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Extension′s role in disseminating information about climate change to agricultural stakeholders in the United States

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Abstract The U.S. Cooperative Extension Service was created 100 years ago to serve as a boundary or interface organization between science generated at the nation′s land grant universities and rural communities. Production agriculture in the US is becoming increasingly complex and challenging in the face of a rapidly changing climate and the need to balance growing crop productivity with environmental protection. Simultaneously, extension budgets are diminishing and extension personnel are stretched thin with numerous, diverse stakeholders and decreasing budgets. Evidence from surveys of farmers suggests that they are more likely to go to private retailers and consultants for information than extension. This paper explores the role that extension can play in facilitating climate change adaptation in agriculture using data from a survey of agricultural advisors in Indiana, Iowa, Michigan and Nebraska and

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a survey of extension educators in the 12 state North Central Region. Evidence from these surveys shows that a majority of extension educators believe that climate change is happening and that they should help farmers prepare. It also shows that private agricultural advisors trust extension as a source of information about climate change. This suggests that extension needs to continue to foster its relationship with private information providers because working through them will be the best way to ultimately reach farmers with climate change information. However extension educators must be better informed and trained about climate change; university specialists and researchers can play a critical role in this training process.

1 Introduction

In an era of diminishing resources for public extension services and increasing reliance on private consultants by farmers, concerns have been raised about the ability of extension to meet the needs of agriculture in the US (Wintersteen et al. 1999). If that is the case what is an appropriate role for extension? This is an especially salient question when it comes to providing information related to climate change. Climate variability and change is rapidly shaping the landscape for agriculture and the recently released US Third National Climate Assessment notes that "production of all commodities will be vulnerable" both directly and indirectly in the coming years (Hatfield et al. 2014). Climate change will not only impact crop yields and livestock health, but will also amplify environmental degradation associated with agriculture (Hatfield et al. 2014). For example, increasing numbers of extreme events in portions of the Midwestern United States are expected to lead to more soil erosion and nutrient runoff, necessitating the use of adaptive strategies (Hatfield et al. 2014).

The growing impact of climate variability and change on agricultural production has generated a rich literature focusing on the potential value of weather and climate information to help farmers to prepare and respond to these impacts (Solis and Letson 2013). In this context, there have been calls for a stronger role of extension to support climate adaptation in all areas but especially in agriculture (Brugger and Crimmins 2014). But while the science of climate change impact on agriculture has steadily increased and become more robust (Hatfield et al. 2014), evidence of actual application of this science towards preparation and adaptation is low (Haigh et al. 2014; Lemos et al. 2014a; Prokopy et al. 2013). In this context, boundary (or

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"interface") organizations that mediate between producers of climate-related knowledge and users have an important role in increasing the usability of climate information (Lemos et al. 2012). In recent years, much has been written about boundary organizations (see e.g., Cash and Clark 2001; McNie 2007), but while such terms are new, these organizations are not. In the US, the Cooperative Extension Service (hereafter extension) has been operating as a boundary organization since 1914 when it was created by the Smith-Lever Act, which stressed the importance of translating research knowledge into practical outcomes and disseminating new or improved agricultural technologies. After a century of operation, there is little argument that extension has done an effective job performing both these tasks especially during periods of great turmoil such as the Great Depression and both World Wars (Osmond et al. 2010; Wang 2014). Although currently extension advice spans numerous areas, it is in agriculture that that the organization is arguably most active, focusing on "research and educational programs (to) help individuals learn new ways to produce income through alternative enterprises, improved marketing strategies, and management skills and help farmers and ranchers improve productivity through resource management, controlling crop pests, soil testing, livestock production practices, and marketing (United States Department of Agriculture USDA 2014)." To meet these goals there are two types of personnel within the extension system: (1) extension educators who are university staff often located in communities around their state and not housed at their university, and (2) extension specialists who are located at universities and typically produce the applied science that gets disseminated by extension educators.

Traditionally, extension has been funded through a combination of federal, state and local funds; however, recently, extension's ability to perform its role has been challenged by diminishing budgets and consequently fewer personnel (Wang 2014). It has also been challenged by the changing structure of agriculture. As farms get larger and more specialized, farm operators have increasingly relied on private information providers such as agricultural retailers and Certified Crop Advisors (CCAs) for production advice (Samy et al. 2003; Wang 2014). This reliance on private information providers is not a new trend, with survey data from the Midwestern United States as far back as the early 1960s showing that agribusiness was more important than extension for farmer decision-making related to new technology and prices. However, despite the growing role of private information providers, extension educators remained the most important sources for production information at that time (Mawby and Haver 1961).

Over time, evidence suggests that extension has become less relevant for many types of decisions, including marketing decisions (Schnitkey et al. 1992), soil conservation information (Pompelli et al. 1995; Tucker and Napier 2002), fertilizer application rates (Arbuckle Jr and Rosman 2014; Osmond et al. 2014; Stuart et al. 2014), and numerous other types of decisions (Ford and Babb 1989; Arbuckle Jr et al. 2012; Ortmann et al. 1993). Yet despite their diminished influence, extension educators remain highly trusted among farmers. For example, evidence from numerous surveys conducted in Midwestern watersheds shows they are the most trusted group for soil and water conservation decisions (Mase et al., in review). But being trusted and having influence is clearly not the same thing. The findings in the literature about who influences farmers are consistent with those of a recent survey of large (>80 acres and $100,000 in gross sales) corn farmers across the Midwestern United States. When asked to indicate how influential different groups and individuals were in their decisions about agricultural practices and strategies, farmers placed extension far down the list after family, chemical dealers and seed dealers, and CCAs (the four highest ranked groups). Moreover, a combined 40 % of farmers reported that they either have no contact with extension or extension has no influence on their agricultural decision-making (Loy et al. 2013; Prokopy et al. 2014).

In this paper, using empirical data from a broad survey of agricultural advisors carried out in four Midwestern states (Iowa, Nebraska, Michigan, Indiana) and extension educators in all 12 states in the North Central Region, we explore the changing role of public extension in providing agricultural information. Based on our analysis, we suggest a path forward for extension, specifically in terms of staying meaningful and relevant in disseminating information about climate change.

2 Materials and methods

An online survey of about 7,770 agricultural advisors in Indiana, Iowa, Michigan, and Nebraska was implemented in the spring of 2012. These states were selected to represent a continuum of the Corn Belt in terms of climate, use of irrigation, and intensity of corn production. A team of social scientists from universities across the Midwestern U.S. designed the survey instrument with input from climate scientists. The questionnaire contained a variety of questions, including the type of advice given to farmers, when farmers make decisions, trust in climate change information sources, and climate change beliefs, among others.

Email invitations to the online survey were sent to a variety of agricultural advisors, including Certified Crop Advisors (CCAs), Natural Resource Conservation Service (NRCS) staff, Farm Bureau employees, Soil and Water Conservation District (SWCD) staff, Agricultural Bankers and other groups with the potential to advise corn farmers. Over 1,600 survey responses were received, for an approximate response rate of 26 %. At the same time, the survey was sent to extension educators in all 12 states in the North Central Region (North Dakota south to Kansas and east to Ohio) and 239 responses were received for a response rate of 35 %. For additional information about the survey methodology, see Prokopy et al. 2013. In-depth qualitative interviews were conducted in early 2014 with eleven CCAs in Indiana and Nebraska. The interviews covered a number of topics including who they trust as a source of information about climate change.

3 Results

3.1 Advisors′ perspectives of extension

Figure 1 aggregates data from the advisor survey in all four states and illustrates that the most trusted source of information about climate change is extension followed closely by scientists. In the survey, it was not specified whether extension meant extension educators, specialists or both. The most distrusted groups are radio talk show hosts, mainstream news media and blogs & social media. Table 1 focuses on different advisor groups' trust in extension. NRCS and SWCD staff have higher levels of trust in extension than both CCAs and agriculture retailers in all locations. Disaggregating the data by states (not presented here) does not provide any additional insights.

Qualitative data from interviews with CCAs supports the quantitative evidence and adds some additional context about why extension is a trusted organization. When asked in an open-ended question who they trust for information on climate change, 8 of 11 CCAs discussed extension specifically. Reasons for trust include: "*science based information*", "*more resources for experience or studies*", "*they're paying attention to [climate change]*", "*They're more conservative and down the middle of the road*", "*I'm an old UNL [University 0f Nebraska-Lincoln] guy*". One CCA who disagrees with extension on the existence of climate change noted that "*If they're saying this practice will help protect against climate change. . . I'm going to call it weather so the practice is still valid.*"

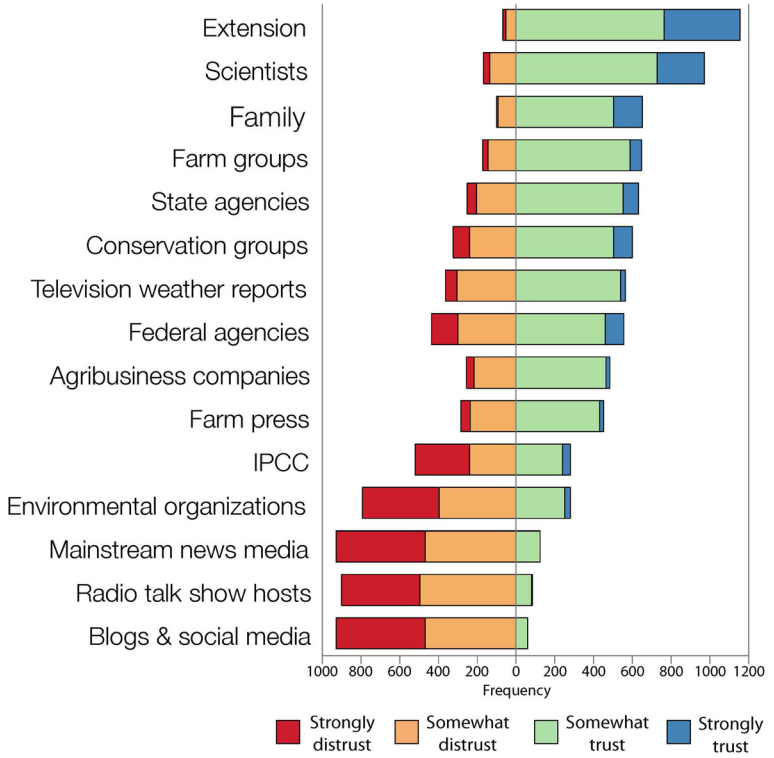

Fig. 1 Non-extension agricultural advisors' trust in different groups as sources of information about climate change. This diverging stacked bar chart presents the trust data sorted by "Strongly trust". The axis is the count of number of respondents. Bars to the right of 0 indicate trust and bars to the left of 0 indicate distrust

3.2 Beliefs about climate change

Table 2 reports beliefs about climate change. These data come from all 12 states in the North Central Region for extension and only four states for the other advisor groups. While only 1.3 % of extension educators who responded to our survey believe that climate change is not

Table 1 Influential advisor groups' trust in Extension. The specific question wording was: "Thinking about the following agencies, organizations, and groups, how much do you trust or distrust them as sources of information about climate change and its potential impacts?" Answers were given on a 5-pt Likert scale from "Strongly distrust" to "Strongly trust". Overall/statewide averages are for all advisors excluding Extension agents. Superscripted letters in the mean column represent significantly different groups from a post-hoc Tukey HSD test following a one-way ANOVA; different letters for a group within a question indicates that means are significantly different from the other groups for that question

Group	N	Mean trust in extension	SD
Agriculture retailers	58	3.53^{A}	0.90
CCAs	379	3.83^{A}	0.88
NRCS staff	199	4.16^{B}	0.78
SWCD staff	176	4.10^{B}	0.90
Overall average	1,469	3.99	0.83

Table 2 Climate change beliefs among extension educators, CCAs/agricultural retailers, and NRCS/SWCD personnel. Specific question wording: There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change

Response	Group	n	%
Climate change is occurring, and it is caused mostly by natural changes in the environment	Overall	434	24.9
	Extension	56	23.4
	CCA/Agricultural retailers	132	30.1
	NRCS/SWCD	68	17.5
Climate change is occurring, and it is caused mostly by human activities	Overall	219	12.6
	Extension	46	19.3
	CCA/Agricultural retailers	22	5.0
	NRCS/SWCD	80	20.6
Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities	Overall	645	37.0
	Extension	75	31.4
	CCA/Agricultural retailers	149	33.9
	NRCS/SWCD	158	40.7
Climate change is not occurring	Overall	41	2.4
	Extension	3	1.3
	CCA/Agricultural retailers	11	2.5
	NRCS/SWCD	5	1.3
There is not sufficient evidence to know with certainty whether climate change is occurring or not	Overall	406	23.3
	Extension	59	24.7
	CCA/Agricultural retailers	125	28.5
	NRCS/SWCD	77	19.9

occurring, close to a quarter of them do not believe there is sufficient evidence to know with certainty whether or not it is occurring. Slightly over half of them believe that human activities play some role in climate change. There are statistically significant differences between groups with CCAs and agricultural retailers being disproportionately likely to report either that there is insufficient evidence or that climate change is not occurring when compared to all other groups of advisors (including extension) (see Mase et al. 2015 for a detailed analysis of these findings).

Table 3 reveals that the means of a five-point scale for questions related to potential impacts of climate change are similar for extension educators and CCAs/agricultural retailers. The one statistically significant exception is the statement: "I have the knowledge and technical skill to help farmers deal with any weather-related threats to the viability of their farm operation" for which CCAs/agricultural retailers expressed more agreement. Extension educators and NRCS/SWCD employees responded similarly to four of the six statements with two notable exceptions: (1) NRCS/SWCD employees are less confident than extension in their knowledge and skills, and (2) NRCS/SWCD employees are more likely than extension to think farmers should take additional steps to protect farmland. CCAs and agricultural retailers are different from NRCS/SWCD employees for five of the six questions and only agree that, in their roles as advisors, they should help farmers to prepare for the impacts of increased weather variability (for more detailed analysis of non-extension agents intermediaries see Haigh et al. 2014 and Lemos et al. 2014b).

Table 3 Extension educators', CCAs'/agricultural retailers', and NRCS/SWCD personnel's beliefs about the potential impacts of climate change on agriculture in the Corn Belt. Specific question wording: "Given what you believe to be true about the potential impacts of climate change on agriculture in the Corn Belt, please provide your opinion on the following statements." Responses were given on a 5-point, Likert-type scale from "Strongly Disagree" to "Strongly Agree". Superscripted letters in the mean column represent significantly different groups from a post-hoc Tukey HSD test following a one-way ANOVA; different letters for a group within a question indicates that means are significantly different from the other groups for that question

Statement	Group	n	Mean (SD)
I have the knowledge and technical skill to help farmers deal with any weather-related threats to the viability of their farm operations.	Overall	1,680	2.93 (0.97)
	Extension	236	3.11 (0.92)^{A}
	CCA/Agricultural retailers	430	3.39 (0.86)^{B}
	NRCS/SWCD	371	2.89 (0.93)^{C}
There's too much uncertainty about the impacts of climate change to justify advising others to change their agricultural practices and strategies.	Overall	1,682	3.23 (0.94)
	Extension	237	3.17 (0.96)^{A,B}
	CCA/Agricultural retailers	431	3.31 (0.98)^{A}
	NRCS/SWCD	369	3.11 (0.97)^{B}
I am concerned that current best management practice technologies are not effective enough to protect the corn farmers I advise from the impacts of climate change.	Overall	1,669	2.86 (0.87)
	Extension	233	2.88 (0.90)^{A,B}
	CCA/Agricultural retailers	429	2.74 (0.89)^{A}
	NRCS/SWCD	370	2.95 (0.90)^{B}
Farmers should take additional steps to protect farmland from increased weather variability.	Overall	1,684	3.67 (0.77)
	Extension	236	3.67 (0.74)^{A}
	CCA/Agricultural retailers	430	3.53 (0.80)^{A}
	NRCS/SWCD	373	3.94 (0.72)^{B}
In my role as an advisor, I should help farmers to prepare for the impacts of increased weather variability.	Overall	1,665	3.58 (0.81)
	Extension	234	3.72 (0.80)^{A}
	CCA/Agricultural retailers	430	3.63 (0.79)^{A}
	NRCS/SWCD	370	3.76 (0.80)^{A}
It is important for farmers to adapt to climate change to ensure the long-term success of U.S. agriculture.	Overall	1,680	3.82 (0.82)
	Extension	233	3.85 (0.81)^{A,B}
	CCA/Agricultural retailers	425	3.77 (0.89)^{A}
	NRCS/SWCD	373	3.97 (0.79)^{B}

Looking at the distribution across the five-point scale presented here for extension only (Table 4), 70 % of the extension educators agree/strongly agree that "farmers should take additional steps to protect farmland from increased weather variability". Over 70 % of them agree/strongly agree that "In my role as an advisor, I should help farmers to prepare for the impacts of increased weather variability." More than 75 % of them agree/strongly agree that "It is important for farmers to adapt to climate change to ensure the long-term success of U.S. agriculture."

Responses to several questions about adaptive capacity pointed to a great deal of uncertainty, however. The plurality of extension educators (41 %) were uncertain that they have the knowledge and technical skill to help farmers deal with any weather-related threats to the viability of their farm operations, compared to 25 % who disagreed and 35 % who agreed. Over 40 % of the educators believe there is too much uncertainty about climate change to justify advising others to change their practices.

Table 4 Extension educators' beliefs about the potential impacts of climate change on agriculture in the Corn Belt. Specific question wording: "Given what you believe to be true about the potential impacts of climate change on agriculture in the Corn Belt, please provide your opinion on the following statements"

Statement	N	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
I have the knowledge and technical skill to help farmers deal with any weather-related threats to the viability of their farm operations.	236	3.81 %	20.76 %	40.68 %	29.66 %	5.08 %
There's too much uncertainty about the impacts of climate change to justify advising others to change their agricultural practices and strategies.	237	2.95 %	24.89 %	29.11 %	38.40 %	4.64 %
Climate change is not a big issue because human ingenuity will enable us to adapt to changes.	235	12.77 %	34.04 %	34.89 %	17.02 %	1.28 %
I am concerned that current best management practice technologies are not effective enough to protect the corn farmers I advise from the impacts of climate change.	233	4.29 %	31.76 %	38.63 %	22.75 %	2.58 %
Farmers should take additional steps to protect farmland from increased weather variability.	236	1.69 %	4.24 %	26.69 %	60.17 %	7.20 %
In my role as an advisor, I should help farmers to prepare for the impacts of increased weather variability.	234	3.42 %	2.99 %	20.09 %	65.38 %	8.12 %
It is important for farmers to adapt to climate change to ensure the long-term success of U.S. agriculture.	233	2.15 %	3.43 %	17.60 %	60.52 %	16.31 %

4 Discussion

There is increasing evidence in the empirical literature that farmers are turning to private information providers for farm management advice more so than they are turning to extension educators. However, this does not mean that extension has outlived its usefulness, as empirical research also shows that extension information is reaching farmers through private information providers who often disseminate university-generated and extension-processed knowledge (Just et al. 2003; Wintersteen et al. 1999; Wolf et al. 2001). Consistently, we found that extension is a trusted source of climate change information about climate change among highly influential agricultural advisors.

The historical model for extension was direct contact with farmers and others have recommended that extension still needs to provide farmers with "appropriate, high quality information" in order to stay relevant (Samy et al. 2003). We argue here, however, that providing climate change-related information directly to farmers at the local level is not necessarily the right path forward for extension and, consistent with others' recommendations, we suggest that extension should focus on disseminating information in support of adaptation and mitigation through intermediaries (Arbuckle Jr et al. 2012; Ford and Babb 1989; Wintersteen et al. 1999). Budget constraints and ever growing informational channels (agricultural retailers, CCAs, agricultural lenders, NGOs, agricultural media, internet, etc.) have reduced extension's contact and standing with farmers. Concurrently, farmers across the Midwest have focused their attention on recommendations/advice from private consultants. However, agricultural retailers and CCAs still rely on extension for credible, salient and legitimate climate information to support their advice to farmers (Cash et al. 2003). This

suggests that, at least for climate change-related information, extension should follow a "train the trainer" model to decrease the high transaction costs (especially in terms of personnel and time) involved in personal interaction with clients (Lemos et al. 2014b). For example, more climate related topics could be added to existing crop meetings or specific categories could be added to CCA certifications related to climate change. In this approach, while extension may no longer have the direct influence with farmers it once had, it can still provide relevant information that influences farmer decisions through intermediaries. In the language of current literature, extension as a boundary organization could function as a "link" in a boundary chain arrangement (see Lemos et al. 2014a). By providing information to other boundary organizations (e.g., CCAs or existing farmer networks), extension can reduce transaction costs, pool resources across the chain with other advisors and reach a broader audience. Moreover, consistent with their public mission, extension should continue to foster, and perhaps formalize, its relationships with agricultural retailers and CCAs both at the local level (extension educators) and state level (extension specialists) to help shape the discussion of climate variability and maximize the indirect impact extension information can have on future production decisions in relation to climate variability and change. In addition to subject matter expertise, extension emphasizes adult education and community engagement skills that are unique among farm advisors and can strengthen communication networks (Brugger and Crimmins 2014).

These findings and recommendations raise a question about whether extension educators are willing and able to disseminate science-based information on climate change to information providers who work more directly with farmers? A recent editorial in the Journal of Extension would suggest that not all extension educators are prepared to engage in a conversation about climate change (Tyson 2014) and extension educators are not as convinced that climate change is happening as scientists at land grant universities (Prokopy et al. 2015). Yet the evidence presented in this paper shows that a majority of extension educators believe that they should help farmers prepare for impacts from increased weather variability, but suggests that they are insufficiently prepared at present to do this work.

Additionally, compared to agricultural advisors, extension educators are less confident that they have the knowledge and technical skills to help farmers adapt. There is no reason to expect that agricultural advisors really have more knowledge or technical skills than extension, therefore this is likely false confidence. Extension educators also tend to think that there is too much uncertainty about climate change to justify advising others to change their practices. This false confidence and uncertainty stress the need for extension educators to receive objective, science-based information from extension specialists to complement their field experience, so they do not pass along inaccurate information to farmers. We suspect that, unlike CCAs and retailers, extension educators are more likely to know what they don't know given their participation and exposure to state of the art university research and resources related to the issue of climate change.

These findings suggest that better information linkages are needed between agricultural retailers and CCAs, extension educators, and extension specialists and research faculty in land grant universities. The agricultural retailers and CCAs who are most influential with farmers trust extension most for information about climate change and value the science-based information coming from universities. Development of strategies that engage extension educators and university faculty in efforts to make the latest research-based information on adaptation and mitigation strategies to both agricultural retailers and CCAs and farmer audiences would be a worthy investment of extension resources.. This is perhaps a role for the new USDA Climate Hubs (for more information see http://www.usda.gov/oce/climate_change/regional_hubs.htm).

This manuscript is far from the final word on the role of extension in disseminating information about climate change to an agricultural audience. While we have strong recommendations about who extension should talk to at the local level, we did not examine how information should be presented. For example, Wintersteen et al. 1999 showed that agribusiness professionals want multiple types of information delivery methods; this is something extension needs to explore further going forward. We also do not have specific evidence about what information should be presented, e.g., is it necessary for farmers believe in anthropogenic climate change or do they just need information that helps them adapt? Our data also only cover the Midwestern US and, while there is evidence that private information providers are important sources of information for farmers across the country, future studies should examine how trusted extension is by these private providers in other regions. We also have not examined what agricultural advisors do with the information they receive from extension – do they pass it along to farmers directly or do they first repackage it and add their own spin? Finally while all reviewed evidence suggests that farmers are increasingly going to private advisors for information, there may be audiences who are underserved and topic areas that are undervalued by these private advisors and future studies should explore this potential gap.

5 Conclusions

Extension was founded 100 years ago to disseminate scientific information from land grant universities to the agricultural sector. Over time, the market for agricultural information has become congested and there are now numerous information providers competing with extension for farmers' attention. However this does not mean that extension is irrelevant in the current context, where scientific information generated by universities to help farmers adapt to climate change in ways that sustain crop yields and minimize environmental degradation is critical. Extension is well suited to disseminate climate change information to farmers through the private information providers the farmers already trust, but to serve this function well, extension educators must better informed and trained. University specialists and researchers can play a critical role in the training process.

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