development programmes or forest industry support programmes. Some combine motivation of owners, with development of markets, or analysis and support to forest services, and business skills (PACEC, 2006a; Wippel, 2011; Chabé-Ferret and Sergent, 2012; Selter *et al.*, 2013). Others focus on a wider range of stakeholders including state forestry advisers and harvesting contractors (Wippel and Becker, 2008; Munsell et al., 2011; Shivan and Potter-Witter, 2011; Sergent, 2014).

Successful interventions mix regulation, incentives and advice, in ways that contrast with the simple typologies used in academic analysis (Weiss, 2000; Appelstrand, 2012). In many of the evaluated interventions, regulation is a part of the mix. For example, the UK examples support landowners who are

unfamiliar with the regulatory process, in obtaining felling licences – they do not remove the need for felling licences (Hamilton, 2016; Raitila *et al.*, 2012).

Wood harvesting is a social issue

A growing number of studies show that money is not the only, or even the main, motivator for forest owners' behaviour (Blennow *et al.*, 2014). Personal, social and cultural factors are often more persuasive than economic incentives (Domínguez and Shannon, 2011; Lawrence and Dandy, 2014; Stevens *et al.*, 1999). These social studies are supported by econometric ones; in a major review, Beach *et al.* (2005) find that non-industrial private landowners are 'less responsive to market signals' than is often expected.

This is not to say that price is not influential, but rather that other factors can be more influential. Younger owners, those with larger holdings, new owners, male owners, those who need income, social networks: all these factors are often, but not always, associated with higher harvest levels.

The diversity of these findings is important. It shows that social factors need to be understood on a case-by-case basis. Wood mobilization programmes (or the rural development programmes of which they form part) will then need to decide: who should change agents (extension workers, advisers and consultants) target and work with? Should incentives be designed specifically for the unengaged or the less likely to harvest? An evaluation of heartwoods in England concluded that the most significant achievement was reaching out to woodland owners that other organizations had not been able to engage, in particular farmers (Resources for Change, 2013). Innovative approaches to work with the new urban generation of owners in Finland are achieving new levels of engagement, if not yet increased wood harvest (Hokajärvi *et al.*, 2011). Technical intervention may be more important in Baltic countries where owners are already motivated or organized (Asikainen and Routa, 2014); associations may be more important in areas with small fragmented forests; but even similar countries have different institutional structures, financial processes or cultures of contractors (Spinelli *et al.*, 2015).

Organization is a significant component of approaches to wood mobilization

The multifaceted approach and the social dimensions of the wood mobilization challenge are reflected most strongly in the range of approaches which address organization.

There are two distinct trends in the development of organizational modes. In more forested countries, where ownership is becoming fragmented and urbanized, the traditional functions of forest owner associations are evolving to encourage membership of owners who live far from their forests, often employing forest advisory and management professionals on behalf of absent owners (Sarvašová *et al.*, 2015; Kronholm, 2016; Weiss *et al.*, 2018). In less forested countries, without traditions of forest owner associations, innovation focuses on new platforms to reach more owners. Thus, new types of associations are emerging to suit changing ownership, e.g. forest clubs in north-west Germany, associations of owners for joint management in southern Germany or new owners following post-socialist privatization (Selter *et al.*, 2013; Põllumäe *et al.*, 2014). Other innovative forms of organization include platforms where timber and biomass buyers can engage with small-scale owners and achieve economies of scale (Kooperationsabkommen Forst Holz Papier, 2011), or where forest management consultants and contractors can work with multiple small owners (PACEC, 2006a; Hart, 2013; Hamilton, 2016). Proactive formation of forest owner groups can stimulate learning and networking (Kueper et al., 2013; Raitila et al., 2014; Ruseva *et al.*, 2014; Bonsu et al., 2017). These forms of organization link into changes in forestry extension, addressed in the next section.

The way in which interventions are delivered is important

The evaluations of real interventions provide insights into process, in particular the design and content of interactions between forest owners and change agents such as NGOs, forest owner associations, consultants and extension officers. Trust, social networks and peer-to-peer sharing of experience are some features of successful approaches, while cultural rigidity and professional distance are features of less successful and more cumbersome approaches.

This aspect of mobilization interventions can benefit from another growing body of literature, on forestry extension and advisory services. Conventionally, forestry education and outreach activities have focused on transfer of knowledge, from professionals who aim to teach landowners about forest management and conservation (Ma *et al.*, 2012).

Recent decades have seen a shift towards more inclusive approaches (Johnson *et al.*, 2006; Böcher, 2012; Kueper *et al.*, 2012; Vangansbeke *et al.*, 2015; Lindahl *et al.*, 2017) accompanied by diversification and privatization of advisory sources (Lawrence *et al.*, 2016) and a focus on networks, peer-to-peer learning and knowledge exchange (Korhonen *et al.*, 2012; Kueper *et al.*, 2012; Fazey *et al.*, 2014; Lind-Riehl *et al.*, 2015). Some work focuses on the particular relationships between advisor and forest owner (Schraml, 2006; Gootee et al., 2010). These developments, and analyses, can also contribute to the agenda of wood mobilization, and there is more work to be done here to understand the value of good advisory support, which can bring about change without the necessity of expensive funding or technology development.

For many mobilization programmes, the challenge is not just to reach owners, but to reach particular owners. Research has shown that owners who adopt programme goals and management plans are those who were already predisposed to manage their forests and harvest timber (Shockley and Martin, 2000; Butler *et al.*, 2014; VanBrakle et al., 2013; Butler et al., 2014). If some owners are already predisposed, they may be rewarding targets; or resources might be more efficiently targeted to those who are not yet engaged.

Conclusions

Successful interventions to increase the harvest of timber and biomass from forests require behaviour change. Forest owners, managers and contractors must not only think or plan in ways different from before, they must take action which results in

larger volumes of wood being harvested. That action may require a change in attitude or intention; or it may require the removal of physical or financial barriers. But in all cases, there will be connections between stakeholders' attitudes, beliefs, intentions and actions; there will also be connections between constraints (whether social, cultural, institutional, economic or physical) and the design of interventions to overcome them. Finally, there will be connections between adoption of interventions, increased harvesting and wider impacts.

These linkages are not clearly set out in scientific peer-reviewed literature, nor are they always explicit in project evaluation reports. So, while there is evidence that some interventions can and do lead to the harvest of more wood from privately owned forests, most studies fall short of making that assessment, and of understanding why an intervention does or does not work.

Most of the published scientific literature focuses on owners' willingness to harvest and perceived constraints. This is an understandably appealing and accessible topic of research, but the findings of this review highlight a need to apply academic rigour to more challenging questions: the processes whereby interventions are designed and adapted to context, and how or why they eventually lead to a change in wood harvested. Scientific papers on silvicultural interventions, and harvesting innovations, are also relatively abundant, but to contribute real value, researchers must not only reflect on the possibility of adoption, but test whether such innovations are adopted, and do make a difference. Furthermore, mobilization needs interaction with forest managers, contractors and buyers, from the public and private sectors.

One way to address this is through more methodologically innovative studies which can compare 'before-and-after' or 'with-and-without-intervention' harvests. Another is through more mixed methods approaches which include qualitative social research. We can look to the wider literature on 'behaviour change' for examples, and find an emphasis on the need not only to measure change but to understand 'why' a strategy was (un)successful (Steg and Vlek, 2009). Work on 'cumulative impacts' acknowledges how social impacts differ from other types of impacts, owing to the role of human interpretation in determining how individuals experience interventions (Loxton *et al*., 2013). Both of these areas point to the need to include qualitative social research in evaluations of wood mobilization. Quantitative approaches can include proxy indicators (such as standing stock on properties with and without management plans; numbers of felling licences approved and income from timber); and adoption of intermediate steps, such as number of management plans, membership of associations or numbers participating in programmes.

It is important to test, however, whether these proxy indicators do represent harvest behaviour and whether these intermediate steps do lead to change in practice. Because most of those documents which evaluate success (whether intermediate or final) are project reports, much relevant work remains unpublished, and there is an urgent need to see academic rigour applied to testing and disseminating lessons from these complex innovations.

Meanwhile, the evidence from this review is that cases where real change is happening have two features in common. They are often multifaceted projects, where a mixture of tools provide support to producers, to harvesters and to markets, sometimes in the wider context of rural livelihoods. Linked to this, they show that social and biological contexts are highly specific to regions. Land ownership structures, traditions of associating, trust relations with state and commercial forestry, and public attitudes to forest management and renewable energy, all affect wood mobilization, and the most effective solutions are developed and tailored to local social and political conditions as well as environmental and economic.

Supplementary data

Supplementary data are available at *Forestry* online.

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