

AN ABSTRACT OF THE THESIS OF

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Parcellization of the rural landscape threatens the provision of social, ecological and economic benefits to society due to loss of economies of scale. A continued provision requires new approaches to forest management for multiple, interconnected goals. I used interviews, archival records and field measurements to learn how select, experienced owners of small forests simultaneously manage for income and structural diversity. The analysis of six 25 to 150 acre forests in the Central Willamette Valley of Oregon revealed that each landowner had income sources other than timber from their forests and had integrated their forest in diverse financial portfolios. Deliberate management for structural diversity in the assessed forests resulted in the three categories 'close-to-industry', 'close to preserve' and 'intermediate'. There were considerable differences in landowner's approaches to generate income and structural diversity. However, I also identified twenty-four general resource and strategy patterns which I explain through three theoretical contributions on 1) landowner learning, 2) understanding of the architecture of the complex system of small forest management and 3) integration of actions to achieve management goals. I conclude that the forests under examination add structural diversity elements to a conifer-dominated landscape component while not necessarily sacrificing economic goals.

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Management Strategies for Small, Structurally Diverse & Income-Generating Forests

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Julian Geisel, Author

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INTRODUCTION

Management of small private forests has been a concern in the United States and Europe for more than half a century, and is part of a large body of research referred to as the Small Woodland Problem. First, parcellization and the associated loss of economies of scale hamper traditional timber harvesting to generate income (Hatcher et al. 2013). This may make it difficult for family forest owners to keep managing their land (D'Amato et al. 2010). Over the years, small forest research has developed into a multidisciplinary field. In addition to investigating the economic aspects, social scientists have looked, among other things, at owner's motivations, their alternative and concurrent management goals and how managers of small forests are perceived by the rest of society (Fischer et al. 2010). The last point is particularly relevant due to increasing awareness of social and environmental benefits small private forests provide to society (Bliss 2003) and which are put at risk through mismanagement. The role of small forests, which constitute 12% of Oregon forests (OFRI 2015), 35% of US forests (Butler et al. 2016) and around 10% of global forests (FAO 2017), as a part of landscape resilience to natural disturbances is also increasingly recognized (Olson 2017). Governments and Environmental Non-Governmental Organizations have tried to mitigate the decline of benefits associated with parcellization through cost-shares, co-operatives, tax incentives, and easement programs (D'Amato et al. 2010). The success of these efforts in the United States has been slow and mostly effective only for larger holdings (Butler et al. 2016).

Viable management of small forests providing benefits to owners and society alike may require overcoming marketing challenges (Huber et al. 2013; Wade 2015) as well as the application of new tools and wider ecosystem considerations in forest management (Curtis et al. 1998). The latter are documented but still not widely applied (Puettmann et al. 2015). Posing considerable challenges when looked at separately, combining income generation with the creation of structural diversity goals exacerbates the problem. Moving away from managing even-aged, single species plantations may additionally result in having to market uncommon dimensions, qualities, and small quantities of forest products.

Only a few owners of small forests practice silviculture and market their forest products in a way that allows them to generate adequate income and at the same time maintain structurally diverse forests. Very few cases, like Birkemeier (2013) who describes how he combines forestry and marketing, are described and publicly available. Therefore, the purpose of this study is to develop theories covering the process of establishing and managing small (<200ac) income-generating, structurally diverse small forests.

To approach this question, I extend on the fact that forests as well as people and their social systems have been described as complex adaptive systems (Buckley 1968; Puettmann et al. 2009) that are linked (Levin et al. 2013). Among others, this requires investigations to take time into consideration (Blanco et al. 2015). To gather data on all the different aspects of this system, a combination of methods will have to be employed as no single method has yet been presented to analyze complex adaptive systems. Placing the landowner in the center of that system however may make my endeavor suitable for methods from other anthropocentric fields.

Complex business environments are frequently navigated and described in a strategic manner. Because there are numerous valid definitions of the term strategy, this does not imply a standardized procedure. Fujimori (2001) uses the term strategy but offers no definition when describing 11 different approaches to ecological silviculture. For my study, Porter's (1996) widely cited definition of strategy as "creating a unique position through variable activities" constitutes a good basis. Mintzberg (2005) offers several helpful definitions, among them "patterns in somebody's actions, intentional or not, that can be identified retrospectively". Gane (2007) considers many more definitions when applying strategic approaches to forest policy. Providing a more practical approach, Gilbert (1988) emphasizes the importance of room for intentional, decisive and timely action of the actors as well as attention to how these actions may affect the surrounding system, when endeavoring to reach a goal through strategy. With regard to looking for the different elements of strategy, Nath and Inoue (2014) provide an

example for the feasibility of this approach. They strategically examine livelihood strategies of forest dwellers on a community scale by taking the actors, their actions their environment and available resources in a temporal context into account. Possibly due to its novelty and despite accounting well for complexity, this approach, especially in the developed world, is seldom used.

By identifying and examining management strategies of selected owners of small forests in the Willamette Valley of Western Oregon, I aspire to begin laying the theoretical foundation for solutions to the Small Woodland Problem with regard to income generation and creation of structural diversity in small forests

METHODS

I executed the methods in overlapping steps. Figure 1 shows a process overview and timeline; the following text provides additional detail.

	year 1				year 2				year 3			
immersion into study environment												
gathering of basic information												
acquisition of funds												
acquisition of essential skills												
pilot interview 1												
formalized proposal of methods												
knowledgeable insider selection												
liaison with Institutional Review Board												
training of assistant												
further development of methods												
development of framework of silvicultural theory												
pilot study 2												
field test of structural diversity assessment												
adjustment of diversity assessment												
participant screening and selection												
data collection round 1												
data analysis round 1												
theoretical sampling												
data collection round 2												
structural diversity assessment												
final analysis												

Figure 1: Method elements and timeline. Green bars show concurrent activity and completion time of method elements. Timeline begins in fall 2014. Each bar represents three months. See main text for details methodologically relevant sections (grey background).

I gathered basic information (Figure 1) on my study area from various sources. The landowner database of the Oregon Forest Resources Institute (OFRI), a harvest-tax financed center for forest education, as well as Oregon-specific information from the National Woodland Owner Survey (Butler et al. 2016) provided an overview of my study population. The resulting large number of potential interviewees allowed me to decide on a relatively small study area comprising the counties of Benton, Linn, Polk and Yamhill in the Willamette Valley of Oregon. Through this, I also gained flexibility with regard to timing field visits, the funds to hire a

research assistant for coding and transcription processes, and the ability to visit with landowners repeatedly.

I furthermore went to local and regional meetings and field trips offered by the Oregon State University (from here on OSU) forestry Extension Service (from here on Extension Service) or the Oregon Small Woodlands Association, the state chapter of the National Woodland Owners Association who represents non-industrial forest owners nationwide. These activities served the immersion into the study environment (Figure 1).

To conduct this study, I had to acquire and practice essential qualitative research skills (Figure 1), including: 1) theory and application of various qualitative methods and 2) basic information about data analysis software. Bourgois and Schonberg (2009) served as a convincing first example of the validity of qualitative research in general, and Easter (2005) provided an example of qualitative research in my field, chronicling the life stories of forest owners in the State of Washington. Further literature drawn on were Yin (2009) for information on case studies and Oktay (2012) for Grounded Theory methodology. To familiarize myself with the new procedures, I conducted a pilot case study with a landowner who volunteered. These skills formed the base of my study design.

I elaborated and formally proposed a multiple case study approach (Figure 1) with the following, selected elements from Grounded Theory: Theoretical Sensitivity, Theoretical Sampling, Constant Comparison (Glaser and Strauss 1967). In this method, more than one case (after this section referred to as forest ownership or landowner) is examined with the intention to gather detailed information about each. Case selection is usually not representative and inferences are theoretical, not statistical, as a consequence. The aim is a credible and trustworthy presentation of the cases, if possible with findings that reoccur in several cases (Creswell 2007; Yin 2009). Ways to methodologically assure these attributes in the data that is collected can, for instance, be found in the Grounded Theory approach. This method was developed to generate so called mid-range theory (Glaser and Strauss 1967). Mid-range theory,

as opposed to grand theory, consists of concepts that help people on the ground (e.g., Extension agents or landowners as opposed to academics) to make meaning of their immediate surroundings, in my case the human dimension of forestry. Using Grounded Theory implies a basic understanding of already existing theory about the subject (Theoretical Sensitivity). A sample selection designed around confirming or disconfirming emerging theories with future cases (Theoretical Sampling) and previous cases (Constant Comparison) are the second and third pillar of the method. The fourth pillar, Theoretical Saturation demands further research until no new information can be obtained (Oktay 2012).

Considering the study goals and what I had learned about strategy I defined strategy as:

Actions taken to achieve a goal under consideration of actors and resources in a timely manner.

This definition as well as the literature (Fischer et al. 2010) called for mixed sources of data and incorporation of a rigorous yet flexible (Walters 1986) system of qualitative data evaluation. I deemed Theoretical Saturation, the fourth and last Grounded Theory element, possible but unlikely.

Tools for primary data collection included a compass, a small digital video camera and a Dictaphone. For transcription, I used the Wreally© transcribe software, standard headphones and a Wavpedal. For data analysis I used the software NVIVO®, and Microsoft Excel®. In addition to the quantitative data collection skills I considered practical experience in small-scale forestry, my pilot studies and an extraverted (opposed to introverted), intuitive (opposed to factual), feeling (opposed to strictly logical) and perceiving (as opposed to judging) type temperament (Myers et al. 1985) important. Hiring a local research assistant also increased my understanding of people and land.

My landowner recommendations came from selected knowledgeable insiders (Figure 1), i.e. people associated with the Extension Service, the Oregon Small Woodlands Association, Oregon Department of Forestry Stewardship foresters and local forestry equipment retailers. My

criteria for insider selection included a good understanding of my project and the readiness to volunteer names of candidate landowners after a personal conversation. I am fairly certain to having created potential access to my entire sample population (approximately 3000 landowners) through them.

To obtain suitable participants for my study, I provided the insiders with four selection criteria upon which they based their recommendations to the best of their knowledge. First, the potential participant had to have structural diversity and income generation as stated management goals, either in form of a management plan or based on insider information. Second, the potential participant had to have managed the forest for more than 10 years, the amount of time I assumed was at least necessary to detect patterns in landowner actions. Third, the owner had to have sold, or be about to sell, forest products as proof of viability of their operations. Last, the potential participant's forest could not be significantly larger than 200 acres.

Sixteen knowledgeable insiders supplied me with 70 candidates for the screening, around 40 additional candidates volunteered after reading an email, newspaper article or participating in an online survey about my study. Few of these met the selection criteria and where they did, I discussed their suitability with my knowledgeable insiders and inquired via email directly before considering them.

The ensuing participant screening and selection (Figure 1) was a multi-step process. In spite of ongoing uneasiness about promoting my project via cold-calls, unsolicited emails or directing conversations towards my project, only these personal approaches proved to be effective and under my control. To attend to the concurrent activities (Figure 1) without losing information, organization of leads, facts, and ideas was paramount. Organizing information benefited from the use of digital conversation logs, journaling, spreadsheets, and digitally archived whiteboards. After a final personal phone inquiry with the final 76 candidates approved by my knowledgeable insiders, 20 proved to be suitable based on my selection criteria. I could not

clearly determine the suitability of 40 candidates. Determination of suitability usually preceded recruitment by at least one day to enable intentional and hence theoretical sampling. I only once combined the two activities under time pressure after a selected landowner unexpectedly refused to participate a day before the first interview. I never encountered this problem again after proceeding with the study subjects in the following fashion:

- 1) Inform landowners about their suitability for the study
- 2) Explain procedures, answer question and obtain consent.
- 3) Agree on a date and a substitute date for interviews one to three weeks in advance
- 4) Have another, preferably more distinguished member of the team send a thank you note to the participant reiterating the importance of the study
- 5) Send a reference copy of procedures to participant several days before the interview.

My approach resulted in recruitment of the first landowner after nine months, mainly due to concurrent activities. Especially coursework, training of the research assistant and the unfamiliar Institutional Review Board process slowed study progress.

Two semi-structured interviews per ownership with several months between rounds (Figure 1) comprised the main source of collected data. The prepared questions (see appendix) included all elements of the Integrated Model of Marketing Planning (Hansen and Juslin 2011). This model also inspired us to create a similar model of important aspects of forest management (see appendix) to inform my questions and data analysis. Supplementary data sources included management plans and landowner field journals. The forest tour, a videotaped walk with the landowner through their forest represented an additional, novel data source.

I visited each forest three times, each time for several hours. During the first visit I

- 1) assessed the management plan,
- 2) videotaped the forest tour and
- 3) conducted the first interview.

This procedure took the potentially large amount of collected data for immediate analysis, as well as the limited attention spans of researchers and landowner into account. The second visit took place several months later, allowing me to:

- 4) collect answers to specific questions derived from analysis. Moreover, I
- 5) elicited feedback on my overall findings to date and
- 6) assessed finances.

Additionally, I brought a short synthesis of my analysis as well as a concept map (similar to Figures 3 to 8) created from analysis of the first interview. I refreshed my memory by watching the forest tour video the night before the interview, which often yielded additional questions. Last, I specifically inquired about activities in the forest in chronological five to ten year increments, helped by a printed timeline. This activity complemented the facts about income from the actual interviews to arrive at the most important income proxy, number of log truck loads of timber sold. When hauling receipts were unavailable, I assumed 4000bf (approximately 9.5 m³) equal one load when analyzing scaling tickets or tax-related records,

I captured structural diversity (Figure 1) during a separate third visit without the owner. I estimated the structural diversity of nine plots per forest based on a simplified assessment after Spies et al. (1991) (appendix). I selected the plot size to include either the six closest trees or a radius of 15 meters around the randomly assigned plot center.

The basis for my four-step qualitative analysis (Figure 1) was 315 pages (or 23 hours) of 12 transcribed interviews. The research assistant and I 1) independently coded each transcript substantively (free coding). All text seemingly relevant to the study topic was coded into a so-called node in NVIVO and given a descriptive name (i.e. 'doing the right thing'). This resulted in 40 to 80 nodes per interview. After completion, we 2) compared codes between coders. Using my field notes, the original recordings and placing our code side-by-side, we shared thoughts on divergences, seemingly important passages, sentences and words. We also clarified node labels, and compared observations across interviews for the purpose of constant comparison

Next, using different colors for each coder's nodes, I 3) integrated all nodes into a concept map (Novak and Cañas 2008) for each landowner. They show the interrelation of important concepts by using labelled arrows. I linked each node to one or more themes based on the passages contained in the node. Before proceeding, I elicited direct feedback on my themes in the second round of interviews and modified them where necessary (Figures 2-7). Nodes relating to income and structural diversity are located towards the top, landowner traits and sometimes important resources are located towards the bottom. I chose this structure in accordance with the general structure of concept maps which have the key elements located at the top. Also, it fit the strategic approach to base strategy on actors, environment, resources, and actions. After the second round of interviews, I 4) corrected the models where necessary and created a collective pattern concept map drawing on the entire dataset. This pattern map later evolved into Figures 11 and 13 and showed the overall diversity of themes but also documented similarities between interviews we had identified during our discussions surrounding coding. In contrast, the categorical coding served as a repository for facts that also facilitated comparison between interviews. Passages from interview transcripts were placed in 50 defined (see appendix) categories. I initially based the defined categories on the Integrated Model of Marketing Planning (Hansen and Juslin 2011) and my own Model of Theoretical Silviculture. I considerably simplified the model during the pilot interviews and found it indispensable to keep a diagram (as opposed to a list) of the codebook fully visible while coding.

Several adjustments to the raw data were necessary before the captured structural diversity (Figure 1) could be analyzed. I found that in several plots the transition between vertical layers of vegetation was blurred due to shade-tolerant mid-size trees and advanced regeneration. I defined all trees larger than six meters as overstory, with the exception of vine maple (*Acer circinatum*) which I still counted towards the understory and advanced regeneration at 10m.

For the understory, I distinguished and color-coded five categories: No understory, tenuous understory, tenuous mixed understory, solidly established understory and solid mixed

understory. The term mixed is defined as containing coniferous as well as deciduous species. An understory with several coniferous species is hence not classified as mixed. The status of tenuous or solid establishment of a species is defined by multiplying height in m of the largest individual with the species abundance in a plot. If the product is larger than five (e.g. three trees of the same species, and one of them is two meters high), I deemed the species solidly established.

RESULTS

In order to create a relatable picture of each forest, I will describe them separately. Names of landowners are changed for anonymity and arranged alphabetically. After a brief biographical overview, I address my selection criteria and describe structural diversity and income generation. I address the underlying resources next. They are important for an understanding of the more submerged layers, the management strategies for structural diversity and income generation, which I present after that. I describe and illustrate the management strategy using text, a table and a figure for each landowner. Text, map and the table containing interview references should be used as if they were one figure. For ease of reading, they are presented on two consecutive pages. Maps and texts feature strategies at the top, below them resources and at the bottom actors supporting and comprising the strategy. All nodes of the maps and text sections are numbered and reference the associated Tables 1-6. Finally, I identify and arrange identified patterns in order of importance, distilling results via text and figures to lay the foundation for the discussion.

OWNERSHIP DESCRIPTIONS

Forest 1: Anna (and Abe)

Biography: Anna and Abe managed their forest jointly (since 1974) until Abe passed away after 32 years of management. During these years, Abe and Anna made the 100 mile round trip to their forest for a weekend about once a month, either for the various stages of a large afforestation project, family enjoyment or a combination of both. Following Abe's death 11

years ago, Anna visited the forest every other month for light management or supervision when contractors were on site, the social aspect has declined almost entirely as her kids have grown up. The site class two forest has a size of 145 acres.

Captured structural diversity: More than half of the trees in Anna and Abe's forest were deciduous trees. These areas were complemented by mixed, vertically stratified, conifer-dominated forests and planted monocultures. Crown cover was mostly between 60 and 70%, sometimes significantly lower. This allowed for a robust and diverse understory rich in shrubs but also a considerable amount of invasive vines. All sampled plots had at least a minor deadwood component, but large standing deadwood was absent.

Income generated: In spite of relatively large harvest volumes, the forest continuously and increasingly held high standing volumes of timber throughout the years. Harvesting about once or twice per decade, Abe and Anna sent 334 loads of logs to the mill. A rental house on the property represented an additional and regular source of monthly income. Apart from two cords of firewood per year to supplement regular heating at home, no further expenses were reduced.

Resources: While being intellectually and materially well-endowed, human resources were scarce in this forest. Various pieces of equipment would allow for timber management operations, including small harvests. However, all large operations including logging were always hired out and only the equipment for light maintenance, mainly mowing of open areas, was currently used. Since Abe's death, activity patterns shifted and hands-on management strongly declined. There was little involvement from the rest of her family in spite of Anna's best efforts to be inclusive. Having done her own operations planning and log marketing until recently, Anna now increasingly relied on a trusted consultant.

Throughout their time as managers, Abe and Anna were, and Anna continues to be, strongly involved with most public education offers and attended classes, tours and events regularly. Abe and Anna occasionally went beyond what was offered and have experimented with

equipment and techniques in their forest such as specifically-bred seed, Japanese pruning saws and mechanical planting. Lastly, Anna and Abe had sufficient alternative income streams, among others from Anna's work as a teacher, throughout the years and rarely used any income from the forest for their personal sustenance.

Strategy: Anna and her late husband mainly managed the forest as a place for the family to enjoy, yet they generated income and structural diversity in the process (13). Their increasing affinity for the forest (5) and continuous involvement in learning (3) was one of the main influences on their intentional silvicultural practices (11) but also on their ability to tap into various income other than timber management (9). Learning also enabled them to create a forest that was both neat and diverse, as desired for family outings. Also fundamental to their practices were familiarity with forestry from an early age as well as a lack of financial necessity (6,8). The latter enabled them to purchase additional services from verified sources to meet their management goals (4). Over time this strategy has become harder and harder to follow. In spite of public recognition (7) interests of the next generation are different (12). A decreased energy budget (2) also decreased necessary hands-on management (1,10) and shifted towards reliance on external resources (4), including for silvicultural decisions.

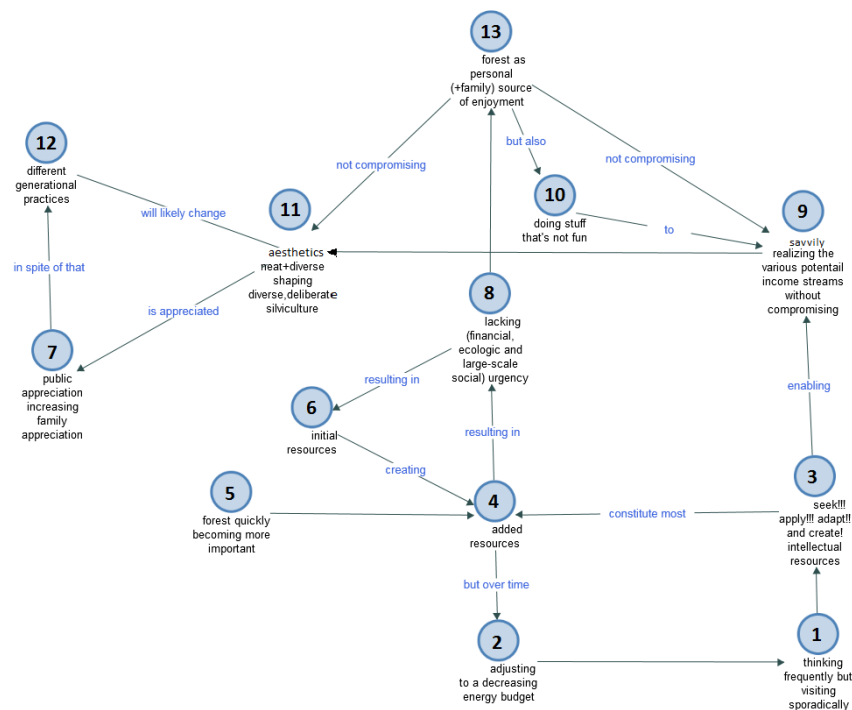


Figure 2: Anna's (and Abe's) forest management strategy. Supporting references for each node are listed in Table 1. Elements are numbered in order of importance. Strategies are located at the top.

Table 1: Interview references describing Anna's strategy Explanation of symbols in square brackets: ☺=chuckle, +=agreement, P= pause

node	Interview citation corresponding to strategy text and concept map
1	J: And how often do you think you were out there. Ah, from 2003 onwards? Like once a week or twice a week or? A: No, probably more like every other month. [J+] Except when I did that house.
2	A: Yeah, and just the driving, you know. At my age, you've got the long drive too. J: Yeah, and um, however, 20 years before, not so much of a problem though, yeah. A: Well, there was two of us.
3	A: [...] The ladders were New Zealand and the pole saws from Japan [J+], which we imported. Really interesting to bring stuff [...] through the import process.
4	A: Yeah, yeah we'd go to tree school, and we do Master Woodland Manager, and go to, when the local counties have tours, uh, the local tree farms [...] J: And the consultant then took care of the logs once they were on the landing [A+] A: Yes, that kind of stuff. [...]. That's kind of the hard part, you know? For me.
5	J: Or when did that interest in the forest pick up [...]? L: [Papers rustling] Probably the first time we logged. Um, '77 is when we, um, first did some actual logging.
6	. A: I was kind of aware of what scale tickets should look like and what scaling information should be. So I had a little bit of information on that just from the way I grew up.
7	A: Another big milestone was when we were chosen regional tree farmers of the year.
8	J: It was important to consider that you never had a real need to generate money from that forest. [A+] It was always, uh ... there was no urgency in it [...] A: That's right. It was mostly done for the benefit of improving the forest.
9	A: Here, I'm doing probably more thinning, you know. More regular logging, but probably a majority of income that pays for the property tax and everything is my rental.
10	A: No, when you're stomping around and it's snowing on you and it's really, really cold. ☺ But, you know. We didn't go, "Oh yay, we get to go plant!" It's like, "Oh, we better get this done.
11	J: So you've been through every single stand and done something and... A: Yeah, we have some of it was deliberate, you know, some thinning. And some of it was repair after storm damage. [J+] So it's all been gone over once or twice.
12	A: Who's gonna do that if I'm not gonna be the one to start it. A's son: yeah, and we're not telling her ... ☺ A: Do you know? Do you have a plan [son-] see, you don't!
13	A: I want to keep trees here for the future generations [...]. So there's always gonna be some income, and there is gonna be some place that is kind of unique

Forest 2: Bill

Biography: Bill bought his father's 150-acre forest in the Coast Range of Oregon 41 (1976) years ago. He also took over his logging business at that time. Bill gave priority to work in his customer's forests, hence whether he can afford to work on his own land always depended on where more money can be made. Work is the only reason that motivates Bill to be in his forest. In spite of living very close, more than two weeks may go by without a visit.

Captured structural diversity: Bill clearly emphasized plantation-type forestry, yet his particular management style entailed some structural diversity. The plots in Bill's forest exclusively comprised Douglas-fir plantations, mostly freshly replanted or in the stage of stem exclusion. Overstory stratification was minor as no tree was higher than 30 meters. The distribution of crown covers was bimodal, exhibiting very low (0-20%) and fairly dense (60-90%) cover. Understory and advanced regeneration were present in six plots spread all across the spectrum of crown cover. Deciduous trees often dominated or even exclusively occupied the understories. Grass or leaf litter frequently covered the ground. Standing deadwood was rare, and large standing deadwood was completely absent from plots.

Income: Bill generated substantial income from his forest through timber harvest in the past, to the detriment of current income. Endowed with a mature forest and the equipment and knowledge to manage it, Bill started harvesting four to five acre patches immediately. Five to ten logging events per decade resulted in approximately 276 loads of logs leaving his property. During that time, contracting accounted for the majority of his income, but his own forest served as an important fallback when the economy slowed. This ended after 20 years when Bill decided he did not like the constraints on management that came with large and fast equipment, selling most of it. This left him slightly better equipped than to begin with, but also with a forest where few areas would be ready for a final harvest in the near future. The current income from his forest is limited to thinnings.

Resources: Bill's work as a contractor gave him access to most necessary resources for his timber management, but not always the time to use them on his land. Bill owned all equipment for the efficient harvest of large diameter trees on small tracts and employed two loggers. After owning his own harvesters and loader for several years, he decided to downsize again to a caterpillar and manual falling. His forest contained several dead-end winter-haulable roads for the sole purpose of timber extraction. Bill relied on the workshop and the loader of others to keep his equipment running and his logs hauled to the mill. He had exclusively done business with his mechanic and hauler for many years, the latter also being a valuable source of market information. Bill's decisions were informed by what he had learned while working as a logger under the tutelage of the OSU logging crew and his father. Annual meetings with a logger association, infrequent tours with a small woodlands association and the work he did for his customers, complemented the experiential knowledge he gained by working for many different people with different ideas, among them also government agencies and large industrial landowners. Being a self-declared computer illiterate, Bill predominantly learned from experience, face-to-face interaction, and observation.

Strategy: Bill's only goal was sustained income, but he tolerated some structural diversity that was a result of his management style. Bill enjoyed gainful work in the forest and acknowledged the mental and physical health benefits of doing so (2,7). Financial return was a potential deal breaker in terms of where he put his energy (6) and he was not sentimental about the forest (4). Bill learned about forest management early in his life, mostly through hands-on work (1). He considered learning important and continuously gained knowledge through logging and advising people on their forest management resulting in a solid understanding of the forces in small forest management (9). Bill was at a stage, however, where he merely tweaked his management instead of innovating (5). Bill heavily invested in equipment to become more competitive in his contracting. After several years he scaled back down, unwilling to let the cost of machines govern his management, both in contracting and his own forest (6). Bill saw no incentive in deliberate management for structural diversity (3) on his own property. In his customers' forests, who appreciate his local, loyal and thorough approach, he however had a financial incentive to do so if that is what the customer asked for (12). Eager to not disappoint and diminish his only way of advertising (word-of-mouth) he generally gave customers priority over his own forest (8). This sometimes lead to less-than-desired effectiveness of silvicultural tools aimed at promoting monocultures on his land, with unintentional structural diversity as a consequence. Bill was nevertheless very intentional about continuous generation of income from the very beginning (10). He reinvested his income diversely yet traditionally, creating a solid income portfolio (11).

Table 2: Interview references describing Bill's strategy

node	Interview citation corresponding to strategy text and concept map
1	B: Any time you're around and you are working for somebody else and you can see what they are doing and [...] that it's really wrong, you learn. You learn and sometimes it is years later but you do learn from it.
2	B: [...] it's a peaceful time, I'm not around a lot of people, so it's more me and the elements that I am battling...it's just good. Just a healthy time.

3	B: I think they think they're (other owners) managing their property but they want to hold on to wilderness areas instead of getting the garbage out and getting it producing.
4	B: If you got money to just buy stuff and just look at it and get all fuzzy and warm, that's great. I got no problem with it. [J+] I'm not that person, I don't have that kind of money, I have to plan this so this can help benefit me and move forward in life [J+].
5	B: I've been engrained in it long enough where I kind of know what needs to be done.
6	B: Well let's face it. We have to have income to make everything go together.
7	B: Well, the forest is gone, your house is somewhere else. You don't have that bank account, you don't have that therapy time...[J!]. When you're out working in the woods, it's therapy time.
8	B: See, a lot of my people I've worked for 20, 30 years [...] You try to keep them happy [J+]. Um, because they are your bread and butter.
9	B: And then you know you got your economy, you got all these little factions coming in [...]. There is just a system all around that you gotta stay on top of.
10	B: We just gradually worked through it and my idea was to make it last long enough for the young stuff to come back [...] Mostly small patches, 4 or 5 acres at a time.
11	J: [...] did you put any of the money that came out of the forest sale back into the business or the forest? B: I bought a store with it really.
12	B: Well, when you manage it for somebody else [J+], you have to do what they want, whether you agree with it or not.

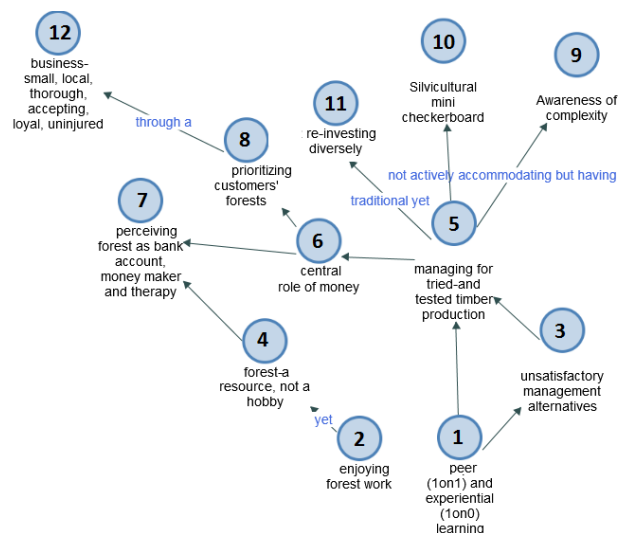


Figure 3: Bill's forest management strategy. Supporting references for each node are listed in Table 2. Elements are numbered in order of importance. Strategies are located at the top.

Forest 3-Colin

Biography: Colin had owned and managed his forest for 46 years (since 1972), but had exposure to practical forestry work before that. He dedicated most of his weekends to forest management early on, until his occupation forced him to put forestry on hold for around ten years. He has been living in his forest as a full-time tree farmer for almost two decades now, working on his site-class two 110-acre property at least four to five days a week. He is gradually logging off the original mature timber and replacing it very successfully with intensively managed conifer plantations.

Structural Diversity: Colin managed a forest dominated by Douglas-fir. Canopy heights ranged from 20 to over 50 meters. Plot-scale vertical stratification was the exception, especially in plots with higher trees. Crown cover becomes continuously lighter with increasing tree height, ranging from 45 to 90%. This corresponds with the occurrence of understories almost exclusively at lower crown densities, leaving five plots without any understory at all. Litter, vines, moss and bare soil respectively were the most common ground covers. Large deadwood of any kind was completely absent from the plots, small and medium-sized recumbent deadwood is common throughout.

Income: Colin harvested a total of around 209 loads of logs over the years with four to six logging events per decade. Timber harvest started in earnest 10 years after acquisition with 142 loads leaving the forest over the next 15 years. While the volume has changed, Colin still sold about two loads every other year. Colin also generated income through land lease for a portion of his property that was unsuitable for large trees. Colin was able to avoid expenses by burning around 10 cords of his own firewood annually in a custom-built wood furnace. Additionally, Colin had a diverse portfolio comprising a pension, social security, real estate, stocks, brokered money loaning and shares in a small family timber corporation. His forest currently represented a small part of the income. Money from earlier harvests however helped him to build his portfolio in the first place.

Resources: Colin's tractor and four-wheeler were both equipped with winches or hooks and enable him to log and yard small harvests himself. Intensive pruning with a ladder and backpack-spraying were important parts of his day-to-day management. While confident with small operations, he left large harvests and tree dimensions as well as hauling to contractors with bigger equipment.

Colin sometimes regretted not having gone through forestry school. He however held advanced degrees in unrelated fields and read widely. He occasionally sought help from university professors for his management. He cultivated strong ties with the Extension Service from the beginning of his management activities and was associated with other small woodland owners in his region. He attended but also gave tours, occasionally to log buyers, on his property and regularly attended seminars related to forest management. Experimentation was a given for Colin in all of his activities, including documentation of his trials, experiences and observations for later reference.

Colin allowed a hunter on his property as a second set of eyes which forestalled trespassing. He planned operations annually and frequently ran his day-to-day management decisions by his wife. Very large logging jobs involving sending logs to several mills were usually handled by a trusted consultant. He attributed his understanding of money to good teaching from his father.

Strategy: Colin worked towards his main goals of inflation-proof income and a diversity of different age classes employing an integrated strategy (10). The motivation, gratification and social network (2) he derived from work in the forested surroundings of the region he grew up in (1) constitute the foundation of his strategy. The resulting long exposure to forestry, the region and reflected experiences from a life of more than seven decades (3) informed his actions. Turning a huge and steadily growing wealth of information into operable knowledge (6) his goal-oriented actions (5) deliberately incorporated abstract topics such as societal systems, taxes, laws and regulations (4,9) Moreover, his experience and outlook transcended generations (8) and sensitized him to deal with the complexity of changing forests and an ageing body (7).

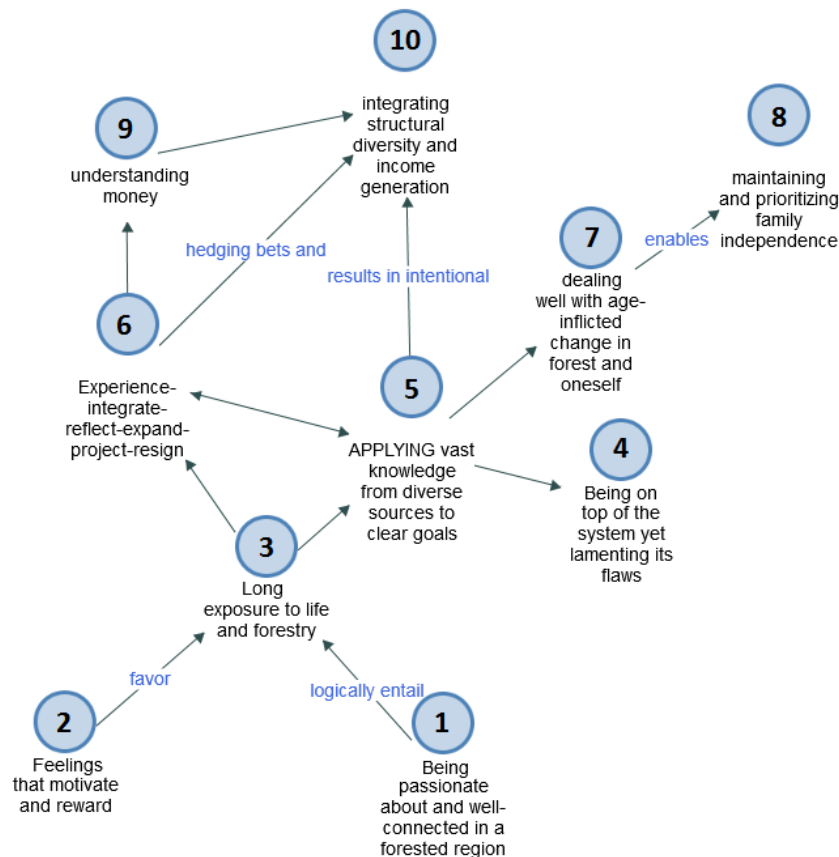


Figure 4: Colin's forest management strategy. Supporting references for each node are listed in Table 3. Elements are numbered in order of importance. Strategies are located at the top.

Table 3: Interview references describing Colin's strategy

node	Interview citation corresponding to strategy text and concept map
1	C: And I had spent much of my life traipsing around these mountains and I wanted to live some place on the lower slopes of these mountains and if you do, there are trees. And I was used to being in trees.
2	C: I would say that the overarching thing, use that term, is a feeling of trying to do the best you can with what you've got. And I'm happy, I take pride in the fact that you know, the stand looks really good
3	C: People have such a very short-term outlook, politics wants to look at the next election, business wants to look at the next quarterly report and religions want to look at the next size of the people putting money into the collection box. [...]. And I have such a long term view.
4	C: you come in from the woods a little earlier in the day because you are tired to do something, you end up paying a little more attention to the things like the paperwork and the bookwork and the zoning and rules and taxes, all that sort of thing.
5	C: [...] Then about two years later, I said no, I'm going to really do it, and I cut a log load log and I hate to use the telephone, but I got on the telephone and called the mills. C: I experiment with everything, I had failures. I've had intentional failures. Not very many but...
6	C: But boy, the first few times I was logging it was: 'How do I hook the choker?' and [J+] and 'Oh, I should not have drug it down the road that far, I lost two inches of the scale 😊 J: Yeah, and then that, ah, that further led to um, experience, which you integrated, which you reflected, by which you also projected into the future. [C+]
7	C: So you learn that it is quite a bit more complex and pretty soon this becomes the way you operate and then more and more, I guess in a poetic sense, as old age creeps in on me [...] So what I do is I manage and hire a contractor to come in and at my age now it's okay if I'm gonna hire the contractor and we're gonna do even a small clearcut. I'm also gonna have them plant the trees.
8	C: But economic driver, for me and perhaps many of these people has changed from: 'I don't need the money but it would be nice to continue to have the trees grow so my children will have more money.
9	C: And the way that ties in with the tree farm is my alternative rate of return, if I whack some trees, is about 8%, not 1% that I would get from the bank.
10	C: It gives me options... [...] if I have a diversity of stand structure, I have a better chance of not getting wiped out. But it's more from the standpoint that it just gives me a great deal of options if the [...] buyer from the mill up there and says: ' [...] we're running a little short on this kind of a log. Are you thinking about doing any logging?

Forest 4: Daniel

Biography: Daniel became a forest owner 45 years ago (1972) when he went halves on a 25-acre property with a customer at his restaurant. Daniel sold his restaurant and moved onto the land without any prior knowledge in forestry, adapting quickly. During the next eight years he first managed a Christmas tree plantation, then worked as a farrier, and finally logged with his own draught horse for four years. A series of coincidences and marriage saw him running a growing business back in town, however, his weekends and evenings were spent tending his horses and his forest. He dedicated himself to his forest full-time when he sold his business 26 years later and, having acquired the adjacent 25 acres of pasture recently, started reforesting them eleven years ago (2006). At first his reforestation efforts were done with the help of a cost-share program, later out of his own pocket.

Structural diversity: Daniel's forest contained a roughly equal mix of conifers and deciduous trees. Three distinct types of forest, mature coniferous, mature deciduous and young conifer plantation characterized the canopy structure of his forest. Notable was the absence of conifers between 10 and 28 meters. Five of the six plots featuring a closed canopy differed from each other in canopy height structure and composition. Their crown covers ranged from 50-90%, a number likely reduced after a recent ice storm. All plots contained understories, five of them contained various mixtures of conifers and deciduous trees. Grass dominated as ground cover in the newly afforested plots, with a mixture of moss and shrubs or litter and shrubs in the coniferous and deciduous plots respectively.

Income: Daniel sent 43 loads of logs to the mill, spread out over two to three logging events per decade. The co-owner, not interested in forest management, was happy with a 70-30 split of the income after hauling when Daniel did the logging. Before he decided to turn the acquired neighboring house into a guest house, Daniel had additional irregular income from his forest through rent for a few years. When his daughter moved into the guest house permanently, he built another one, mostly using lumber harvested and milled on site. This new guest house was

the fourth building he built using lumber from his forest, he has also built a barn and two residences. Six to eight cords of firewood annually constituted another expense reduction. His business, first the income then likely the sale of it, and now social security represented the remainder of Daniel's portfolio and the principal part of his income.

Resources: Daniel was equipped for light logging and had the means to process timber into lumber in his sawmill and wood workshop. He discontinued using his draught horse soon after he changed careers. For larger trees and hauling logs, he relied on contractors.

Daniel's main sources of knowledge were his practical experience in his early years as a professional logger and later on his own property. Observation of, and the desire to, emulate natural processes also strongly influenced his management. Conversations with the co-owner, former owner, befriended loggers and most recently the Natural Resource Conservation Service staff also inspired his actions.

Strategy: Daniel managed his forest as a sanctuary from the outside world for his and his co-owner's families. A longing for living in nature (1) with as few concessions to society as possible (7) was the foundation of his strategy. A regular income became necessary when Daniel started the family that to this day remains his first priority (3). The expression of his attitudes (2) gradually shifted from merely living in nature to forestry. His perception of nature (4) and his approach to make the best out of every situation without regrets shaped a reactive approach to forest management. Harvesting only to clean up after natural disturbance events may only have been possible due to the small size of his forest (5). Income is more a consequence of his approach and skills than an explicit goal (9), while the creation of structural diversity is more deliberate (8). Until recently self-taught or opportunistic about knowledge acquisition, participating in a cost-share that gave Daniel the know-how to begin afforestation activities (6).

Table 4: Interview references describing Daniel's strategy

node	Interview citation corresponding to strategy text and concept map
1	D: I decided that I was going to pursue a life in the country and so I could have horses. [+] That was the premise.
2	D: Well since I can't, I just have to be able to appreciate what I do have. And not regret and have remorse about: 'Oh, I never see this tree big' you know? It's like: So what? I can see it now.
3	D: You know the lifestyle that I wanted when I came out as a young man to spend all day every day out in the country and... [...] with the difficulties that there are, still, I started this (guest house) at the same time my wife got ill and so I'd managed to do quite a bit.
4	D: Well that's... Would the land like it...Yeah! I mean I don't know...Is it ecologically sound, you know? Is it not gonna hurt the environment?
5	D: Don't mess with it, just store them standing up and then when the situation arises, then deal with it. [...] But as long as they were alive and standing up, I had a choice.
6	D: I did I study how? No, you just do it. 😊 D: So while I did not have that help with the forest, I did when doing the river. So it was good that I had those people and those people with that knowledge base to help me make the decisions. And significantly improving my chances of success, you know, on this (river) project.

7	D: Part of the motivation for living on, you know, less [ell?] that I do is to become less involved with information that does not refer to my life or things that I can't do anything about or (sighs) you know. [+] Trying to maintain a mental sanity in a chaotic world. This is my [P] my sanctuary.
8	D: Creating an environment that was...You know, would promote fish. The interactions between trees and fish was, is why I planted the trees. Not for a woodlot, [...] it was because that's what was originally there.
9	D: I [...] didn't need the firewood, so I didn't just want to let it die, and that was one where... (inaudible) why not pay the taxes?

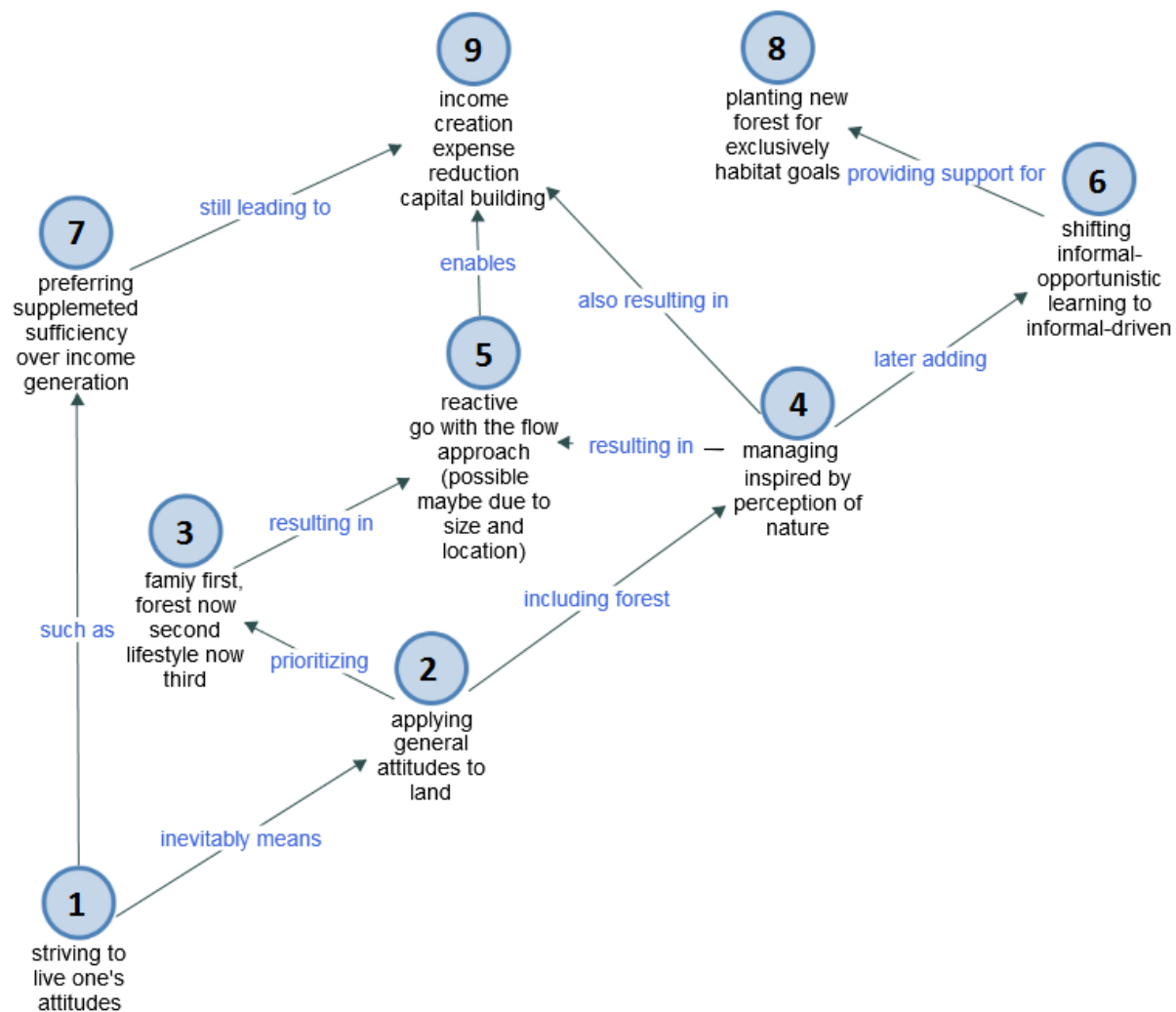


Figure 5: Daniel's forest management strategy. Supporting references for each node are listed in Table 4. Elements are numbered in order of importance. Strategies are located at the top.

Forest 5: Eric and Erin

Biography: Eric and Erin became managers of their 87-acre forest 21 years ago (1996) when Eric's parents bought the forest as something that could be managed as a family business. After resolving major infrastructural and invasive species constraints in the predominantly young forest, Eric and Erin bought Eric's family out and became the sole proprietors. When largely retiring seven years later, Eric and Erin began to drive out to their forest for between two or three days instead of one or two a week. Their joint naturalist and leisure activities now more strongly complement forestry related tasks such as thinning, light harvest, planting and road maintenance.

Structural Diversity: Eric's and Erin's forest reflected their deliberate efforts to enhance structural diversity through silviculture. Seven plots with top heights ranging from 21 to 41 meters contained mixed canopies with at least 10 meters of vertical stratification. Crown cover was fairly high, ranging from 80 to 95% in all but one plot. Five plots, particularly the ones with lighter crown cover, had a solidly established hardwood understory, in four cases with a tenuous conifer component. Litter, in four cases accompanied by moss, dominated as ground cover, small shrubs were rare throughout. Plot 8, the least diverse plot in all aspects but ground cover, was located on an old skid track. While not included, it featured a mature deciduous tree growing so close that its leaves influenced the crown cover of the plot.

Income: Eric and Erin will generate significant income through timber harvest in the next decades as many trees in the forest will become merchantable. Being a relatively young forest they have sent only 14 loads of logs to the mill. They have not generated other sources of income from their forest, but have avoided some expenses through cutting a cord of firewood annually and by renting a tractor from a small cooperative they co-own with three neighbors instead of buying one by themselves. Both Eric and Erin have retired and their retirement funds and social security are their only other source of income.

Resources: Eric and Erin owned little in terms of material resources as they rented the tractor and various attachments for small area and selective harvests from the equipment co-op. Logging requiring larger equipment was contracted out. Their office, a little hut with a view and a stove, markedly increased their comfort while staying in the forest. Eric and Erin took regular advantage of educational offerings through the Extension Service and the Small Woodlands Association. Eric's forestry schooling provided for access to and understanding of primary scientific literature. His professional background also gave him access to a large network of forest scientists and professionals, among them the other shareholders of the equipment cooperative. Less common silvicultural tools such as selective ringbarking were employed as a result. Eric did most of the work in the forest. He was reluctant to solicit help from friends due to liability but he let them cut firewood for themselves and sought their advice in management decisions that he and Erin usually took jointly.

Strategy: Both income and structural diversity featured prominently in Eric's and Erin's management goals. By not desiring to maximize either of the two, they compromised very little due their ability to meet multiple goals through any one activity (7). Both Eric and Erin were at ease with what the forest provided to them as a result of their management approach (2), meeting common and individual needs in it (1). With the necessary know-how to continue to do so already in place (4), they were able to curb unenjoyable activities (6), think critically about forest management (5) and investigate alternatives better suited to their management (3). Proactive and hands-on management provided a learning environment for larger operations soon to come (8,9). While this was also true for their management with regard to structural diversity, there is a strong social aspect to it also (10).

Table 5: Interview references describing Eric and Erin's strategy

node	Interview citation corresponding to strategy text and concept map
1	. E: I don't want to just observe it. I want to go out there and push it some way. So that's an element too. And where'd that come from? I don't know. E2: [...], if we had 5 acres of fruit trees and a vegetable garden, then ... E: It might do most of the same things for us, psychologically.
2	E2: My mom came out a long time ago and her expression of, she looked it over and said, "Oh, it's so much work! So much work, and it's so messy!" And I said, "Yep!" 😊 So not ... it's not everyone's cup of tea. We do know that. 😊 That's okay.
3	E: Alright, if they say you can only have 12 inches of knots in a [...] So that means you have to keep your density of the forest above a certain level so those branches die. E: [...] people can mix habitat, in our sense, management with Douglas-fir management. [E2+] And I guess I say that simply because we don't see hardly anybody doing it.
4	E: And obviously my professional background has given lots of detail to that kind of outline.
5	I am not sure when you're talking about something as fuzzy as what we put on the sustainability chart, whether you necessarily have to believe that more of one means less of another.
6	E: We've been very reluctant to go down that pathway because of liability issues. [J+] Having people do work on your property who aren't employees of somebody, it becomes a personal liability to us, and I don't want to go there.

Forest 6: Frank and Fae

Biography: Frank and Fae acquired the first 25 acres of Fae's parents' 100 acre pastures with remnant deciduous forests 37 years (1980) ago. By the time they bought the remaining 75 acres of site class 3 forest 20 years later, Frank had rekindled his passion for forestry he acquired working in his father's forest as a teenager. He and Fae planted several thousand conifers, restricted movement of their small cattle herd, sold a few Christmas trees, the first cords of firewood and several flatbed trailer loads of logs to a hardwood mill nearby. The additional acreage prompted Frank and Fae, to also think about trees as a source of income rather than the arboretum they had planted so far. As a consequence, they began taking advantage of educational offers about forestry regularly and are now very involved in Extension Service and small woodlands association activities. Frank also slowly began scaling back his carpentry contracting to spend more time on the tree farm. As their firewood and ornamental bough business grew, Frank and Fae decided to join a woodland cooperative in 2012 to help them market these products. As their son grew, he earned a degree in forestry and started a logging business. Frank now works three to four days in the family forest and helps his son with logging for the remainder of the week. Frank and Fae still make all the decisions in the family forest, while the management is slowly transitioning to their son.

Structural Diversity: Frank mostly afforested and replanted his forest with conifers. However, some of the original deciduous forest, randomly omitted but captured by an additional 10th plot, remained. Trees, almost exclusively conifers with the occasional deciduous tree, were frequently as high as 40 meters. Canopy heights in all other plots differ in height by at least five meters, producing a diverse distribution of top heights. Four of the plots featured canopies that are stratified over more than 10 meters. Canopy cover was bimodal and either under 20% or over 40%. Seven of the 10 plots have solidly established understories or advanced regeneration, only one of them contained deciduous trees and conifers. Alongside prominent litter, herbs cover parts of the ground in all plots.

Income: Frank and Fae lived exclusively off their land. The capacity to do so took them almost 30 years to build while Frank was working as a full-time carpenter. In addition to the variety of other products such as firewood, select hardwood logs and conifer boughs they have sent 34 loads of logs to the mills, but have scheduled more harvests in the near future. Firewood, marketed directly by the cord and in little bundles through a woodland cooperative was labor-intensive to produce but annually contributes around \$10,000 to Frank's and Fae's income. The sale of boughs around Christmas earned around \$350 annually. Selling a flatbed trailer load of hardwood logs roughly once every other year added around \$1000 per trailer. Their cattle operation broke even. Frank also earned \$2000 from working with his son. Frank and Fae attributed the ability to live off what they produce to their frugal lifestyle and a lack of debt. They reduced heating expenses through a custom-built radiant floor heat system using a wood furnace, they cultivated a large garden, and had cattle butchered for personal consumption. Frank and Fae could fall back on a Roth IRA and will soon be eligible for social security, which completed their portfolio.

Resources: Frank accumulated a tremendous range of equipment for farming, forestry and carpentry work. Few of the items, such as an ascender enabling pruning beyond 30ft (10m) or the firewood processing barn only served one purpose. Tractors, skid-steers and four-wheeler were used for farming, carpentry work or in his son's business. The large equipment bought for the logging business will in turn be used on the family farm in the future.

When Frank or his son did not have the equipment or required facilities for complicated repairs, one of their friends or family members was usually willing to help. Frank and Fae hauled hardwood logs and firewood themselves using a pickup, but hired a hauler to move larger felled conifers. Frank's upbringing and a year of forestry school were complemented by almost four decades of trial and error. The insistence of knowledgeable friends and family lead Frank and Fae to begin taking advantage of educational offers. Recognizing the value in it over time, Frank and Fae are now heavily involved in forestry education and shared their experiences with others. They also based decisions on their personal activity logs and an increasing amount of

reading and internet research. Frank and Fae, together with their son and his forestry experience, discussed management on a daily basis. Frank did all forest management himself, sometimes helped by Fae or his son. All three refused to dedicate more time than strictly necessary to marketing or accounting, for which they hired professional help.

Strategy: Frank and Fae's management plan featured revenue and 'maintaining a diversity of conifers deciduous trees wild areas and pastures' as their first and third priority, respectively. Family and upbringing were a strong influence on their strategy to reach these goals (2). Development of their approach to learning (1,3,4) constituted the second important pillar. Ideas and discussions around the dinner table (5) were ample and lead to purposeful experimentation with silviculture and equipment (6). Frank's and Fae's ability to cope well if things did not end up happening (7) results in a lifestyle that de-emphasized stress, risk and financial obligations (10). This was also reflected in their approach to marketing their products- Ideas for specialty products were seldom put into practice (11). Frank and Fae preferred doing business with friends and family that sought them out for their products and to serve established markets for the remainder of the cases (11). Their silviculture, inspired by learning from external sources but also by experimentation and experience, reflected that (12). Within that framework, prescriptions, such as staggered or extremely dense rows, were sometimes unusual to accommodate the land, machines and management preferences (8). Further areas of integration were forestry and farming, which had administrative advantages (12). Their approach to creation of structural diversity on the other hand was separate and characterized by cessation of management in certain areas (9).

Table 6: Interview references describing Frank and Fae's strategy

node	interview citation corresponding to strategy text and concept map
1	F: I am not opposed to trying different things, or thinking outside the box a little bit.
2	F: I worked in the woods, a little bit in the woods with my dad growing up.
3	Fa: [...] We are changing over to just our farm and forest. [...] You like to read. F: That's partly why I have been able to be more involved in the woodlands education
4	F: J. was a friend that ... [...] talking about Master Woodland Manager, and... Fa: He encouraged us to attend.
5	J.: You don't necessarily get to all of them, but there's always ideas. Fa: Mmhmm, yeah. That's our only subject. 😊 Usually.
6	F: Thinking, well, what's the plan for this? That's kinda why I've experimented a little bit with planting spacing because [...], what's gonna happen when you're thinning?

7	Fa: But we've, we doesn't really bother me what we don't get done. If it did, then we'd be in trouble. We would be depressed because there's a lot we don't get done..
8	F: We can go in since we're doing it (thinning) ourselves, we can go in more often. Fa: And we're not doing a lot at once.
9	F: we feel we have enough of other types of stands on the place that where we are changing over pasture or brushy areas to go that way.
10	F: We're not your average couple probably, [...] The place is paid for, we don't mind living [...] Some of the equipment that we had..[...].And experience that we've had.
11	J: So both marketing and accounting are areas of where you perceive potential, but it's not necessarily something you would want to, uh, invest time in. F: Right, let the bean counters do their thing.
12	J: So, and also you integrate farm and forest. You also integrate friends and customers. And you integrate income and education. [F+]

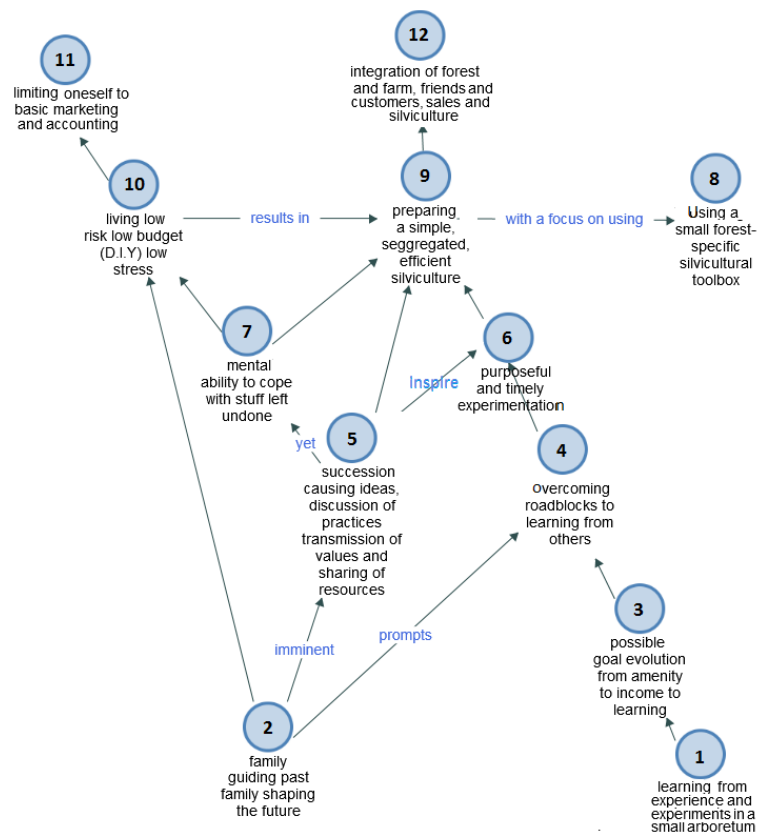


Figure 7: Frank & Fae's forest management strategy. Supporting references are listed in Table 6. Elements are numbered in order of importance. Strategies are located at the top.

SUMMARY OF CAPTURED STRUCTURAL DIVERSITY

I encountered exclusively conifers in Bill's and Colin's forests (Figure 8). All but Colin's forests contained plots with unoccupied growing space. I encountered trees with maximum diameters of close to 80cm DBH in Frank and Fae's and Eric and Erin's forests (Figure 9). Only Anna's and Daniel's forest had a relatively uniform distribution of diameters, all other forests' distributions were skewed towards 10-30 cm DBH trees. With the exception of Bill's forest, the others contained plots with distinctly layered canopies and deciduous trees were part of the canopy in four forests. All forests contained plots with crown covers between 55 and 65%, no forest however featured crown covers between 20% and 40%. Solidly established monocultures usually had very little to no understory. I detected no patterns across forests with regard to ground cover. No forest lacked any of the assessed ground covers, variability was large between forests and a less among plots within the same forest. The most common types of deadwood were from small and medium downed trees. The least common type, only found in Daniel's, Eric and Erin's and Frank and Fae's forests, were large snags. Bill's forest consistently had the smallest amounts of deadwood, Eric and Erin's the highest in all but small deadwood. The amount of small and medium downed wood in forests in Anna's, Colin's Eric and Erin's and Frank and Fae's forests was very high.

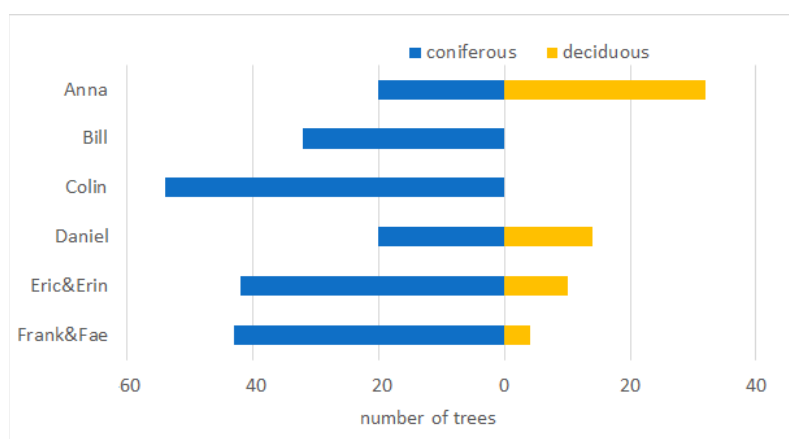


Figure 8: Captured life-form composition across forests

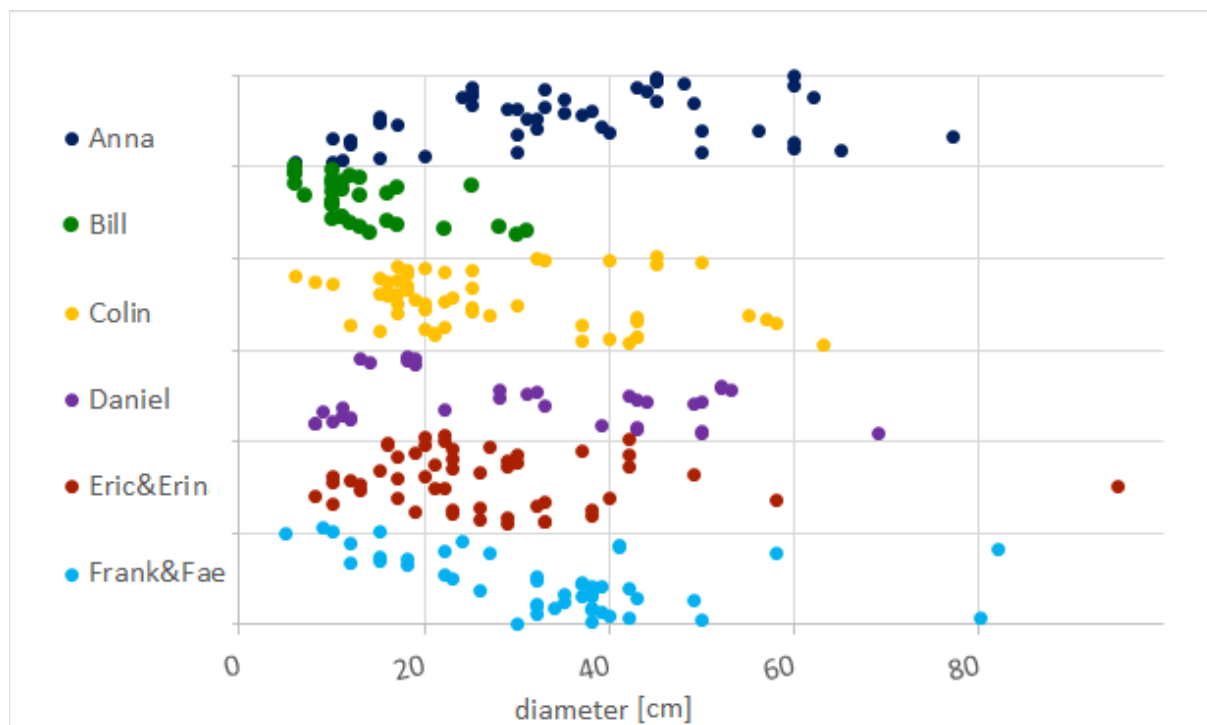


Figure 9: Diameters across forests. Y-axis elongated to avoid overlap of trees

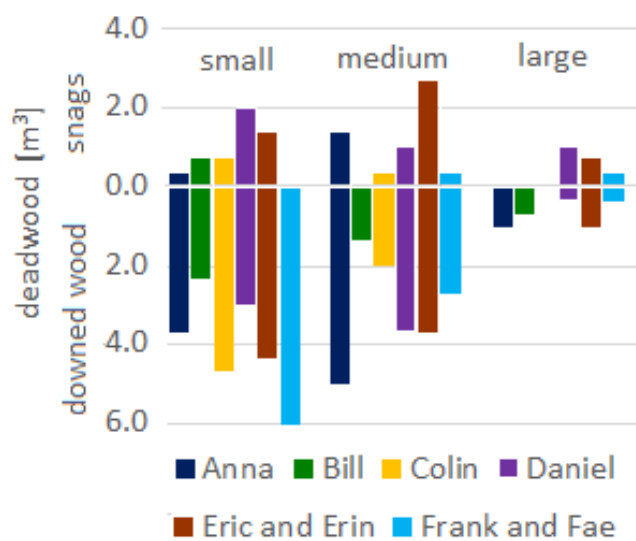


Figure 10: Occurrence of small medium and large snags and downed wood across forests

SUMMARY OF INCOME GENERATION ACTIVITIES

Table 7 shows a summary of income generation activities from all studied forests. Harvest amounts are presented in three different ways. The number of acres necessary to send one load of logs to the mill per year on average is surpassed by all but Eric and Erin, who have managed their forests for the shortest time and started out without larger quantities of merchantable timber. All landowners generated additional revenue from contracting, land lease or the sale of goods other than timber and at least saved some money by burning wood from their forests.

Table 7: Basic forest facts and income generation and income preservation activities

	Anna (and Abe)	Bill	Colin	Daniel	Eric and Erin	Frank and Fae
years owned	43	41	46	44	21	37
total acres (estimates of area deliberately kept open)	145 (10)	150 (0)	110 (0)	47 (25)	87 (5)	100 (25)
board foot per acre per year across property	214.3	179.5	158.1	85.0	30.7	36.8
board foot per acre per year forested area only	230.1	179.5	158.1	186.1	32.5	49.0
acres currently needed to log one load per year (40	17.4	22.3	25.3	21.5	123.0	81.6
logging events per decade	1-2	5-10	4-6	2-3	1-2	0-3

regular income through sales of forest products other than timber	no	no	no	no	no	yes
regular income from forest through lease or rent	yes	no	yes	Yes (discontinued)	no	no
regular income through hiring out forestry skills and equipment	no	yes	no	initially	yes	yes
income preservation through own accounting	no	no	yes	yes	no	no
income preservation through burning firewood (cords per year)	2	5 (until 2005)	10	5	1	4
income preservation through use of wood for construction	no	no	no	yes	no	yes
income preservation through water use from forest	no	yes	yes	yes	no	yes
income preservation through cooperative membership	no	no	no	no	yes	yes

DATA PATTERNS

After looking at the six forests separately and summing up the findings from the assessments of captured structural diversity and finances I condensed my findings further. Similarities with regard to structural diversity, income, resources and strategy among the six forests are important indicators of the contribution of these forests on a landscape scale. I classified

patterns as either resource patterns (Figure 11) or the more integrated and important strategy patterns (Figure 12). Strategy patterns, in accordance with the definition given in the methods section take the listed human, physical and intellectual resources into account. I sub-classified strategy patterns as applicable to the forest (eco-) system, the people system or the man-made system.

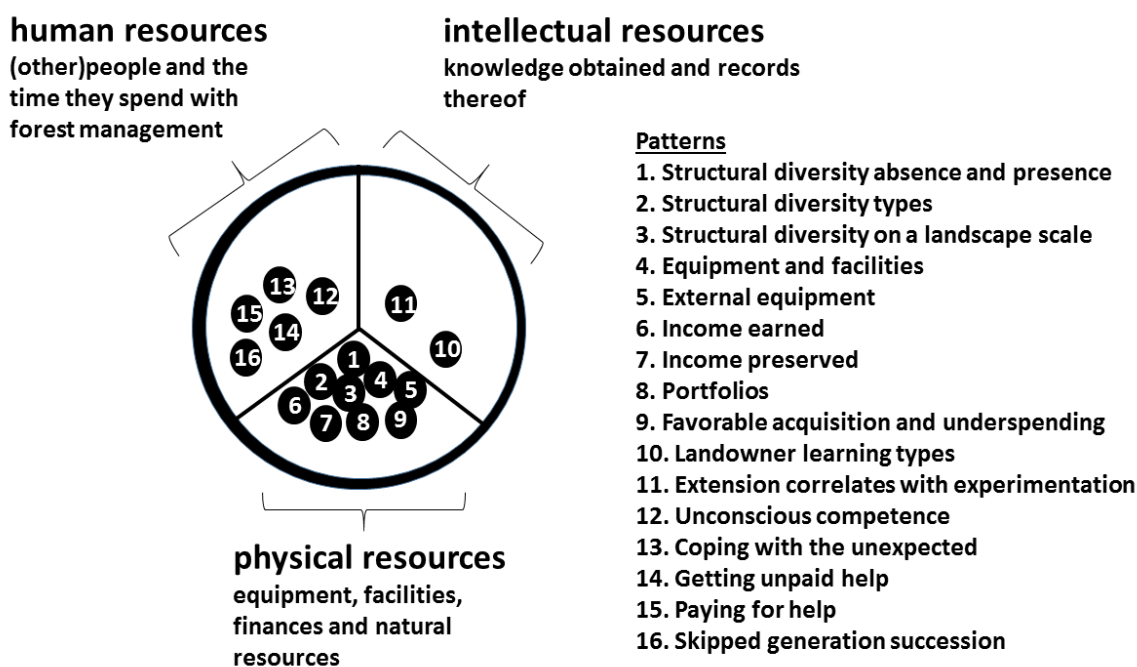


Figure 11: Resource patterns. Numbered patterns (listed on the right) are nonhierarchically divided into physical, intellectual and human resources.

RESOURCE PATTERNS

Physical resources

Physical resources encompass equipment, facilities and forest characteristics but also the financial resources to obtain or modify them. Physical resources are most easily assessed and detected.

1. Structural diversity

Anne, Bill, Colin and Daniel all started out with at least 20% of their forest stocked with harvestable timber, enabling almost instant harvests. For Anne, Colin and Daniel who were new to forest management, it took around five years before they actually harvested timber. Unmanaged plots, most of them located close to rivers, contained the majority of total deciduous trees and medium and large deadwood. Anna's and Daniel's forest, grouped as close-to preserve forests (see resource pattern two) had the highest share of deciduous trees. The two remaining unmanaged plots of the study, located in intermediate-type forests and away from rivers, also contained deciduous trees in the canopy and understory. Another common trait of unmanaged plots were mixed or at least solidly established understories. A certain type of structure was missing entirely from this study. Crown cover distribution was decidedly bimodal (see Figure 13). Closer examination of the conditions in plots grouped closely around this gap revealed either conifer forests in the development stage of understory re-initiation or patchy advanced regeneration, or mature deciduous forests. All plots featured solid understories, predominantly deciduous. The overall number of both mature conifer and deciduous forests were very low.

2. Structural diversity types

I grouped forests three ways with regard to their predominant stand structure and composition. The close-to-industry group contains stands similar in structure to those typically found on large industrial holdings (Bill and Colin). Close-to-preserve forests (Anna and Daniel) resemble undisturbed ecosystems in structure but were not necessarily old-growth Douglas-fir forest. Intermediate forests are located somewhere in between (Eric and Erin and Frank and Fae). These groupings are based on canopy stratification and composition, deadwood as well as shrub/advanced regeneration layer with a tendency for all these attributes to increase from close-to industry to close-to preserve. The number of untreated plots per forest and a uniform rather than skewed distribution of diameters (Figure 10) also followed that trend. In contrast, I

encountered variable crown covers and diverse ground cover throughout all forests, not indicating any grouping.

3. Structural diversity on the landscape scale

Figure 13 shows that of all 55 plots seven were still in the regeneration stage. Thirty-two of the remaining 48 plots contained understory vegetation with the regeneration in 22 of them solidly established, while the future of regeneration in nine plots was tenuous. Most of them, as well as all sixteen remaining plots with no understory, were young planted conifer monocultures. Nineteen were typical conifer monocultures with little crown stratification, eighteen plots were conifer-deciduous mixtures. Litter was the most common ground cover.

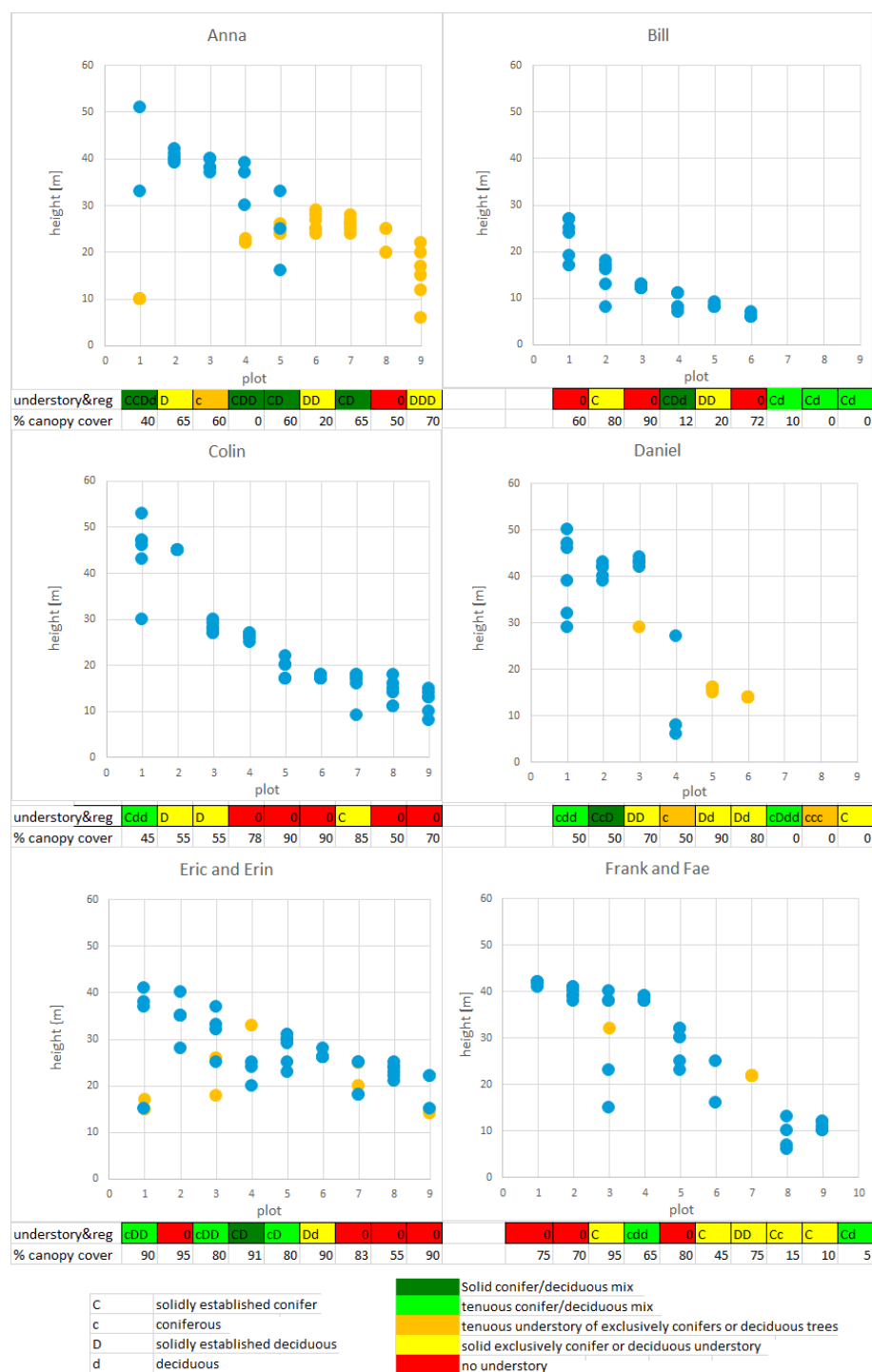


Figure 12: Tree heights, composition of understory/advanced regeneration and crown cover on aplot level. Blue dots are conifers, orange dots deciduous trees. See legend at the bottom of the figure for understory details

4. Equipment and facilities

All forest owners had one to several chainsaws. In Bill's and Frank and Fae's forest, larger logging equipment doubled as equipment used for contracting. All landowners had bought, or had easy access to tractors with various attachments, most commonly a winch, sometimes a mower or log arch. In the early days of their management, forest owners had frequently used smaller yarding equipment that also served other purposes such as horse (Daniel), four-wheeler (Colin) or skid-steer (Frank and Fae) and still used it occasionally. I recorded pruning equipment (ladders, spurs or ascenders) in Anna's Colin's, Eric and Erin's and Frank and Fae's forests. Eric and Erin shared all forestry equipment beyond handheld tools with three friends that had forest close to theirs. Bill, Colin, Daniel and Frank and Fae resided in their forests, Anna Eric and Erin had theirs equipped for camping in comfort. All forests had a barn, shed or workshop, five had a woodstove. Two forests contained rental houses.

5. External equipment

All owners contracted out hauling services, Anna contracted out all logging operations. Colin, Daniel, and Eric and Erin employed loggers only for large harvest activities, regarding area (around contiguous 0.5ac/ 200m²) or tree size (around 200bf/0.5m³ per log). Bill and Frank and Fae did all their logging themselves.

6. Income earned

Each landowner had at least one additional and regular source of income directly derived from the forest. Only Frank and Fae engaged in the sale of additional forest products, such as specialty woods or firewood and only Eric and Erin lease out equipment. Leasing or renting parts of the forest (Anna, Colin and Daniel) or charging for forest services (Bill and Frank and Fae) are more common.

7. Income preserved

Heating with firewood was the most common, albeit likely not the most significant, cost avoidance. However, Colin and Daniel avoid considerable accounting expenses (ranging from \$500 to close to \$2000 annually). Daniel and Frank processed wood for personal use in their carpentry workshops, Eric and Erin and Frank and Fae were members of cooperatives that shared equipment or marketing resources. Everyone but the absentees Anna and Eric and Erin took advantage of clean water from their forest for their domestic supply.

8. Portfolios

One to nine external sources of income complemented the income from the forests, making the forest the principal income source only in Frank and Fae's case. Other than straight income, Anna, Bill and Colin and Daniel also saw their forest as a fallback, the former three had used forest income to invest in other, now income-earning parts of their portfolios. While these sources changed over time, social security from previous full-time jobs were mentioned four times, two of them in forestry. Cattle farming and brokered money investments were substantial sources for two owners.

9. Favorable acquisition and underspending

None of the landowners made disadvantageous financial commitments in order to acquire the property. Anna could afford the sale outright, all others acquired their forests at very favorable conditions from family or the former owner without banks involved. Throughout their lives, Anna, Colin, Daniel, Eric and Erin and Frank and Fae all underspent their incomes, and it is likely that Bill did, too.

Intellectual resources

10. Landowner learning types

Table 8 shows the numerous identified intellectual resources possessed by respondents. Some resources were generated by the owners themselves through observation (observe-reflect), experience (do-observe-reflect) and experimenting (question-do-observe-reflect). All owners observed and learned through experience in their forests, all but two had actively experimented with different aspects of forest management. The remainder of intellectual resources were not generated but accessed by the owners in formal (university for Anna, Colin, Eric and Erin and Frank) or informal settings (Extension Service, association meetings or conversations with knowledgeable individuals).

Table 8: Sources of external information landowners took advantage of. Blue columns indicate shared access to information, green indicates exclusive access and white indicates the direct lack of involvement of other people.

	Extension Service	associations	scientist	government or industry	family	friend	written	experiment
Anna and Abe	X	X		X	X		X	X
Bill		X	X	X	X			
Colin	X	X	X	X	X		X	X
Daniel				X		X		
Eric and Erin	X	X	X	X		X	X	X
Frank and Fae	X	X	X		X	X	X	X

11. Extension Service correlates with experimentation

The different offerings of the Extension Service were drawn on heavily (Anna, Colin, Eric and Erin and Frank and Fae) or not at all. Anna, Colin, Eric and Erin and Frank and Fae also all consulted written documents and experimented with novel management, yet only Colin had seriously thought about and investigated new forest products and markets for them. Bill and Daniel, who had not participated at all in offerings of the Extension Service, neither read about forest management nor experiment. However, Daniel, who had recently reached out to the National Resource Conservation Service, was now considering experimentation. All landowners gleaned information from knowledgeable individuals they personally knew, i.e. family, friends or acquaintances associated with the government, academia, forest industry or otherwise deemed knowledgeable. However, without preferring any particular group. Getting information from family always coincided with childhood exposure to forest management, in Bill's case this was on the land he was currently managing.

Human resources

12. Unconscious competence

All landowners with the exception of Frank and Fae professed to not having thought about certain topics brought up during the interviews at all. They welcomed these parts of conversation as intriguing, enjoyable and useful to them.

13. Coping with the unexpected

All owners professed to be occasionally overwhelmed with the tasks in and around their forest, especially after disturbances or during larger management tasks. Emotionally, Anna, Bill, Daniel and Frank and Fae dealt well with disturbance or failure to follow their original plan. Colin and Eric worried more and lost sleep over it. As a consequence, however, they also proactively incorporated risk-minimizing management practices such as diversified reforestation, herbicides logging outside fire season to limit events beyond their control.

14. Getting unpaid help

Only Bill made all management decisions without any prior discussions. In the five other ownerships, decisions were frequently discussed with co-owners family members or close friends. To a much smaller degree, these people were also usually the only ones available for physical help with forest management, leading to the male owners mostly working alone.

15. Paying for help

Complementing pattern 5, Anna, Bill, Eric and Erin and Frank and Fae relied on accountants to take care of their taxes. Two owners solicited management help from consultants for larger operations from time to time, and another was building a relationship with one to do so in the future.

16. Skipped generation succession

Only Frank and Fae were certain that their son was going to not only inherit the forest but continue its management. The certainty that their kids would not manage the forest in the future prompted Anna, Bill, Daniel and Eric and Erin to excite their grandchildren about forest management, mostly through tree planting. Colin chose a different approach to keep the forest in the family: He made sure that his forest would still produce regular income, an aspect he believed his children would surely be interested in, under professional management.

STRATEGY PATTERNS

The strategy patterns are located on a deeper level than the resource patterns. Patterns 17-19 are classified as learning strategies, patterns 20-24 as income and diversity strategies.

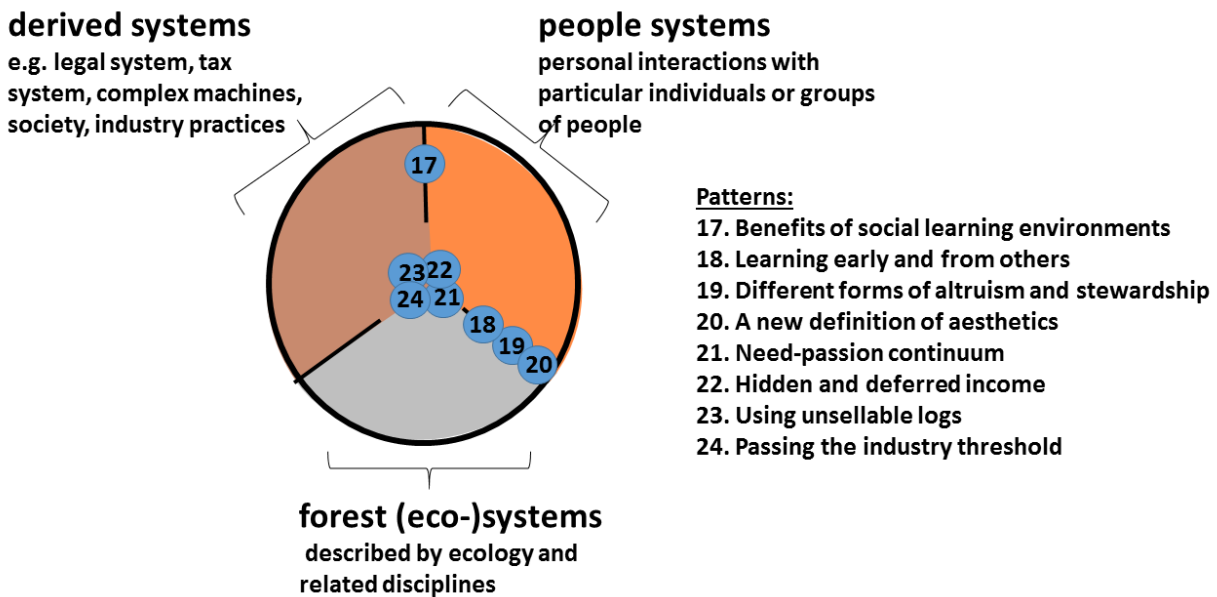


Figure 13: Strategy patterns. Located on intersections between forest-, people- or (human-) derived systems. Patterns located on boundary lines (17-20) contain elements of both neighboring systems, patterns located in the center (21-24) pertain to all three systems.

17. Benefits of social learning environments

Anna and Abe, Colin and Eric and Erin found it easy and straight-forward to associate with other landowners or take advantage of education offers. Bill, and initially Daniel Frank and Fae, were decidedly more reluctant to see a benefit. None of them, for different reasons however, perceived the goals of Extension Service, National Resource Conservation Service or woodlands association to align with their objectives. Bill was associated with other loggers, however. As neither Bill nor Daniel had ever dealt with the Extension Service, pruning, a tool employed by all other owners, did not feature in their management.

18. Learning early and from others

Anna, Bill and Frank and Fae all were involved in some form of forest management throughout their childhood in their parents' forest. Colin, in spite of a lack of role models, also dabbled in

forest management in his childhood. Daniel and Eric chose to learn about forestry as young men. Hence, each forest profited from four to six decades of experience in forest management. Everybody but Bill expressed that external education offers and schooling had particularly benefitted their management.

19. Different forms of altruism and stewardship

All landowners used their forest to benefit others in one or several ways. Friends and acquaintances recreated in Bill's and Eric and Erin forest, while Anna, Colin, Daniel, Frank and Fae limited these activities to family members. Anna, Daniel and Eric and Erin all referred to themselves as stewards when they justified management beyond immediate or personal return. Anna and Colin steward strictly for the future generation of their families, Daniel and Eric and Erin feel a social responsibility to society, actively promoting riparian and mineral spring habitat. Colin shared Daniel's and Eric and Erin's long-term perspective, but it was more out of concern about how changes in nature, people or society might impact his management goals rather than thinking about the benefits their forest would provide to others.

20. A new definition of aesthetics

All landowners considered aesthetics in their management but meant totally different things by it. Bill cherished straight rows of trees, Daniel promoted the opposite. Anna, Frank and Fae and Eric liked both (Erin however did not...). Colin's preferences about his forest were location dependent. The general resulting pattern for all landowners was that aesthetics are rather the manifestation of whatever the landowner set out to do in a particular spot in his forest than a generally applicable sense of beauty.

21. Need-passion continuum

All landowners were passionate about their forest and gained emotional well-being from their work. This passion drove management goals in all cases, but was, at least for Bill, Frank and Fae, sometimes compromised by an immediate need for money, with harvest of timber the best

option. Colin pointed out how much mill specifications and the need to meet them could influence the remaining forest, often making him reconsider a harvest. Their financial cushion enabled Anna, Colin, Daniel and Eric and Erin could be more deliberate about harvest or even realize considerable capital gains by taking advantage of fluctuating timber prices.

22. Hidden and deferred income

All landowners improved their financial situation by directly generating income or preserving income as a result of actions in their forests (see pattern 6 and 7). Some landowners additionally understood the need to (re-)invest income at present time to receive a deferred but significantly larger income.

Last, their actions in the forest generated non-monetary or hidden income, such as physical health, stress reduction, increase of mental well-being and social status. All landowners generated income in at least two of the three dimensions.

23. Using unsellable logs

Logs that did not meet mill specifications ended up as firewood in Anna's, Bill's, Colin's and Frank and Fae's forest by default. Eric and Erin considered dead wood in itself a good use and often left it in the forest. They also deliberately created snags. So did Colin, however only to get rid of deciduous trees. Frank and Fae were considering snag creation during an imminent harvest. Daniel was able to mill odd pieces himself and use them for construction on-site. However, his need for wood was generally lower than overall tree mortality. Only Fank and Fae were able to sell deciduous trees at a profit on a regular basis, Colin had done so once. Bill and Anna had tried but failed.

24. Passing the industry threshold

With the exception of Anna, all owners were skilled and equipped for timber harvest. This enabled them to slowly accumulate enough timber to fill a self-loading log truck and sell trees that no contractor could have harvested at a profit to himself and the landowner. Given the

yarding limit of a tractor, between 20 and 80 trees can already be sufficient to gain access to the timber market and generate income. Additionally, the trees can be harvested little by little over long time periods, Daniel still milled logs left in a deck for more than a year, apparently without any loss in quality. While lowering the threshold to sell timber into the mainstream market lead to considerably decreased amounts of snags in Bill's and Colin's case, it did not in Daniel's and Eric and Erin's.

DISCUSSION

The Grounded Theory approach prescribes to abstain from gaining more than a basic understanding of one's topic before conducting investigations and producing results of your own. Moreover, employing the iceberg analogy once again and diving beneath the surface even further, one may find that beneath common patterns in each individual iceberg (or ownership) there is actually a common base.

This section will first place my results in the context of the scientific literature I consulted after data analysis. I also put my quantitative data, i.e. the assessment of captured structural diversity and the assessment of finances into the context of Oregon forests. I then integrate the identified patterns and variabilities, highlight their significance for landowners, Extension personnel and policy makers and propose three theories for further scientific investigation. The section concludes with limitations and flaws of the study and suggests ways to overcome them.

RIVERS, NO MANAGEMENT AND STRUCTURAL DIVERSITY

Pabst and Spies (1999) as well as Acker (2003) examined the riparian forests of my study area (pattern 1) and highlighted the connection between increased abundance of deciduous trees and streams. More importantly in the context of this study, they highlighted the important contribution to structural diversity in terms of life-form (i.e. deciduous or coniferous) of these forests. Preservation of these areas in small private forests may be especially beneficial to their structural diversity. The riparian deciduous plots in Daniel's forest were in fact left untreated intentionally for habitat reasons. Anna claimed to having treated every stand in her forest at

least once and I assume that, because the riparian plots showed no sign of management including the removal of firewood (pattern 23) she consciously chose to preserve the stands. A combination of economic reasons such as lack of established markets (pattern 23) and scale of operation (pattern 24) come to mind. Policy makers should consider this an opportunity for the promotion of structural diversity. Dutcher et al. (2004) suggest in their work on small landowner's perceptions of riparian areas that informing landowners is a more promising option than legally restricting their approach to riparian area management. Due to the fact that resident landowners in my study all used the water from their forests domestically (Table 8), water quality may prove to be a successful pathway to educating landowners. In a larger context, close to 60% of owners of forests between 10 and 200 acres in Oregon selected the protection of water resources as one of the reasons for owning forests (Butler 2016). Giampaoli and Bliss (2011) indicate that a similar approach is possible for general forest resource conflicts and add recognition of landowner's conservation efforts, compensation schemes for the provision of services and consistency with regard to treating landowners in case of conflict to the list of useful approaches for policy makers.

LACK OF SMALL GAPS IN CANOPIES

I noted a scarcity of mature deciduous and coniferous plots and the connected absence of small gaps within the closed forest, indicated by the absence of the 20-40% crown cover range (pattern 1). It is possible that my sample density was insufficient, however this finding may also indicate that none of the owners purposely manages for small gaps or contiguous areas of large trees, a fact that may hamper deciduous tree regeneration further away from streams in particular and reduces structural diversity. Bill, Colin and Frank and Fae reservations against deciduous tree regeneration in their planted forests due to them being hard to harvest, taking up a disproportional amount of growing space and posing safety risks. Only Daniel managed for the goal of creating an old-growth forest that would eventually contain those gaps (Franklin and Spies 1991). None of the owners were creating them on purpose through silviculture as suggested by Bauhaus et al. (2009), in spite of suitable equipment. Extension personnel, as a

first step, should make owners with their own equipment and structural diversity objectives aware of this literature as canopy gaps may be particularly beneficial to structural diversity outside of riparian areas.

DIVERSITY TYPES

The assessment of structural diversity revealed that roughly identical management goals can be interpreted in very different ways, resulting in a mini-typology of structural diversity types (pattern 2). Typologies are common in the small forest literature (for example Bieling 2004; Blanco et al. 2015), however they are commonly based on owner- rather than structural diversity attributes and are collected via surveys. One weakness of surveys is the lack of verifiability of data. My small sample and unique combination of data sources allowed me to verify claims, sometimes uncovering unconscious competence (pattern 12) or deliberate/accidental integration (see theory 2 below) being responsible for more or sometimes less structural diversity than could be surmised from the interviews alone. Landowners and Extension Service alike may find the simple assessment of structural diversity conducted for this study (see appendix) a helpful addition to yield plots or even surveys to gauge management effectiveness in terms of structural diversity.

IMPORTANCE OF EXTERNAL SOURCES OF KNOWLEDGE, EXTENSION SERVICE IN PARTICULAR

With regard to the external learning, the offers of the Extension Service featured very strongly (patterns 10 and 11) as a source of knowledge. Being involved coincided with the practice of pruning, consultation of written documents and experimental learning and was perceived as very beneficial to management for income and structural diversity. These findings differ from Ruseva's (2014) social network study and survey in the northeastern United States. She found that less than one in five landowners, from a sample selected for heterogeneity of conducted harvests and solicited help from professionals, drew on the Extension Service for information. My data, from a small population selected for active generation of income and structural diversity indicate a stronger correlation, but this may be due to relying, among others, on

Extension personnel when selecting landowners in this study. An alternative explanation may be that the information provided by the Extension Service in Oregon is provided by other sources elsewhere. However, the importance of external observational (forest tours and classes) learning as ways to inform management was a finding of both studies.

LACK OF EXPERIENTIAL AND EXPERIMENTAL LEARNING AS INITIAL HURDLES TO INCOME GENERATION

The importance of experiential learning, emphasized as particularly important by Lunnan et al (2006) for entrepreneurial activities, surfaces as a crucial component in my study. In spite of merchantable timber (pattern 1) and direct and external observational knowledge (pattern 10), all landowners, with the exception of Bill, took several years to make their first successful sale also adds to that assumption. A fact that could likely be mitigated by good ownership succession or early ownership mentoring. This is particularly important to notice for the Extension Service. Another recommendation for the Extension service is to take advantage of scientific findings on how experiential and experimental learning components could be strengthened in their offerings to the public. I found that gaining experience on one's own eventually leads to most landowners gradually upgrading their equipment (pattern 4) or changing management and opinions over time (pattern 17). Bieling (2004) draws on modernization theory to explain this behavior. Dedeurwaerdere (2009; 2016) however emphasizes the importance and benefits of experiential learning in a social context when investigating the success of government-instigated, decentralized groups of forest owners organized similar to the Extension Service in Oregon. Vokoun et al. (2010) find that educated landowners already recreating on their neighbor's land are more likely to cooperate on their own but suggest policy makers to incentivize neighbor-to-neighbor cooperation.. This indicates an opportunity for the Extension Service to emphasize these aspects in existing programs. With regard to incentivizing experimentation, Ansell and Bartenberger (2016) suggest Darwinian experimentation, a type of experimentation aimed at systemic innovation, as particularly suitable for this endeavor. Ballard and Belsky (2010) suggest and demonstrate that

Participatory Action Research, a type of research that directly involves community members in data collection and finding-based decision making, is suitable framework that could be drawn on by policy makers.

AESTHETICS

The alternative view of aesthetics (pattern 20) that my data indicates has potential implications for current research. The National Woodland Owner Survey (Butler et al. 2016) classified aesthetics as a management goal without any clear definition. Given my alternative interpretation of aesthetics as the manifestation of one's management goals rather than a goal itself, everybody would be managing for aesthetics, making the question redundant. Ribe (2006) did not define aesthetics either but furthers my point for an intentional use of the word aesthetics. He conducted a public survey in which he provided images of forests, among them untreated forests, to be rated for various criteria to disentangle the concept. He suggested that surveys dealing with aesthetics in forestry should provide visual aids in order to accommodate the varying perceptions of respondents. I attempt to accomplish the same by suggesting a definition of aesthetics, backed up with field data, accommodating the diverse perspectives encountered in my study. Either way, extension agents may find inspiration in the landowner's more concrete management goals when advising on aesthetics and bear in mind that a sense of beauty and income production are not mutually exclusive.

ACCESS TO MARKET THROUGH HARVESTING

In addition to whether timber is harvested, my study yielded information about how timber is harvested and who harvests it (patterns 5 and 24). Motivations determining whether timber is harvested or not have been reviewed and summarized by Silver et al. (2015), confirming my findings about the need-passion continuum (pattern 21) by stating income as one of the primary motivators to harvest. I found that tractors are the equipment of choice for timber yarding for Colin, Daniel and Eric and Erin and Frank and Fae, providing temporal flexibility and requiring only the hire of a self-loading log truck to get their timber to the sawmill. The research

on tractor logging and yarding in the English language is limited, (however, see Turk and Gumus 2010) but this field should be investigated further, given its advantage of gaining mainstream market access in a one-man operation (pattern 13). The negative income implications of hiring help (pattern 15) are immediately seen. Trying to offset them by more efficient, large, uniform treatment with larger machines and meeting certain mill specifications to increase income has a less immediate and obvious effect on forest structure and composition. This effect however increases as operation size increases. Landowners should carefully consider their choice of contractor and mill specifications when carrying out larger operations. To my knowledge, no literature exists on how silviculture, marketing and operations can easily be integrated for small forests, my work is a mere basis for further investigations.

THE OTHER SIDE OF INCOME

Income other than timber harvest from the forest (pattern 6), the preservation of income by using one's skills or products from the forest directly (pattern 7), income from sources outside the forest (pattern 8) or underspending of income (pattern 9) and non-monetary benefits (pattern 22) are the additional dimensions of income identified in this study.

The physical and psychological health benefits are well-known (Meyer and Bürger-Arndt 2014), all other identified aspects of income have not yet been deliberately focused on. Income preservation for instance features in Oikonomou et al.'s (2011) ecosystem function analysis framework but is allocated a minor role in environmental planning and decision making skills and knowledge. For landowners, it may be helpful to consider the other aspects of income as also adjustable to achieve a better balance between income generation and creation of structural diversity (Leopold 1938).

Variability

Almost as important as patterns in data may be the data that show no patterns at all, especially in a study that is concerned with diversity. The variable portfolios, management styles and degrees of dependence on income from the forest show that, under considerations of the aforementioned patterns, small forests have the potential to be managed in many different ways, even for the same goals.

THEORETICAL CONTRIBUTIONS TO CREATING INCOME AND STRUCTURAL DIVERSITY IN SMALL FORESTS

In this section, I describe two theories and a model, principally aimed at scholars and policy makers. Guided by Shoemaker et al. (2004), I postulate the following theories to express the patterns above succinctly:

Theory 1: Diversity of learning types (ski slope) theory

I observed that landowners could learn in four ways, through observation, experience, from others' experience or through experimentation (pattern 10). All landowners learned through observation, experience and from other's experience, Anna, Colin, Eric and Erin and Frank and Fae experimented. Their experimentation may be due to exposure to the Extension Service or their schooling or to a curious nature that also drew them to university and the Extension Service. Another possible cause could be a lack of available solutions for a particular problem related to their management. The effect of their experimentation is the generation of new knowledge that can be shared with others and expanded upon. I postulate:

Generating income and structural diversity in a small forest begins with personal observational and experiential learning. Next comes the step to learn from observations and personal experience of others. Experimental learning, likely employed after experiential learning is exhausted or too risky, is the type of learning usually developed last and is a good indicator of sophisticated forest management

Observation and experience come naturally in active forest management.(Dedeurwaerdere 2009) points out the importance of the social component of learning for owners of small forests achieved by learning from others, confirming pattern 18. Additionally, and supported by Ruseva (2014), learning from others may make the range of available solutions clearer and prompt experimentation with them. A test of this theory would be to assess the financial benefits of innovations made by small forest managers or assessing the management of landowners with the same goals but different-size social networks.

I envision the learning journey of a landowner like reaching the top of a ski slope. Observation will show the landowner that there is a rope tow going up part of the way and that most people are not using that rope tow for various reasons to get to the top but instead walk up the slope. Experience will have the landowner start walking up the slope towards the top (experience) or take advantage of the rope tow (other's experience) to get to the top. The landowner may also begin walking and then grab the rope half way up or begin by using the rope tow and letting go half way up, or switching back and forth. However once at the top and only now visible to the landowner, the slope steepens and the snow deepens. In order to continue towards the invisible mountaintop, the landowner has to now blaze her own trail (experiment). Others however can follow in her footsteps for as long as they like

Theory 2: Integrated action theory

I observed Bill trying to eradicate maple trees from his property through the use of herbicides but, due to infrequent entries he was not entirely successful. This was due to him prioritizing contract work over work on his own land and the ensuing lack of time to re-administer treatments. He unintentionally produced structural diversity. I observed similar behavior in Anna's forest. She was very focused on the intensive management of a certain portion. She admitted to the other parts repeatedly slipping her mind, leaving them untreated. Both observations are examples of intentional actions with unintended effects due to a lack of human resources (time and mental capacity).

I also observed Frank and Fae checking cattle fences and looking for fallen trees to process as firewood. Eric and Erin thinned their plantations, leaving head-high snags to create standing deadwood. I postulate:

Single actions in forest management have multiple effects that the landowner, if aware of them, can use to create additional income (patterns 6,7 and 22) or structural diversity without much additional effort. Intentional integration of actions plays an important role in small forest management for multiple goals and is advisable if not enough space for segregation of goals is available.

Additional evidence for the applicability of this theory can be found in the permaculture and strategy literature. Bell and Brick (2005) consider ‘minimum effort maximum effect’ as one of the universal aims of permaculture. Permaculture is an integrated and already widely applied way of land management that is also applied in extremely small forests (Shepard 2013). Perhaps other permaculture principles also apply to slightly larger forests. Porter (1996) classifies actions reinforcing each other and the minimization of redundancy and wasted effort as second and third order fits. He furthermore uses the term fits to describe the absence of tradeoffs when actions, goals or even strategies are combined. Interviews and questions about certain prescriptions are very suitable for verifying landowner awareness of additional outcomes of their actions. Additional quantitative data like the structural diversity assessments or financial analysis are also suitable for testing the theory.

Bill’s and Anna’s actions are examples of intentional actions with unintended effects, like the brewing of coffee also produces a lot of non-consumable coffee grounds. Eric and Erin’s and Frank and Fae’s actions are examples of the intentional combination of one action that serves two intended, separate purposes, like the brewing of coffee and using the grounds to raise the PH value of one’s compost pile

Concentric model of the small, income-generating and structurally diverse forests

This model further integrates Figures 12 and 13 and shares several attributes with Bronfenbrenner's (2005) ecological model of human development. Bronfenbrenner and I see the human being, in the context of this study the landowner, at the center of a concentric system. Bronfenbrenner visualizes concentric circles in terms of the factors influencing the development of a child. I visualize the domains of understanding necessary for small forest management for income generation and structural diversity as concentric shapes with the two limitations:

- Just like in Maslow's pyramid (Maslow 1943), the lines separating the different sections of the model appear clearer in the illustration than they likely are in reality and
- this model only applies to small forests with the goals of income generation and creation of structural diversity

I propose the following model (Figure 14):

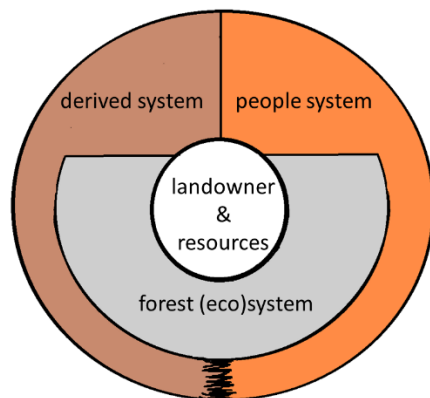


Figure 14: Concentric model of generating income and structural diversity in small forests This figure further integrates Figures 12 and 13.

The model takes the socio-ecological system (Levin et al. 2013; Olson 2017) into account. It locates the forest (eco-)system as mostly enveloping the core of resources available to the

landowner at its center. Located further out but still with a connection to the landowner are people systems and (human-) derived systems. The former encompass the direct interactions between the landowner and other people, the latter encompasses the landowner's interaction with systems devised by people (i.e. complex machines) or represented by people (i.e. government agencies). To illustrate that all systems, most strongly however the natural system, influence the landowner directly, I decided against a representation of the systems as slices grouped around the center (see Figure 12). Instead, I represented human and human-derived systems as touching the center in a small section and enveloping the natural system. The result is similar to what can be seen when looking at the pointy end of an American football with the seam oriented towards the ground. I postulate that:

Increasing one's expertise in small forest management requires an integrated understanding of people-, derived-, and forest (eco-) systems. Increasing one's expertise stalls if the landowner neglects to take information from all systems into account. Drawing a circle around the owner's current resources represents where the landowner should focus her learning. A small circle would include mostly the forest (eco-system) and only small parts of the human and human-derived system. A large amount of the required knowledge may be found in the disciplines of silviculture and ecology. As the understanding grows (drawing a bigger circle), the proportions of what is required for a better understanding of the landowner's surroundings shift towards the human and human-derived system. It is here where, for instance, the discipline of marketing or an understanding of equipment or laws becomes more important.

This theory offers a potential explanation why only Frank and Fae, albeit with the help of a cooperative, sold forest products other than timber. Everyone was able to potentially produce a suite of products due to their knowledge about the forest system and how to manipulate it, nobody however had the necessary derived system (marketing) or people (customers) information to actually do it. Wade's (2015) work supports this hypothesis. An alternative hypothesis for this, also supported by the proposed theory, is that landowners knew or strongly

suspected that more income could be generated or time could be spent more wisely by better understanding or selling into an existing market, i.e. the timber industry. The latter hypothesis could be tested by investigating businesses selling alternative forest products started during the recession (Oregon Forest Resource Institute 2015) in the last decade.

RESULTS IN THE LARGER CONTEXT OF OREGON FORESTS

Two additional studies help to put the obtained quantitative data into perspective. The Oregon Forest Resources institute (2015) compiles annual harvest data and area for each ownership type across Oregon, which can be compared to the harvest data I collected (Table 9)

Table 9: Harvest per acre per year in the studied forest compared to other ownership types in Oregon in 2015

	Anna and Abe	Bill	Colin	Daniel	Eric and Erin	Frank and Fae	small private	federal	large private	state
Mbf / ac/yr	0.21	0.18	0.16	0.08	0.03	0.04	0.11	0.03	0.42	0.3

None of the landowners harvest as intensively as the statewide average across large private ownerships or state forests, Anna, Bill and Colin are however harvesting more than one and a half times the timber that an average small private landowner harvests per year. Daniel harvests slightly less than the average small forest owner, Eric and Erin as well as Frank and Fae, are closer to federal forest harvest levels. This comparison highlights the advantage gained through economies of scale realized in large private and state forests. The numbers from my study could however also be a clue for the effectiveness of the integrated action theory (see above), particularly in small forests, to counteract the loss of economies of scale. Given the location of all forests on the lower end of the spectrum of what is classified as small forest owners and the probably huge variability across the entire state of Oregon, the results have to be treated as being no more than approximations. I would assume that the harvest levels in my

study area are higher than the state average due to favorable growing conditions and access to markets.

Another study of interest is the Oregon Department of Forestry's (2006) Harvest Habitat Model Project which encompasses assessments of forest structure based on data similar to my structural diversity assessment. The data, available on a district scale, enables a comparison of the combined data from my study to the federal forest lands in my study area with regard to diameter classes (approximated from age classes), and canopy composition and structure. Diameter-wise, federal forests are similar to the forests assessed in my study. Diameter distributions of both datasets peak at around 20 cm, with tree numbers decreasing as trees get larger. The only notable difference is a markedly smoother decline in tree numbers in the forests of this study than in the state forests. Federal forests feature just over half as many pure and mixed deciduous plots (9%) as the forests in this study (17%). The higher number comes at the expense of mixed conifer forests. This may be a remnant of formerly more production oriented management on federal lands. Pure conifer forests (65%) are equally strongly represented in both datasets. With regard to canopy structure, layered canopies are about five times as common in the forests of this study (20%) as they are in state forests. Anna's and Daniel's forests, grouped as close-to-preserve, but also Eric and Erin's forest contribute the majority of this structural diversity. The difference in vertical structure may be due to relatively greater presence of older stands that had more time to develop vertical structure, or simpler prescriptions on federal land, which is the downside of economies of scale. Owners of small forests may be able to create structural diversity more swiftly than managers of federal forests. Summing up the comparison, managing for structural diversity and income as opposed to one of the two may mean a slight decrease in either one or the other in small forests (Bill, Colin and Daniel, but does not have to (Anna).

ASSESSING SMALL FOREST MANAGEMENT THROUGH THE LENS OF STRATEGY

When defining strategy as timely action taking the actors, their resources, their actions and their environment in a temporal context into account to reach a goal, the lens of strategy was a very useful approach to examine the generation of income and structural diversity in small forests. More so than the integrated model of marketing planning (Hansen and Juslin 2011) and my model of theoretical silviculture I tried to use initially. Most landowners however preferred the term management philosophy when asked directly for their strategy. The alternative definition by Minzberg (2005), who defines strategies as patterns, deliberate or not, that can be analyzed before and after the fact, seems more appropriate. In conclusion, a strategic approach yielded the right data to adequately describe landowner strategies.

STUDY DESIGN FLAWS AND SUGGESTIONS FOR IMPROVEMENT

Treacherous terminology

Usually talking mostly with peers about my study made me forget that certain terms commonly used when discussing forests in an academic setting are not commonly used by landowners. The opposite also happened, where I assumed, when landowners used a word that also had a certain meaning in forestry more loosely. Examples of ambiguous terms were aesthetics, stand, plot, tree health, strategy and structural diversity posed an invisible language barrier. Due to meeting with each owner twice, I was able to clarify with landowners once a term had surfaced as ambiguous (see methods). This highlights the possibility of misunderstandings and hence misinterpretations hidden in the data. I recommend getting direct oral feedback on potentially ambiguous terms surfacing during interviews and analysis.

Structural diversity assessment

In the larger and more diverse ownerships, my small sample size did likely not capture the full scope of structural diversity. While unacceptable as a complete assessment of the present structural diversity in each ownership, my assessment was detailed enough to at least identify three distinct subcategories within small forests managed for income and structural diversity. I

recommend two possible improvements to an assessment of structural diversity: 1) increasing the sample size for similar studies to one sample for every five to 10 acres of property or 2) a transect-based rather than a plot-based approach. The latter may yield more representative results for the same effort, but may have other disadvantages when not assessing trees. If combined with qualitative analysis, the data, just like the qualitative data, should be analyzed between the first and second interview to be able to discuss the results with the owners. A second limitation was the timing of my structural diversity assessment, I was only able to assess perennial herbs. Trends in seasonal herbs may have increased the usefulness of the ground cover assessment beyond a mere indicator of variability. Returning to the plots in spring and reassessing the ground cover would have been ideal but was impossible due to time limitations.

Insufficient time horizon

In order to see strategies unfold entirely, 20-30 years were not sufficient. After the imminent harvests in Eric and Erin's as well as Frank and Fae's forest, the picture will look very different in terms of harvest levels and structural diversity or would have looked differently for Bill's forest 10 years ago. I recommend selecting ownerships with at least 35 years of active management, longer in less productive forests, to avoid misrepresentation in similar studies in the future.

Theoretical saturation

I did not reach complete theoretical saturation after 12 interviews. The data I collected about the six forests included in my study was however comprehensive. I am confident to having captured most of what there is to learn about marketing timber as a small forest owner, sources of knowledge, and additional sources of income from the forest. More interviews to learn about the marketing of non-traditional timber products, the next logical step in theoretical sampling, could however not be carried out due to time restrictions. This is where a follow-up study should pick up. All three theoretical contributions are in early stages and require further investigation. They are, however, based on a fair amount of reoccurrence

among cases. This is a good indicator that analytic generalization (Yin 2009) may be drawn from them. In summary, I perceive having made a small but potentially helpful contribution to the body of knowledge on small forest management.

CONCLUSIONS

The qualitative and quantitative analysis of six small forests in central Western Oregon, endorsed by knowledgeable insiders, showed a variety of strategies and nuances for reaching the goals of generating income and structural diversity. Despite superficial variability between forests in terms of resources and manifestation of management goals, I found 23 common patterns with regard to structural diversity, resources and strategies that I further integrated into three theories. These were the rope-tow theory on different styles of learning, integrated action theory and the concentric model of income and structural diversity generation in small forests (football model). Four patterns and two theories highlighted the importance of learning from various sources in small forest management. These findings may not only be instructive to landowners but to Extension personnel who so far focus on providing consumable knowledge instead of encouraging learning through experience or experimentation. Within my sample I detected three distinct groupings with regard to structural diversity, namely close-to preserve, intermediate and close to industrial forests. Harvest levels are surprisingly not correlated inversely, a fact that could be partially attributed to intentional or accidental integration of management practices.

While the additional studies I used to put my study into a more general context are not ideal for various reasons, comparisons hint at the importance of integration and the advantage of small landowners to manage on a small scale, generating income and a considerable addition of structural diversity through deciduous trees. Last, the suggested theories intended to help landowners, Extension personnel and policy makers may find application in other forested regions of the globe, in spite of a lack of theoretical saturation. The strategic approach proved to yield appropriate data to generate theories on the creation of structural diversity and income in small forests.

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APPENDIX

1. Interview guide

Interview guide: Silviculture and Marketing Strategies for small, structurally diverse and income-generating forest

Date	Place	Interviewee
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1. Opener: The present situation and a bit of history.

- 1 How did you come to own and manage this forest in the first place?
- 2 *Tell me which of your routine life activities pay your bills?*
- 3 *Tell me about the inception and nature of your forest business*
- 4 *Tell me about your land and business ethic* (Definition: what you think is good for the land and the right thing to do, management philosophy?)
- 5 What do others tell you about your forest? (say your neighbor, family, officials)

Activity: Mark your management in a triangle where the corners represent economic, ecologic, and social

- 6 *Where did you learn your forestry/business skills?*

2. What is being done

- 7 What do you think you're doing well in terms of forest stewardship (**actions resulting from your land ethic**)
- 8 What do you think you're doing differently than anyone else in terms of forest stewardship?
- 9 Tell me about (silvicultural) treatments you carried out that promote your land ethic.
- 10 Recall (from forest tour) the last time you made money
- 11 Tell me about marketing activities (producing, communicating and selling a product/service) that promote your land ethic.
- 12 What information are you collecting pertaining to your forest AND business? How do you keep track of it?

Activity: Show the spectrum cards: Which of these words are important/connected to your stewardship?

- 13 How do your treatments and activities interact and form strategies?
- 14... And with special regards to income generation?

15...And with special regards to the creation of structural diversity?

3 Circumstances (evaluating the spectrum cards)

16 Which particular skills were instrumental to your strategy?

17 Which resources (objects, people) enabled you follow your strategy?

18 Who had those resources?

19 Which natural/forest/market/regulatory conditions are/were helpful to you?

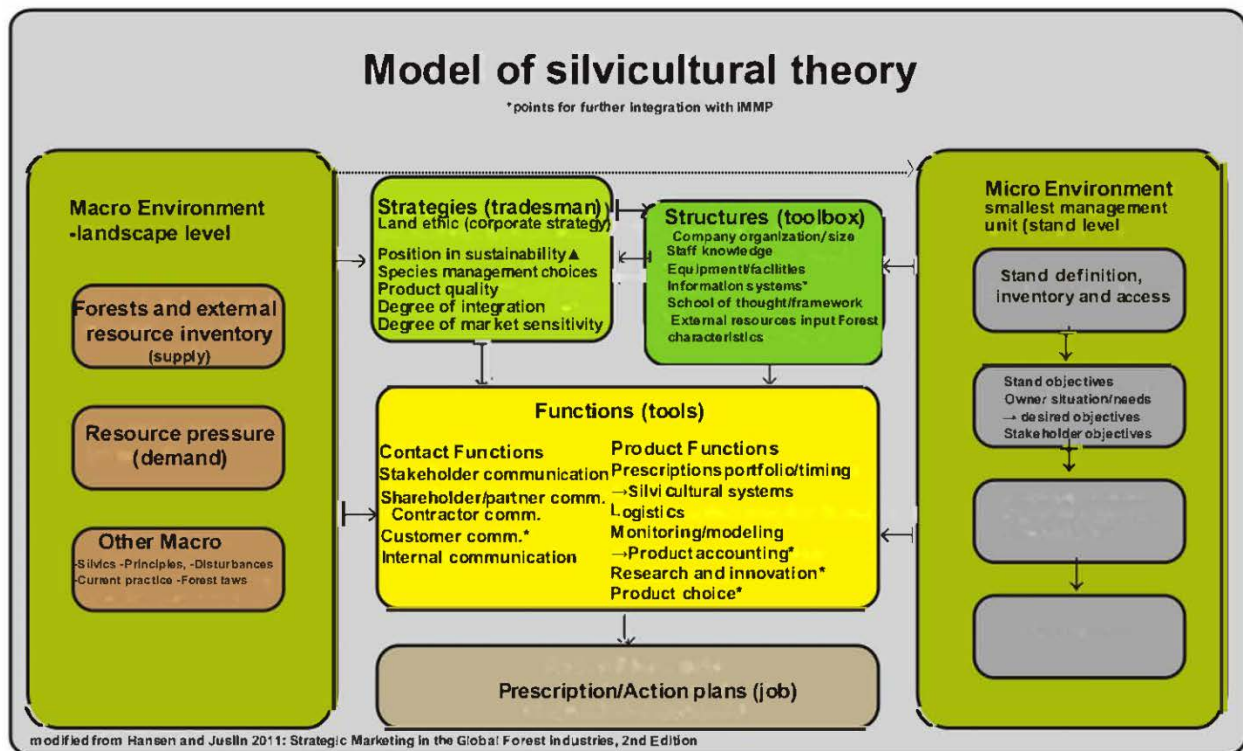
4. Wrap-up

20 If not mentioned already, what are the two most important things you would advise the owner of a small forest who tries to manage for income generation and structural diversity to do/not do?

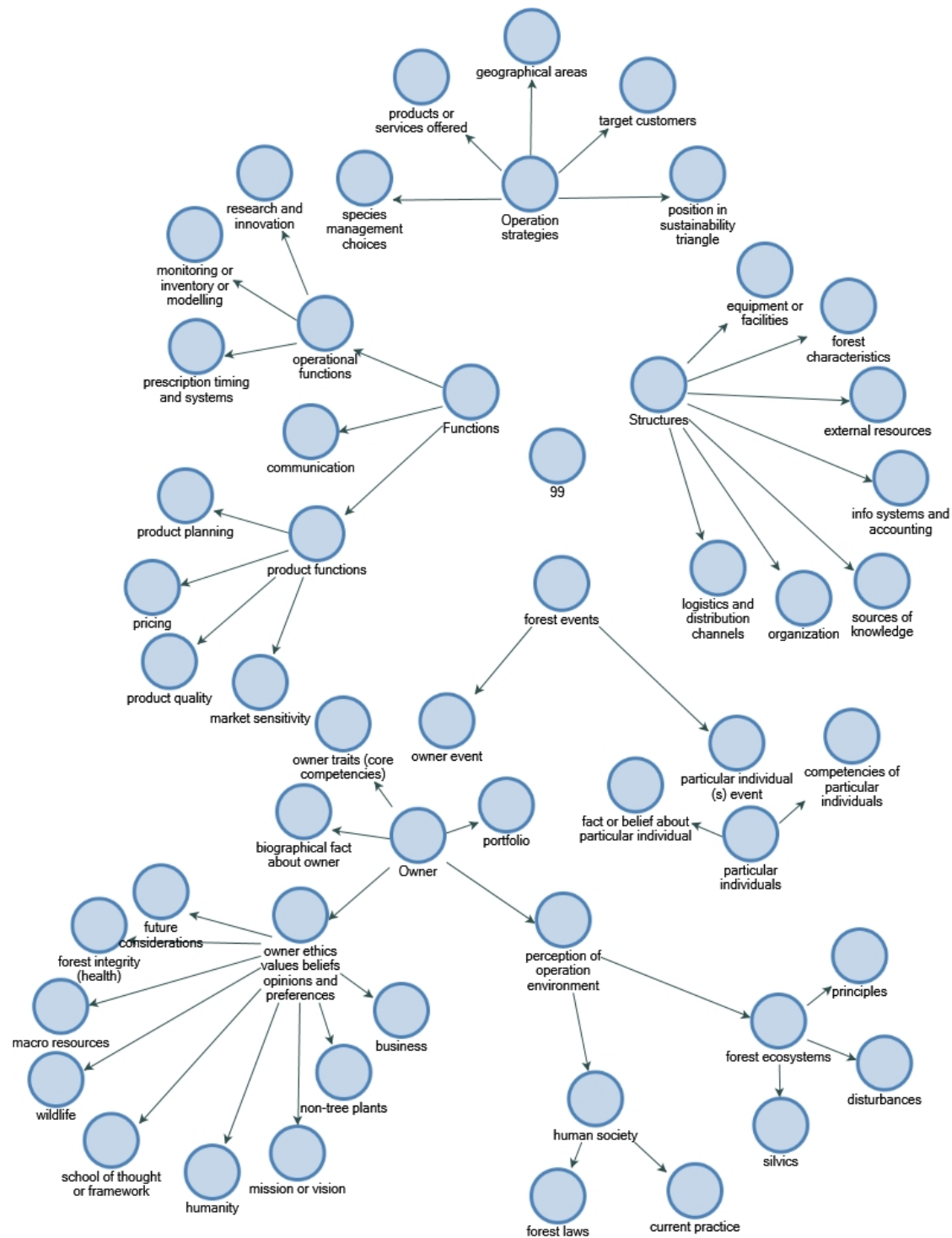
21 What was your most important thing we talked about today?

22 Which changes would you like to see happen around you?

2) model of silvicultural theory



4) categorical code



5) verbal stand descriptions

Forest	Plot	Description
1	1	edge of patch cut next to large south-facing opening
1	2	north slope, no stumps
1	3	plantation pruned two lifts, branches after pruning and pieces of logs left behind after first thinning
1	4	Clearing with traces of harvest. Clearcut of 2 ac. 6 ft high blackberry, poor form
1	5	Riparian buffer by creek. Has deer trail, poor form in all trees
1	6	Open deciduous, north slope, close to creek, no visible sign of entry, poor form
1	7	planted to cedar but overtopped by naturally regenerated alder. Birds audible, trees have poor form
1	8	edge of mowed meadow by creek and house, solitary shape of trees
1	9	riparian buffer stand edge to old DF stand, scattered DF nearby. Very wet ground, understory more than head-high, very open, never harvested, poor form of trees
2	1	DF planted, thinned once, spindly maple where left, flowerpot where cut and resprouted, cat-logged on dirt, soil pretty churned up. Signs of light fire non-permanent road nearby
2	2	Patch of slightly older trees amidst regen, 2x the height of surrounding stand. Appears planted. Has medium and large stumps nearby. Used by deer that I spooked
2	3	Planted DF in stem exclusion unthinned stumps (few) from previous harvest outside plot, deer trails throughout, Maple and oak pocket to be overtopped soon nearby

2	4	replanted logging road SE slope deer trails
2	5	Patch in past clearcut, homogenous regen, surprisingly diverse, representative of forest regen method SW slope deer trails
2	6	NE facing, steep slope, hazelnuts on the ground, clearcut diameter 60 trees late re-initiation, lots of deer trails, regen heterogeneous, patches with madrone, some cherry occasional large deadwood, some oak alder and maple
2	7	10yo clearcut replant with DF rows not straight, birds audible, big stump nearby, steep west-facing slope
2	8	transition between clearcut, just replanted and 10yo planted DF stand
2	9	Clearcut of 30-35 yo DF stand, unburnt slash piles with Maple and DF wood close by replanted with DF all seedlings look browsed cut ca one ha bordering a stream with hardwoods
3	1	open stand on steep slope, rich understory w mushrooms, few old stumps snag nearby complex crowns.
3	2	Limby trees , gap north of plot, big ilex nearby
3	3	Thinned and pruned 20 years ago. Clayey loam soil, Mole hills, trash and deer poop in plot
3	4	plantation, pruned two lifts on every tree wide rows narrow spacing, many roads
3	5	slight pistol butting on trees due to slope, plantation, some maple nearby (leaves in plot)
3	6	lots of deer tracks, rock wit cone remnants->Squirrel? Birds audible
3	7	Deer In plot. Wide rows, small in-row spacing, all trees but the runts are pruned 2 lifts
3	8	unusual gap in plantation, deer tracks
3	9	Squirrell feeding, blackberry thicket right close, some maple in understory surrounding plot deer tracks evident

4	1	mature DF on NE slope. Wind damaged, no sign of harvest woodpecker hole
4	2	Mature DF with wind damage, damaged trees marked for removal old skid trail nearby
4	3	by creek, selectively harvested DF
4	4	edge of meadow, forest side super dense and mossy but not very high. More of a 6m thicket
4	5	peninsula close to river, never entered, thick, close to bearing tree for surveys
4	6	deciduous close to river, never managed
4	7	afforested meadow trees protected with wire cages against beaver close to river
4	8	row plantings of DF WRC and hemlock on former pasture at different spacings all around 2.5 by 2.5
4	9	row plantings of Douglas-fir at 4x 3 spacing on former pasture
5	1	plantation, selectively thinned hardwoods. Deer trails
5	2	plantation harvested replanted dead blackberry from when there was more light, smaller trees ringbarked madrone nearby and tractor turnaround nearby
5	3	Close to an oak grove, no management
5	4	plot overtopped by giant oak, creek through plot, WRC grows in the overstory nearby, PP grows in the overstory nearby
5	5	steep slope, thinned once, diverse understory
5	6	plantation on NW slope by creek thinned high stumps with woodpecker holes, deer trail.
5	7	plantation thinned once several trees ringbarked when ~ 10 cm

5	8	deer trail, opening close by plantation
5	9	harvested and replanted, no management since replant. Close to former skid trail that is disappearing.
6	1	Plantation thinned once, high initial mortality, slight slope creep, south facing slope underplanted crw close by, some more medium-sized recumbent deadwood also close by
6	2	Plantation underplanted with crw nearby. Some medium size recumbent deadwood is also close by. Planted and thinned once, stumps over 20 cm. DF natural regen nearby. Red mushrooms
6	3	Pruned 2-3 lifts plantation surrounding remnant black walnut tree. WRC and CRW grow close by. Smaller DF pruned only one lift
6	4	Deer trail and predator scat, big oaks nearby, property and stand boundary with unclear (unmanaged) borders leaving a wild strip between properties
6	5	Low foliage, steep slope DF advanced regen close by
6	6	Slight east slope, close to spring-fed pond. Former oak woodland replanted silty clay loam, oak deadwood, lots of browse, understory trees all dead, poor tree form
6	7	No previous harvest close to fenced off pasture. Very large DF in close proximity
6	8	Replanted (stumps)after afforestation failure with DF and CRW, east facing slope, rivulets of water, some rocks hardwoods (alder) nearby DF pruned
6	9	On old skid road, Oak woodland converted to DF, slight south slope, regen variably successful, least so in plot.
6	10	DF plantation, staggered planting 2bx2.5wm spacing partially shaded by giant oak