



MANAGING MIXED STANDS FOR SOUTHERN FOREST LANDOWNERS: THREE FAMILY STORIES FOR DECISION-MAKING ASSISTANCE

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INTRODUCTION

Mixed-stand management (MSM) involves growing of pine and hardwood trees in the same stand (Figure 1). You may be familiar with pine plantations, which have been successful across the southeastern United States due to logistical simplicity, silvicultural advancements, pine genetic improvements, and the past existence of a vibrant pulp industry region wide. While plantation management continues to be an attractive management strategy to many landowners, changing social, biological, and economic conditions may make MSM a viable alternative for landowners looking to accomplish a broader set of management objectives. For example, MSM might be feasible when traditional plantation management (planting 600 pine trees per acre) is no longer economically feasible (for instance, due to lack of pulp mills or small tract size), site limitations or issues (percent slope, site quality, etc.), when broader sets of ecosystem services are desired, or when the landowner's values, risk aversion, and objectives do not fit well with pine plantation management.

The objectives of this publication are to provide landowners and managers illustrative stories of different forest management scenarios where MSM (either planted or natural stands) might be appropriate. In addition, these stories will discuss possible pitfalls and opportunities presented by MSM. Landowners should also be apprised that significantly less research has been devoted to MSM compared to pine plantation or hardwood management. It is important for landowners to remember to discuss tradeoffs with a professional forester prior to any decision to move forestland to MSM. For a more detailed discussion of the state of MSM scientific knowledge, refer to Willis et al. (2019).



Figure 1: Mixed stand management involves growing pine and hardwood trees in the same stand. Loblolly pine and hardwoods such as red oaks are frequently found growing together in mixed stands throughout the Southeast.

Photo: David Dickens

WHEN AND WHERE TO CONSIDER MIXED STAND MANAGEMENT:

Certain types of forest landowners' will consider MSM while others may think that the approach is unsuitable for their management objectives. Land management values and attitudes, risk perceptions, economic constraints, and site limitations all influence whether a landowner should pursue MSM. However, MSM may interest some landowners who would otherwise exclude themselves from forest management. There are several biological, economic and social factors that will dictate whether MSM should be considered or avoided. Below is a summary of some of the factors to consider:

BIOLOGICAL FACTORS:

The management of forest systems relies on a number of complex biological and site factors and application of various management techniques that influence the composition, density and growth of a forest system. Below are a few biological factors to consider for MSM, please note, these are general statements and will not capture the numerous combinations of factors that may or may not allow a certain management style to succeed.



Figure 2: *Low quality site (low site index) where hardwood growth is stunted due to dry and low fertility soils. A site like this might be better suited for pine plantation management.* Photo: David Clabo

When to consider MSM:

- **Intermediate site index value:** Site productivity for specific tree species or groups of similar trees species is measured as site index or the heights of free-to-grow upper canopy position trees at a certain base age. Most literature suggests that mixed stand management can be most successful on sites that are intermediate in site productivity. For instance, upland oak site index (SI) would typically fall between 60-75 ft at base age 50. On sites with low productivity (SI<60 ft) hardwood species composition, growth, and stem quality will be poor (Figure 2), and pine production by itself will be less profitable due to longer rotation lengths. On sites with high productivity (SI>75 ft), it may be difficult to cost-effectively manage for pines due to excessive hardwood competition. Identifying the soil series and determining site index values for common species on the site can help with decisions on whether a site is right for MSM.

- **Early successional stands with existing pine:** Younger stands with an existing mixture of pines and desirable hardwoods create good candidate stands to practice MSM. These stands have the right species composition and structure in place and may only need to be managed with herbicides and/or fire to promote the desired species and stocking levels depending on management objective. The balance between pines and hardwoods may also be fine-tuned using precommercial or early thinning, if feasible for the landowner (logistics of the operation and possible costs). These stands may also not require any management depending on their species composition and structure. Stands younger than 5-10 years old will be easiest to manipulate using herbicides with application methods such as foliar, hack and squirt, and basal bark sprays.

- **Compatible species mixtures:** Compatible species are an important consideration for MSM. Species grown in mixtures should have complementary functional traits such as shade tolerance, height growth rates, crown structure (wide spreading lateral crown versus a more narrow conical crown), and foliar phenology (i.e. deciduous versus evergreen). If species have compatible characteristics that differ, they may capture site resources more effectively and produce more biomass than would occur in monocultures. For example, two compatible species might have different height growth rates, crown structures and shade tolerances. A species with a faster growth rate and a more narrow and conical crown structure that is shade intolerant will stratify or grow above a species with a slower height growth rate, large and spreading crown structure, and slightly more shade tolerant (especially if the faster growing species has foliage that allows some diffuse sunlight through its canopy, e.g. pines). Two species that often occur together naturally in mixed stands on certain sites in the Southeast that fit the previous description are cherrybark oak and loblolly pine (Clatterbuck 1989) (Figure 3). When choosing species for mixed stands, consider if candidate species have timber and/or wildlife value. Also, mixed stands do not have to be limited to two species though management may become more challenging with three or more species. Other possible examples of complementary pine and hardwood species in the Southeast might include shortleaf pine and white oak. These are both slower growing species that often occur together on lower productivity sites, but these species have different crown structure and leaf phenology which could make them compatible. Another example is loblolly pine and yellow-poplar, which are both fast growing species that perform well on good productivity sites, yet they have different crown structures and leaf phenology. Limited information is available on compatible species mixtures in the Southeast (Clatterbuck and Hodges 1988).

- **Availability of prescribed fire:** Prescribed fire (if feasible) may also be a tool that landowners might consider for MSM. Prescribed fire is an important component to various forest management techniques including MSM, but especially in pine monocultures. Especially in younger mixed stands, burning can influence or alter species composition and stem densities, but the degree to which this occurs will depend on fuel bed characteristics (e.g. a fuel bed with pine needles will burn more readily than hardwood leaves only), seasonal influences and the way the burn is conducted. Prescribed fire should be used cautiously with young hardwoods and loblolly pine until they reach groundline diameters larger than 3-4 inches and heights greater than about 15 feet as fire can easily topkill trees smaller than these thresholds. Overall, more frequent prescribed fire tends to favor pines and early successional vegetation such as grasses and forbs, which is generally beneficial for deer and



Figure 3: Example of an even-aged twenty-year-old loblolly pine and cherrybark oak stand. These two valuable timber species often occur together naturally on certain sites in the Southeast. Photo: Mike Blazier, Louisiana State University

turkey habitat. However, prescribed fire may be unavailable on properties located near urban or sensitive areas (schools, hospitals, etc.) due to smoke management concerns. In addition, bottomland or riparian sites may not reliably burn at all or on a regular basis. For these properties MSM might be a good alternative as they can rely on herbicides to maintain desired species diversity and density.

- **Presence of invasive species:** Management will need to be more aggressive to maintain MSM on sites where invasive species such as kudzu, Chinese tallowtree, and yaupon holly are already established. Invasive plants crowd out native and desirable vegetation, and can be difficult and costly to manage after they are established. Herbicides are most effective at killing the entire plant, but with some species herbicides must be combined with mechanical methods or prescribed fire to make herbicide applications more effective. The earlier that invasive plants can be controlled after they become established, the less effort and cost will go into their management. Mechanical, herbicide, and prescribed fire treatments to suppress or control invasive plants might also be compatible with MSM.

ECONOMIC & SOCIAL FACTORS:

As landowners consider MSM there are a number economic and social factors to contemplate. Factors such as ownership size, proximity to mills, profit generation, management interests and level of risk aversion associated with management factor into the types of forests landowners might consider managing. Below are a few factors to consider:

When to consider MSM:

- **Smaller tracts (under 40 acres):** The economies of scale for traditional pine plantation management are challenging on small tracts. Planting, thinning, and prescribed burning can be difficult on tracts smaller than 40 acres. Tracts smaller than 40 acres that already have naturally occurring mixed stands on them may offer a low cost, limited to no management situation. Cost share funds for qualified landowners of smaller tracts may allow for intermediate management activities such as herbicide midstory removal to improve tree species composition or crop tree release to concentrate growth on more valuable wildlife and/or timber trees.
- **Interest in species diversity:** Hardwoods offer their own aesthetic value. Landowners interested in greater stand diversity, wildlife habitat and recreation values associated with different stages of forest development that occur with MSM might consider it as a management option. Depending on the species composition, mast producing hardwood species could be favored in the species mix, and/or lower basal areas may be managed for to maintain understory herbaceous vegetation diversity.
- **Risk adverse:** Pine monocultures can offer greater economic returns but may have risk factors that landowners might not like. Pine monocultures are subject to loss from insect pests such as pine bark beetles. Pine bark beetles are likely to become a greater concern with climate change models projecting more frequent and intense droughts in the Southeast, though mixed stands (especially older stands) would still need to be actively managed (e.g. thinning, prescribed fire, etc.) to avoid issues with insect pests. Mixed stands are projected to be resilient and more adaptable to predicted climate change than less diverse forest types in the Southeast (Kabrick et al. 2017). Additionally, MSM diversifies landowner portfolios between both pine and hardwood markets, which may reduce investment volatility. Market downturns, as experienced in the last decade, have resulted in softwood price drops and markets have only partially recovered. Hardwood markets, by contrast remain strong. Diversifying a 'timber portfolio' reduces investment risk for risk adverse landowners.
- **Interest in low-intensity management:** While MSM can be intensively managed to maximize timber production or specifically alter species compositions, they can also be ideal management styles for absentee or busy landowners (Figure 4). Properly managed pine plantations can require fertilization, vegetation management, and thinning at fairly precise intervals in order to optimize stand development and prevent losses to pine bark beetles; these activities may be difficult for absentee landowners to implement. Mixed-stand

management may be no management or only consist of one management activity until the stand reaches thinning or rotation age. For example, a one-time release herbicide application to alter species composition and reduce competition for desirable species may be the only management activity needed for a rotation.

- **Profit is not a priority:** Increasing numbers of landowners do not place profit as their top priority. While income generation is generally one of the top ownership priorities, landowners less interested in maximizing profits may find MSM as a good alternative. As compared to pine plantation management, MSM has lower revenue generation potential, but it also has a lower floor due to a lack of possible downturns with softwood markets or losses associated with pine bark beetle outbreaks. Mixed stands will tend to grow somewhat slower than pine plantations due to growth rates associated with individual species and competitive interactions among species; as a result mixed stands will have a lower rate of return on investment in most situations. In regions where pine markets are limited (demand for pine pulp and sawtimber has decreased) or certain product classes offer poor returns, MSM management may offer the best management option to offset low pine prices.

- **Strong hardwood and pine markets:** Regardless of whether income is a top priority, having markets to sell timber will be necessary to attract loggers to selectively harvest (i.e. harvest either pines or hardwoods) or thin forests. In pine systems, all that is needed are pine mills in close proximity (usually 50 to 100 miles). For MSM, hardwood markets will also be needed. Ideally, for landowners interested in active management, there would be both a hardwood pulp and sawtimber mill in the area. Without both markets, MSM will be difficult to implement, as their will be limited economic returns and loggers will be unwilling to thin or harvest hardwood stands. Using Georgia as an example, there are 33 sawtimber mills that accept both hardwoods and softwoods, only 10 of those are south of Macon (approximate north and south midpoint line of the state). There are 12 hardwood sawtimber mills in the state, and only three of those are south of Macon. There are 39 pine sawtimber mills and 27 of those are south of Macon. There are 11 pulp mills and only three are north of Macon. Georgia has 20 chip mills and only 6 of those are north of Macon. There are other mills such as energy, veneer, mulch, shaving, etc. that also accept various mixtures of pine and hardwood. This example illustrates that MSM may be suited to more specific regions of the state you live in based on markets. Consult with a forester to determine what markets are available and where they are located (haul distances) in your state. Nevertheless, it is important to remember that MSM can also be managed in the absence of timber sales, which may suit landowners with aesthetics or ecological management objectives.



Figure 4: *In some instances, mixed-stand management can offer a “hands-off” approach to management as has been done in this young loblolly pine-hardwood mixture following a clearcut harvest. This form of management may be appropriate for absentee landowners.* Photo: Stephen Peairs, Clemson University.

MIXED-STAND MANAGEMENT LANDOWNER SCENARIOS

The Hargraves Family and the Silvicultural Considerations of MSM

Mr. and Mrs. Hargraves live with their two teenage sons, John and Shawn, in downtown Atlanta. Mr. Hargraves is an attorney with a large Atlanta law firm, while Mrs. Hargraves is a pediatrician. Mrs. Hargraves recently inherited 87 acres of forestland in rural central Georgia from her deceased father. Mrs. Hargraves has no specific objectives for the property other than to keep the property in the family. She is willing to listen to professional opinions to help decide on the best management option(s) for the property. With school, work, after-school activities, and weekend commitments, the Hargraves do not intend to put a lot of time or effort into the property. Therefore, they anticipate using a more hands-off management approach.

Being a resourceful person, Mrs. Hargraves contacted her cousin Fred in Albany, Georgia, for some ideas. Fred is a forester and had just returned from Alabama after attending a continuing education class on MSM. During the course, Fred learned that stands with both hardwood and pine components have the potential to mitigate a variety of risks. For example, pure pine stands may be more likely to experience stand level disturbances, or volatility in softwood (pine) markets could occur. Mixed-stand management, by contrast, reduces these risks, because the volume in a stand is spread across species, which mitigates risk from species-specific threats or market volatility.

Fred explained to Mrs. Hargraves that while in most cases overall stand productivity decreases with MSM, there is the potential for more variable timber products and markets with the presence of fast growing hardwood species such as sweetgum, yellow-poplar, or cherrybark oak growing in association with pine (Figure 5). Mixing pine and hardwood species can increase the availability of a limiting resource (e.g. crown and root growing space) and ultimately may reduce overall stand stress. Additionally, differences in crown architecture (shape), shade tolerance, and various physiological characteristics could result in complimentary resource use, while also decreasing among species competition and ultimately increasing production, though information is limited with regards to MSM and complimentary species mixtures in the Southeast (e.g. Clatterbuck and Hodges 1988).



Figure 5: *Example of an even-aged, twenty-year-old mixed loblolly pine sweetgum stand. Though overall stand volume growth usually decreases with mixed stands, other important management objectives may be met.*

Photo: Mike Blazier, Louisiana State University.

Mrs. Hargraves became interested in MSM after Fred told her about what he had learned at the continuing education class. Ideally, Mrs. Hargraves would simplify the process of converting to MSM by clearcutting the existing stand and replanting an even-aged, mixed-plantation consisting of loblolly pine and sweetgum, or by planting the pine and allowing sweetgum to regenerate naturally from sprouts and root suckers if sweetgum was present in the prior stand. Each species has a similar intolerance of shade and relatively high growth potential, but differing leaf phenology as well as susceptibilities to common pests and diseases. Most of the timber on Mrs.

Hargraves property is around age ten. Because the timber Mrs. Hargraves owns is in small size classes or consists of undesirable species, she currently does not have any timber worth harvesting; therefore, starting over will be expensive (it would require costly site preparation without a timber harvest to offset the costs) Instead, Fred recommends a slow process of using herbicides to select undesirable tree species for removal (these include species with limited economic or wildlife value). Herbicides will be applied to undesirable species using the hack-n-squirt application method. The stand is on an upland site, has a moderate site index for loblolly pine and sweetgum, and has a relatively even number of young pines and hardwoods per acre, so there is some potential for growing a pine-gum mixture. Mrs. Hargraves would like to apply prescribed fire for wildlife habitat benefits, but some hardwood species such as small diameter sweetgum do not have thick enough bark to resist heat associated with a prescribed burn and fire can kill the stems or reduce their wood quality. Mechanical or chemical thinning (hack-n-squirt) are probably better for these situations. Importantly, Fred tells Mrs. Hargraves that if the site had a higher site index, establishing a pine plantation might be better than MSM for increased forest productivity

Fred told Mrs. Hargraves that he would meet her at the property to discuss MSM. He also wanted to bring a Georgia Forestry Commission forester and a wildlife biologist into the discussion because MSM is not a common forest management approach in the Southeast and all perspectives and tradeoffs need to be addressed before beginning the project. He wanted his cousin to fully understand that transitioning into MSM would require more than low-intensity management based on the current conditions of her forest, yet it would be a more hands-off form of management than plantation management that would not require her to lose ten years of growth if she started over.

Bob and Chet Miller and the Economic Considerations of MSM

Bob and Chet are brothers living in rural Choctaw County in south Alabama. Both in their sixties, the brothers' properties are adjacent, and they farm the land their forefathers had worked for generations. The two brothers both want to manage their farms to produce periodic income from timber harvests and to maintain suitable habitat for white tail deer and wild turkey. The two brothers enjoy many of the same hobbies, such as hunting, college football, and gardening. However, like all brothers, they are also very different. Bob left home at eighteen to travel the world. During his travels, he took up skydiving and, whenever he can find the time, he drives his red sports car to the airport to pursue his favorite, adrenaline-filled past time. Unlike his brother, Chet does not like change, he does not take chances. He never left the farm. He rises every day – even Saturdays – at dawn, performs his daily routine to prepare for work, eats his daily oatmeal, and drives to his fields in his 2001 model pickup.

Bob's property contains a 150-acre loblolly pine plantation with a high site index (75 feet), while Chet's farm has three mixed stands, all of moderate site index. The mixed stands consist of planted sweetgum and loblolly pine as well as planted cherrybark oak and loblolly pine. Chet's farm also has a pure sweetgum plantation. One of the mixed stands had not been thinned (cherrybark oak and pine), one was thinned at age 18, and another was thinned at age 14. Chet decided not to put his land entirely in pine because he was concerned about an outbreak of southern pine beetle. Another concern for Chet with managing only pine was a gradual decrease in pine timber prices in his area at the time of plantation establishment. Mills that accepted both pine and hardwood were also within hauling distance of his farm, which improved prospects for multiple bids from different logging contractors. After consulting with his forester, he decided to spread the risk out through a diverse "portfolio" of pine, sweetgum and cherrybark oak.

Economically, Bob's pine plantation tends to outperform Chet's mixed stands, with the sweetgum performing worst of all. Over the years, the mixed stands achieved an average of 6% rate of return on initial establishment investments, Chet's goal for his investment. In one of the mixed stands, the pine in the mixture was thinned completely at age 14 achieving an internal rate of return of 8%. Pine and sweetgum were thinned at the same time in the stand that was thinned at age 18. This stand resulted in an internal rate of return of 4% because of smaller sweetgum wood yields per acre. The cherrybark oak and loblolly pine stand has not been

thinned yet due to the slower early growth rate of the cherrybark oak as compared to the loblolly pine, but the pine component of the stand should be thinned soon as Chet has noticed Ips beetle kill locations throughout the stand.

About five years ago, when the stands were 30 years old, insect damage resulted in 30 percent mortality of pine in all stands. The pine monoculture still outperformed the mixed plantations and sweetgum monoculture; however, the financial losses in mixed-plantations were smaller in percentage terms. Chet was happy with his decision to plant mixed stands because he knew the resulting financial losses indicated lower risk exposure in the mixed stands, regardless of whether there is a pest outbreak or not. Moreover, the mixed stands lost less volume than either monoculture stand (10-16% of green tons per acre) for the mixed-plantations and 20% of total stand volume (green tons per acre) for both pine-and sweetgum monocultures.

One of the most important aspects of Chet's success with MSM is a mill within 25 miles that accepts pine and another mill nearby that accepts sweetgum. This mill diversity, within an economically feasible distance to the farm, allows all parties involved to make a profit. Similarly, the opportunity to turn a profit means there are several loggers who will harvest Chet's trees, and loggers who have quotas may prefer mixed stands. This is an important consideration because, while the demand for pine sawtimber is stagnant, there is increasing demand for sweetgum used to make shipping pallets and railroad crossties. In summary, all the necessary factors have come together to make MSM a reasonable alternative management option for Chet.

The Byrnes and the Social Considerations of MSM

David, Jill, and daughter Abitha are the Byrnes family living in Southaven, Mississippi. David works in pharmaceutical sales, Jill is in marketing, and Abitha attends a college in Memphis. Of the three family members, only David is interested in the family's 27 acres of bottomland hardwood forest in Bolivar County, Mississippi. David inherited the property from his mother, who split the original parcel of 135 acres among her children. David and his siblings manage the property together for hunting white tail deer and wild turkey. He is open to the idea of harvesting timber if a harvest can provide income to be used for improving wildlife habitat across the property. David's property is a highly productive, late successional stand (mature) of cherrybark oak, and he has worked for several years with a professional wildlife biologist to ensure regeneration of his oaks.

Last year, David attended a workshop discussing MSM with the thought he would learn something about improving his stand for wildlife management. He liked the idea of MSM – in many ways it sounded good for his situation because he was not engaged in pine timber management and there are a number of characteristics of MSM that benefit wildlife such as more variable forest structure to provide shelter for wildlife and retention of mast producing trees while also having faster growing pines. After the workshop, he met with his biologist to discuss the prospect of MSM further.

Although David initially liked the idea of MSM for his property, his discussion with his biologist elucidated several reasons why the management approach does not fit well with his objectives, ownership situation, or the characteristics of his property. First, his primary objective is recreation. Regular revenue generation provided by MSM management is appealing, but he is primarily interested in recreation management for which he must maintain productivity of his mast producing hardwoods and maintain quality wildlife habitat. Second, he has no intention of investing in site preparation, or planting, and prescribed fire is difficult to implement on bottomland hardwood sites. Without significant cutting or site preparation it would be difficult to successfully establish pines in the stand he has now. He is interested in the long-term outlook of the property, and he knows that the oaks he has now could potentially become more valuable in coming years.

In addition, while he might consider growing sweetgum and oaks, pine may take more intensive management to grow on the site. Pine is not an ideal species for bottomland sites due to periodic flooding, unless intensive site preparation such as bedding is used to create raised planting beds and improve soil aeration for pine seedlings. Unless David clearcuts or creates large openings and mechanically beds the site, pine will most likely be unsuccessful if planted under mature hardwoods on this site. The concept of intentional MSM usually works best by planting fast growing shade intolerant hardwoods at the same time as pine, or by planting the pine component and allowing hardwoods to sprout or seed in among the pines. One of David's most critical limitations

is the parcel size. While small parcel sizes can work well for MSM depending on management activities that are utilized (e.g. herbicide applications), David would be unlikely to produce enough timber volume to be worth a logger's time and effort. Complicating matters is the lack of any pine sawmills in the area; therefore, there would be no market for his pines, even if he was determined to plant pines. Given these limitations, David decided to continue managing his property for wildlife habitat and hardwoods.

CONCLUSIONS

Mixed stand management offers a viable alternative to pine plantation management for private landowners in certain situations. Landowner objectives, scale of ownership, site characteristics, current vegetation, and local timber markets all should factor into deciding to manage for mixed stands. Mixed stand management has the potential to provide landowners with several benefits including: increased tree species diversity for timber products and wildlife habitat; low intensity and less involved management; suitability for small acreages; and it can be a low risk alternative to pine plantation management (insect and economic issues). Consult with a local forester or natural resource professional to determine if mixed stand management is a good management option for you and your property.

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