McKenzie A, Emery S, Franks J, Whittingham M. Landscape-scale conservation: collaborative agri-environment schemes could benefit both biodiversity and eccosystem services, but will farmers be willing to participate? ***Journal of Applied Ecology*** **2013, 50(5), 1274-1280.**

Collaborative agri-environment schemes could benefit both biodiversity and ecosystem service provision but will farmers be willing to participate?

Ailsa J. McKenzie, Steven B. Emery, Jeremy R. Franks & Mark J. Whittingham.

Summary

~~A large body of evidence now supports the inclusion of spatial scale in the design of agri-environment schemes (AES).~~ The primary aim of many agri-environment schemes (AESs) is to enhance biodiversity and they are, almost exclusively, administered at a ~~Most currently active AES operate at~~ farm level. We provide evidence that suggests collaborative level AESs (neighbouring land-owners working collectively) may be a fruitful way forward.

We found that 41% of bird, mammal, reptile, amphibian and bumblebee species important on English farmland, for which data could be found, operated at scales larger than that of the typical English farm (145ha). We discuss these findings in the context of climate change and also ecosystem services.

We go on to present data obtained through interviews with 33 farmers with differing AES backgrounds (currently participating in AES at a shallow level (Entry Level Stewardship), currently participating in a more intensive AES (Higher Level Stewardship/Countryside Stewardship Scheme), currently not involved in any AES). 81% of respondents were found to be willing, in principle, to participate in a cAES programme should it become available. Data from an on-line survey of a further 122 farmers support this finding, with 75% of respondents willing to participate in such schemes, although 'passive' options (such as management of existing hedgerows) was much more favoured than 'active' land management options.

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Overall we suggest that landscape-scale schemes are likely to be beneficial for biodiversity and ecosystem services and are likely to attract widespread participation from land owners.

However, given that many important species found on farmland are known to operate at scales larger than that of an individual farm, the current approach may, in many cases, be unfit for purpose. However, for such a paradigm shift to be implemented, farmers would be required to work collaboratively with their neighbours. While some collaborative AES (cAES) options are currently available, these remain extremely limited.

We report findings from a RELU-funded project which had two main aims - 1) to identify important farmland species in England and determine the scale at which they operate, and 2) to consult farmers on their willingness to participate in cAES should they become more widely available.

- We found that 41% of bird, mammal, reptile, amphibian and bumblebee species important on English farmland for which data could be found operated at scales larger than that of the typical English farm (145ha). We discuss these findings in the context of climate change and also ecosystem services.

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~~respondents willing to participate in such schemes. We discuss these findings in the current policy landscape.~~

Running title: Collaborative AES – biodiversity benefits vs. farmer attitudes.

Keywords: landscape-scale conservation, large scale conservation, collaborative agreements, co-operation, land-owner participation.

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Introduction

Agri-environment schemes (AES) are one of the most extensive and expensive biodiversity experiments ever undertaken. While biodiversity gain is not the sole aim of these schemes, it is arguably the most important (e.g. Whittingham 2007). However, the results of AES designed with biodiversity in mind have, to date, been largely underwhelming (Kleijn et al 2012; Kleijn & Sutherland 2003, Kleijn 2006, Whittingham 2007, Whittingham 2011). A review of AES outcomes across Europe (Kleijn & Sutherland, 2003) found that on average, for all species or species groups for which data were available, a positive biodiversity response was found in only a little over 50% of studies. The remainder showed a negative impact (6%), no change (23%) or a mixed response (17%). For birds, the proportion of positive responses was considerably less than the average – only 21%. While the reasons behind these results are likely to be multifold (e.g. problems with the design of individual options, which options are actually being employed in the landscape, difficulties in defining the "success" of a scheme), it is the scale on which the majority of AES options are currently deployed which may be one of the ~~hold the~~ key underlying reasons for~~to~~ their poor returns to date.

AES tend to be implemented at farm- rather than landscape- scale. However, several studies have highlighted that ~~many of the~~ the organisms for which the schemes are targeted operate at scales larger than a single farm unit (Whittingham 2007; butterflies- Ellis et al 2011; Batary et al 2012; Batary et al 2010). This mismatch of scales alone may be significantly limiting the success of many AES. For example, while bee visitation rates to crops has been shown to increase significantly on farms which possess semi-natural habitats of the type created by AES, this is only the case when those farms are not isolated in the landscape – i.e. when there is also semi/natural habitat in the surrounding area (Brittain *et al.* 2010). Similarly, Carvell et al (2011) showed that sowing a mixture of nectar-rich forage plants in farmland significantly enhanced the density and species richness of bumble bees, but that the strength of the response depended on the composition of the surrounding landscape. Gabriel et al. (2010) showed greater positive trends for a range of biodiversity measures, including birds, a range of invertebrates (e.g. arthropods, bees and butterflies) and plants, when there was a greater area under AES management at a 10 km scale. Thus, the extent of AES within the landscape is likely to alter the potential outcomes of schemes, and logically this also means that placement of AES in areas of high existing biodiversity is (in general) likely to yield greater gains (Whittingham 2011).

AES can be thought of in a similar way as protected area networks, with the habitats created through agreements essentially comprising fragments of resource in the overall landscape matrix. The distance and, importantly, connectivity between AES patches will have a direct impact on the species which depend upon their resources. Island biogeographic theory (MacArthur & Wilson 1967; Diamond 1975), from which most "protected area theory" has evolved, predicts that the more fragmented a habitat is, the less useful it will be in sustaining the populations which live within it (Bennett 2003; Diamond 1975). Decreasing fragmentation, via a landscape-scale approach to AES may help reverse this pattern.

This approach has been shown to benefit a range of important farmland taxa, including farmland birds and pollinator insects. Positive outcomes for birds have been reported via the spreading of resource-based options, such as seed-rich margins, throughout the landscape rather than being isolated on one farm (Siriwardena 2010), while crop pollination via wild bees has been shown to increase with reduced distances between from crop fields and natural/semi-natural habitats (Ricketts 2004; Goldman *et al*. 2007).

However, the implementation of landscape-scale AES would not be straightforward, as, to be effective, would require some form of collaboration among farmers. Such collaborations can be difficult, invoking issues of trust, both in managing organisations and in neighbours (Goldman *et al.* 2007). But it can work - in the Netherlands, for example, about 10% of farmers belong to Environmental Co-operatives (Franks & McGloin, 2007). These organisations arrange for farmers to work with one another to take advantage of Dutch AES options that encourage collaborative conservation.

In this article we discuss the findings of a RELU-funded project which, using England as a case study area, had two main aims - 1) to identify important farmland species and determine via systematic review the scale at which they operate, and 2) to consult farmers on their willingness to participate in cAES should they become available. We argue that many important farm land species and ecosystem services will benefit from enlarging the scale at which AES are designed and implemented, and report the barriers farmers have identified to their working more collaboratively within formal AESs. We conclude by offering our thoughts on how future AESs can be designed to facilitate farmer-farmer cooperation.

Case study – Background to current English AES

Comment [n3]: I would be tempted to put this in an Appendix or on-line

The UK government has been actively subsidising AES across England since the mid-1980s via its Department for Environment, Food and Rural Affairs (Defra). In general terms, English AES pay farmers for production losses incurred through the modification of their land for the benefit of the wider environment - the current annual spend on AES compensation payments in England stands at £360 million (Natural England 2009). The current active scheme (Environmental Stewardship) is administered by Natural England (a government advisory body). The scheme has two main levels of participation - Entry and Higher level stewardship (ELS and HLS) -the different levels reflecting the scope and scale of the options offered to farmers.

While their form, structure and name have changed over the years, participation in these schemes has never been greater. As of 2012, 67.4% of the total utilisable agricultural land in England was under some form of subsidised stewardship (Natural England, 2012).

However, even with this level of participation, biodiversity gains via AES in England, as elsewhere, have been underwhelming. For example, uptake of the lower level scheme (ELS) has not been found to correspond with increased bird abundances, at least in terms of important declining bird species (farmland bird index species) (Davey *et al.* 2010b).

However, the devil may be in the detail. The majority of the land managed via AES in England (86%) is managed solely under ELS, with only the remaining 14% managed under HLS (NE 2011). The emphasis of ELS is on uptake rates rather than success rates and, as a result, the approach to date has been a "broad and shallow" one. While such an approach increases participation overall, it may be this very approach which is restricting biodiversity gains. As discussed above, many farmland species may operate at the landscape-, rather than farm-scale. Currently, the only options offered in the Environmental Stewardship scheme for collaborative landscape-scale management are option UX1 in Upland ELS (a compulsory management tool for instances where farmers jointly manage stock on common land), and option HR8 in HLS, which offers a £10 per hectare supplement for "group action". However, uptake of these options has been extremely low, HR8 currently included in just 10 HLS agreements, less than 0.2% of all HLS agreements now active in England. The absence of more broadly applicable landscape-scale options may, at least in part, explain the limited success of the scheme for biodiversity.

Comment [SBE4]: Well Jeremy interviewed at least 18 people involved in HR8 agreements so there is a definite discrepancy here! [obviously each HR8 agreement will involve multiple individuals – so perhaps this is the reason?? Best to check with Jeremy)

Which species are likely to benefit from cAES? – A review

i) Methodology

The systematic review carried out by this study was designed following guidelines in Pullin & Stewart (2006). A total of 92 species found in farmland habitats were selected for inclusion in the review - as biodiversity conservation is focussed on the species level, we addressed the issue in a corresponding way. Selections were made based on a combination of conservation lists, species legislation and general ecology (i.e. known to live/forage/breed on farmland) (see Appendix 1 for full species list, including reasons for inclusion). Records of ranging behaviour for each of these species were searched for using the "ISI Web of Knowledge" database. Search terms used featured species English and Latin names used in association with a wide range of descriptive terms including "foraging range", foraging distance", "home range", "radio-telemetry" and radio track*". While animals use the landscape at a range of different levels (regular/foraging use, seasonal migratory movements, dispersal, range expansion (Bennett 2003)), the review focused on regular/foraging use as it is the use of this space at this level which is most likely to impact directly on population sizes via its use in the breeding season.

Comment [n5]: I know this is true but a REF might help

Comment [n6]: Need to have a look at this at some point

For each species where records of range and/or forage distance (on farmland) were found, means and standard errors were calculated. Where only one record was found this was included with no standard error. The majority of home range data was found to have been calculated using the minimum convex polygon (MCP) method (either 95 or 100%). Therefore, results obtained using other methods (e.g. kernel analysis) were not included in the analysis.

Mean foraging/home ranges were then compared with mean farm size in England (145.2ha - Defra, 2010). While the majority of the terrestrial mammal data found took the "area" format (e.g. a home range of 100ha), much of the bird and bat data was in "distance" format (e.g. mean foraging or ranging distance). Therefore, in order to be able to use both forms of data, an estimate of farm length was made. This was estimated to be 1km- 145.2ha equals 1.452 square kilometres, which equates, in theory, to a farm 1km by 1.452km. Therefore, species with a foraging distance greater than 1km were deemed to use the landscape at a scale larger than the average farm. We consider this to be a conservative~~demanding~~ criterion given the irregular shape of most farms which means neighbouring farmers' fields are often intermingled with one another.

Comment [SBE7]: Do you mean a 'conservative' criteria? As well as irregular field shapes and sizes there is also the point that the calculation makes the assumption that the animal lives in the centre of the farm, whereas if you centre the range on a boundary between one/more farms then it can suggests need for landscape intervention even if the individual range is smaller than the individual farm… [we found that the people we disseminated the findings of the research to, were quite keen to clarify this issue

Comment [J8]: Mark – I'm not quite sure I understand this issue – any thoughts?

Comment [n9]: I think conservative covers it without further need for discussion

ii) Results

Ranging behaviour for more than 40% of the farmland species for which data could be found covered areas larger than that of an average farm (41% - 22 from 54 species). This figure is likely to be an underestimate as there were large numbers of species common on farmland for which data could not be found, including many invertebrate (with the exception of bumblebees) and bird species.

The "farm-size" used in this study is the mean farm size across England. However, it is worth noting that mean farm size differs considerably among different farm types. Mean cereal farm size (212.7ha), for example, is considerably larger than mean dairy farm size (125.7ha) which in turn is considerably larger than that of lowland grazing livestock farms (98.1ha). As farming types have become largely polarized in different parts of the UK (broadly speaking, arable in the east, grassland in the west), there will undoubtedly be a need to include this regional variation in any future landscape schemes (e.g. Whittingham *et al.* 2005).

iii) Consequences

Species increases – positive and negative effects

A large proportion (95%) of the species identified by this study as using the landscape at the larger-than-farm scale are species of conservation concern, receive some degree of statutory

Comment [n10]: Worth including this information in the Appendix protection, and/or feature in Biodiversity Action Plans and UK targeting lists. Therefore, their promotion by this approach is likely to be viewed favourably by the conservation community.

Increases in the populations of a small number of the remaining species, however, may not be so welcome. Badgers, stoats, red foxes and roe deer all tend to be viewed unfavourably by the farming community for their perceived role in: 1) disease transmission (specifically badgers and bTB); 2) crop damage (badgers, foxes and deer); 3) stock predation (badgers, foxes and stoats). With the exception of badgers (Protection of Badgers Act 1992), these species are not in receipt of any form of statutory protection or regarded as species of conservation concern.

However, while the knowledge base surrounding mammals and AES is extremely poor, the likelihood that already abundantextremely successful species like badgers and foxes would increase significantly under cAES, given their proliferation in an already highly fragmented landscape, appears low. In fact, the networking of AES areas required by cAES may instead reduce home ranges of these species via increased habitat availability, concentrating prey numbers in smaller areas. Badger home ranges, for example, have been found to reduce to areas as low as 30ha in landscapes where food and habitat are abundant, larger home ranges only observed in very highly fragmented habitats such as the far north of Scotland.

In terms of disease –transmission, AES-centred farming at the landscape scale has actually been shown to reduce bTB transmission between badgers and cattle. bTB is thought to be spread between badgers and cattle via cattle ingestion of badger excretions (both urine and faeces). As badgers prefer to defecate in field margins or hedgerows, extra provision of this habitat through wildlife friendly farming appears to result in the deposition of badger excretions away from main cattle feeding areas and reduces contact between the species.

Therefore, establishment of cross farm-boundary hedgerows may, therefore, actually help decrease bTB transmission (Mathews et al. 2007).

Could cAES help populations withstand climate change?

Comment [n11]: Done up to here

Climate change effects are already identifiable in many species, typically manifesting themselves via range redistributions (Parmesan & Yohe 2003; Donald & Evans 2006; Hole *et al.* 2011). The extent to which a species can withstand such redistributions depends almost entirely upon the quality and spatial structure of the habitat in which it is found (Donald & Evans 2006). If that environment is harsh and connectivity to other good habitat is low, species are less likely to survive environmental changes and risk extinction. If habitat connectivity is high, however, species will be able to move through the environment more easily, and extinction risk will be substantially decreased (Higgens *et al.* 2003; Donald & Evans 2006). This is exemplified by UK butterflies, which are a species group already displaying considerable distribution changes as a result of a changing climate. Range expansion by this group has been shown to increase more slowly in heavily fragmented environments, highlighting the susceptibility of fragmented populations to climate change (Warren *et al.* 2001; Donald & Evans 2006).

The current AES system in England does not adequately tackle problems associated with climate change-related range expansions. Models known as "climate envelope" models are now available for many farmland species (Donald & Evans 2006),; however their incorporation into current AES policy has proved difficult. The outcome of such models tends to require action to be taken at a scale larger than that of a single farm unit, something which cannot adequately be handled by the current system. A switch to cAES is likely to make the incorporation of climate change mitigation into environmental policy much easier.

The range of taxa which could potentially benefit from such a change would be great, extending far beyond the list of 22 highlighted by the current study.

The effect of cAES on ecosystem service benefits

Ecosystem services (ES) are defined as "products of an ecosystem which support human wellbeing" (Fisher *et al.* 2009; Bradbury *et al.* 2010). They are many and varied and are categorized by the Millennium Ecosystems Assessment (2005) as products which (i) provide (e.g. timber), (ii) regulate (e.g. water quality and quantity; climate, carbon sequestration), (iii) support (e.g. pollination and pest control) and (iv) provide culture (e.g. recreation).

Given that ES are likely to become part of AES in the near future (Whittingham 2011), it seems pertinent that the potential effects of cAES on these services should be explored. By their nature, ES tend to be extensive, and not limited to single farms (Goldman *et al.* 2007). By this token, they, like biodiversity, are likely to be better supported by a landscape scale AES system than the existing farm-centric approach. This is best described via two examples, outlined below.

Pollination

Around 75% of globally important crop species are thought to benefit from insect pollination. As such, this service has been valued at €153 billion per annum globally, and £400 million per annum in the UK (POST, 2010). Studies have shown habitat at the landscape scale to be extremely important in maximising pollinator visitation rates to crops. Both visitation rates and richness of important pollinator species has been shown to increase significantly with reduced distances between cropland and natural/semi-natural habitat in the wider landscape (Ricketts *et al.* 2008; Brosi *et al.* 2007; Goldman *et al* 2007). This means that coordinated supply of these habitats across the farm landscape is required if adequate populations of pollinators are to be maintained. For example, if one farmer in a landscape provides suitable habitat for bees, but none of his neighbours do the same, the value of that farmer's habitat will be greatly reduced through isolation.

Water services

Agricultural lands play a significant role in water management (Rhymer *et al.* 2010; Goldman *et al.* 2007) and is vital in controlling both water purification and flood mitigation. If managed poorly, however, agricultural lands can have extremely negative effects on both (Goldman *et al.* 2007).

Water bodies typically span large areas and as such, options to protect these areas are unlikely to work unless implemented at a landscape scale. For example, if one farmer includes flood mitigation options in his suite of ES options (which do currently exist in the HLS scheme), they are likely to have little impact if not also instigated in surrounding areas. A similar pattern is seen for control of run-off – if one farmer upstream controls his runoff, but a farmer downstream does not, there may be no discernible impact on overall water quality.

Therefore, while complex, the majority of ES are likely to be supported more efficiently via a landscape AES system than the existing farm-centric approach. The inclusion of provision for ES in future AES seems increasingly likely, making the landscape element even more relevant and important.

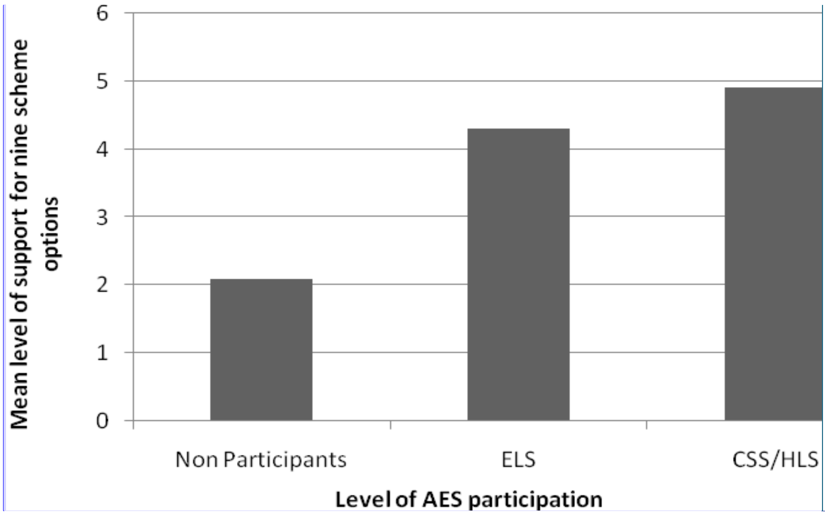
Farmer attitudes to collaboration – barriers and opportunities

From a biodiversity point of view, landscape scale collaborative AES (cAES) appear to be ~~extremely~~ favourable. However, implementation of such schemes would depend entirely on the participation of farmers and/or land owners. While a small number of studies have attempted to assess farmer attitudes towards collaborative AES (cAES) in England and elsewhere in the UK (England - MacFarlane, 1998, Scotland –Blackstock; Wales - Davies), what is unique about our approach is that 1) it considers farmers from a range of AES backgrounds; and 2) we present farmers with a range of different types of potential scheme options.

Comment [J12]: Need to get these refs off Steve

Semi-structured interviews with 32 farmers were conducted in three carefully selected survey areas in England (Peterborough, Grafton - Worcestershire and the Tamar valley - Cornwall/Devon; Figure 3)). Interviewees were selected from a range of AES backgrounds - current non-participants, participants in ELS and participants in HLS (or its predecessor, the Countryside Stewardship Scheme (CSS). First asked for their initial “knee-jerk” reaction to cAES, 81% of farmers interviewed (26/32 said that they would support cAES should they become available. The remaining 19% were either unsure (two farmers) or not in favour (four farmers).

Farmers were then presented with nine potential collaboration scenarios (see table x) to test their “resolution”. The number of scenarios which each farmer would in theory support was found to vary according to their existing level of participation - between 4 and 5 for current participants, and around 2 for current non-participants (Figure xx). This is an extremely encouraging result as it shows that even farmers currently not participating in any AES would be willing to consider adopting at least some collaborative environmental management options should they become available.



Comment [n13]: Yes need error bars and stats on this…

Comment [SBE14]: We changed the title on the y axis following reviewer comment to 'Mean number of the 9 scheme options that were supported'

Comment [n15]: We might do some quick stats on these results, and pop on some error bars

The examine the robustness of these responses, an on-line consultation open to every farmer in the UK was established. 75% of the 122 reponses received also supported the principle of collaboration conservation with 16% being "undecised", and the remaining 9% "against".

Passive vs. Active Collaboration

The nine collaborative options presented to interviewees would require different degrees of farmer-farmer cooperation: those that would require high levels of cooperation ("active" collaboration) and those which would require less cooperation ("passive" collaboration). For example, "active" collaboration with neighbours might involve coordination of the timing of grass and cereal harvesting in neighbouring fields, while 'passive' collaboration, might involved the strategic placement of hedges (so they join-up with neighbours' hedges or other environmental features to form and/or extend corridors), placement of buffer zones around high environmental value sites which may be on their neighbour's property, or location of ponds in strategic locations as dictated by environmental features in the landscape. ~~R~~

Respondents overwhelmingly preferred "passive" to "active" collaborative options. It

Comment [n16]: Give supporting data to back this up – how many out of what sample size?

is clear that a degree of ‘passive’ collaboration (co-ordination) already exists, particularly in HLS areas where natural England Project Officers (NEPO) are, to some extent, able to recommend revisions to HLS submissions. However, this raises a professional dilemma because the HLS is a competitive scheme, therefore individual farmers are unlikely to discuss (or want discussed) their plans with neighbours for fear of losing any competitive advantage they may have. This issue clearly reduces incentives for farmers to collectively devised integrated environmental management plans. .

The fact that ‘passive’ collaboration would allow AES contracts to ~~remain substantially~~remain substantially single agency, farmer-by-farmer, agreements would ~~allow cAES~~allow cAES to be incorporated within AES in as ~~a gradual~~a gradual, evolutionary change.

Comment [J17]: Maybe need something more in here

Conclusions and policy implications

Ecologists and farmers agree that current AES options have, to date, delivered only moderate biodiversity benefits (Emery and Franks, 2012, Kleijn and Sutherland 2003). It is clear from evidence presented by this study, and from work carried out by elsewhere, that the deployment of AES on a larger landscape scale may be one way to boost populations. We have highlighted 22 species or species groups (from important farmland species for which data could be found) which would be likely to benefit from such schemes as a result of their large home ranges on farmland. The exact number, however, is likely to be far greater.

While collaboration between farmers can be difficult (e.g. Goldman *et al.* 2007), cAES received a largely positive ~~reposnse~~response from the farmers approached by the current study. Even farmers not currently participating in any stewardship schemes were, in theory, open to the idea of collaborative management. Evidence presented suggests that farmers would be willing to engage in some forms of collaboration (“passive”) more readily than other forms (“active”). For example, farmers were found to be most willing to provide “linking/corridor” type features between their own and neighbouring farms (e.g. hedges, woodland) that are important strategically but do not impose demands on the productive farming on the rest of their land (Emery and Franks 2012). However, this is something which could be accounted for in the development of cAES.

How such schemes would be implemented financially is an entirely different issue. Can Defra simply introduce a new payment stream? Current rules allow compensation only for income foregone, and for transaction costs and direct costs incurred. Clearly, any additional payment for farmers’ higher transaction costs related to their involvement in “passive” collaboration would be low (as contracts remain on a farm-by-farm basis and existing payments already reflect their costs of participation in AES). However, the environmental benefits would be higher. Therefore, the rules relating to AES payments need to be amended to take into account the contribution of participants towards the successful outcome of cAES.

In conclusion, among the important issues still to be resolved are (i) how to initiate farmers forming groups, (ii) the role of outside agencies in developing multi-agency agreements, and iii) what payment rates are needed to cover transaction costs of collective action. These research needs must be addressed if AES is to improve its effectiveness in addressing existing and future problems alike.

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