Landscape and Urban Planning 188 (2019) 19–29

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Factors associated with family forest owner actions: A vote-count meta-analysis

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ARTICLE INFO

Keywords:
Private landowners
Behavior
Private forests
NIPF
Vote count
Synthesis

ABSTRACT

Family forest owners in the United States have an important role in providing social and ecological benefits across landscapes. Thus, a detailed understanding of their land management behavior is critical to determine whether or not these benefits will be realized. In this paper, we report on a vote-count meta-analysis of peer-reviewed quantitative studies in the U.S. to examine an array of forest landowner behaviors. We extend other reviews of this literature by including papers with any behavioral dependent variable, rather than only timber harvesting or land management behavior. We document the significance, direction, and frequency of independent variables examined with regard to 13 categories of behavior including participation in policy tools, cross-boundary cooperation, invasive species management, and wildlife management. Study-level characteristics are reported for the 128 published studies that met initial inclusion criteria for this analysis (quantitative studies within the U.S. modeling landowner behavior that were published between 2002 and 2016). Thirty-eight studies that statistically modeled landowner behavior were further analyzed. Studies examining intentions were excluded, as were qualitative explorations of landowner behavior. The most commonly studied behavior included in our analysis was participation in landowner incentive programs, and the least common was participation in cross-boundary cooperation. Among independent variables, owner characteristics and ownership objectives were most commonly included. Independent variables found to be significant across behaviors examined included: current/past landowner behaviors, knowledge, and parcel size/forested acres. Actions like cross-boundary cooperation and landowner interactions have not been quantitatively modeled as often as other actions, and represent key areas for future research.

1. Introduction

Many landscape-scale forest stressors exist that are likely to increase as land ownership patterns, climate, and other conditions shift. Invasive insect and plant species, fungal diseases, wildfire risk, and severe drought have the potential to severely affect forests and mitigation of these stressors is dependent upon landscape-scale management of forested land. Given that nearly a third of United States (U.S.) forests are owned by private individuals and families (Butler, Hewes et al., 2016), understanding the forest and land management behaviors of family forest owners (FFOs) is critical for predicting the trajectory of forest ecosystems and their provision of benefits like carbon sequestration and recreational opportunities. Family forest owners have many options for managing their forested land, including taking no action at all. Their choices of whether to harvest woody material, manipulate the composition and structure of the forest to encourage select wildlife species, or undertake invasive plant removal activities in coordination with neighboring landowners, among others, are behaviors potentially predicated on the landowners' values, perceptions, attitudes, perceived behavioral control (e.g., knowledge of what tree species will grow well on their land), and behavioral intentions (Fischer, Bliss, Ingemarson, Lidestav, & Lönnstedt, 2010; Young & Reichenbach, 1987).

Three major reviews of the FFO literature have been conducted since 2005. Beach, Pattanayak, Yang, Murray, and Abt (2005) conducted a vote-count meta-analysis of 39 econometric studies of FFOs' harvesting, afforestation, and timber stand improvement behaviors that

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https://doi.org/10.1016/j.landurbplan.2018.08.024
Received 16 November 2017; Received in revised form 6 July 2018; Accepted 12 August 2018
Available online 12 October 2018
0169-2046/ Published by Elsevier B.V.

were published between 1981 and 2002. Straka (2011) wrote a thorough narrative review of the history of FFO research from the 1940s onward, identifying major themes and findings. Silver, Leahy, Weiskittel, Noblet, and Kittredge (2015) reviewed the FFO timber harvesting literature published between 1970 and 2014, evaluating variables used to predict harvesting behaviors and the reported findings to support their conclusions. We build upon these three approaches in our paper, also conducting a vote-count meta-analysis of studies that employed quantitative analysis techniques of landowner behaviors. Our study reviews studies published since 2002, picking up where Beach et al. (2005) concluded theirs. Like Straka (2011), we expand the behaviors considered for inclusion in our meta-analysis beyond timber harvesting, afforestation, and timber stand improvement. We use Silver et al.'s (2015) 'levels of evidence' description to guide the types of studies included in our vote-count review. Using an evidence based framework includes weighing evidence and conducting rigorous evaluations, results of which are used to inform decision-making and policy (Silver et al., 2015). The three FFO reviews, along with additional literature, are discussed in the "variable characterization" section below where their findings are reviewed to support our work. We also use a highly-cited vote-count meta-analysis of agricultural best management practice adoption research (Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008) to inform our methods and presentation of results.

The intent of this paper is to provide those interested in FFO behaviors with a resource that identifies a comprehensive suite of independent and dependent variables that have been examined in quantitative modeling studies with regard to FFO actions. We aim to enhance understanding of variables and constructs that have been largely unexplored or under-explored to date, as well as those that are commonly included, and those often found to be predictive of FFO behaviors in quantitative modeling studies. Practitioners can use our results by incorporating a more in-depth understanding of landowners into their programming based upon behavior adoption goals.

Our specific research objectives were to characterize the FFO literature (2002–2016) to understand: 1) quantitative data collection and sampling methods used to study FFOs; 2) the range of actions and behaviors that have been quantitatively examined in the literature; and 3) the predictors that have been used to understand those actions and behaviors within quantitative modeling studies. We explain our approach below, along with theoretical and empirical support from the literature.

2. Methods

2.1. Vote-count approach

The vote count methodology emerged from a need to integrate and summarize findings across studies in a given field (Light & Smith, 1971). The methodology involves coding three possible outcomes of the effect of an independent variable on a dependent variable: positive significant, negative significant, or no statistical relationship in either direction. All dependent and independent variables included in the vote-count are characterized in this way, and then summed across studies to provide insight into general trends of inclusion and (in)significance of variables. With this type of meta-analysis, researchers get a sense of which independent variables are most/least commonly used to model a given dependent variable, as well as the frequency that each independent variable is positive, negative and insignificant. For example, in the Beach et al. (2005) vote-count paper, plot size was included as an independent variable in 55% of the models that examined harvesting behavior, and found to be significant in 82% of the models in which it appeared, supporting its utility and consistency in predicting various landowner behaviors.

2.2. Study characteristics and inclusion

We used a systematic literature review approach to identify articles for analysis (Jesson, Matheson, & Lacey, 2011). We began with a comprehensive literature database of 2639 articles about "family forest owners" and alternative names for this group (e.g., non-industrial private forest owner) maintained by the Family Forest Research Center (FFRC). To maintain this literature database, the FFRC conducts snowball sampling on all articles pertaining to FFOs in the U.S. between 2000 and the present, excluding articles that do not include a formal peer-review process, such as opinion pieces, dissertations, and other gray literature. Snowball sampling is a process where the reference section of each qualifying article is reviewed, and new articles that also meet the above criteria are added to the database. This process is repeated until no additional references are identified. This database is updated monthly. We began with this list of articles, and narrowed it down for our sample time frame of January 2002 through May 2016, for a total of 480 articles (see supplement for the 480 citations).

Abstracts from the 480 studies published were reviewed by two authors to determine whether they met our initial criteria for inclusion. Inclusion criteria for this meta-analysis were: 1) published in a peer-reviewed outlet between 2002 and 2016; 2) study took place in the U.S.; 3) research utilized a quantitative model; 4) model examined some type of FFO behavior (e.g. program or group participation, using/writing a management or succession/legacy plan, any type of forest management activities). These behaviors were selected for inclusion as they comprise the full range of landowner behaviors we identified in the published literature. Following similar meta-analyses of the agricultural best management practice literature (Baumgart-Getz, Prokopy, & Floress, 2012; Prokopy et al., 2008), studies included in this vote-count must have used a statistical model with behavior as the dependent variable. Our goal in this research was to examine studies of actual landowner behavior (versus behavioral intention or willingness). Thus, papers that assessed willingness or intent to adopt were not included in this analysis, nor were studies that created landowner typologies, unless the typology was used in further analysis of a behavior dependent variable. We limited our analysis to papers from the U.S. in order to have consistency in federal policy tools available for FFOs: for instance, those available through Farm Bill programs and United States Forest Service (USFS) funding to states to use for FFOs.

One hundred and twenty-eight studies were selected for possible inclusion in the vote-count based upon the abstract review (Fig. 1). After establishing inter-rater reliability (details below) among 5 coders, all 128 studies were fully read and coded by authors for their study level characteristics (Table 1) to capture similarities and differences among the types of studies we initially reviewed and those that were included in the vote-count. This information allows researchers interested in further exploration of the data to understand the extent to which characteristics related to study quality (sample size, methods) may be related to each study's conclusions. The studies were then categorized according to the evidence-based review criteria developed by Silver et al. (2015): the highest level of evidence included measurement of an actual behavior; moderate evidence included measurement of a past behavior; and the lowest evidence level included studies that only measured attitudes or intentions as the dependent variable. These studies were dropped from the vote-count analysis.

Citations of the studies included in the vote-count analysis, along with the dependent variable categories examined in each, can be found in Table 2. The full list of studies and inclusion decisions can be found in the supplement. Thirty-eight studies were fully coded and included in this vote-count (see Fig. 1).

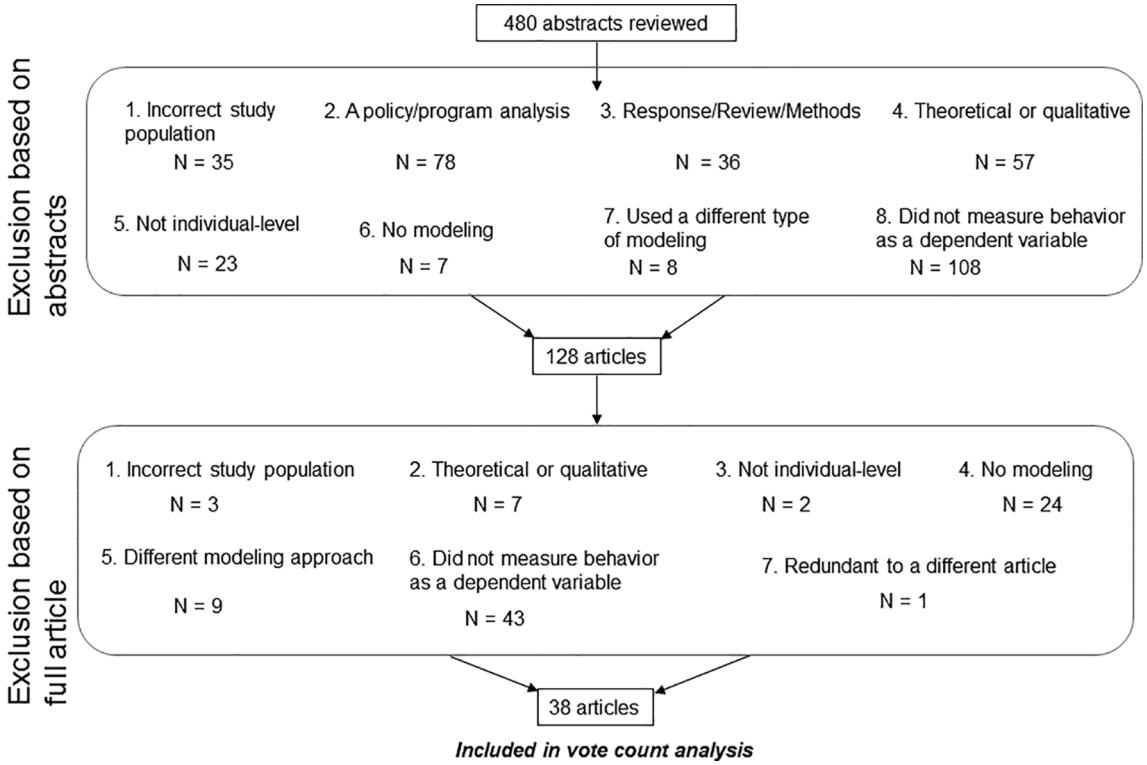

Fig. 1. Number of articles by levels of evidence.

Table 1
Characteristics of included and excluded studies.

	Included	Excluded	Total
Total reviewed	38	90	128
Data collection method			
Mail survey	30	59	89
Phone survey	2	2	4
Mixed-mode survey	3	7	10
Observed behavior	1	4	5
Interview/focus group	1	2	1
Mixed methods	–	2	1
Secondary data	–	3	3
Not applicable	–	4	4
Not described	–	1	2
Sampling method			
Simple random	13	25	38
Stratified random	13	29	42
Other random or both random/non-random	2	4	6
Census	1	5	6
Non-random	3	17	20
Not described	4	3	7
Not applicable	–	9	9

3. Coding process

3.1. Variable categorization

Dependent and independent variables were identified in an iterative process and coded according to category and subcategory. The authors, along with two additional family forest owner research experts, developed the initial code frame based upon knowledge of the literature, and then categorized our codes within the Beach et al. (2005) categories where possible. We added policy tool participation categories and subcategories based upon those developed by Schneider and Ingram (1990), and added categories based upon behaviors found in manuscripts. For instance, the dependent variable (DV) category wildfire mitigation practices was added further into the coding process, as it was not represented in the initial code frame. A number of subcategories were generated as we developed the initial code frame that ultimately were not included in our analysis because none of the evaluated studies used them; several subcategories within the independent variable (IV) category market drivers, for instance, were not found in the studies we coded. These subcategories are not described in this paper, but are available from the authors upon request.

The final set of 13 dependent variable categories (e.g., FFO behaviors) includes: cross-boundary cooperation, general stewardship, harvest, invasive species management, management plan, planting/reforestation, policy tool participation (DV), recreation, road construction/maintenance, timber stand improvement, wildfire mitigation, wildlife practices, and other or any management. Descriptions of variable categories and subcategories are found in Table 3.

The final set of nine independent variable categories (e.g., influencers of FFO behaviors) includes: attitudes, current/past behaviors, knowledge, market drivers, subjective norms, owner characteristics, ownership objectives, plot/resource conditions, and policy tools (IV) (Table 4).

We used the National Woodland Owner Survey (NWOS) (Butler, Dickinson et al., 2016; Butler, Hewes et al., 2016) and several key studies in developing the list of explanatory factors used in our study. From Beach et al. (2005) we adopt the four major independent variable categories they defined: *market drivers, policy tools, owner characteristics,* and *plot/resource conditions*. From Schneider and Ingram (1990), we draw upon major types of policy tools relevant to FFO behaviors to provide a more fine-scale evaluation of policy approaches, and from the NWOS we incorporate ownership objectives, current/past behavior, and knowledge.

Beach et al. (2005) invoked a utility maximization framework to examine FFO behaviors relative to harvesting, reforestation, and timber stand improvement activities. That is, they posit a landowner will undertake the optimal set of land management actions that maximize their utility, as influenced by four categories of factors: market drivers, policy drivers, owner characteristics and plot/resource conditions. Market drivers are defined as factors or conditions that influence the costs and/

Table 2
Sample size, publication year, and dependent variable categories for included studies.

Author(s) and Year	Sample size	Dependent Variable Category
Arano, Munn, Gunter, and Bullard (2004)	538	Planting/reforestation
Bagdon and Kilgore (2013)	1341	Policy tool participation
Brook et al. (2003)	379	Wildlife protection
Conway et al. (2003)	566	Harvest
Creamer et al. (2012)	1228	Policy tool participation
Fischer (2011)	505	Wildfire mitigation practices
Fischer and Charnley (2012a)	505	Cross-boundary cooperation
Fischer and Charnley (2012b)	505	Invasive species management
Fischer, Kline, Alger, Charnley, and Olsen (2014)	505	Wildfire
Fortney et al. (2011)	939	Policy tool participation
Gan et al. (2005)	410/313	Policy tool participation
Gan et al. (2015)	585	Wildfire mitigation practices
Gan et al. (2014)	585	Policy tool participation
Gan and Kebede (2005)	171	Harvest
Hendee and Flint (2013)	531	Policy tool participation
Jagnow et al. (2006)	1022	Recreation
Jarrett et al. (2009)	585	Wildfire mitigation practices
Jennings and McGill (2005)	1672	Harvest, TSI, Invasive species, General stewardship, Planting/reforestation, Road construction/maintenance, Wildlife protection
Joshi and Arano (2009)	244	Harvest, Recreation, TSI, Other/any management
Joshi et al. (2015)	703	Management plan
Kaetzel et al. (2009)	504	Policy tool participation
Kaetzel et al. (2010)	504	Policy tool participation
Kauneckis and York (2009)	251	Policy tool participation
Ma et al. (2012)	9688	Policy tool participation
Mehmood and Zhang (2005)	162	Wildlife protection
Molnar et al. (2007)	205	Invasive species management/monitoring; general
Potter-Witter (2005)	1221	Other/any management
Rasamoelina et al. (2010)	983	Other/any management
Rickenbach, Guries, and Schmoldt (2006)	503	Harvest, Invasive species mgmt., Other/any mgmt., Planting/reforestation, Wildlife protection
Ruseva, Evans, and Fischer (2015)	1938	Planting/reforestation
Snyder and Butler (2012)	15,799	Recreation
Snyder et al. (2008)	645	Recreation
Song et al. (2014)	2594/1044	Policy tool participation
Steele et al. (2006)	660	Invasive species management
Sun et al. (2009)	2229	Policy tool participation
Williams et al. (2004)	168	Policy tool participation
Wyman et al. (2012)	188	Wildfire mitigation practices
Zhang et al. (2006)	227	Recreation

or benefits of management actions; factors such as timber prices. Policy variables are factors that are associated with government programs or interventions such as tax incentives or cost-share programs that subsidize activities and thus alter the flow of costs and benefits. Owner characteristics represents the influence that landowner resources can have on actions and decisions, such as income, age and education. Physical conditions of the plot or resource included factors such as site potential, soil quality, slope, and parcel size. In their synthesis, Beach et al. (2005) found market drivers to be the most commonly *included* explanatory variable, followed by plot/resource conditions, owner characteristics, and policy variables. However, they also found that policy variables, when included, were most likely to be significant, followed by plot/resource conditions, owner characteristics, and market drivers. Thus, they advocated for greater consideration of broader policy tools as independent variables in models and analyses seeking to understand FFO harvesting actions, and suggest that FFOs may not be primarily responsive to market or other economic conditions as previously thought. Since Beach et al. (2005) strictly examined three types of harvesting activities, their analysis does not provide evidence for the statistical influence of policy tools to a broader suite of FFO actions, however.

We draw upon the political science framework that Schneider and Ingram (1990) outline in further defining the policy tools dependent and independent variable categories and to understand how different types of policy tools and approaches may influence a broad range of FFO behaviors. These policy tools also constitute actions on the part of FFOs, and are used as both dependent and independent variables in the FFO literature. Schneider and Ingram (1990) argue that policy tools influence behavior in five ways by: providing authority through regulations or laws that require or legitimize action; providing incentives that enhance the utility associated with behaviors; enhancing an individual's capacity to act through the delivery of information, training, education or resources; seeking to influence or align the perceptions and values of individuals with desired policy outcomes via symbolic and hortatory tools; and finally through learning tools which are designed to promote greater understanding among target groups about a particular problem and potential strategies to address the problem.

Schneider and Ingram (1990) argue then that a comparative analysis among policy tool types and behavioral responses allows for a deeper understanding of the effectiveness of each for different policy and management problems. We follow that suggestion in adopting three of the five policy tool approaches they define: incentive, capacity, and learning tools. We did not include authority tools, as authority tools regarding FFO behaviors are generally associated with their participation in an incentive program (e.g. FFOs are required to harvest if they enroll in Wisconsin's Managed Forest Law) and there were no papers addressing whether FFOs followed laws and regulations. We also did not include symbolic tools in our coding structure, as they tend to focus on the persuasive elements of behavior change programs, rather than on how people perceive them, and because the normative influences detailed by Schneider and Ingram (1990) for this category were captured elsewhere in our coding structure. We also refined their capacity category of policy tools into four more specifically defined concepts to provide greater detail about the approach used to build capacity: formal education or training, formal peer networking, networking with a professional, and seeking/receiving information. The final capacity

Table 3
Dependent variable category and subcategory descriptions.

Category (# studies)	Subcategory	Description	#*
Cross-boundary cooperation (1)	None	Any type of cooperative landscape management with neighboring landowners	10
General stewardship (2)	None	Any type of general activity noted as protecting resources like enhancing or protecting aesthetics, soil, or water	50
Harvest (7)	None	Conducted timber harvest, thinning	65
Invasive species management (8)	Identification	Engaged in invasive species identification on their property	9
	Monitoring	Monitored property for invasive species	10
	Removal	Removed invasive species from their property	32
	Other/not specified	Managed for invasive species	11
Management plan (2)	None	Has a management plan	18
Other or any management (3)	None	Composite of behaviors or behavior is non-specific (e.g., the authors modeled "any" behavior)	18
Planting/reforestation (4)	None	Planted trees on property	50
Policy tool participation (13)	Incentive	Participated in financial incentive programs	240
	Capacity – sought/received information	Sought or received information about forest management	15
	Capacity – Networking with professional	Communicated with forester or other land management professional	9
Recreation (7)	Lease	Leased land to others for recreation	6
	Posts against hunting	Posted land to prohibit hunting specifically	27
	Provides public access	Allowed public access in general	60
	Other/not specified	Engaged in action on property to enhance recreation activities that aren't specified	31
Road and boundary construction/maintenance (2)	None	Built, maintained, or otherwise managed property access and boundaries	29
Timber stand improvement (3)	None	Conducted timber stand improvement other than commercial harvest to improve tree stand	38
Wildfire mitigation practices (6)		Any activities associated with wildfire mitigation, including purchasing wildfire insurance	51
Wildlife practices (4)		Behaviors with the intent of protecting wildlife, including wildlife habitat and programs	48

*#Refers to the number of times the dependent variable was modeled. This number is greater than the number of included studies, as one paper may have investigated the same dependent variable using multiple models.

subcategory – seeking/receiving information – can potentially be seen as two different actions (one intentional, one passive), but some studies did not differentiate whether owners requested information or if it was simply delivered to them.

Attitudes, subjective norms, and intent were included as key variables to code based upon their prevalence in the FFO literature, particularly through the lens of the Theory of Planned Behavior (TPB, and its successor, the Reasoned Action Approach) (Ajzen, 1991; Fishbein & Ajzen, 2010). The TPB is a widely used social psychology theory that links attitudes, subjective norms, behavioral intentions, and behavior. According to the theory, human behavior is primarily guided by three considerations: (1) beliefs about the likely outcomes of the behavior and the evaluations of these outcomes (behavioral beliefs); (2) beliefs about the normative expectations of others and motivation to comply with these expectations (normative beliefs); and (3) beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors (control beliefs). The TPB has been used to predict a variety of landowner behavioral intentions including intention to participate in a government-sponsored riparian improvement program, natural reforestation (versus seeding/planting), in carbon sequestration and trading, and timber harvesting (Bieling, 2004; Corbett, 2002; Karppinen, 2005; Rekola, 2010; Young & Reichenbach, 1987; Vogt, Winter, & Fried, 2005).

Silver et al. (2015) conducted a comprehensive, evidence-based review (Pullin & Stewart, 2006) of studies that focused on FFO timber harvesting attitudes, intentions, and behaviors, identifying 19 significant predictors or correlates of FFO timber harvesting behaviors. From their review, the most reliable indicators to predict harvesting behavior were landowner age, parcel size, extension activity participation, timber production ownership objective, possessing a management plan, white collar occupation, education, debt to income ratio, and site value tax. While three other variables were found to be significant (i.e., membership in a woodland organization, farmer occupation, and non-timber amenity objectives), the evidence explicitly linking them to harvesting behavior was weak. Many of these variables fit broadly within the four categories (market drivers, policy drivers, owner characteristics, plot/resource conditions) defined by Beach et al. (2005). Finally, we used common categories of variables from the NWOS in our initial coding frame: landowner behavior (current/past), communication preferences, landowner knowledge, and ownership objectives. Communication preferences was dropped from further analysis because no studies used it in their models. Ownership objectives, on the NWOS, includes 16 possible reasons FFOs own their property. These were collapsed into 7 subcategories, plus an additional "other", in our analysis, as seen in Table 3.

For each of these broad IV categories we developed a number of finer differentiation sub categories. The decision to define such a large number of independent variable subcategories was done to allow us to examine the diversity of ways that these broad categories of independent variables were being defined and operationalized, and to then allow us to determine whether certain subcategory variables were better indicators of the broad IV categories as indicated by significance in the models. The fine scale definition of the independent variables also allowed us to 'roll-up' to broader categories or constructs with confidence that we had adequately captured the language and intent of more precisely defined variables in each of the individual studies.

For all variables, coders noted how a variable was measured – scale range, response options, question wording – when that information was included in the paper. When provided, analysis methods were coded as they were written in the paper, as were the hypothesized direction of relationships, the p-value, and number of observations included in the model.

3.2. Inter-rater reliability

Inter-rater reliability was established on a random sample of the papers through an iterative process when developing and testing the initial coding frame. Papers were coded for dependent variables,

Table 4
Description of independent variable categories and subcategories.

Category	Subcategory	Description
Attitudes	Environmental	Importance individual places on environmental quality
	Concern	Concerned about issue relevant to behavior
	Risk	Willingness to take risks
	Government	Willingness to take part in government programs, or general attitudes toward government/government programs
	Intent/willingness	Intent or willingness to engage in a behavior other than government programs
	Legacy and succession	Importance of passing land on to family members
	Toward behavior	Evaluation of specific behavior, certainty of plan recommendation
	All other	All other attitudes
Current/past behavior	Allows family/friends access	Allows family and friends on land
	Has harvested	Landowner has previously conducted a harvest
	Leased land	Leases/leased land to others
	Management plan	Landowner has forest management plan; refers to management plan
	Posted land	Posted land against public access
Knowledge	Environmental	General environmental knowledge
	Forest management	Knowledge related to impacts of forest management activities
	Program	Knowledge related to programs related to forest planning and management
Market drivers	Land value	Value of land
	All other	Includes market-based program characteristics
Norms	Normative beliefs	Beliefs about the behaviors and opinions of neighbors/peers
Owner characteristics	Absentee	Owner does not reside on land
	Age	Owner age
	Agricultural producer	Whether or not owner is farmer
	Formal education	Years of education or level of education
	Gender	Owner gender
	Income	Total household income, does not include income from land (farming, forestry).
	Inherited land	Whether owner inherited land
	Informal peer networking	Communicates informally with peers about forest management issues
	Manages own land	Whether owner manages their own land
	Ownership structure	Whether land is owned by an individual or jointly owned
	Purchased land	Whether individual purchased land
	Race/ethnicity	Race or ethnicity of owner
	Resides on land	Whether owner resides on land
	Retired	Whether owner is retired
	Years in family/years owned	Number of years property has been in a family
	Works with forester	Whether owner works with forester to manage land
Ownership objectives	Amenity	Includes beauty, scenery, privacy, raise family, nontimber forest products
	Conservation	Includes protecting nature, diversity, water, wildlife
	Financial	Includes owning land for investment
	Hunting	Includes owning land to hunt
	Personal use of wood	Includes using wood from land
	Recreation other than hunting	Includes using land for recreational activities other than hunting
	Timber	Includes owning land to manage for timber
	Other	All other ownership objectives
Plot/resource conditions	Accessibility of roads	Accessibility of roads on property
	Amenity/recreation opportunity	Opportunities for recreation and other amenities on property
	Parcel size	Total size of parcel or total forested acres
	Adjacent to public land	Property is adjacent to public land
Policy tools	Capacity – formal education or training	Participated in formal education or training activities dealing with resource management or forestry
	Capacity – formal peer networking	Participated in organized peer network(s), such as those organized through Extension activities or a woodland owner's association
	Capacity – networking with professional	Communicated with forester or other land management professional, other than works with a forester to manage their land
	Capacity – sought/received information	Owner sought or received marketing/communication about land/forest management
	Incentive	Participates in cost-share or tax incentive programs, including programs that apply to their non-forested land

independent variables, theoretical framework, data collection method, data analysis method, and direction of significance. For dependent and independent variables, percent agreement was 87% and the average Kappa value for rater-pairs was 0.6. For data collection, analysis, and theory use, inter-rater agreement was 100%, with a Kappa value of 1.0. Kappa values over 0.5 are considered acceptable for inter-rater agreement (McHugh, 2012). Further, frequent meetings to discuss coding were held, and all variables were discussed until we came to consensus on coding decisions. All coding was reviewed by the first author for consistency prior to analysis. When variables were potentially incorrectly coded, meetings were held with at least one additional author to make coding decisions.

4. Results

In this section, we present a broad overview of results, and then discuss more specific findings with regard to a sub-set of independent and dependent variables.

Table 5
Independent variable vote-count results by category.

Independent variable category	Sig −	Insig	Sig +	Total	%sig
Attitudes	4	55	41	100	45%
Current/past behavior	3	21	30	54	61%
Knowledge	0	5	9	14	64%
Market drivers	0	4	4	8	50%
Norms	0	2	0	2	–
Owner characteristics	48	123	75	246	50%
Ownership objectives	26	98	31	155	37%
Plot/resource conditions – parcel size/ forested acres*	6	10	27	43	77%
Policy tools	8	78	55	141	45%

* Only parcel size/forested acres was included in counts.

4.1. Study level characteristics

Of the 128 studies read (see Table 1, supplement), 94 used a mail survey, 8 used observational or secondary data, and 13 used a mixed method or mixed mode approach. Six studies did not describe or provide their method of data collection, or directed readers to other documents for basic methodological information. Studies were scattered across the U.S., with the greatest concentration in the Southeastern U.S. States with 3 or more studies focusing on Oregon, Indiana, Alabama, Mississippi, Virginia, North Carolina, New York and Massachusetts.

4.2. Dependent variable overview

The range of FFO behaviors that have been investigated over the past 15 years via quantitative modeling approaches is quite broad, though by far the most common dependent variables fell within the *policy tools (DV)* category and specifically within the incentive subcategory. *Policy tools (DV)* were included 264 times in 13 studies (i.e. 264 vote-counts – the number of times a given dependent variable was investigated is reported by the number of studies including it and the number of times it appeared in a model in relation to an independent variable). The dependent variable category least often modeled was *cross-boundary cooperation*, investigated 10 times, but only in 1 study.

4.3. Independent variable results

The independent variable category most often included in primary studies was *owner characteristics*: combined, the 16 subcategories were investigated 246 times in 28 studies, and were significant 50% of the time. *Ownership objectives* were used 155 times in 16 studies, and significant 37% of the time. *Subjective norms* were rarely used as predictors – only two studies used this variable and both found it to be insignificant. As with dependent variables, *policy tools (IV)* were common (examined 141 times in 20 studies), and were significant 45% of the time. *Market drivers* and *knowledge* also appeared far less often in the examined models than the remaining independent variable categories.

Independent variable categories that were significant typically included: a) *past/current behavior*, which was included 54 times and significant 61% of the time, b) *knowledge*, which was included 14 times and significant 64% of the time (and always positive when significant), and c) *plot/resource conditions-parcel size/forested acres*. *Parcel size/forested acres* was included 43 times and significant 77% of the time. In only six cases was *parcel size/forested acres* negatively related to a dependent variable.

Closer examination of *owner characteristics* subcategories shows *education* level of FFOs was most commonly investigated (50 times) and usually insignificant (Table 6). Two subcategories, *absentee* and *resides on land*, together were included 39 times, and show that residing on one's land is usually positively, rather than negatively, related to behaviors, though it is insignificant just as often. *Age*, while usually

Table 6
Owner characteristics subcategory counts.*

	Sig −	Insig	Sig +	Totals
Age	10	15	4	29
Absentee	1	9	1	10
Education	3	28	19	50
Female	1	0	2	3
Male	4	5	0	9
Resides	4	9	16	29
Years owned	2	12	6	20

* Income was removed from this analysis, as it was not consistently measured, and a simple significance count of the numerous categories reported in primary papers does not include enough information to make further conclusions.

Table 7
Ownership objectives subcategory counts.

	Sig −	Insig	Sig +	Totals
Amenity	7	17	3	27
Conservation	3	19	5	27
Financial	4	11	7	22
Hunting	2	10	5	17
Recreation	3	12	3	18
Timber	5	17	6	28
Other	2	12	1	15
Totals	26	98	30	154

Table 8
Selected counts of independent variable significance by dependent variable (number of studies examining this dependent variable included in parentheses).

DV	IV	Sig −	Insig	Sig +
General stewardship (2)	Attitude-toward behavior	0	0	4
	Ownership objective (any)	2	15	4
	Policy tools – incentive	0	14	4
	Policy tools – capacity	0	0	4
Harvest (7)	Ownership objective (any)	3	11	2
	Parcel size	0	0	3
	Policy tools (all)	0	8	4
Invasive species (8)	Attitudes (all)	0	11	6
	Knowledge – environmental	0	3	3
Planting/afforestation (4)	Knowledge – program	0	0	5
	Ownership objective (all)	0	8	0
	Parcel size	0	1	3
	Policy tools – incentive	0	3	3
Policy tool participation, Incentive – inducement (13)	Management plan	0	2	2
	Land value	0	4	0
	Ownership objective (all)	9	21	4
	Absentee landowner	0	8	0
	Age	1	3	9
	Education	1	12	8
	Gender – male	4	2	0
	Resides on land	2	2	3
	Retired	3	0	0
	Years in family	0	7	4
	Parcel size	3	4	9
	Policy tool participation Incentive – inducement	0	3	3
	Policy tools capacity – received/used information	0	8	14
Recreation – posts against hunting (2)	Concern	1	2	5
Recreation – provide public access (1)	Concern	0	8	0
Wildfire practices (6)	Concern	0	1	5
	Management plan	0	0	4
	Resides on land	0	1	6
Wildlife habitat (4)	Attitude – government	1	4	0
	Attitude – environmental	0	1	4
	Ownership objective (any)	0	6	3

insignificant, is negatively related to behavior more often than positively.

Ownership objectives, while frequently included in models of behavior, shows no clear trends in terms of the importance of the overall category or the subcategories (Table 7). It was insignificant 98 of the 155 times it was included, and, when significant, almost evenly split between negative and positive impacts. In general, this pattern is true whether looking at the category or its individual subcategories. However, the hypothesized direction of any given ownership objective is highly behavior-dependent: that is, one would not necessarily expect a timber objective to be positively related to participating in wildlife habitat protection program, whereas a strong and positive association between a timber objective and timber harvesting would be expected.

4.4. Independent variable relationships to landowner behaviors

This section highlights some of the interesting trends with regard to selected dependent and independent variables (Table 8). The information presented was selected either because it was investigated often or because the results exhibit a trend with regard to significance.

The *general stewardship* dependent variable category represented any type of general land care activity like protecting water quality or soil, or enhancing aesthetics. *Policy tools (IV)-incentive* was most often an insignificant predictor of these actions (14 times), but when significant (4 times), it was positively related to *general stewardship behavior*. *Policy tools (IV)-capacity* was significant and positive each of the 4 times it was investigated. *Attitudes toward the behavior* was included four times, and was positive and significant each time.

There were few clear trends with regard to *harvesting* actions. *Parcel size/forested acres* was included three times and was always positively associated with the harvesting action. *Ownership objective*, regardless of the specific objective, was insignificant 11 of the 15 times it was included in a model, and both positively (twice) and negatively (twice) related to *harvesting*. *Policy tools (IV)* was insignificant 8 of the 12 times included in *harvesting* models, but was positively related to harvesting the remaining four times.

Invasive species management included an environmental *knowledge* variable six times, which was positive and significant three times and insignificant the remaining three. *Attitudes* (e.g. toward forest land, information sources, or invasive species) were included 17 times, and were insignificant 11 times, but significant and positive the remaining 6.

Planting and afforestation was positively related to *knowledge of programs* all five times it was included. *Ownership objective* variables were insignificant all eight times they were included, and *parcel size* was positively related to *planting* three of the four times it was significant. *Policy tools (IV)-incentive* was evenly split between insignificant and positively related to *planting* the six times it was included.

Participation in incentive programs was the most often investigated dependent variable, and results show a number of interesting results. Once again, *ownership objective* is most often insignificant, and clear trends regarding the relationship of ownership objective subcategories to *policy tools (DV)* weren't apparent. The two *owner characteristic* variables *absentee landowner* and *resides on land* show that usually (10 of 15 times) there is an insignificant relationship between these and incentive program participation, and the remaining 5 are split between negative (n = 2) and positive (n = 3) times. *Age* is positive and significant nine of 13 times included in models, insignificant only three times and negative only once. *Education*, when significant (9 of 21 times), was almost always positively related to *policy tools (DV) – incentive program* participation (n = 8). *Parcel size* was positively related (n = 9) more often than insignificant (n = 4) or negative (n = 3). Finally, other *policy tools (IV)* were positively related to incentive programs. First, participating in any other incentive program was positive and significant three of the six times it was included – the other three times it was insignificant. Second, *receiving or using information* about forest management or related activities was significant and positive 14 times and insignificant the other eight.

Posts against hunting or *provides public access* both included attitudinal variables capturing concern about doing so. For *posts against hunting*, the more concerned people were about allowing access, the more likely they were to post against hunting. It was significantly and positively related to this decision five of the eight times it was included, negative once, and insignificant twice. For *provides public access*, however, it was insignificant in all models. Given that only one included study investigated *provides public access* and one include *posts against hunting*, these results should be interpreted cautiously.

Wildfire mitigation practices also showed several interesting and consistent trends, particularly in relation to *attitudes* and *owner characteristics*. Specifically, *concern* about wildfire was positively related to taking some type of action five of six times and never negatively related. Having a *management plan* was positive and significant all four times it was included. *Resides on land* was investigated seven times; only once was it insignificant, and was positively related to *wildfire mitigation practices* the other six times.

Finally, *wildlife practices* were not often a dependent variable, but did have potential trends with regard to independent variables. Having negative *attitudes toward the government or government programs* was negatively associated with *wildlife practices* once, and insignificant the remaining four times. *Environmental attitudes* were positively and significantly related to this behavior four of the five times it was included, and insignificant the remaining one time. *Ownership objectives* were usually insignificant (6), but were positive when significant (3).

5. Discussion

One of the main findings from the Beach et al. (2005) meta-analysis was that policy tools were the least utilized independent variable in models of harvesting behaviors although likely to be significant when they were included. Our vote-count illustrates wider usage of policy tool explanatory variables than Beach et al. (2005) encountered, as well as supports their contention that policy tools when included are often found to be significant correlates of landowner behavior. In contrast to Beach et al.'s (2005) analysis of timber harvesting behavior, our analysis of broader behaviors found much less use of market drivers as explanatory variables, but, when included, we found the influence of market drivers to be limited as Beach et al. (2005) also found. This limited utilization could be due to difficulty finding such data for specific studies or regions, or recognition that market/economic conditions aren't that influential, or that such factors aren't as predictive of FFO behaviors outside of timber harvesting. The overall lack of theoretical, rather than empirical, grounding of the FFO behavior literature included in this study may also be a factor with regard to variable (in) significance. Our results may also be indicative of the departure this literature has taken from primarily studying timber harvesting to a broader set of behaviors.

5.1. Landowner attitudes

Landowner attitudes as a category of explanatory variable to predict landowner behavior showed some salience in our analysis (e.g., for general stewardship activities, invasive species management, posting one's land, wildfire risk reduction, and wildlife protection). While not as broadly consistent as a significant factor as some of the other variables, there was nonetheless a signal that landowner attitudes can be captured and utilized within statistical models of behavior and may be useful as a class of independent variables in predicting a spate of FFO behaviors. Beach et al.'s (2005) 'owner characteristics' category of IVs did not include attitudinal variables, but rather relied upon socio-demographic characteristics of landowners. Thus, since attitudinal variables weren't included in their analysis, we cannot say whether attitudinal variables were included by authors in their models of harvesting

behavior or not, further, whether such variables were found to be influential. Silver et al. (2015), while acknowledging the potential role of attitudes in models of harvesting behavior, did not find any attitudinal variables to be significant. Prokopy et al. (2008), however, found positive environmental attitudes to be important and consistent indicators of farmer adoption of BMP practices. We suggest that FFO attitudes are an important category of explanatory variables that researchers strive to consider and incorporate when seeking to model landowner behavior, particularly because they are relatively efficient to measure. The challenge, however, may rest in determining the nature of the attitudinal variables that are most salient to specific forestland owner behaviors and actions.

Exploring papers that link attitudes and behavioral intentions could be one approach to beginning to understand the role of attitudinal variables. We had a number of papers that were fully read based on the abstract, but were determined to be based upon willingness or intention rather than actual behavior (e.g., Arano & Munn, 2006; Dickinson, Stevens, Lindsay, & Kittredge, 2012). These intention papers are important contributions to our understanding of what may lead to action, and are particularly valuable for developing new policy tools that can nudge people from intention to behavior, but paper titles and abstracts are often not clear that they do not include any investigation of actual or self-reported behavior. While some modeling studies have found FFO intentions to be fairly predictive of future behaviors (e.g., Withrow-Robinson, Allred, Landgren, & Sisock, 2013), others suggest this relationship is weak (e.g. Egan & Jones, 1995; Leahy, Reeves, Bell, Straub, & Wilson, 2013; Silver et al. 2015).

5.2. Ownership objectives

Ownership objective subcategories, while included in numerous FFO studies, were insignificant predictors far more often than significant. While ownership objectives may be useful in helping to target information, outreach and policy tools, they may, in fact, not be all that indicative of behaviors, or of all behaviors. Although Beach et al. (2005) did not examine ownership objectives, Silver et al. (2015) did and found a timber production ownership objective to be a significant predictor or correlate of timber harvesting behavior. Our findings that ownership objectives were not often predictive of a broader suite of FFO behaviors could suggest a number of things: 1) that the ownership objectives that are being defined and used in modeling studies don't fully capture landowner goals or intentions for their land, 2) that owners have multiple ownership objectives that are interrelated and possibly conflicting and that the interplay of multiple objectives confounds influence of individual ownership objective variables in models, or 3) other factors may ultimately override stated ownership objectives when it actually comes time for FFOS to take actions.

Ownership objectives, however, tend to comprise an important part of landowner typologies, and while there are numerous articles developing such typologies in the FFO literature (e.g. Nielsen-Pincus, 2011; Ross-Davis & Broussard, 2007), a landowner's categorization within a "type" is not often examined as an independent variable in quantitative studies of FFO behavior (i.e. used to understand behaviors other than those included in the analysis creating the typology). Further, the extent to which these typologies are used or tested to determine if they are helpful for policy development or practitioners working with FFOs is not clear. However, syntheses that have grouped the typology literature may provide insight for policy development and FFO outreach programs. For instance, in their global literature review of FFO typologies and "entrepreneurial activity" (e.g. generating income from one's forested land), Dhubháin et al. (2007) grouped all landowner clusters in the literature as indifferent or as either production- (of timber and/or income) or consumption- (e.g., personal use of wood, intangible benefits, recreation) oriented. Silver et al. (2015) grouped clusters of typology studies in North America and Europe into six general categories (adapted from Boon, Meilby, & Thorsen, 2004 and Urquhart & Courtney, 2011). Given the lack of consistent findings of significance of landowner objectives – regardless of the specific objective – as IVs in the behavioral models reviewed, greater attention to landowner typologies as IVs that seek to segment landowners based on more nuanced or expansive criteria seems warranted.

5.3. Significant variables of landowner behavior

Independent variable categories we found to be significant more often than not, overall, include current/past behaviors, knowledge, and plot/resource conditions – parcel size/forested acres. One implication of current/past behaviors being an important predictor of behaviors is that it suggests that if landowners are active or engaged in their land in *some* capacity (e.g., already doing/have done something on their land), then this is an indicator they are more likely to continue to that activity and/or do other things on their lands. This suggests that it is important to identify ways to entice unengaged landowners to take some first steps in meaningfully engaging with their land. Management plans have often been looked to as that first vital form of engagement and catalyst for action for private forest landowners. While this has been questioned (Kilgore et al., 2015), we did find that having a management plan was positively related to behaviors. In light of our other findings, though, the forestry community must continue to work to develop the assistance, outreach, and support networks that can catalyze new landowners to become actively engaged with and on their lands, whatever the best vehicle is.

While plot/resource conditions – parcel size is often positively related to a DV, it is important to consider that the specific DVs that were modeled (e.g. providing public recreational access, harvest, and planting/afforestation – see Table 8) may be more appropriate or feasible for those with larger parcel sizes.

6. Limitations

One limitation of the vote-count approach is that its focus is on statistical significance, and thus does not allow us to say anything about the magnitude or marginal contribution of the independent variables to the various dependent variables. However, findings from previous meta-analyses of the agricultural BMP literature (Baumgart-Getz et al., 2012; Prokopy et al., 2008) were quite similar, even though Prokopy et al. (2008) used a vote-count and Baumgart-Getz et al. (2012) used a statistical meta-analysis (i.e. statistically estimated effect sizes) of the same data. The final limitation is that our analysis was strictly focused on research conducted using quantitative methods as this is the type of analysis that can be evaluated using vote-count meta-analytic methods. Important issues regarding equity and access, underserved populations, and others gaining more traction and addressed more thoroughly in the qualitative literature are not examined in this paper. Future research is needed to conduct a synthesis of the FFO literature that utilizes qualitative inquiries to examine landowner behaviors.

7. Conclusion and recommendations

While we found three independent variables to be generally significant across a diversity of dependent variables (current/past landowner behaviors, landowner knowledge, and parcel size/forested acres), it is important to state that these findings don't necessarily negate the potential explanatory power of the host of other independent variables explored in this meta-analysis. Our lack of finding of significance of other variables across behaviors and studies in this meta-analysis could be attributed to a variety of things. It could be that certain explanatory variables may not have relevance or association for all FFO behaviors; but may be more/most salient for specific types of behaviors. Our vote-count meta-analysis was focused on identifying independent variables that had broad explanatory power over a diversity of behaviors. Findings could also be attributed to potential

differences in the FFO populations examined in the studies; e.g., regional or state-level differences may exist for FFO behaviors throughout the country as a result of differing forest resource conditions, markets and regulatory controls, and/or demographics of the study populations. Moreover, findings of insignificance of variables could also be attributed to these having little variability among the study population or within the study respondents. The fact, though, that we found three independent variable categories to be generally consistent in their influence across a diversity of behaviors suggests that these are ones that researchers should strive to include in models of FFO behavior.

It is also important to note that although the breadth of behaviors that was examined in this meta-analysis was broad; the number of studies in which any particular behavior was modeled often was small. Thus, our findings of which explanatory variables were found to most often be significant for any *particular* behavior should be viewed with that point in mind. We suggest more 'replicates' are needed of modeling studies for the FFO behaviors that have not been widely examined in order to be able to determine whether there are common explanatory variables of influence or association.

The small number of instances of modeling studies for some FFO behaviors was somewhat of a surprise given the growth in attention to and research on family forest landowners in the last twenty years. Part of the explanation may be that many inquiries into FFO behavior have focused on intentions and willingness rather than actual behavior. While there is much to be learned from studies that examine intentions and willingness, additional inquiry and follow-up research is needed to determine whether statistically significant explanatory variables in models of intentions can be viewed commensurately as significant explanatory variables in models of actual behavior. It is because these linkages have not been well-documented in the FFO literature that we chose to exclude the intentions/willingness studies from this meta-analysis. Thus, future research that seeks to validate findings from studies of FFO intentions and willingness as predictors of behavior is an important area for researchers seeking to understand drivers of FFO behaviors.

We suggest that FFO researchers make greater attempts to categorize the IVs that they do use according to established frameworks and theories, when appropriate, (e.g. Beach et al., 2005; Silver et al., 2015; Schneider & Ingram, 1990; and this paper) so that comparative analyses may be easier between studies in the future. As noted in Table 5, few studies in our vote-count included subjective norms as independent variables. We suggest more attention should be focused on it in future modeling studies to determine whether a better understanding of subjective norms might enhance our understanding of FFO behaviors and in particular whether norms can be effectively captured within a quantitative modeling framework.

In terms of dependent variables, one topic that has not received much attention to date (using quantitative methods) is landowner interaction or coordination with other FFO landowners and/or natural resources professionals when undertaking activities such as wildfire risk reduction or invasive species management: actions that address landscape-level disturbance factors which call for *cross-boundary cooperation* (e.g. Kittredge, 2005; Rickenbach, Schulte, Kittredge, Labich, & Shinneman, 2011). We suggest this is an important area for future FFO research emphasis to improve our understanding of potential facilitating and inhibiting factors to *cross-boundary cooperation* and whether intentions or willingness to cooperate actually materialize into actions.

While there is a robust literature that seeks to understand FFO behaviors, our work highlights that there is much we have yet to learn about factors that influence landowner behavior. Those who study FFO behavior can contribute to the research community's mutual understanding of this by focusing on actual behaviors and by strengthening our knowledge of how intentions relate to behaviors in a forestry context.

Acknowledgements

We are grateful for the early feedback on this project from Brett Butler and Tricia Gorby, and reviews of an earlier draft provided by Conner Bailey, Zhao Ma, and three anonymous reviewers. While no funding was received for data collection or field work, authors' salaries were supported in-kind by their organizations/agencies.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2018.08.024.

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