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RESEARCH PAPER

The Influence of Multiple Ownership Interests and Decision-Making Networks on the Management of Family Forest Lands: Evidence from the United States

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Abstract A national assessment of how the number of parcel owners influence family forest land management and use decisions in the US was conducted using a subset of the US Forest Service's National Woodland Owner Survey Dataset. Seventy-two percent of single parcel family forest land ownership respondents of at least 4.05 ha had multiple owners. The extent to which past land management practices and future intentions for the land are influenced by the number of owners of an individual parcel was evaluated. We also examined how landowner decision-making networks are related to past practices and future intentions. Contrary to previous findings, our research suggests that having more than one owner does not necessarily reduce the likelihood that a variety of different forest management activities, including commercial timber harvesting or wildlife habitat improvement, will occur. Moreover, we found that one-owner forested parcels are less likely to have experienced activities like harvesting, invasive plant removal, fire hazard reduction, wildlife habitat improvement, and cost-share program participation than parcels with two or more than two owners. We also found that family member involvement in landowner decision-making has a minimal effect on past and planned land management actions, while the involvement of a forester or land manager in decision-making increases the likelihood many land management actions have been or will be undertaken.

Keywords Undivided interest · National Woodland Owner Survey · Anti-commons · Social capital · Family forest · Heir property · NIPF

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Introduction

Undivided interest (UDI) is a land ownership arrangement in which a parcel of land is collectively owned by two or more individuals. With an UDI ownership arrangement, all owners share joint possession of the property, as opposed to each individual owning a discrete portion of the land. While many pathways to UDI ownership exist, we describe several of the typical ways in which it arises. One pathway is if an owner bequeaths the property to more than one heir (e.g., four siblings each receive a one-fourth ownership interest in a parcel per their parent's will). Another pathway is when a landowner dies without a valid will. In this situation, partial ownership of the property is distributed to all heirs, in varying percentages determined by state laws of intestate succession, who become 'tenant in common' owners. This type of UDI property is also referred to as heir property. Yet another way an UDI ownership structure can arise is through the sale or transfer of forest land by an individual to two or more individuals. Regardless of pathway, the new owners can own a fractional share of the forest land individually, or form a non-profit corporation or similar legal entity such as a limited liability corporation for shared use of the property for activities such as hunting (Hansen and Dickinson 1975; Deaton 2007; Eyvindson et al. 2011).

With UDI property, each co-owner has the same right to use and access the entire property as all other owners, regardless of the specific fractional ownership interest held (Deaton 2012). If this ownership structure persists through multiple generations of estate succession events, complicated ownership structures can develop with many co-owners having varying percentage interests in a single parcel, each with full use-rights to the entire property. A review of forest ownership arrangements in Carlton County, Minnesota found several hundred undivided interests in relatively small (e.g., 16.19 ha) forest parcels, some containing more than 10,000 fractional undivided interests.[1]

The UDI land ownership structure has been found to be particularly prevalent in the United States (US) with rural lands owned by minorities, Native Americans, and in low-income regions of the country (Mitchell 2001; Shoemaker 2003; Deaton 2007; Dyer et al. 2009). As noted by Dyer et al. (2009), it is difficult to derive precise estimates of the amount of land held in UDI arrangements in the US and, as such, little research has been done to empirically document its prevalence. Estimates of the percentage of rural African American-owned land in the southeastern US held as UDI parcel ranges from one-third (Graber 1978) to over a half (Rivers 2006). Shoemaker (2003) reports instances of tribal land holdings with hundreds of co-owners due, in part, to the legacy of Indian reserve land allotments. Dyer and Bailey (2008) find UDI ownership to be prevalent among lower-income Appalachian landowners. It is important to note that the UDI ownership structure examined in this paper is a different institutional and legal arrangement than that of community forest property. Common in developing countries, community forest property exists when the property rights or rights of access and use are transferred from a governmental entity to groups of individuals or

[1] Personal communication, Carlton County, MN Land Commissioner, June 7, 2013.

communities proximate to the forested area to be collectively managed (e.g., Rasul et al. 2011; Pinyopusarerk et al. 2014).

The UDI ownership structure has been found to be problematic for agricultural and forested lands for a number of reasons. For example, if all co-owners cannot agree on how the property will be used or managed, the land will often be unmanaged, abandoned, partitioned into smaller separate tracts, or subject to a forced sale through legal proceedings of one of its co-owners (Vranken et al. 2004; Deaton 2007, 2012). UDI ownership of family forest lands is not just a phenomenon in the US. Eyvindson et al. (2011) found that joint ownership of family forest lands in Finland is a common situation, and one that can hamper decision-making and management if owners, particularly of different family generations, cannot come to agreement on how to manage the forest land.

Research has also found that heir property, in particular, is less likely to be productively used (Graber 1978), and less likely to be invested in for upkeep and management due to concerns about unequal returns on investment (Deaton 2012). In terms of forest management practices, Gordon et al. (2013) note that multi-person ownership arrangements may complicate the ability to undertake practices such as thinning, harvesting, and prescribed burning because all landowners typically must sign a contract approving such activities as well as provide proof of ownership. Moreover, they find that parcels with a large number of owners will often not qualify for loans or landowner technical or financial assistance programs due to difficulties in either securing agreement among all parties on the conditions of the loan or program and/or providing clear title to such lands which is very often a legacy of heir property. While providing important foundational information on the topic of UDIs and forest land management, these studies have primarily focused on heir property (a specific type of UDI land ownership) and have been limited in their geographic scope, relying on localized case studies, interviews, and/or reviews of case law.

Thirty-six percent of the 331 million hectares of forest land in the US is owned by private, non-corporate entities, often termed ‘family forest landowners’ (i.e., families, individuals, trusts, estates, and family partnerships) (Butler et al. 2016a). The collective actions of these forest landowners have a substantial impact on the provision of forest-based goods and services throughout the country. In addition, given the current age class structure of this ownership group, a large-scale transfer of family forest lands is anticipated in the near future (Mater et al. 2005; Butler et al. 2016a; Markowski-Lindsay et al. 2016), which could result in greater prevalence of multi-owner arrangements if land transfers involve multiple heirs and/or a spate of private forestland sales if current owners choose to sell rather than pass land on to heirs. Together, these facts suggest that family forest owners are a compelling group to examine through the UDI lens.

To provide a more comprehensive analysis of family forest land ownership structure with a specific focus on UDI, we undertook a study utilizing a national dataset containing information on family forest lands and their owners, the National Woodland Owner Survey (NWOS) (Butler et al. 2016a). The NWOS is a long-term, on-going survey of private forest landowners in the United States administered by the USDA Forest Service. Implemented as a mail survey, the NWOS collects

information on the types of forest land management activities landowners have undertaken, their reasons for forest land ownership, concerns and information needs associated with owning and managing forest land, future plans for their forest land, and information about the landowner. While the NWOS does not ask specifically whether the respondent's forest land is held as an UDI, it does ask how many people are part of the ownership structure of the respondent's forest land. Consequently, the NWOS data allow us to examine the relationship between forest management behaviors and intentions and the number of owners.

By examining a subset of the NWOS data, we sought to identify how prevalent multi-owner ownership arrangements are among family forest lands throughout the US, and evaluate whether relationships exist between the number of owners and select forest management actions and intentions. NWOS data provide an opportunity to examine these research questions on a national level; a spatially-broad scale that has not been previously explored. We contend that having greater knowledge about the prevalence and characteristics of multi-owner ownership arrangements among private forest land holdings and relationships between the number of owners and forest management behaviors across the US will be useful to public land managers as they design and deliver private forest landowner assistance and education programs and as they try to anticipate changes and trends in the management and use of family forest lands.

Background

A theoretical framework for understanding why forested UDI properties may fail to be productively used can be found in the economic model of the anti-commons developed by Buchanan and Yoon (2000). They argue that an anti-commons situation occurs when owners of a common property resource have a right to both use the resource and exclude activities and uses by other owners. In this situation, Buchanan and Yoon (2000) show that resources tend to be under-utilized from an economic perspective. They term this phenomenon the tragedy of the anti-commons, an extension of Hardin's (1968) Tragedy of the Commons theory which postulates that common property resources may become over-used in situations where many have the right of use and none have the right to exclude those uses.

In the case of UDI property, all owners have the right of access and use and all have the right of exclusion. That is, owners can prevent other owners from undertaking land management or use activities such as harvesting or trail development by refusing to agree to such actions. Deaton (2007) examined heir property (one pathway to UDI ownership) through the lens of the anti-commons framework, finding that this ownership arrangement constrains economic development of rural lands. Mitchell (2001) and Dyer et al. (2009) found that heir property ownership is a driver for land loss or conversion because any one of the owners can force a subdivision or sale of an heir property (i.e., a partition sale). Schlueter (2008) argued that it is the anti-commons situation that leads to underutilization of forest resources (i.e., timber extraction, ecological benefits, social uses) in many small-scale, family-owned European forests. We follow Deaton (2007) and Schlueter

(2008) in invoking the anti-commons framework, hypothesizing that multi-owner ownership arrangements may limit family forest landowners' capacity to productively use, manage, or enjoy their property due to the practical and legal difficulties in securing agreement among all owners. Specifically, we model whether family forest lands held by multiple owners are associated with a: (1) lower likelihood of forest management activities; (2) reduced likelihood of future management intentions; and (3) higher likelihood (intention) of forest land transfer due to the possibility of partition sales by any one of the owners.

Two significant literature reviews conducted during the past decade provide a synthesis of the factors that have been found to be associated with or determinants of select forest land management activities. Beach et al. (2005) conducted a meta-analysis of forestry studies published between 1980 and 2003 to examine factors associated with private forest landowners' decisions or intentions to undertake timber harvesting, reforestation, and timber stand improvement. Their analysis identified four categories of factors often associated with these timber management activities: market drivers, policy variables, owner characteristics, and plot/resource conditions. Although their meta-analysis found variables associated with landowner characteristics are often associated with the three timber management behaviors they examined, variables related to the ownership or decision-making structure or number of owners were not identified or discussed. Silver et al. (2015) reviewed 44 years of non-industrial private forest landowner literature to identify factors associated with timber harvesting behavior. Their review found that larger parcel size, timber prices, and distance from residence are the most common significant predictors of harvesting behavior. While they also found that socio-economic factors are often also reliable predictors of harvesting behavior (e.g., income, education, age), again no variables associated with number of owners or ownership structure were identified in their review.

In a related area, Prokopy et al. (2008) conducted a meta-analysis of the agricultural literature to identify factors associated with farmer adoption of agricultural best management practices (BMPs). They found that education level, capital, income, farm size, access to information, environmental attitudes, environmental awareness, and utilization of social networks are often positively related to the adoption of BMPs. Again, there was no finding or discussion of any potential influence in the adoption of management activities as a function of the number of owners.

In a review of the family forest landowner literature specific to UDI ownership, we found only two predictive modeling studies of family forest landowner behaviors or intentions which included an explanatory variable related to the number of parcel owners or some other aspect of UDI ownership. Zhang et al. (2006) included a binary variable indicating individual versus joint ownership in a logit model examining factors associated with forest landowner decisions to lease their land for hunting, finding that parcels with joint ownership were more likely to be leased. Greene and Blatner (1986) explored the influence of undivided interest ownership on timber management behaviors in Arkansas forest landowners in a different way. They conducted a discriminant analysis, including a variable defined as the percentage of the landowner's wooded land held in an undivided estate, and

found landowners with higher percentages of their wooded land in an undivided estate were less likely to manage for timber on their land.

Our analysis provides exploratory research to examine whether relationships between number of parcel owners and management actions and intentions may exist on family forest lands throughout the US. Specifically, based on our review of the UDI literature, we hypothesize that having more owners makes a family forest land parcel less likely to have experienced active management in the past, less likely to be managed in the future, and more likely to be sold or given away in the future. Our contention is that having more owners could result in a greater diversity of ownership goals and owner attitudes, values, and interests for the land. This, in turn, might lead to greater conflict and difficulty reaching agreement and, thus, less management, use, and stewardship of the land, as well as a threat of subdivision and partition sales that could be brought by any one of the owners.

Methods

Data

We used the most recent available cycle of NWOS data collected from 2011 to 2013.[2] The NWOS questionnaire was sent to 21,511 private forest ownerships. Of the surveys returned, 8576 were from family forest ownerships with at least 4.05 ha of forest land (Butler et al. 2016a). Although questionnaires were sent to several types of private forest landowners, we focused only on the responses from non-corporate family forest landowners for this analysis (i.e., individual, joint, family partnership, trust, estate). We further limited our analysis to NWOS respondents who own at least 4.05 ha, as we felt smaller parcels might not be large enough to undertake meaningful forest and other land management activities. We also removed from consideration all respondents who indicated they own more than one separate, unconnected wooded property in the state. We did this because if the respondent owns more than one parcel, we have no way of knowing whether the information provided (number of owners, past land management actions, future intentions) applies to all or just a subset of the respondent's wooded landholdings. Thus, by limiting our analysis to respondents with single parcel ownerships, we can be certain of the ownership structure, physical characteristics, and the parcel-specific management actions taken on and future intentions for the respondent's forest land. Applying these three filters produced a dataset consisting of 4259 records.[3]

[2] For additional details on sample design and survey administration, refer to Dickinson and Butler (2013) and Butler et al. (2016b).

[3] Per Butler et al. (2016a), non-response bias checks of the response data were performed. Specifically, telephone follow-up interviews were conducted with 11.7% of mail survey non-respondents. No statistically significant differences were found between mail and phone respondents in terms of forest holding size or cost-share program participation. Mail respondents were found to be more likely to have obtained a management plan and received forest management advice. Findings should be interpreted with these points in mind.

It is important to point out that removing multi-parcel ownerships from the NWOS dataset may bias our analysis towards forest parcels with fewer owners, as 25% of the 4.05+ ha multi-parcel ownerships in the full NWOS dataset have one owner, whereas the number of single owner-parcels in our culled dataset is 29%. Additionally, the average parcel size in our dataset is significantly smaller than the average size owned by multi-parcel ownerships in the complete NWOS dataset (149 and 444 ha respectively), which could bias our results towards smaller parcels. Our results should be interpreted with these two points in mind.

Variables

When multiple owners exist, the NWOS is sent with instructions that the primary decision-maker for the ownership complete the survey. Given that our analysis focuses on the relationship between the number of owners of a forest landholding and management actions, we were limited in the types of NWOS response data we could use. That is, while the NWOS asks a range of questions related to the respondent's demographics, attitudes and reasons for land ownership, we concluded that data from these types of respondent-specific questions could not be used in our analysis since we do not have this information for all of the owners of each parcel.[4] Consequently, we focused on those NWOS variables that contain information about the parcel, not the respondent.

We used Beach et al. (2005) as an initial guide for the selection of our model's explanatory variables, which identified four categories of variables that drive landowner actions: market, policy, owner, and plot. Market variables such as timber prices or harvesting costs were not used in our model, due to the significant variability and availability of these data nationally. The policy variables in our dataset that characterize landowner actions (e.g., cost-share assistance program participation) are included in our model as some of the landowner actions we evaluated. Because the NWOS dataset only contains demographic information on up to two of the owners, none of the data describing the respondent (e.g., attitudes, concerns, demographics) could be used in our model since we did not have those data for all of the owners. The only parcel variable collected by the NWOS describes parcel size (acres) and is used as a covariate in our model. Larger parcel size has been repeatedly found to be associated with or a predictor of various forest and agricultural management actions (Beach et al. 2005; Prokopy et al. 2008; Straka 2011; Silver et al. 2015). We hypothesize that larger parcel size is positively associated with forest land management behaviors and intentions.

We included the number of owners as a set of three mutually exclusive binary variables (ONE_OWNER, TWO_OWNERS, THREE-PLUS_OWNERS).[5] The

[4] The NWOS does not collect information for more than the respondent except for demographic information (retirement status, occupation, age, gender, education, race and ethnicity) for up to two owners.

[5] These categories were chosen to represent the numbers of owners for two reasons. First, the distribution of owners in our dataset is heavily skewed towards one and two-owner parcels, with only 16% of the records containing parcels owned by three or more individuals. Thus, creating categories of ownership numbers at finer divisions than one, two or more than two is difficult to justify. Secondly, we believe that

selection of these three categories was based on the distribution of the number of owners in our dataset (i.e., over half of the forest parcels in our dataset have two owners; 16% have three or more owners). We hypothesized that parcels with more owners are less likely to have experienced select forest management actions, less likely to have been enrolled in forest conservation or incentive programs, less likely to experience select future management activities, and more likely to experience future land transfer.

Finally, we created two explanatory variables from responses to the question: 'Who makes the management decision, such as whether or not to harvest trees, for your wooded land?' The NWOS instructed respondents to check all that applied from the following: 'Me, my spouse, my children, my parents, another family member, my business partner, or my land manager/forester.' From these response choices, two binary variables were created. The first indicates whether the respondent's decision-making structure includes a land manager or forester (PROFESSIONAL).[6] The second variable (FAMILY) indicates whether any family members are included in the decision-making structure (i.e., spouse, children, parents and/or other family member).[7] As noted by Eyvindson et al. (2011), it is common for family members to be involved in decision-making on family forest lands, even if they aren't owners of the land.

We included the variables FAMILY and PROFESSIONAL in the model to enable a comparison of these two decision-making structures to one that only involves the NWOS respondent. By doing so, we are able to identify the marginal effect additional decision-makers beyond the owner(s) has on past forest management actions and future intentions. The inclusion of these two variables as predictors of forest management behavior is somewhat exploratory, as the influence these variables might have in our models is unknown. Having more decision-makers or decision-influencers, similar to having more owners, might complicate the ability to come to agreement on how to manage the land given a greater diversity of opinions, interests, experience, attitudes, and values. Alternatively, if we consider research on the role of social networks in resource management, we might hypothesize that owners or ownerships utilizing broader networks in their decision-making process and/or the inclusion of a forestry professional might be more likely to be engaged and active managers (e.g., Knoot and Rickenbach 2011; Ruseva et al. 2014). For example, Prokopy et al. (2008) found that the greater a farmer's social network and social capital (e.g., strength of interaction, familiarity and connectivity with agencies, professionals, and neighboring farmers), the more likely he/she is to

Footnote 5 continued
these groupings of owners have practical significance that might shed insight their forest management actions (e.g., solo owners, two owner-ownerships (many of which might represent married couples), and three plus owners (representing an ownership arrangement outside of a marriage structure).

[6] Note, the response category 'business partner' was not used in creating either the Family or the Professional variables as there was no way to discern whether a business partner might be a family member, a professional, or other categorization. Fifty-six respondents indicated the use of a business partner.

[7] Four-hundred thirty-nine respondents indicated *only* people other than themselves were involved in decision-making for their forestland. These respondents were not included in our analysis since, by their response to this survey question, they were not part of the decision-making structure for their land and we were interested in examining the marginal influence of family and/or professional involvement on a landowner's decision-making.

undertake agricultural BMPs. Silver et al. (2015) found evidence that contact with a professional forester is positively related to timber harvesting behavior, and Beach et al. (2005) found technical assistance is often positively associated with timber harvesting, reforestation and timber stand improvement activities. Table 1 contains a description of the study variables.

Models

Binary logit models were developed to examine the relationship between ownership number and decision-making network and the likelihood that respondents had undertaken twelve forest management actions (i.e., within the past 5 years: commercially harvested timber, improved wildlife habitat, eliminated invasive plants, built or performed maintenance on roads or trails on their forest land, reduced fire hazard, conducted a controlled burn; since owning their forest land: participated in a cost-share program, conveyed an easement, leased their forest land, commercially harvested timber; currently: participated in a forest property tax program). Binary logit models were similarly developed to evaluate the relationship between the number and decision-making network of owners and their stated intentions to undertake five actions in the next 5 years (i.e., commercially harvest timber, improve wildlife habitat, build or maintain a forest road, build or maintain a forest trail, plan to sell or give away any of their forest land). Finally, a binary logit model was developed to examine the relationship between ownership number and decision-making networks and lack of management activity (i.e., if a respondent indicated they had not done any of the following in the past 5 years: harvested commercially or for personal use, collected non-timber forest products, reduced fire hazard, conducted a prescribed burn, eliminated invasive plants, eliminated

Table 1 Definitions and descriptive statistics of the explanatory variables used in the logistic regression models ($n = 4259$)

Variable	Description	Min	Max	Mean
Parcel characteristics				
Size	Natural log of forest hectares owned	1.40	9.93	5.01
Ownership characteristics				
One_owner	1 if the ownership structure consists of one owner, 0 otherwise	0	1	0.29
Two_owners	1 if the ownership structure consists of two owners, 0 otherwise	0	1	0.55
Three_plus_owners	1 if the ownership structure consists of three or more owners, 0 otherwise	0	1	0.16
Family	1 if the decision-making structure consists of the respondent and other family members; 0 otherwise	0	1	0.28
Professional	1 if the decision-making structure includes a forester or land manager; 0 otherwise	0	1	0.05

unwanted insects or diseases, constructed or maintained a forest road or trail, improved wildlife habitat, grazed livestock). The eighteen logit models were run twice; once with THREE-PLUS_OWNERS as the reference condition, and once with TWO_OWNERS as the reference condition so that all of the pairwise relationships between the three categories of owner number could be examined.

For the majority of the models focusing on the past management actions, the dependent binary variable was created from an NWOS survey question that asks whether each activity had occurred with response options of "yes" or "no." For the models focusing on program participation (cost share, easement, tax program), the dependent binary variable was created from a NWOS question that asks whether the respondent has ever participated in such a program with response options of "yes," "no," or "don't know." For the purposes of our analysis, only the yes and no responses are included in the models.[8] For the models focusing on future owner intentions, a binary dependent response variable was created from NWOS questions that asks how likely these activities are to occur on a 5-point Likert scale (5 being "extremely likely" to 1 being "extremely unlikely"). Responses to these questions of either 5 (extremely likely) or 4 (likely) were coded as a 1 and remaining responses were coded as 0. The natural log of the parcel size (hectares) was taken (SIZE), as diagnostic tests concluded this transformation improves the models' functional form. Tests for multicollinearity among the independent variables found acceptable correlations, the highest being −0.31 between FAMILY and ONE_OWNER. The variance inflation factor (VIF) was also estimated for each of the independent variables as another check for multicollinearity. The VIF values were all <2.5, which Allison (1999) states is a reasonable threshold for rejection of multicollinearity issues. Marginal effects are calculated for statistically significant predictors using sample means. All data analysis was performed using SPSS version 21.

Results

Within our NWOS dataset consisting of respondents who own only one parcel in a given state that is at least 4.05 ha, there are, on average, 2.34 owners per family forest parcel, with individual parcels containing as many as 235 separate owners (Table 1). Twenty-nine percent of the parcels are owned by one individual (Fig. 1). The majority (55%) of family forest land in this dataset is owned by two individuals. Combined with the one-owner parcels, one and two owner parcels represent 84% of the forest land ownership arrangements. Five hundred thirty-five parcels (12%) have three to five owners, while 152 parcels (4%) have six or more owners.

Individual parcels range in size from 4.05 to 20,639 ha. Mean parcel size in our dataset is 149.33 ha. Just under one in three (28%) of the respondents indicated that they, along with other family members (i.e., spouse, children, parents and/or other family member), make the

[8] Dropping the 'Don't Know' responses resulted in the removal of 129, 463, and 517 observations for the cost share, easement, and tax program participation models, respectively.

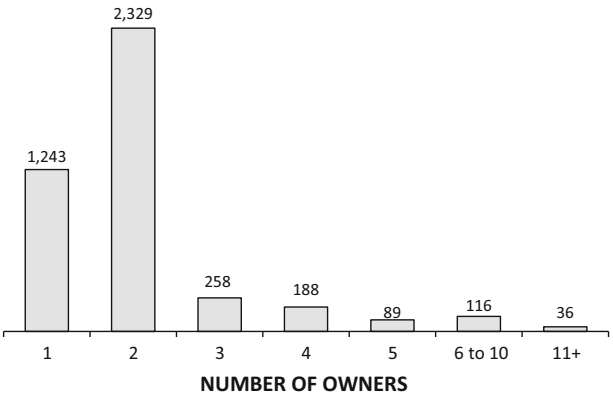

Fig. 1 Distribution of number of owners of family forest land for one-parcel respondents to the NWOS owning at least 4.05 ha of forest land ($n = 4259$)

management decisions for the forest land, while only 5% of respondents indicated that a forester or land manager is part of their decision-making structure.

In examining the frequency by which past or planned future landowner actions are identified by the respondents in our dataset, none of the landowner actions evaluated were identified by a majority of family forest owners as already undertaken or likely to be undertaken in the next 5 years (Table 2). Conveying a conservation easement is the least-common action undertaken, cited by only 5% of the respondents. In contrast, nearly half (47%) have commercially harvested timber since owning their forest land. The percentage of respondents that have commercially harvested timber in the past 5 years (24%) is similar to those that plan to conduct a harvest in the next 5 years (23%). A higher percentage of respondents plan to improve wildlife habitat in the next 5 years (49%) than had done so in the previous 5 years (31%). Participation in forestry assistance programs is modest, with 15% having participated in a cost share program and 27% in a forest property tax program. Undertaking activities related to fire management is also modest, with 16% having taken actions to reduce fire hazard and 9% conducting a controlled burn. A substantial majority of respondents (85%) do not have near-term plans to transfer their forest land. A similar proportion (82%) have undertaken at least one type of forest management activity in the past 5 years. Moreover, χ^2 tests of differences in rates of implementation of the practices among the three ownership groups are significant for all but two of the actions and intentions examined (past wildlife habitat improvement activities and intentions to build a trail), indicating implementation or planned adoption of the actions does vary by the number of owners as we have defined owner number groups (Table 2). Inspection of Table 2 does not illustrate any systematic trends between our categories of the number of owners and adoption of the behaviors or intentions examined, however.

Table 3 contains the results of the logistic regression models. All models are statistically significant at $\alpha \leq 0.001$. Parcel size (SIZE) is a significant, positive predictor of past or planned future landowner actions in all models, meaning that the likelihood a landowner had undertaken an action or planned to do so in the next

Table 2 Past and planned future actions of one-parcel respondents to the NWOS owning at least 4.05 ha of forest land by owner number groups. (Sample size varies among actions due to incomplete and missing responses.)

Landowner action	One owner parcels Number (%) of respondents		Two owner parcels Number (%) of respondents		Three plus owner parcels Number (%) of respondents		All parcels Number (%) of respondents	
	Yes	No	Yes	No	Yes	No	Yes	No
Past actions								
Commercially harvested timber (last 5 years)*	269 (25)	819 (75)	451 (22)	1603 (78)	160 (33)	328 (67)	880 (24)	2750 (76)
Commercially harvested timber (since owning land)*	439 (52)	469 (48)	745 (44)	952 (56)	225 (55)	188 (45)	1409 (47)	1609 (53)
Improved wildlife habitat (last 5 years)	315 (29)	773 (71)	642 (31)	1412 (69)	171 (35)	317 (65)	1128 (31)	2502 (69)
Removed invasive plants (last 5 years)*	258 (24)	830 (76)	569 (28)	1485 (72)	160 (33)	328 (67)	987 (27)	2643 (73)
Built or maintained trails (last 5 years)*	289 (27)	799 (73)	635 (31)	1419 (69)	144 (30)	344 (70)	1068 (29)	2562 (71)
Built or maintained roads (last 5 years)*	193 (18)	895 (82)	373 (18)	1681 (82)	145 (30)	343 (70)	711 (20)	2919 (80)
Reduced fire hazard (last 5 years)*	144 (13)	944 (87)	339 (17)	1715 (83)	107 (22)	381 (78)	590 (16)	3040 (84)
Conducted controlled burn (last 5 years)*	82 (8)	1006 (92)	189 (9)	1865 (91)	68 (14)	420 (86)	339 (9)	3291 (91)
Conveyed conservation easement (since owning forest land)*	42 (4)	925 (96)	93 (5)	1780 (95)	34 (8)	416 (92)	169 (5)	3121 (95)
Received cost share (since owning forest land)*	140 (13)	928 (87)	287 (14)	1748 (86)	113 (24)	365 (76)	540 (15)	3041 (85)
Leased land (since owning forest land)*	206 (19)	910 (81)	303 (15)	1783 (85)	162 (32)	338 (68)	671 (18)	3031 (82)
Participated in forest property tax program (currently)*	274 (29)	685 (71)	475 (26)	1372 (74)	130 (32)	282 (68)	879 (27)	2339 (73)
No activity (last 5 years)*	241 (22)	847 (78)	340 (17)	1714 (83)	74 (15)	414 (85)	655 (18)	2975 (82)
Future intentions								
Commercially harvest timber*	256 (24)	805 (76)	436 (22)	1564 (78)	170 (35)	313 (65)	862 (24)	2682 (76)
Improve wildlife habitat*	506 (49)	533 (51)	1053 (53)	924 (47)	254 (55)	209 (45)	1813 (52)	1666 (48)
Build or maintain roads*	244 (24)	779 (76)	429 (23)	1471 (77)	164 (36)	296 (64)	837 (25)	2546 (75)
Build or maintain trails	384 (37)	648 (63)	765 (39)	1178 (61)	174 (38)	285 (62)	1323 (39)	2111 (61)
Transfer forest land*	186 (17)	920 (83)	293 (14)	1799 (86)	86 (17)	409 (83)	565 (15)	3128 (85)

* Significant χ^2 test of differences in implementation among the three ownership groups at $p \leq 0.05$ for 1 versus 2 versus 3+ groups

Table 3 Logistic regression coefficients examining the relationship between number of parcel owners (modeled as sets of binary variables) and family forest owner behaviors and intentions

Land owner action	Size	Family	Professional	One owner[1]	One owner[2]	Two owner[2]	*N*
Commercially harvested timber (last 5 years)	0.322**** (0.058)	−0.212** (−0.037)	1.395**** (0.246)	0.054	−0.216* (−0.038)	−0.270*** (−0.048)	3630
Commercially harvested timber (since owning forest land)	0.282**** (0.070)	−0.080	1.170**** (0.291)	0.125	−0.043	−0.168	3018
Improved wildlife habitat (last 5 years)	0.341**** (0.072)	−0.075	0.496*** (0.105)	−0.183** (−0.039)	−0.025	0.158	3630
Removed invasive plants (last 5 years)	0.173**** (0.034)	0.087	0.151	−0.207** (−0.041)	−0.286** (−0.056)	−0.079	3630
Built/maintained trails (last 5 years)	0.119**** (0.025)	0.119	0.719**** (0.148)	−0.198** (−0.041)	−0.023	0.176	3630
Built/maintained roads (last 5 years)	0.483**** (0.070)	0.055	0.433*** (0.063)	−0.077	−0.287** (−0.042)	−0.211* (−0.031)	3630
Reduced fire hazard (last 5 years)	0.281**** (0.037)	0.099	−0.140	−0.268** (−0.035)	−0.344** (−0.045)	−0.076	3630
Conducted controlled burn (last 5 years)	0.377**** (0.029)	−0.138	0.011	−0.311** (−0.024)	−0.388** (−0.030)	−0.077	3630
Conveyed easement (since owning forest land)	0.313**** (0.014)	0.185	0.751*** (0.033)	−0.136	−0.265	−0.129	3290
Received cost share (since owning forest land)	0.553**** (0.060)	−0.130	1.124**** (0.122)	−0.214* (−0.023)	−0.353** (−0.038)	−0.139	3584
Leased land (since owning forest land)	0.579**** (0.075)	−0.068	−0.851**** (−0.110)	0.235** (0.030)	−0.320** (−0.041)	−0.555**** (−0.072)	3702
Participated in forest property tax program (currently)	0.199**** (0.039)	0.252*** (0.049)	1.894**** (0.369)	0.196** (0.038)	0.086	−0.110	3218

Table 3 continued

Land owner action	Size	Family	Professional	One owner[1]	One owner[2]	Two owner[2]	*N*
No activity (last 5 years)	−0.351**** (−0.049)	0.087	−0.707*** (−0.099)	0.445**** (0.062)	0.250	−0.195	3630
Commercially harvest timber (in next 5 years)	0.385**** (0.072)	−0.108	1.442**** (0.252)	0.051	−0.294** (−0.051)	−0.346*** (−0.060)	3544
Improve wildlife habitat (in next 5 years)	0.289**** (0.074)	−0.173** (−0.043)	0.555**** (0.138)	−0.282**** (−0.070)	−0.074	0.208* (0.052)	3479
Build road (in next 5 years)	0.479**** (0.085)	0.101	0.497*** (0.088)	0.040	−0.184	−0.224* (−0.040)	3383
Build trail (in next 5 years)	0.178**** (0.042)	0.063	0.711**** (0.168)	−0.101	0.127	0.227** (0.054)	3435
Transfer land (in next 5 years)	0.141**** (0.018)	−0.192* (−0.024)	−0.474** (−0.061)	0.149	0.040	−0.108	3693

Marginal effects for statistically significant variables are shown in parenthesis

[1] TWO_OWNERS is reference category

[2] THREE_PLUS_OWNERS is reference category

* $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$; **** $p \leq 0.0001$

5 years increases as the size of the parcel increases. In general, the likelihood of the management actions we evaluated (already undertaken or planned) increases from 1.4 (convey a conservation easement) to 7.5% (lease forest land) for every 2.72 ha owned. The SIZE coefficient is negative in the model that focuses on a lack of management actions in the past 5 years, indicating that the likelihood of an ownership being inactive decreases as the size of the parcel increases.

The individuals that family forest landowners consult when making decisions about their land has a relationship to some of the land management behaviors and intentions we examined. Compared to when the respondent is the only decision-maker, the inclusion of other family members (FAMILY) in decision-making reduces (by 3.7%) the likelihood that a commercial timber harvest has occurred in the last 5 years or that the owner(s) plan to improve wildlife habitat (4.3% lower). However, when family members are included in the decision-making process, the likelihood that the landowner has enrolled in a forest property tax program increases by 4.9%, and the likelihood that the owner plans to dispose of their forestland in the next 5 year decreases by 2.4%.

The involvement of a land manager or forester (PROFESSIONAL) in the decision-making process has a wide-ranging and substantial impact on the likelihood that the forest land has been and/or will be managed. Except for attempts by landowners to eliminate invasive plants, reduce fire hazard, or conduct a controlled burn, all other past or planned management actions are influenced when a professional is included in decision-making for the ownership. Forest owner decision-making that involves a forester or land manager is associated with a greater likelihood of the following activities: conducting a commercial timber harvest (past, recent past, future intention); building or maintaining roads or trails (past, future intention); undertaking wildlife habitat improvement projects (past, future intention), participating in landowner assistance programs (e.g. forest property tax programs, cost share program); and conveying an easement. The degree of a professional's influence on past and planned land management activities can be large. For example, the likelihood that the forest land has been enrolled in a forest property tax program increases nearly 37% when a forester or land manager is part of the landowner's decision-making network. Similarly, landowners are 25% more likely to have harvested in the past 5 years and in the next 5 years when a professional is involved. Including a professional in the decision-making process reduces the likelihood the forest land has been leased in the last 5 years and will be transferred in the next 5 years. Moreover, ownerships that include a forester or land manager in their decision-making network are also less likely to have been inactive on their land in the past 5 years.

Overall, the inclusion of family members in the landowner'(s) decision-making network was found to have limited impact on the likelihood of undertaking or planning to undertake management activities. In contrast, including a professional forester or land manager in one's decision-making structure has a substantial influence on landowner behaviors and intentions, and a greater relative impact on behaviors and intentions than the inclusion of family members.

Our variable categories that defined the number of owners of a parcel is significant in a number of the models (Table 3). Specifically, one-owner parcels are

less likely than two-owner parcels to have had the following activities: improve wildlife habitat, invasive species removal, trail building or improvement, fire hazard reduction, controlled burn, and cost-share program participation. One-owner parcels are also less likely to have future intentions to improve wildlife habitat than two-owner parcels. Conversely, single owners are more likely than dual owners to have leased their land, participated in a forestry property tax program, and undertaken no activities on their forest land in the past 5 years. The magnitude of the differences in likelihood of undertaking activities when comparing one to two-owners ranges from a 3.8% increase (tax program participation) to a 7.0% decrease (plan to improve wildlife habitat).

Similarly, sole owner parcels are also less likely than ownerships of three or more people to have undertaken a number of the same activities, including recent and future harvesting activities, removal of terrestrial invasive plants, road building and maintenance, fire hazard reduction, controlled burning activities, cost share program participation, and leasing. The marginal effects range from a 3.0% reduced likelihood of conducting a controlled burn to a 5.6% reduced likelihood of invasive plant removal for single owners versus ownerships with three or more people. Thus, in general, the findings suggest that sole owners are less active than ownerships comprised of either two or three or more people.

The actions of two-owner and three-plus ownerships are similar in many respects, although a few differences emerge. Compared to three-plus ownerships, parcels owned by two individuals are less likely to experience harvesting activities (past 5 year and future 5 years), road building and maintenance activities (past 5 years and future 5 years), and leasing activities. Alternatively, two-person ownerships are more likely to have plans to improve wildlife habitat and build trails in the next 5 years than ownerships of three or more people. As with all of the relationships between the binary owner variables and the actions modeled, the magnitude of the influence of owner number on landowner actions and intentions is modest. That is, the marginal effects when comparing two-owner ownerships to ownerships of three or more people range from a 7.2% decrease in the probability of past leasing activities to a 5.4% increase in the probability of future trail building.

Discussion

While our study was motivated by the anti-commons theory, we did not find strong support for this theory in our analysis. That is, we did not find that having more owners of private forest land resulted in less active management or intentions for future management. In fact, we found evidence of quite the opposite. For example, when it comes to harvesting activities, parcels held by ownerships of three or more individuals are more likely than ownerships with either one or two people to have had a recent commercial harvest or near-term plans for a future harvest. Our results offer numerous other examples that illustrate that one owner parcels are less likely than ownerships comprised of two or more than two individuals to undertake various land management activities (e.g., removal of invasive species, fire risk reduction activities, controlled burning and cost-share program participation).

Generally speaking, single owner parcels have a smaller (albeit modest) probability of undertaking or planning to undertake a number of the modeled activities than parcels with either two or more than two owners.

Our findings are counter to previous research that found a reduced likelihood of management action is associated with a greater number of owners (e.g., Vranken et al. 2004; Deaton 2007, 2012; Gordon et al. 2013). This difference in findings could be attributed to several factors. One, much of the previous UDI research has focused on heir property specifically, which is but one of several pathways to UDI property ownership and is an ownership arrangement that involves some unique demographic characteristics and challenges (Schelhas et al. 2012; Dwivedi et al. 2016). UDI ownership created through inheritance or intestate succession may result in owners who have no interest in or ability to engage with, invest in, or manage forest land owned in common. In this scenario, it seems conceivable that hypotheses about family forest land UDIs and anti-commons might bear true. However, the situation may be different for multiple ownership structures that arose through a more deliberate decision, perhaps resulting in more engaged owners who may be more motivated to cooperate in decision-making. Thus, there may well be differences in the relationships between multi-owner arrangements and forest management behavior that arise through different UDI pathways. As noted by Deaton (2007), the tragedy of the anti-commons rests on the assumption that joint owners do not cooperate. Other explanations for our counter findings could be due to our selective screening of the NWOS data that may have biased our resulting dataset towards ownerships with fewer owners and/or fewer acres; the manner in which we segmented ownership groups into categories of one, two and three plus owners; and/or a lack of an exclusive focus on ownerships with very large numbers of owners.

Our findings are encouraging in the sense that multi-owner ownership arrangements that may increasingly arise out of intergenerational land-transfers need not necessarily lead to reduced management, stewardship, use, and investment in family forest lands. The ability to undertake actions affecting forest land owned in common appears to be a function of other factors that might perhaps include the ownership group working out a plan for the cooperative use and management of the forest land. Based on the analysis of Beach et al. (2005) and Silver et al. (2015), there are likely to be myriad factors other than those we included in our models that influence or are associated with forest management actions and intentions. However, our research suggests that having a greater number of owners of a private forest land holding, all other things considered, may not necessarily reduce the likelihood of activities, such as timber harvesting or wildlife habitat improvement, from occurring. Moreover, our results suggest that it may be the single-owner parcels, some of which may arise through the death of a spouse or co-owner, that exhibit a decreased likelihood of several of the forest management activities we examined.

Our analysis found that parcel size is an influential driver of forest management behaviors–it is significant in all of our models. Having a larger parcel appears to be an important determinant of forest management behavior, although it is not clear whether this is an issue of causality or correlation with other factors such as

landowner income, forest land ownership costs, greater targeting by foresters and/or assistance programs, and/or opportunities to generate income from the land. Parcel size has been repeatedly found to be an influential factor associated with the undertaking of or participation in various timber and agricultural management activities (e.g., Beach et al. 2005; Prokopy et al. 2008; Straka 2011; Silver et al. 2015), likely due to the economies of scale that make land management activities such as commercial timber harvesting more economically viable on larger parcels. It may also be due to public agencies targeting assistance programs to larger parcels, or a greater landowner emphasis on and interest in financial return on investment when a large forest holding is involved. However, our research found that greater parcel size is associated with a broader range of forest and land management activities than has previously been reported in the literature. Regardless, one implication is that the forced subdivision of UDI parcels that can occur as a result of legal action by one of its owners could decrease the types and extent of land management actions that might otherwise occur.

The influence of having a forester or land manager as part of a family forest land ownership's decision-making structure is very pronounced. Regardless of who else may be involved in the decision-making process beyond the parcel owner, the involvement of a professional enhances the likelihood of several forest and land management activities, underscoring these individuals may play an important role in encouraging active management of family forest lands. This finding is consistent with the findings of Beach et al. (2005) and Silver et al. (2015), who found that contact with a professional increases the likelihood of certain forest management activities. Moreover, Ruseva et al. (2014) found that active forest managers have at least twice as many social ties with people who have expertise in forest management issues as compared to passive forest owners. Given that only 5% of our respondents include a forester or land manager in their decision-making network, substantial opportunity exists to increase the involvement of resource professionals in family forest owner decision-making. Inclusion of a professional varies little among the three owner-number groups: 6% of one-owner ownerships, 8% of two-owner ownerships, and 5% of ownerships of three or more people included a professional in their decision-making structure. Thus, opportunity exists across all ownership number groups to enhance the role of professionals in decision-making about active forest management. Given that our analysis indicates that one-owner parcels are less likely to undertake several different forest management actions than parcels with more owners, it could be argued that the need for the inclusion of a forester or land manager in an owner's decision-making structure is actually greater among parcels owned by one individual. Additional research is needed, though, to explore this question.

Our research found that the inclusion of family members as decision-makers has only modest influence, and only on a few of the landowner forest management actions and intentions we examined. This finding of limited influence stands in contrast to some of the literature on social networks, social capital and family forest landowner decision-making. For example, Lind-Riehl et al. (2015) found that family members often exert a substantial influence on forest landowner decision-making, and can serve to instill familial expectations for how future generations of owners

ought to manage and maintain forest land. Moreover, Creighton et al. (2015) suggest that one of the keys to successful intergenerational transfer of family forest lands may lie in motivating the children of current forest owners to become involved with the management of the forest lands early on as a way to build social capital and foster shared values and attachment for the land among generations. One explanation for our finding could be that family members simply don't have strong opinions about the specific types of forest and land management activities we examined. Additionally, since the NWOS data only contained responses from one of the owners, it is possible that the responding owner was underestimating the potential input and influence of other owners and/or family members. Research is needed to more fully understand the structure, dynamics and processes that multi-owner groups use to make decisions about their forested lands, as well as the role that social networks and community and familial relationships play in these processes.

Our data and analysis are subject to several important limitations. Principally, our choice of model covariates was limited by the data from the NWOS that we chose to include in our analysis. Having additional variables that characterize the respondent's forest land (e.g., stocking and productivity) and market conditions (e.g., stumpage prices, land prices), as well as attitudes, ownership objectives, method of acquisition and length of ownership tenure for all owners of a parcel may have yielded more robust model results. Moreover, the wording of the some of the NWOS questions we analyzed may have influenced our results. For example, for many of the activities that we analyzed, the respondent was asked whether it had occurred in the previous 5 years (e.g., harvesting, improving wildlife habitat, removing invasive species, building or improving roads or trails, receiving cost-share, and reducing fire risk). It is possible that respondents have undertaken these activities, just not in the 5-year time frame in which they were queried.

Our dataset was dominated by one and two-owner arrangements. With 84% of the parcels in individual or dual ownership, their overwhelming presence might mask the impact of having many additional owners on past and planned future actions. Thus, evidence of the anti-commons situation, and reduced use and management of family forest lands, might be found in a data set that isn't so dominated by single and dual ownership parcels. Finally, our focus on single-parcel owner respondents to the NWOS may also be imparting some bias towards landowners of relatively smaller wooded land holdings, which could be masking some of the influence of ownerships with many owners.

Conclusions

Our research represents the first attempt to quantitatively explore the relationship between the number of family forest owners and past or planned land management actions using a national dataset of US family forest landowners. In spite of its limitations, we anticipate our analysis will provide the foundation for more focused work on UDI ownership of family forest lands. To this end, we offer the following suggestions for future research in this area.

While our analysis found that, generally speaking, having a greater number of owners is not associated with a reduced likelihood of undertaking a range of forest management actions or intentions, additional research is needed to more fully examine this issue, perhaps in relation to a wider range of forest and land management activities and/or a specific focus on ownerships with large numbers of owners. This is particularly true, given our findings are contrary to prior work in this area. Moreover, regional analyses might be useful to determine whether social, economic, or biophysical factors unique to a particular area might influence relationships between number of owners and forest land management activities, particularly given that much of the UDI research that has found relationships between owner number and behavior has focused on heir property and/or minority land holdings in the southern US (Graber 1978; Mitchell 2001; Shoemaker 2003; Deaton 2007; Dyer and Bailey 2008; Dyer et al. 2009).

Future research that explores the manner by which owners in multi-owner ownership arrangements acquire their land could be useful in furthering our understanding of UDI ownership and the role that inheritance may play in future generations of family forest landowners. While the NWOS does ask about how the respondent obtained their land (e.g., purchased, inherited, received as a gift, other), this information is only known for the owner who completes the survey. The influence of the method of land acquisition on behaviors and intentions of family forest landowners has been previously studied, but with contradictory findings. Majumdar et al. (2009) found that NWOS respondents who are inheritors are more likely to be active forest managers, both for timber and non-timber forest products, than non-inheritors. Butler et al. (2017b) examined the influence of having inherited land on past harvesting activities, past wildlife management activities, and near-term intentions to transfer their forest land of NWOS respondents. Their results found that inheritance was only significant in the intent to transfer land model. Thus, there is no consensus on whether or how method of land acquisition among family forest landowners influences management actions or intentions. We suggest the evaluation of means of land acquisition, among a set of owners, is another important topic to examine in future UDI analyses of family forest landowners.

Particularly surprising was the finding that parcels held by a single owner are less likely to have experienced a number of the forest and land management actions we examined than ownerships held by two or more owners. Thus, mechanisms other than the anti-commons must be influencing these owners and their actions, perhaps related to the method by which an individual acquired the land and/or became the sole owner. One possible explanation for our findings relative to single owners is that some of these respondents could be widows. While the average age of the respondent among our three ownership groups does not vary greatly (65, 62, and 66 for one, two and two-plus owner groups respectively), gender differences exist. Specifically, the percentage of single owner respondents who are women in our dataset is 36%, which is considerably higher than female respondents from two-owner ownerships (10%) and ownerships of more than two people (23%). Longitudinal studies that trace the ownership trajectories of current single-owner parcels to determine whether they were once part of a multi-owner ownership structure, perhaps through marriage or inheritance, and whether and how

management actions might change as the ownership structure and owner number changes through time, would be instructive. Thus, we suggest another fruitful line of research will be in increasing our understanding of single owner ownerships: how, when and why they form and whether they have unique characteristics, assistance needs, and/or land transfer outcomes. We suggest that single owners who are younger may have very different motivations, attitudes, resources and thus behaviors than single owners who are older, following from Butler et al. (2017a) who documented differences in forest landowner characteristics and behaviors as a function of their stage in life.

We also suggest that additional qualitative research is needed to begin examining the interplay between ownership and decision-making structures of family forest land and intra-familial dynamics. Specifically, it would be instructive to conduct in-depth case studies of family forest lands held in multi-owner arrangements to illuminate the structure and dynamics of the decision-making processes that are used, as well as the role that social norms, and community and familial relationships play in these processes. There are likely many paths to achieving successful cooperation when multiple forest land owners are involved. Additional research is needed to more fully examine characteristics of multiple ownership structures that facilitate (or inhibit) forest management and stewardship. Moreover, it is likely that many two-owner ownerships involve spouses. We suspect that the decision-making dynamic may be different when dealing with a spousal two-owner arrangement versus two owners who might be siblings or business partners. We were not able to identify relationships among the two-owner parcels in our sample, but suggest that future research might explore whether the nature of the relationship(s) among owners (i.e., spousal, familial, multi-generational, business) influences management and decision-making on family forest lands. Finally, the next iteration of the NWOS will include questions focusing on the decision-making structure of family forest landowners which will enhance our understanding of both single and multi-person family forest land ownerships.

The forestry profession has and will continue to focus significant attention on trying to ensure that family forest owners make concerted plans for intergenerational land transfer as a means to help keep this land forested and sustainably managed. Additional research is needed to assess whether such planning efforts are associated with specific family forest land ownership structures and, if so, the ramifications with respect to use, stewardship and management of family forest lands.

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