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Group Opening Outcomes, Sustainable Forest Management, and the Menominee Nation Lands

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Ideally, variants of single-tree, group, and patch selection create new, spatially aggregated age classes and maintain a diversity of tree species and sizes in multiaged, mixed-species forests. We explored this notion in northern hardwood forests on the Menominee Nation, a forest ecosystem without the exploitive cutting history of most forests in the western Great Lakes region. Although the outcomes suggested a lack of relationship between gap characteristics and tree density, the expectations for tree regeneration were largely met: gap tree densities were >600 stems/ac and predominantly composed of sugar maple (*Acer saccharum*), American elm (*Ulmus americana*), and yellow birch (*Betula alleghaniensis*). Examination of stand diameter distributions indicate that gaps may not be necessary to establish regeneration on Menominee forests. To deepen the interpretation of our results, we include field and office discussions regarding the practicality of group openings when managing this forest.

Keywords: harvest-created gap, natural regeneration, cohort, uneven-aged silviculture, selection system

Maintaining ecosystem function is vital to forest sustainability as interactions of climate, weather-related disturbances, insects, and disease change forests in novel ways. Moreover, society's demands and expectations of forests have changed from subsistence and multiple-use forests to primarily timber resources and, recently, back to multiple uses, again, including timber, recreation, wildlife, and spiritual values (Bengston 1994). The extensive use and changing nature of managed forests increasingly favor complex ecosystem management, where practices can meet specific objectives while maintaining the many goods and services that forests provide (Seymour and Hunter 1999, Messier et al. 2013).

The northern hardwood forests of the United States and Canada are an example of a forest type in which managers often desire to maintain some complexity for a variety of goods and services. In this forest type, the natural disturbance regime maintains complexity through frequent small-scale and infrequent large-scale wind disturbances that create a range of canopy opening sizes (Lorimer and Frelich 1994, Hanson and Lorimer 2007). Canopy gaps are spaces for tree regeneration, microclimate, and resource availability that are different from adjacent closed forest understories (Brokaw 1985, Gray and Spies 1997).

The selection system has long been recognized as a complementary method for the species and disturbance patterns in this forest type (Frothingham 1915). The selection system, an uneven-aged silvicultural system (Nyland 2002), creates canopy gaps when mature-tree dominants are harvested in a cutting cycle. The single-tree selection system has been widely applied across this forest type (Jacobs 1987), although application outcomes can vary from the idealized stand structure (Pond et al. 2014).

Today, northern hardwoods are often characterized as simple in composition and structure. Widespread exploitive cutting at the time of settlement homogenized age class structure and tree composition (Schulte et al. 2007). Moreover, decades of single-tree selection management have been associated with lowering tree diversity and increasing shade-tolerant sugar maple (*Acer saccharum*) (Niese and Strong 1992, Neuendorff et al. 2007). Consequently, the classic selection

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system for northern hardwoods has been altered to establish new age classes and maintain diversity through recruitment of trees less tolerant of shade to develop diversity in age class structure and composition, respectively. For example, in the northeastern United States, group and patch selection has been developed (Leak and Filip 1977, Leak 1999, Kelty et al. 2003), whereas in the western Great Lakes region, a hybrid single-tree/group selection has emerged (Erdmann 1986, Nyland 1987).

Questions about Group Openings

The general efficacy of group openings, or harvest-created gaps, is inconclusive. In northern hardwoods of the northeastern United States, long-term studies have indicated success in age class and species diversity; results show that mid-tolerant trees occupy at least one-third of the basal area 40–60 years after large gap (0.35–0.50 ac) creation (Leak 1999, McClure et al. 2000). Yet, recent observations in northern hardwood forests of the western Great Lakes region suggest that new and diverse age classes are not being established through gap creation due to elevated deer (*Odocoileus virginianus*) browsing, competing vegetation, microclimate extremes, or lack of suitable substrate (Strong et al. 1997, Caspersen and Saprunoff 2005, Matonis et al. 2011, Kern et al. 2012). This result poses the following questions: Are there existing Lake State forests where regeneration depends on gap characteristics? Are gaps providing the needed growing space and tree regeneration to sustain yield and maintain tree diversity?

In this "Practice of Forestry" article, we outline the attempt of a forest management company to collect data that were specific to their management questions and their lands and applied operationally by using their staff with already-planned work. We share the learning process from implementation in the field to dialogue in the office to provide an informative context for other practitioners who might be interested in similar questions and procedures for their lands.

Methods

The project was conducted in northern hardwood forests on the Menominee Indian Reservation, northeastern Wisconsin, USA (44.8781° N, 88.6289° W). The forests have been under the influence of the Native American way of life for thousands of years. Sustaining all components of a forest ecosystem has been central to the Menominees' philosophy in life and practice, passing that knowledge from generation to generation, including knowledge of forest management (Pecore 2003). Their traditional approach is captured by the famous statement of Chief Oshkosh (1795–1854): "start with the rising sun and work toward the setting sun, but only taking the mature trees, the sick trees, and the trees that have fallen. When you reach the end of the reservation, turn and cut from the setting sun to the rising sun and the trees will last forever." For more than a century, the forests have been managed under modern silvicultural systems (e.g., single-tree selection, shelterwood, and others) (Trosper 2007). A memo from the Menominee to the US Department of Agriculture Forest Service indicates that single-tree selection methods were adopted by the tribe in the 1930s.

Today, typical uneven-aged management by the Menominee follows a combination of single-tree and group selection systems on a 15-year cutting cycle with about 86 ft^2/ac residual basal area (70 ft^2/ac in sawlogs). They do not follow a *BDq* method (a stocking control technique that uses Basal area, maximum Diameter class, and a Quotient of decline between increasing diameter classes) (e.g., Leak and Gottsacker 1985). Rather, tree removal is based on biological factors, such that the order of tree removal is prioritized as those with high risk and low vigor in any size class. Stand structure is monitored periodically with their continuous forest inventory (CFI) and then compared with regional recommendations (e.g., Arbogast 1957: a marking guide that specifies a reverse-j curve shape in stem diameter distribution). Before the 1990s, gaps were created inadvertently through Dutch elm disease (*Ophiostoma ulmi*) salvage and timber harvest. The number or size of harvest gaps was not prescribed or monitored.

In 1992, a memo indicated that the prescriptions would begin including the "canopy gap" concept as recommended in Erdmann (1986). Thus, the prescriptions began calling for ~10% of the management unit in gaps large enough to remain open at least until the next cutting cycle (Figure 1). These gaps were defined as 25–60 ft diameter openings (cleaned of all trees >1 in. dbh) created by group cutting or single-tree cutting throughout the compartment and based on the order of removal (Figure 2). Cleaning with chainsaws occurred at the time of harvest to eliminate suppressed trees (i.e., those with low potential to grow into a crop tree) from dominating the gap and to create growing space for more vigorous and younger or new tree regeneration (i.e., those with high potential to grow into a crop tree). Over time, gap trees are tended with crop tree releases (two competitor removal or 7 ft of open space on two sides) with the aim of producing mature (20–24 in. dbh), acceptable (or better) sawtimber. The goal is to provide sustained yields of diverse and high-quality timber over time (Pecore 2003). However, gap regeneration was not a specific focus of Menominee inventory methods, and observations in the field were inconsistent. Managers of the Menominee forests had questions about the efficacy of harvest gaps on tree regeneration. Did the recent findings about gap outcomes in

Management and Policy Implications

In the western Great Lakes region, group openings, simply known as "gaps" in the region, have been an integral part of northern hardwood management for nearly 30 years; however, recent regional findings show regeneration failures in gaps. This article showcases a real-world experience by practitioners to address these recent science findings with a practical approach that included (1) answering their own specific management questions about gaps, (2) using their own lands, (3) using their staff, and (4) integrating with work they are already doing. Overall, we found that tree regeneration in gaps was sufficient, and gaps may not be necessary to establish regeneration in Menominee forests. These results are contrary to recent regional findings and probably are explained by the uneven-aged and species-rich characteristics of the Menominee forests that are largely absent in forests of the larger region. The method and its interpretation was enriched and clarified (including its limitations) over time by the company growing a disciplinary, generational, and cultural rich collaboration. We believe this learning process of data collection, interpretation, and social capital is valuable to share and highlights a process and discussion for managers to evaluate the efficacy of gaps at other sites.

Figure 1. A. Photograph of the typical forest matrix around gaps (in background) in a northern hardwood forest of the Menominee Nation. B. Photograph of a typical gap 1 year after harvest in a northern hardwood forest of the Menominee Nation. (Photos by M. Schoelch.)

northern hardwood forests apply to their lands?

The area under investigation here was located in three large management units (800–900 ac each) designated for cutting in winter of 2016–2017. Harvesting in the study area last occurred in 2000. The habitat classification of the units was *Acer saccharum/Hydrophyllum virginianum*, or mesic, rich to very rich sites (Kotar et al. 2002). Dominant tree species included sugar maple, hemlock (*Tsuga canadensis*), and yellow birch (*Betula alleghaniensis*) with mean heights of 90–100 ft, mean stand basal areas ranging from 107 to 200 ft^2/ac, and mean stand dbh from 12 to 15 in. The deer browse pressure is less on the Menominee forest than on the surrounding forests and farmlands of Wisconsin (Alverson et al. 1988). Deer densities in Wisconsin range from 14 to 49 deer/mi^2 in counties surrounding the Menominee Nation (State of Wisconsin 2016), whereas over the 5 years before data collection, deer densities within the Menominee Nation averaged 9.2 deer/mi^2, which meets the deer population goals for Menominee northern hardwood forests (D. Reiter,

Figure 2. A. Photograph of trees marked for cutting and for a future gap opening in a northern hardwood forest of the Menominee Nation. B. Photograph of a freshly cut stump at center of a new gap in a northern hardwood forest of the Menominee Nation. (Photos by M. Schoelch.)

Menominee Tribal Enterprises, pers. comm., Jan. 5, 2017).

In 2014, gaps and tree regeneration within gaps were systematically sampled within management units by means of a forest operation: strip transects 2 chains (132 ft) wide were established as field foresters walked between cruise plots. Cruise plots were located in a systematic 9 chain × 9 chain grid pattern. Cruise plot data are not used here; rather the data collection needed from the cruise plots provided an economical opportunity to collect additional data on gaps between cruise plots. All canopy gaps >20 ft diameter were visually identified and sampled with basic data and every third gap underwent detailed measurement. Basic data collection characterized natural (e.g., uprooted tree) or management (e.g., cut stump) gap origin, gap size class (small [400–1,600 ft^2], medium [1,600–3,600 ft^2], and large [3,600+ ft^2]), age class (recent [∼15 years ago], old [∼30 years old], or unknown stump or gap maker age), gap shape class (circular, "8"-shaped, oblong, or irregular), estimated regenerating tree cover and mean height of all gap tree regeneration, species and estimated height of dominant saplings, and shrub cover and species. Detailed data collection included gap width and length and, in [1/100]-ac plots at gap center, regenerating tree (>3 ft tall) counts by species.

At the time, the outcomes of gaps were anticipated as follows. Recent (∼15-year-old) gaps created by harvest would represent the most common gap age class and origin. After 15 years of edge tree crown extension (based on gap closure rates from Klingsporn et al. 2012), the gaps would cover ∼2% of the management units, be largely circular in shape, be approximately 20–40 ft in diameter, and contain a regenerating sapling layer below the dominant crown shoulder height (Webster and Lorimer 2005). Successful gaps would have at least three sapling stems (>3 ft tall), an average sapling height of 15–25 ft tall (Webster and Lorimer 2005), and sapling crowns covering >50% of the gap area. Saplings within gaps would be composed largely (>20% each) of sugar maple, yellow birch, and hemlock with minor components (<5% each) of American basswood (*Tilia americana*), American elm (*Ulmus americana*), white ash (*Fraxinus americana*), and eastern hophornbeam (*Ostrya virginiana*).

For interpretation, categorical data were converted to numerical ordinal codes (e.g.,

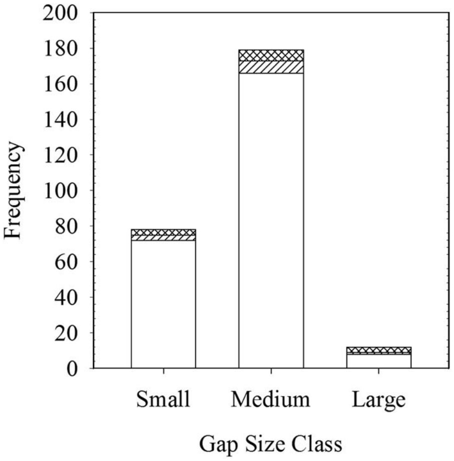

Figure 3. Frequency of gap size and gap age ($n = 269$). Small, medium, and large gap sizes were estimated to be about 20–40, 41–60, or >60 ft on one side, respectively. Age classes were estimated as "recent" gaps formed approximately around the time of the last harvest entry 15 years ago (no hashing), as "old" gaps formed approximately two cutting cycles ago (~30 years ago) (single hashing), or as unknown age class (cross-hashing).

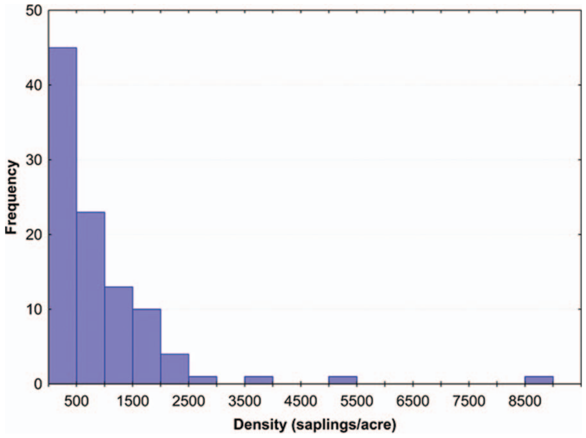

Figure 4. Frequency distribution of sapling density (>3 ft tall) ($n = 105$) in a northern hardwood forest of the Menominee Nation.

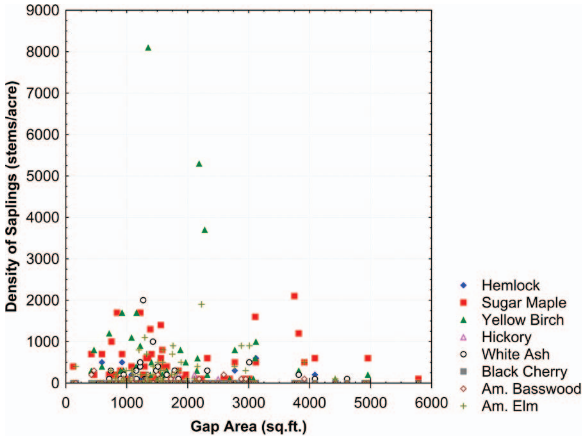

Figure 5. Density of saplings (>3 ft tall) by species versus gap area ($n = 105$) in a northern hardwood forest of the Menominee Nation.

small, medium, and large gap size classes as 900, 2,500, and 4,600 ft^2, respectively) or nominal codes (shapes: 0 = circular, 1 = 8-shaped, 2 = oblong, and 3 = irregular). To identify the most influential variables on tree density, we attempted a multivariate analysis approach, principal component analysis (PCA), and multivariable regression. The PCA revealed two groups of interesting variables to be further investigated: gap size (length, width, and area) and tree density (sum of regeneration and density per acre). Dependencies among variables were checked by correlation analyses. Data processing and analyses were conducted with MS EXCEL and STATISTICA (8.0).

Results

Gap Characteristics

Stand Gap Area. In total, the sampling covered an average of 26% (range, 22–33%) of each management unit and generated 269 sample gaps of which 105 gaps had detailed measurements. The area in gaps ranged between 1.0 and 2.3% among the management unit areas and was similar to the 2% area in gaps we expected.

Gap Dimensions. The average gap measured 50 ft (±1.6 ft SE) in length and 34 ft (±1.0 SE) in width, leading to an average gap area of 1,942 ft^2 (±65 ft SE) or 0.043 ac (±0.002 ac SE). The mean gap size is classed as medium or at least 41–60 ft on one side (Figure 3). The expected minimum average size of 20–40 ft gap diameter was met or exceeded.

Gap Shape. Gap shape was determined to be "oblong" in most cases (55%). This is different from the expected circular shape, which represented 43% of the gap shapes.

Gap Age. Ninety-two percent of the gaps were determined to be recently formed (Figure 3). Three percent (all harvest origin, except one natural gap) were deemed to be old gaps or probably formed two or more cutting cycles ago. For 5% of the gaps, the approximate age could not be determined. Thus, the approximate gap age met the expectation that recent gaps would be most prevalent.

Gap Origin. Gaps caused by management (harvest [66%]) were most common as expected, followed by natural reasons (22%). Road edges (4%) were less important and, in 8% of the gaps, the origin could not be classified.

Gap Trees

Density of Saplings. Saplings or regeneration taller than 3 ft were found in 91% of the detailed measured gaps ($n = 105$). On average, >8 saplings/100th-ac plot or 874 stems/ac were found. The distribution of sapling density was skewed toward zero (Figure 4) so that the median value of 600 stems/ac was a more reliable estimate of sapling density. In gaps with saplings ($n = 95$), mean density was 966 stems/ac with a median density of 700 stems/ac. Sapling crowns covered more than half of the gap area in 41% of the sample plots, whereas shrubs (largely *Sambucus* and *Rubus*) covered more than half of the gap area in 20% of the plots. Although sapling crown cover was lower than we expected, overall sapling density met stocking expectations.

Composition and Diversity of Saplings. The total number of sapling species found was eight and, per plot, the maximum was five species. In the gaps with saplings, we found mostly one species (42%), two species in 30% of the cases, three species in 21%, four species in 5%, and five species in 2% of the cases. The most common species found in gaps was sugar maple (27.5%), followed by elm (22.2%), yellow birch (20.1%), white ash (12.7%), hemlock (7.4%), basswood (7.4%), and hickory (*Carya cordiformis*) (2.1%); black cherry (*Prunus serotina*) was found only once (Figure 5). Our expectations were met with prevalence of yellow birch and sugar maple, but the presence of hemlock was lower than we expected (<20%).

Height of Saplings. Overall, tree heights were lower than the expected 15–25 ft height range. The average height of the regeneration in gaps measured 10.0 ft (±0.3 ft SE) and the average dominant height was 14.1 ft (±0.3 ft SE). Hickory was the tallest species (18 ft), but it was seldom found (5 stems). Elm was the second tallest dominant (17 ft), sugar maple dominants were similar to mean dominant height (14 ft), and the shortest species among dominant stems was hemlock (10 ft).

Relationships of Gap Characteristics to Gap Trees

Even though some significant ($\alpha = 0.05$) but weak positive correlations are given between density and number of species or negative ones between shrub class and habitat type, there were no significant linear correlations or acceptable models (multiple, multivariate, and general linear mixed) of gap characteristics and density of saplings. The attempt to calculate tree density out of sapling crown cover classes failed as well because of unacceptable residual distributions (results not shown).

Interpretation

Review of Gap Outcomes

Developing silvicultural systems that maintain complex ecosystem processes and functions while providing a continuous flow of desired goods and services is key to sustainable forest management (Spittlehouse and Stewart 2003, Mason et al. 2012). We explored gaps and their role in sustainable management on Menominee lands. The history of sustainable management on Menominee lands provided an opportunity to study gaps that is different from that for other regional forests, which are characterized by exploitive cutting at the time of settlement (in the late 1800s), recalcitrant understory vegetation layers, and elevated browsing that, together, have strongly diminished natural tree regeneration in many places across the region (Royo and Carson 2006, Matonis et al. 2011, Kern et al. 2012). Thus, we used an operational approach to examine prescriptive expectations against actual field outcomes without some of the confounding factors associated with other forests.

As expected, we found that gaps most likely originated from the last harvest, and where saplings occupied gaps, a mix of species existed. In addition, the measured gaps were of acceptable size for these forests according to other studies (Webster and Lorimer 2005). Overall, the outcomes are consistent with those for other selection-managed stands (Angers et al. 2005, Shields et al. 2007).

We found that gap characteristics did not predict sapling densities or composition. We considered several possible reasons for this. First, the independent relationship may be due to our sampling design in which we concentrated sampling in the gap's center. We placed plots at center, purposely, to detect saplings, which we felt would have the potential to be future crop trees, because they would be more likely to develop straight boles as they ascended to the canopy. Our plots missed trees regenerating around the perimeter of the gap (Figure 1). High sapling density located along the gap perimeters can occur where soil moisture is high and soil temperature is low and suitable for mid-tolerant species such as yellow birch (Raymond et al. 2006, Poznanovic et al. 2014). In addition, the 105 measured gaps may not express the variation in these forests. Furthermore, harvest activities could have destroyed advanced regeneration in the center. In future investigations, we will consider these caveats and include sampling of the entire gap or using transects or multiple plots across gaps to include regeneration densities and composition along gap edges.

The Learning Process

The operational method to monitor gap regeneration provided useful experience to improve the next attempt in the future. More importantly, the process provided an enriching learning environment as the project developed and the collaboration grew in diversity in generation, culture, and professional experience and training over time. As such, the dialogue about the project extended the data and tackled challenging topics. We share our office discussions to provide additional context for other practitioners. For instance, we had conversations about the worst-case scenario: If regeneration was low or absent in gaps, would the sustained yield of timber be at risk in the future in these three management units? The Menominee use the widely applied Arbogast (1957) guide that recommends an overall reverse-j curve structure in the diameter distribution, as a guide to sustained yield at the stand level (Eyre and Zillgitt 1953). In particular, it recommends 254 saplings/ac in the 2–5.9 in. dbh class (Arbogast 1957). At the gap scale, our numbers were well above this standard at the median and mean sapling densities (600 and 874 stems/ac, respectively; see Supplemental Figure S1[S]). However, we found that gaps only represented 1–2% of the management unit. Then, for example, gaps may contribute only 6–8+ saplings/ac at the stand-scale (e.g., 600 trees/ac × 0.01 proportion of stand area in gaps = 6 trees/ac). If gaps represented 10% of the gap as prescribed, then gaps might contribute about 60–87 trees/ac at the stand scale. In either case, the proportion of area in gaps is too low to meet stand-scale standards alone.

However, gaps are not the only locations with tree regeneration; trees regenerate outside of gaps. At each cutting cycle, light resources are released not only in gaps but also in areas adjacent to gaps as well (Canham 1988). About half of the understory in selection-managed stands increases light availability after harvest, such that frequent harvests homogenize the growing environment, allowing regeneration in the matrix in addition to the gaps (Beaudet et al. 2004, Angers et al. 2005).

Our discussions of the worst-case scenario led us to investigate nongap regeneration. We decided to perform an additional

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[S] Supplementary data are available with this article at http://dx.doi.org/10.5849/jof.2016-092.

investigation based on data of Menominee's CFI. The results of the last inventory in 1999 in the management units we investigated show abundant regeneration at the stand scale: >500 saplings/ac from the 2–5.9 in. dbh class. If gaps represented as much as 10% of the units as prescribed and that 10% had zero regeneration, then stand-scale densities may be as low as 450 saplings/ac (=500 trees/ac × 0.90 proportion of stand area in nongaps). This scenario still resulted in sufficient tree regeneration according to Arbogast (1957). In addition, we examined the stand-scale distribution of tree diameters from the CFI data and found the desired reverse-j shape. Thus, the distribution of tree sizes in the management units investigated here seem to have sufficient regeneration at the gap and stand-scale even under the worst-case scenario of zero regeneration in the gaps, suggesting that timber yield is sustained into the future. We can revisit this notion after the next CFI planned for 2016–2017. Overall, we have reason to assume that gaps are not mandatory to meet stocking requirements in these three management units.

Next, we had discussion about the dogma to use gaps in every prescription: If gaps were not necessary to regenerate a new cohort of trees, then should gaps be prescribed in future harvests for tree diversity in these three management units? Our results suggest that gaps are providing tree regeneration composed of a mix of species. This is a different outcome from what is found in selection-managed stands in the larger region where sapling composition is dominated by sugar maple or undesirable species (e.g., eastern hophornbeam) (Forrester et al. 2014). Thus, if gaps are important for maintaining the richness of tree species, then gap prescription is useful to maintain in future cutting cycles. We doubt whether gaps are obligatory for the diversity of Menominee forest, although additional sampling will be necessary to validate whether a diversity of species also exists outside of gaps.

As data were analyzed, the collaboration grew, and discussions continued, we circled back to our project intentions: If Menominee forests were species-diverse and uneven-aged, why were gaps added to the prescription 30 years ago? What was important at this point in our discussion was the presence of multiple generations from the profession and the tribe. Intergenerational learning has been a cornerstone to Menominee knowledge and lifestyle. Therefore, important context from the older generation foresters that could not have been gleaned from textbooks or experiences was shared with the younger professionals.

About 30 years ago, the regional forestry profession was developing the use of gaps for age class establishment and species diversity goals, because the northern hardwood forest landscape in the western Great Lakes was largely one age class originating around 1900 and strongly dominated by one species. Establishing new age classes and species other than sugar maple was important for rehabilitating northern hardwood ecosystems.

At this same time, the Menominee, whose forests had a range of ages and species, were concerned with developing tree quality. The establishment of gaps was perceived to also facilitate tree quality over time, because understory saplings are often suppressed with broken crowns and defects, making them unsuitable as future crop trees (Erdmann 1986). Therefore, the Menominee adapted their prescriptions to include gap management. The idea was to clean gaps created from large canopy tree harvests for tree *quality* development. Unlike the larger region, the idea was not prompted by the need for age class establishment or species diversity, although these were still expected outcomes.

Until the 1990s, tree quality was developed by removing stems of high risk and low vigor once they met *merchantable* size. Merchantable size was defined as only sawlog-sized trees (>12 in. dbh) until the 1980s when pulp markets developed and then the merchantable size class was lowered to pole-sized trees (>5 in. dbh) in the 1990s. Below merchantable sizes, natural processes of competition sorted high-risk and low-vigor trees from more healthy and vigorous stems. The idea of using natural processes to develop saplings with potential for high-quality boles is the foundation on which selection silviculture was established in central Europe by peasant farmers who cut trees of all sizes to support their subsistence lifestyle (Schutz 1994, 1997, Puettmann et al. 2009). A sustainable flow of small diameter trees of any form for fuelwood was as important to their livelihood as large diameter, well-formed trees for building materials. Working with nature as much as possible is the aim of the Menominee's stewardship of the forest and of organizations such as Arbeitsgemeinschaft Naturgemäße Waldwirtschaft[1] and Pro Silva in Europe.[2]

Although not a formalized prescription, in practice, edge saplings are not normally removed in gap cleaning treatments on Menominee lands, because it has been observed that well-formed saplings often grow along driplines of mature, well-developed crowns or along gap edges. In the southern pines, this type of advanced regeneration has been categorized as "oppressed" rather than "suppressed" in selection stands, because the regeneration, although overtopped, is capable of good growth after release (Reynolds 1959). We agreed that nature has and continues to be at work in developing tree regeneration without a prescription or extra costs. As such, gap creation may be necessary to release saplings along driplines to develop *quality* and not necessarily *quantity* in these management units. Whether gaps are meeting aims to develop future quality from released saplings will need further investigation.

In conclusion, using a field and office experience such as this is a first step to addressing a knowledge-practice gap for a particular site. Here, a forest management company attempted to close the disparity between recent knowledge about gap regeneration failures in the region with the practices and outcomes on their managed lands. In addition, this process has provided baseline data and operational methods that the Menominee can adapt and expand to saplings at gap edges and quality development of gap saplings in general. More importantly, it has generated an enriching, professional collaboration in and out of the field.

Endnotes

1. For more information, see www.anw-deutschland.de.
2. For more information, see https://prosilvaeurope.wordpress.com.

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