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SHORT PAPER

Following up with Forest Inheritors: A Survival Analysis of Recently Inherited and Recently Sold Non-Industrial Forest Land in the State of Washington, USA

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Abstract

A growing body of literature shows that the transfer of forest land from one owner to another in the US is associated with events such as parcelization of forest land and/or the subsequent conversion of the land away from forestry land use. For individuals and families who own forest land, a key driver of ownership transfer is the eventual or actual mortality of forest owners themselves. In the State of Washington as well as the US nationally, studies on forest legacy planning reveal that most forest owners want their children or grandchildren to own their forest properties after they no longer own the forest. In contrast, the same surveys also show that a majority of US forest owners acquired their forest land by purchasing the land from a non-relative. We utilize the Washington State Forestland Database to conduct a non-parametric survival analysis of how long recently inherited forest properties remain fully owned by the new owners (i.e. there is no subsequent sale associated with the property) compared to forest land that was sold. Results show that inherited parcels have a significantly lower survival probability as measured by remaining solely within the ownership of the new owner relative to parcels that were sold within an 8-year period. This study quantifies how the mode of forest transfer influences the duration of the following ownership lifecycle and indicates that stewardship efforts should be tailored for owners who have recently inherited forest lands.

Keywords Lifecycle effects · Land transfer · Longitudinal analysis · Ownership duration

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Introduction

A growing body of literature suggests that the transfer of private forest land from one owner to another in the US is associated with events such as parcelization of forest land and/or the subsequent conversion of the land away from forestry land use (Mundell et al. 2010; Rabotyagov et al. 2021; Riitters and Costanza 2019). Therefore, forest legacy planning is crucial in private forest owner outreach and education to assist in transferring intact forest land across generations while maintaining stewardship (Baumgartner et al. 2003; Markowski-Lindsay et al. 2017). Studies generally reveal that private forest owners often prefer their land to be owned by their "children or grandchildren" in the future (e.g. Majumdar et al. 2009). In contrast to the expressed wishes of the private forest owners concerned with passing their land to their heirs, many surveys show that a majority of US private forest owners acquired their forest land via purchase from a non-relative (Joshi and Arano 2009; Majumdar et al. 2009). This creates a gap between the large proportion of forest owners who want their land to pass to their children or grandchildren and the low proportion of forest owners who have actually inherited their forest land, which we call the forest sales/inheritance gap. The forest sales/inheritance gap can arise from unanticipated future land sales and from inheriting heirs selling their family land to non-relatives. This paper primarily investigates the second factor contributing to the forest sales/inheritance gap: whether owners who inherit forest properties are more likely to sell all or part of their land compared to those who acquire it via market transactions.

Although private forest ownership transfers involve multiple owners over time, most studies focus on prospective transfers (Catanzaro and Markowski-Lindsay 2022; Markowski-Lindsay et al. 2017; Quartuch et al. 2021; Staal Wästerlund 2018) with some examining inherited or recently acquired properties (Lähdesmäki and Matilainen 2014; Matilainen et al. 2019). Rare exceptions are Gruver et al. (2017) and Stone and Tyrrell (2012), who both studied owners who had parcelized and sold some or all of their properties, and who interviewed owners who had sold or donated the development rights of their lands. Among interviewees who had sold some of their forest land or sold/donated the development rights to some of their lands, Gruver et al. (2017) discovered that family circumstances could prompt owners to sell part of their forest properties even if it was not what the owner wanted to do. Stone and Tyrrell (2012) found surveyed owners who had parcelized and sold some forest land did so mostly due to personal circumstances often associated with aging, lack of family interest, and financial needs including property taxes. Gruver et al. (2017) recommend applying life cycle theories and studying family dynamics as a way of providing additional insights into forest ownership transitions. While Butler et al. (2017) framed private forest owner changes as life cycle, cohort, and period-specific effects, few studies discuss how one ownership's life cycle events impact the next. In this paper, we explore forest owner life cycle effects by analyzing how the end of one ownership lifecycle (through sales or inheritance) influences the subsequent ownership lifecycle's forest land retention.

Theories on the intergenerational transfer of family agricultural businesses argue that profitability and survivability can be improved by retaining

firm-specific human capital across successive ownerships (Laband and Lentz 1983). Such transfers may entail a process of increasingly delegating labor and managerial tasks to offspring to prepare the next generation of owner (Chiswell 2018; Creighton et al. 2016; Staal Wästerlund 2018). Intergenerational, within-family transfers as a method of land transfer may help build social capital, foster shared values, and create attachment to the land among generations. From the standpoint of context-specific knowledge and human capital transfer, forest owners who inherit their lands may fare better than their counterparts who purchase land from a non-relative in terms of profitability and firm survival. On the other hand, inheritance of forest land may entail challenges for new owners, such as inheriting siblings selling all or part of their inherited land due to disagreements over ownership and management objectives (Creighton et al. 2016). Owners who inherit their lands may also feel constrained by family traditions (Lidestav 2010) and therefore not as free to pursue their own objectives relative to owners who purchase their lands. Furthermore, the intentional purchase of forest land indicates readiness to assume ownership while an inheritance event does not necessarily occur at a convenient time. Thus, considerations of ownership-specific knowledge, human capital, a sense of familial duty and stewardship continuity tend to favor durable intergenerational transfers. The transactions costs of inheritance, a potential mismatch of intergenerational objectives and preferences, as well as issues identified with multiple heirs involved in decisions (Snyder and Kilgore 2017) tend to favor at least a partial divestment from family control of land, thereby also exposing forest land to market pressures which may lead to forest land parcelization and conversion. The net effect of these competing advantages and constraints on inheritors of forest land is an empirical question which requires the ability to track inherited versus purchased forest parcels over time.

The one national study available on forest land ownership change suggests a relatively high ownership turnover rate. Using 9444 sampled Forest Inventory Analysis points, Huff et al. (2019) found the equivalent of up to 63% of forest acreage had undergone some kind of ownership change in the 12-year period between 2006 and 2018. Of the sampled points, at least 43% underwent a change in ownership that was seemingly not a transition of ownership between family members, 10% may have changed ownership via inheritance, and 10% changed ownership but retained at least one of the same owners. Since Forest Inventory Analysis points are sampled for the National Woodland Owner Survey with a minimum time interval of 5 years, this data source cannot determine the duration of forest ownership lifecycles due to its sampling interval. In a study of eight Mississippi counties between 1999 and 2019, Kuluppuarachchi et al. (2021) found that about 46% of parcels with at least 10 acres of forest were sold. Kuluppuarachchi et al. (2021) followed the sequences of sales events at the parcel level to reveal relatively short average ownership lifecycle durations; about 12 years for all parcels and about 5.5 years for parcels sold within the timeframe. Although it only considered sold and not inherited parcels, the Mississippi study showed that within a 10 year time window after being sold, an average of 49% of parcels were resold, while an average of 30% were resold within a 5 year time window. To our knowledge, no study has been able to follow private forest ownership transitions

over time to see how the mode of ownership transfer impacts the next forest ownership lifecycle duration.

This short paper contributes to the literature on small forest land transfer by following small forest land ownership transitions in the State of Washington over time to evaluate differences in how long new owners retain full ownership of their properties based on whether the forest land was inherited or purchased. We argue that our measure of small forest land "survivability" in the hands of the new owners is analogous to family firm survivability after an ownership transfer. We focus on land transfer (sale) as the endpoint of analysis, leaving the issue how sales events impact forest conversion to related work (Mundell et al. 2010; Rabotyagov et al. 2021; Riitters and Costanza 2019).

Materials and Methods

We draw from two data sources: a 2020 Washington Small Forest Landowner Survey and the Washington State Forestland Database. For both data sources, we focus on a classification of forest owner specific to the State of Washington called Small Forest Landowners (SFLOs), defined as ownerships consisting of a minimum 2-acre parcel with at least 1 acre of forest. Private and tribal land parcels can be classified as SFLO, but not industrially owned parcels. The maximum amount of forest land that a SFLO can own is 2500 acres in the western half of the state and 9900 acres in the eastern half of the state, with larger ownerships having a different classification.[1] The 2020 Washington Small Forest Landowner Survey used the 2019 Washington State Forestland Database of existing landowners to perform a probability sample of 3000 of the state's almost 270,000 SFLOs. A total of 737 usable surveys were returned, resulting in a cooperation rate of 24.6%, fairly common for a survey of this nature in the State of Washington (e.g. about 15% in the State of Washington in Rabotyagov and Lin 2013). Investigations of non-response bias showed no statistical differences between respondents and non-respondents based on the amount of forested acres owned (using National Land Cover Database standards), ownership of forest land on the east side of the state, nor the frequency of forest land sales associated with parcels under ownership. Considering sales associated with parcels under ownership as a binary variable also revealed no statistical differences between respondents and non-respondents.[2] While ruling out the possibility of non-response bias entirely is typically not feasible for survey data, there is no sign of systematic non-response bias in the survey data based on forest land sales history, which is our main variable of interest.

[1] The legal maximum threshold to be classified as a Small Forest Landowner is to have harvested no more than 2 million board feet of timber per year, on average, over a three year rolling period as per RCW 76.09.450. The maximum acreages are estimated based on the amount of forest land needed to meet that level of production. See Rabotyagov et al. (2021, p. 53).

[2] Forest land ownership sales history was not included in the criteria for survey sampling.

The survey followed a modified version of the Tailored Design Method (Dillman et al. 2014), with recipients in the sample frame being sent three rounds of mailings. The 2020 Washington Small Forest Landowner survey was conducted by the School of Environmental and Forest Sciences at the University of Washington as a part of a large-scale policy report commissioned by the Washington State Legislature to address a broad set of policy questions related to Small Forest Landowners and their forest lands. A full description of the survey sample frame, a description of key design features of the survey, the pilot survey performed in preparation for this survey, and details of how and when the survey was administered can be found on pages 68–72 in S. Rabotyagov et al. (2021). We report descriptive results from three survey questions to confirm the gap between the large proportion of forest owners who want their forest lands to pass to their heirs and the small proportion who inherited their own forests. The survey question concerning how forest owners acquired their forest land closely follows how the National Woodland Owner Survey asks about land acquisition (Butler et al. 2021) and includes the possibility for respondents to report if they purchased the land from a family member or from a non-relative. The question asking about who respondents anticipate transferring some or all of their forest land to is based on both the National Woodland Owner Survey as well as a 2016 survey in New England (Catanzaro and Markowski-Lindsay 2022). A question about reasons respondents had sold some (but not all) of their forest lands was developed in collaboration with stakeholders from the Washington State Department of Natural Resources, the Spatial Informatics Group at the University of Washington, and various subject matter experts at the School of Environmental and Forest Sciences at the University of Washington.

The Washington State Parcel Database is a standardized, statewide dataset developed at the University of Washington (Rogers and Cooke 2007). The Washington State Forestland Database (Rabotyagov et al. 2021) is derived from the Parcel Database and integrates ownership, forest, water, economic, and other attributes for all forested parcels in the state, including sales and inheritance events.

To analyze change in small forest landownership, we matched land sales and inheritance events to the entire population of 256,500 parcels present in the Forestland Database. We compared SFLO parcels, using years as the temporal unit of measure. We selected 2011–2018 as the observation time period for a Kaplan–Meier survival analysis (Goel et al. 2010), given the available state-wide data. During the selected observation time period, approximately 148,300 parcels have an inheritance event, at least one sales event, or both. We use these 148,300 parcels for the survival analysis.

Kaplan–Meier survival analysis, and the subsequent survival curves it produces, is a method of conducting times-to-event analysis. Resulting estimates from Kaplan–Meier analysis show the unconditional probability that a unit of analysis, which we subsequently refer to as "parcels," will "survive" without experiencing a particular event for a given interval of time. In our case, we have an 8 year observation time period and the Kaplan–Meier estimate produces a probability estimate that a recently acquired parcel will survive without a subsequent sale into each of the eight time periods. In Kaplan–Meier analysis, each parcel has three variables of importance: (1) the time which the parcel is observed by the researcher, or its

"serial time" (2) the parcel's status at the end of the serial time, with parcels that experience the event being "observed," and parcels that do not experience the event being "censored," and (3) if the parcel is in the "treatment" group or the "control" group (Rich et al. 2010). A survival probability function is estimated for the treatment group and a separate function is estimated for the control group. Statistical differences in survival probability between the treatment group and the control group indicates that the treatment has a causal influence on the likelihood that a particular event will occur within a certain period of time. It is then possible to plot the two survival functions and statistical confidence intervals to visualize the differences in estimated survival probabilities between the treatment group (inherited parcels) and the control group (purchased parcels).

In our case, a parcel's serial time begins the year that a sales event or inheritance event is observed during 2011–2018 and ends either the year when a subsequent sale event is observed or, for censored observations, at the end of the observation time period in 2018. Therefore, parcels can start their serial time in different years, but their serial time will end at the latest in 2018 by either experiencing an event (sale) or being censored. To calculate serial time for parcels with an inheritance event (treatment group), we calculated the years between the inheritance event and the first subsequent sales event or recorded the time until the end of the observation time period for parcels with no sales (censored observations as of 2018). For parcels without an inheritance event but with sales events (control group), we calculated the time between the first sale and the next subsequent sale or recorded the time until the end of the observation time period for parcels with no subsequent sales (censored observations as of 2018). We focused on one ownership lifecycle beginning within the 2011–2018 observation time period, although some parcels had multiple lifecycles during this period (i.e., those with at least one subsequent sale).

Given that, to our knowledge, only two studies have empirically addressed the issue of how forest ownership changes over time, we also employ a cohort analysis to compare our survival analysis to that of Kuluppuarachchi et al. (2021). In a cohort analysis, all units of analysis that experience the same qualifying event in a given year (in our case, parcels that are sold or inherited in a certain year) are grouped together and analyzed over a certain observation time period. Following the same method used in Kuluppuarachchi et al. (2021), we then report the share of parcels in each respective cohort that experienced at least one event (i.e. a subsequent sale) within the 5 years following their initial year of sale or inheritance. Given our relatively restricted observation time period, we are only able to follow three cohorts over a 5-year rolling window (2011–2016, 2012–2017, and 2013–2018). Upon calculating the share of parcels with an event (subsequent sale) in each cohort, we then present the average event rate across the three cohorts for the treatment (inherited parcels) and control (sold parcels).

We present survey data from current SFLOs for context, noting that using this survey data to describe past forest land sales events represents only the experiences of owners who have sold land in the past but still own at least some forest land. We do not have survey data on individuals who inherited forestland and then subsequently sold all of it, as those individuals would not be present in the survey sample frame of forest owners as of 2019. The parcel database, however, allows us

to follow the histories of all forest land sales at the parcel-level (both partially and fully divested) such that we can compare the propensity of inherited parcels versus parcels acquired in the marketplace to subsequently become available for sale. The strategy of our methodology is to use survey data, despite its inherent survivor bias, to provide context, while the sales and inheritance histories of approximately 148,300 parcels from the Forestland Database show differences in ownership duration between inherited and purchased forest land.

Our central focus is the length of the ownership lifecycle that follows a forest sale or inheritance, but the continuity of forest land ownership within a family is a related issue. Huff et al. (2019) used owner names to estimate different types of forest ownership transitions, but their data is not fully comparable as they do not distinguish between within-family land purchases and inheritance events. We expect those who purchase forest land from a family member to have different ownership lifecycles relative to inheritors or those who purchase from non-family members. Based on intergenerational human capital transfer theories, we might expect those who purchased from a family member to be similar to owners who inherited and retained their forestland (represented in landowner surveys), with both types being more invested in forest stewardship than the overall population of heirs (Majumdar et al. 2009). In response to requests from two reviewers, a Supplementary Information file addresses the matter of continuity of forest land ownership within a family after an inheritance event combined with an analysis of how many inherited parcels are subdivided/parcelized or aggregated into larger properties. Analysis was conducted in the statistical software program R (R Core Team 2022) using the 'survival' package (Therneau & Grambsch 2000) with data visualizations using 'survminer' and 'ggplot2' (Wickham 2016).

Results

Similar to results found from other surveys in the US, most survey respondents had purchased all of their forest property from non-relatives (Fig. 1) while "children or grandchildren" was the most popular option for to whom respondents wanted to sell or transfer their forest land in the future (Fig. 2). Note from Fig. 1, that relatively few respondents purchased land from relatives as at least one mode of forest acquisition, but the total percentage of respondents who purchased land from relatives is comparable to the percentage that acquired their forest lands exclusively through inheritance or as a gift. We also draw attention to "family circumstances" and "financial needs" being by far the most frequent reasons for existing forest owners to have sold some, but not all, of their forest property (Fig. 3), which is consistent with Gruver et al. (2017) and Stone and Tyrrell (2012).

Turning to analysis of the parcel database, between 2011 and 2018, the database shows 129,064 small forest land parcels were sold and did not have an inheritance event, while 13,971 parcels were inherited. Of the approximate total of 256,500 small forest land parcels, around 50% had at least one sale event (and no inheritance event), and about 5% had an inheritance event (with some having subsequent sales). The sales volume is comparable to the 63% of US family forest

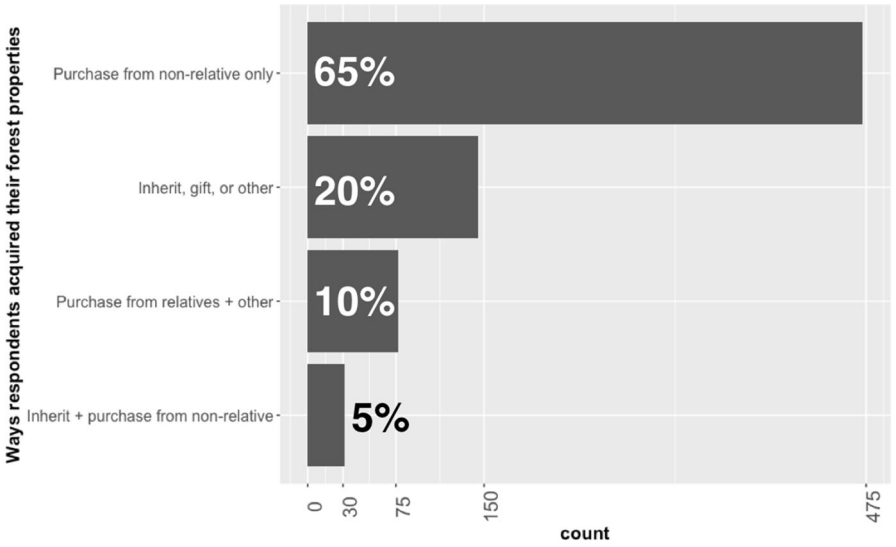

Fig. 1 How survey respondents acquired their small forest land. Reproduced from (Rabotyagov et al. 2021)

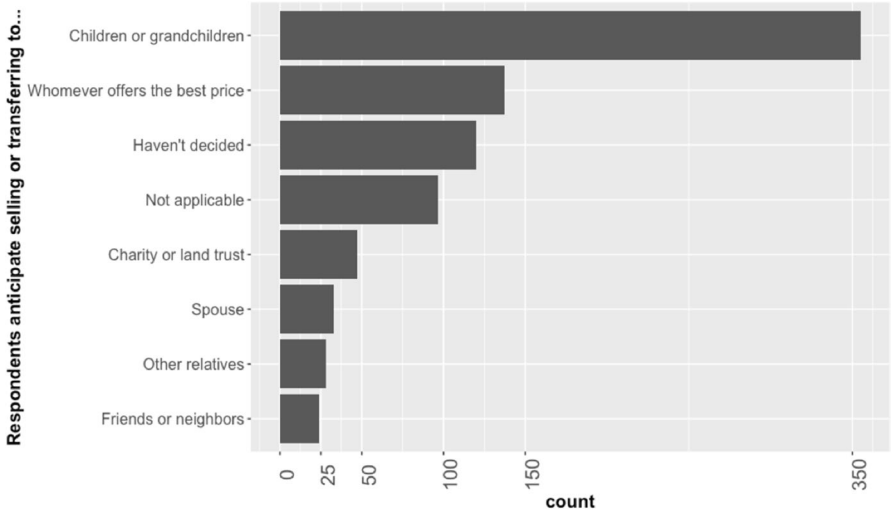

Fig. 2 To whom survey respondents anticipate selling or transferring their small forest land. Reproduced from (Rabotyagov et al. 2021)

acreage changing hands over 12 years reported by Huff et al. (2019), but higher than the total proportion of parcels sold in 21 years in Mississippi (Kuluppuarachchi et al. 2021). The substantial difference between the number of small forest land parcels with a sales event (129,064) and those with an inheritance event

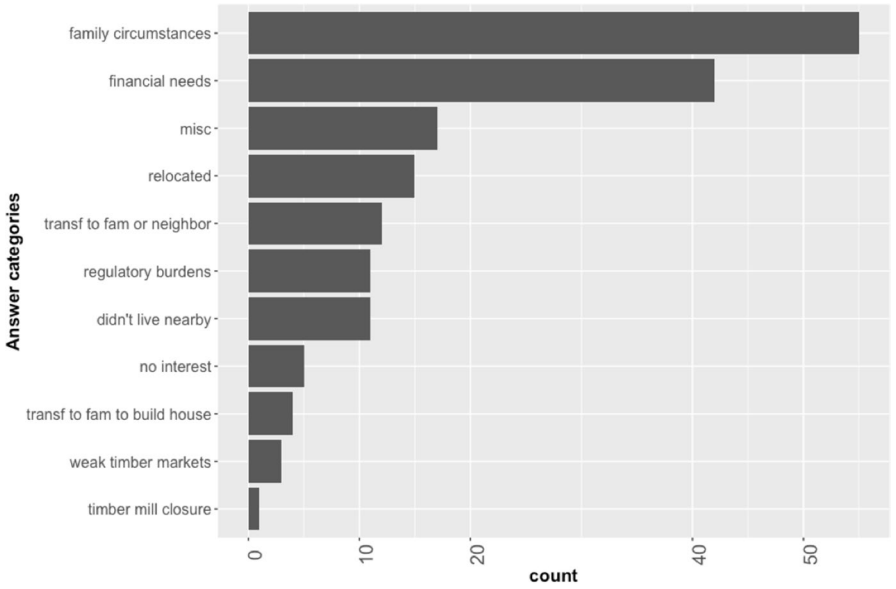

Fig. 3 Reasons why survey respondents said they sold some small forest land in the past (but still retain at least some forest land). Reproduced from (Rabotyagov et al. 2021)

(13,971) indicates that, during this time period, small forest lands were mostly sold despite most owners' preference to bequeath them to heirs.

The Kaplan–Meier survival analysis reveals inherited parcels have a significantly lower survival probability, as measured by remaining solely within the new owner's possession, compared to sold parcels (Table 1, Fig. 4). Most of the difference occurs in the first year, with inherited parcels sold more frequently within the same year as an inheritance event. Heirs inheriting forest land during this time had an estimated probability of divesting some or all of their land at a rate nearly 50% higher than buyers (33.1% event rate compared to 22.7%, see the final "survival" probability estimates in Table 1). In terms of survival probability, within an 8-year period, heirs retaining all of their newly acquired forest land had a 66.9% probability, while buyers retaining all of their newly purchased land had a 77.3% probability.

For comparison with Kuluppuarachchi et al. (2021) and Huff et al. (2019), we calculate the sales event rates for three parcel cohorts during a 5-year moving window: all parcels inherited/sold in 2011, all parcels inherited/sold in 2012, and all parcels inherited/sold in 2013. Table 2 shows the event rates for subsequent sales for each cohort along with the average event rate across the three cohorts' 5-year moving window periods. With a time series of 21 years, Kuluppuarachchi et al. (2021) are able to calculate an average of 15 distinct cohorts over a 5-year moving window, while our shorter time series only allows for an observation of 3 distinct cohorts over a 5-year moving window. While the share of events for inherited parcels during this time window is very similar to the event share for sold parcels found in the Mississippi study (0.303 and 0.30, respectively), the event rate for sold parcels in the State of Washington is lower (0.235).

Table 1 Results of a Kaplan–Meier non-parametric survival probability of small forest land parcels remaining exclusively under the ownership of new owners (i.e. survival means no sales event is associated with the parcel after the first sales event or the inheritance event)

Parcels with an inheritance event (treatment = 1)						
Time	*n* risk	*n* event	Survival	SE	Lower 95% CI	Upper 95% CI
0	13,971	1351	0.903	0.003	0.898	0.908
1	12,620	877	0.841	0.003	0.834	0.847
2	10,137	484	0.800	0.003	0.794	0.807
3	7892	338	0.766	0.004	0.759	0.774
4	6039	238	0.736	0.004	0.728	0.744
5	4463	161	0.709	0.004	0.701	0.718
6	3097	102	0.686	0.005	0.677	0.696
7	1906	47	0.669	0.005	0.659	0.680
Parcels with a sales event (treatment = 0)						
Time	*n* risk	*n* event	survival	SE	Lower 95% CI	Upper 95% CI
0	129,064	3797	0.971	0.000	0.970	0.972
1	125,267	4903	0.933	0.001	0.931	0.934
2	104,833	3656	0.900	0.001	0.898	0.902
3	82,709	2911	0.868	0.001	0.866	0.870
4	61,994	2146	0.838	0.001	0.836	0.841
5	43,983	1478	0.810	0.001	0.808	0.813
6	29,373	820	0.788	0.002	0.785	0.791
7	16,974	310	0.773	0.002	0.770	0.776

The total number of parcels surviving to each time period is labeled "*n* risk" while the number of parcels experiencing a subsequent sales event during that time period is labeled as "*n* event."

For comparison with National Woodland Owner sample points from the Forest Inventory Analysis in Huff et al. (2019), the proportions of parcels with a subsequent sales event in a 5 year moving window is the proportion of sold parcels that change ownerships more than once within a 5-year sampling interval. In other words, if our ownership sampling method was the same as that employed by Huff et al. (2019), then we would not be able to detect that about 30% of all inherited parcels and about 24% of all sold parcels had changed ownership more than once in between the sampling intervals. To clarify, the analysis from Huff et al. (2019) can be inferred to forest acreage in the US and our analysis can be inferred to the population of small forest land parcels in the State of Washington, which somewhat limits a true comparison of our results. If the purpose of looking at changes in ownership status is to estimate average forest ownership lifecycle duration, then the parcels that change hands multiple times within the sampling interval become important.

Finally, we direct readers interested in the continuity of within-family ownership of inherited and subsequently sold forest parcels as well as a limited investigation of the parcelization or agglomeration outcomes of inherited forest parcels

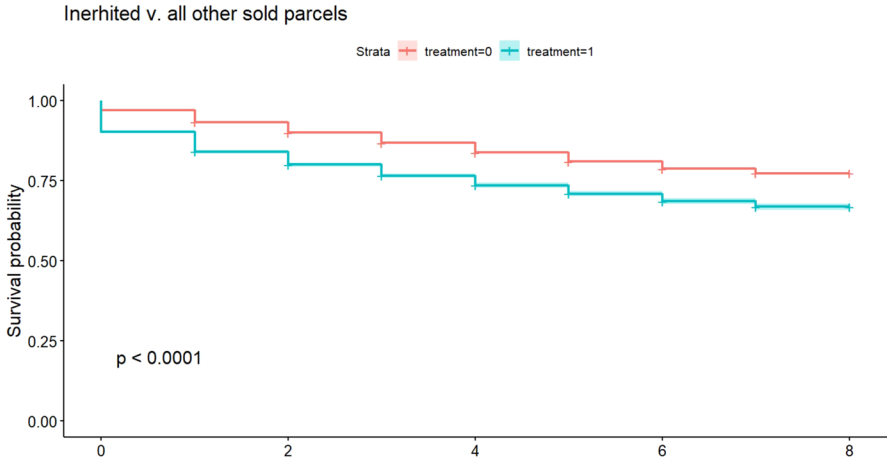

Fig. 4 Kaplan–Meier non-parametric survival curve of small forest land parcels remaining exclusively under the ownership of new owners (i.e. survival means no sales event is associated with the parcel after the first sales event or the inheritance event), based on results from Table 1. Treatment = 1 includes parcels with an inheritance event. Treatment = 0 includes parcels with no inheritance event but at least one sale event

Table 2 The share of events (subsequent sales) during a 5 year moving window for 3 parcel cohorts (sold or inherited in 2011, 2012, or 2013)

Share of events during each 5 year moving window cohort		
Parcel cohort years	Inherited	Sold
2011–2016	0.291	0.245
2012–2017	0.302	0.231
2013–2018	0.317	0.229
Mean	0.303	0.235

Compare to Table 4 in Kuluppuarachchi et al. (2021), who find an average 0.30 event rate in a 5-year rolling window for 15 cohorts (note: their lowest 3-year consecutive cohort average is 0.26)

to the Supplemental Information file attached to this manuscript. In the Supplemental Information file, we demonstrate that forest parcels are overwhelmingly transferred intact from one ownership lifecycle to the next (i.e. very low frequencies of parcelization or aggregation). We furthermore find that parcelization and aggregation are no more frequent among parcels that experienced a subsequent sale after an inheritance event relative to inherited parcels with no subsequent sales events. A names analysis also revealed only a small percentage of post-inheritance forest sales represent inheritors partially divesting of their forest land inheritance or some inheritors buying out other inheritors such that forest ownership remained at least partially within the same family (maximum 12%).

Discussion

We present two factors that may drive the forest sales/inheritance gap: unanticipated sales at the time private forest owners fill out surveys and inheriting heirs selling all or part of their forest land. Between 2011 and 2018 in the State of Washington, forest land sales were substantially more common than inheritance events, by almost an order of magnitude. Our survey data were collected later than the parcel sales data, meaning we cannot directly claim that small forest land owners' in the State of Washington mostly sold their forest properties despite their anticipations that it would pass to their heirs. However, the forest sales/inheritance gap was established as a national phenomenon before our parcel sales time series data began (Joshi and Arano 2009; Majumdar et al. 2009), which leads us to our inferred conclusion that the (previously) unanticipated sale of small forest land is likely the primary contributor to the forest sales/inheritance gap. Moreover, Kaplan–Meier non-parametric survival analysis and subsequent sales events of three parcel cohorts observed over a 5-year moving window confirm that inherited parcels are more frequently sold by their new owners compared to purchased parcels.

Our findings quantify how the mode of forest land transfer influences the duration of the following ownership lifecycle. We encourage further research to explore other legacy effects of events in one lifecycle influencing events in subsequent ownership lifecycles of the same forest properties. Our results and recent work (Kuluppuarachchi et al. 2021) emphasize that landowner assistance efforts should focus on new owners, especially those who inherit forest land. Furthermore, the relatively high ownership turnover rate also favors forest conservation instruments with longer durations that can sustain conservation objectives across several ownership lifecycles which may occur within only a decade or two. We repeat our previous caveat that the parcel database, while it contains the sales histories of all SFLO parcels in the state regardless of their parcelization status, we only investigate within-family ownership continuity for inherited parcels and not for parcels sold without an inheritance event.

With such a limited number of studies that have investigated forest land ownership changes over time with respect to the mode of acquisition, we outline a few directions for future research. An analysis of the complex dynamics influencing land use change performed with the same parcel database used in this manuscript revealed that land sales are significant predictors of subsequent conversion away from forestry (Rabotyagov et al. 2021). Future work could further elaborate on this result by investigating if inheritance and subsequent forest land sales has a unique impact on broader forest land use change processes. Another key component of forest land use change is parcelization and agglomeration, which we only investigate to a limited extent for inherited parcels due to the limited scope of this manuscript. Accordingly, future work could explicitly incorporate forest land parcelization and agglomeration as both a driver and consequence of forest land inheritance and lifecycle duration for parcels with sales events but no inheritance events.

There is likely substantial variation across the US in terms of the proportion of forest land sold and the turnover rate of sold land. Compared to eight counties in

Mississippi, the State of Washington had a larger proportion of small forest land sold in less than half the time. However, the smaller proportion of Mississippi parcels that experienced an ownership change had a higher subsequent turnover rate. We anticipate future work can better characterize this heterogeneity across the US and assist in targeting federal and state forest stewardship efforts.

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Declaration

Conflict of interest The authors have no conflicts of interests to disclose.

References

Baumgartner DM, Creighton JH, Blatner KA (2003) Use and effectiveness of Washington state's extension forest stewardship program. Small-Scale Forest Econ Manage Policy 2(1):49–61. https://doi.org/10.1007/s11842-003-005-7

Butler SM, Butler BJ, Markowski-Lindsay M (2017) Family forest owner characteristics shaped by life cycle, cohort, and period effects. Small-Scale For 16(1):1–18. https://doi.org/10.1007/s11842-016-9333-2

Butler BJ, Butler SM, Caputo J, Dias J, Robillard A, Sass EM (2021) Family forest ownerships of the United States, 2018: Results from the USDA Forest Service, national woodland owner survey. Gen. Tech. Rep. NRS-199. Madison, WI: USDA Forest Service, Northern Research Station. 52. https://doi.org/10.2737/NRS-GTR-199.

Catanzaro P, Markowski-Lindsay M (2022) Expanding family forest owner options to keep their land in forest use. J Forest 120(2):208–221. https://doi.org/10.1093/jofore/fvab052

Chiswell HM (2018) From generation to generation: changing dimensions of intergenerational farm transfer. Sociol Rural 58(1):104–125. https://doi.org/10.1111/soru.12138

Creighton J, Blatner KA, Carroll MS (2016) For the love of the land: generational land transfer and the future of family forests in Western Washington State, USA. Small-Scale For 15(1):1–15. https://doi.org/10.1007/s11842-015-9301-2

Dillman DA, Smyth JD, Christian LM (2014) Internet, phone, mail, and mixed-mode surveys: the tailored design method. Wiley, New York

Goel MK, Khanna P, Kishore J (2010) Understanding survival analysis: Kaplan-Meier estimate. Int J Ayurveda Res 1(4):274–278. https://doi.org/10.4103/0974-7788.76794

Gruver JB, Metcalf AL, Muth AB, Finley JC, Luloff AE (2017) Making decisions about forestland succession: perspectives from Pennsylvania's Private Forest Landowners. Soc Nat Resour 30(1):47–62. https://doi.org/10.1080/08941920.2016.1180728

Huff ES, Butler BJ, Markowski-Lindsay M, Hewes JH (2019) Longitudinal data on family forest owners: the US Forest Service's National Woodland Owner Survey. Landsc Urban Plan 188:93–96. https://doi.org/10.1016/j.landurbplan.2019.03.007

Joshi S, Arano KG (2009) Determinants of private forest management decisions: a study on West Virginia NIPF landowners. Forest Policy Econ 11(2):118–125. https://doi.org/10.1016/j.forpol.2008.10.005

Kuluppuarachchi MK, Sun C, Gordon JS, Grebner DL, Munn IA, Yang J (2021) The length and determinants of forestland ownerships in Mississippi from 1999 to 2019 | Elsevier Enhanced Reader. For Policy Econ, 129. https://doi.org/10.1016/j.forpol.2021.102517

Laband DN, Lentz BF (1983) Occupational inheritance in agriculture. Am J Agr Econ 65(2):311–314. https://doi.org/10.2307/1240880

Lähdesmäki M, Matilainen A (2014) Born to be a forest owner? An empirical study of the aspects of psychological ownership in the context of inherited forests in Finland. Scand J For Res 29(2):101–110. https://doi.org/10.1080/02827581.2013.869348

Lidestav G (2010) In competition with a brother: Women's inheritance positions in contemporary Swedish family forestry. Scand J For Res 25(sup9):14–24. https://doi.org/10.1080/02827581.2010.506781

Majumdar I, Laband D, Teeter L, Butler B (2009) Motivations and land-use intentions of nonindustrial private forest landowners: comparing inheritors to noninheritors. Forest Sci 55(5):423–432. https://doi.org/10.1093/forestscience/55.5.423

Markowski-Lindsay M, Butler BJ, Kittredge DB (2017) The future of family forests in the USA: near-term intentions to sell or transfer. Land Use Policy 69:577–585. https://doi.org/10.1016/j.landusepol.2017.10.007

Matilainen A, Koch M, Zivojinovic I, Lähdesmäki M, Lidestav G, Karppinen H, Didolot F, Jarsky V, Põllumäe P, Colson V, Hricova Z, Glavonjic P, Scriban RE (2019) Perceptions of ownership among new forest owners—a qualitative study in European context. Forest Policy Econ 99:43–51. https://doi.org/10.1016/j.forpol.2018.06.002

Mundell J, Taff SJ, Kilgore MA, Snyder SA (2010) Using real estate records to assess forest land parcelization and development: a Minnesota case study. Landsc Urban Plan 94(2):71–76. https://doi.org/10.1016/j.landurbplan.2009.08.001

Quartuch MR, Broussard Allred S, Markowitz E, Catanzaro P, Markowski-Lindsay M (2021) Applying the transtheoretical model of change to legacy planning decisions. Small-Scale For 20(3):457–478. https://doi.org/10.1007/s11842-021-09476-7

R Core Team (2022) R: A language and environment for statistical computing [Computer software]. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Rabotyagov S, Rogers L, Danley B, Comnick J, Cooke A, Solemslie A (2021) SB5330 Washington's Small Forest Landowners in 2020.

Rabotyagov SS, Lin S (2013) Small forest landowner preferences for working forest conservation contract attributes: a case of Washington State, USA. J For Econ 19(3):307–330. https://doi.org/10.1016/j.jfe.2013.06.002

Rich JT, Neely JG, Paniello RC, Voelker CCJ, Nussenbaum B, Wang EW (2010) A practical guide to understanding Kaplan-Meier curves. Otolaryngol-Head Neck Surg Official J Am Acad Otolaryngol-Head Neck Surg 143(3):331–336. https://doi.org/10.1016/j.otohns.2010.05.007

Riitters K, Costanza J (2019) The landscape context of family forests in the United States_ Anthropogenic interfaces and forest fragmentation from 2001 to 2011 | Elsevier Enhanced Reader. https://doi.org/10.1016/j.landurbplan.2018.04.001

Rogers LW, Cooke AG (2007) The 2007 Washington State Forestland Database, 81

Staal Wästerlund D (2018) Factors explaining the interest of adult offspring in succeeding their parents as forest owners. Forests 9(11):668. https://doi.org/10.3390/f9110668

Stone RS, Tyrrell ML (2012) Motivations for family forestland parcelization in the catskill/delaware watersheds of New York. J Forest 110(5):267–274. https://doi.org/10.5849/jof.11-015

Snyder SA, Kilgore MA (2018) The influence of multiple ownership interests and decision-making networks on the management of family forest lands: evidence from the United States. Small-Scale Forest 17(1): 1–23

Therneau TM, Grambsch PM (2000) Modeling survival data: Extending the Cox Model. [Computer software]. https://cran.r-project.org/package=survival

Wickham H (2016) ggplot2: Elegant graphics for data analysis [Computer software]. Springer, Cham. https://ggplot2.tidyverse.org/