Strategic Reforestation Targeting High Priority Areas Maximizes Benefits to Forest-breeding Birds in the Mississippi Alluvial Valley

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BACKGROUND

One of the first biological plans for landbirds in the Mississippi Alluvial Valley (MAV) was the Partners in Flight (PIF) Bird Conservation Plan for the Mississippi Alluvial Valley (Physiographic Area #5; Twedt et al., 1999). This plan used suites of bird species to identify appropriate forest patch sizes for beneficial conservation. A central tenet of this PIF Bird Conservation Plan was the concept of forest core defined as large, contiguous patches of forest that were buffered from negative edge effects such as increased predation and parasitism. The Lower Mississippi Valley Joint Venture (LMVJV) partnership considers forest core as an essential component of conservation for forest-breeding birds, guiding how partners deliver habitat on the landscape to create intact, contiguous areas of forest.

The focus of restoration on forest core is crucial because over 50% of the forest-breeding species that the partnership has identified as high priority within the MAV are area sensitive (e.g., Prothonotary Warbler, Swainson's Warbler, Kentucky Warbler, Wood Thrush, Red-shouldered Hawk). Area sensitivity means that the size of a patch of forest affects the occurrence and population viability of a species, and that these species generally require large patches of habitat. To maximize conservation benefits to these forest-breeding birds, strategically targeting habitat delivery to areas that will effectively increase not only forest - but forest core - is critical.

The LMVJV Forest-breeding Bird Decision Support Model (FBBDSM; Twedt et al., 2006) was developed to address the need for strategically targeted reforestation in the MAV. Critically, Twedt et al. (2006) demonstrated that concentrating reforestation within the top 10% of reforestation priority bands (i.e., highest priority bands) resulted in a substantially greater proportion of forest core on the landscape than taking a random or opportunistic approach (Twedt et al., 2006). Subsequently, the FBBDSM guided strategic reforestation efforts in the LMVJV for nearly two decades. This model was revised in 2015 (https://www.lmvjv.org/s/LMVJV_FBBDSM_2015_Summary.pdf) incorporating contemporary landcover data and adjusted forest core calculation.

In this report, we demonstrate the continued conservation benefit to forest-breeding birds (i.e., proportion of forest core gained) of strategic reforestation as compared to random or opportunistic reforestation using updated methods and forest data with the latest FBBDSM. The goal of this effort was to compare the efficacy (as measured by acres gained of forest core) of "opportunistic" versus "strategic" reforestation within the MAV using a virtual reforestation approach (i.e., spatially explicit hypothetical reforestation scenarios).

METHODS

Strategic and Opportunistic Virtual Landscapes

We define opportunistic reforestation as non-targeted reforestation randomly dispersed across the entirety of the MAV landscape (i.e., not targeted towards high-priority areas). In contrast, strategic reforestation targets areas identified as high priority, with near or absolute adjacency to extant forested blocks.

Virtual reforestation of the MAV was based on the 2011 MAV Forest Cover classification layer (Mitchell et al., 2016) and the Lower Mississippi Valley Joint Venture's 2015 Forest-breeding Bird Decision Support Model (FBBDSM) for reforestation in the MAV (https://www.lmvjv.org/s/LMVJV_FBBDSM_2015_Summary.pdf, Figure 1, A). The FBBDSM is a distance-based raster layer that defines priority for reforestation of "restorable lands" (i.e., land that is currently in a non-forested state, excluding historic prairie, urban areas, and permanent water) for the benefit of forest-breeding birds in the MAV, where reforestation priority increases with proximity of restorable lands to extant forest and patch size. The FBBDSM layer values range from 0 (lowest priority) to 100 (highest priority), and are grouped into ten percentile bands, where the 90th percentile band (90-100) represents the highest priority areas for reforestation.

We define forest core as unfragmented forested area surrounded by a minimum of 250 meters of additional forest or other non-hostile habitat (e.g., permanent water bodies), which serves as a buffer against hostile habitats (e.g., agriculture/suburban/urban) and the potentially harmful effects associated with forest edge. Previous planning efforts had set the minimum buffer distance to 1000 meters (Twedt et al., 2006). However, a subsequent model update reduced the buffer to 250 meters (see *MAV Forest-breeding Bird Decision Support Model - Update 2015*).

To assess the effectiveness of strategic versus opportunistic reforestation, we cumulatively grouped priority bands within the FBBDSM layer to define ten virtual landscapes (Priority Band Groups [PBG], Figure 1, B) ranging from strategically targeted (i.e., PBG 10 with reforestation efforts restricted to the 90th percentile band area) to fully opportunistic (i.e., PBG 1, with reforestation efforts randomly distributed across the full range (0-100) of FBBDSM priority values for the entire MAV geography).

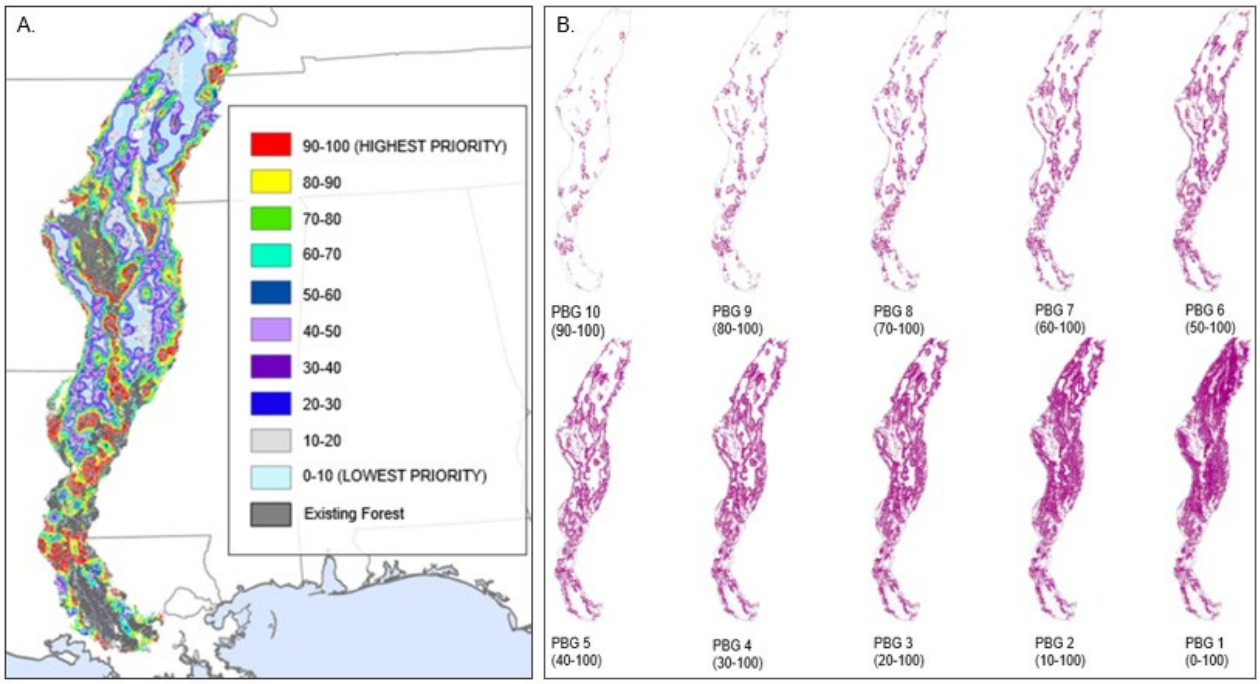

Figure 1. (A) The LMVJV's Forest-breeding Bird Decision Support Model (FBBDSM), updated in 2015 and (B) ten virtual landscapes of Priority Band Groups (PBG) generated for the virtual reforestation analysis in the Mississippi Alluvial Valley. Purple represents the virtual landscape for each virtual reforestation analysis. Virtual landscapes range in area from the most restrictive (targeted/strategic, PBG 10) to the most liberal (random/opportunistic, PBG 1). The numbers in parentheses below each PBG represent the corresponding range of FBBDSM priority values.

Virtual Reforestation

Once virtual landscapes were defined, we created a fishnet grid layer within each of the defined PBGs using (ArcPro 3.1.2) in order to randomly select virtual reforestation blocks. We used the median value (155.6 acres) of all Wetland Reserve Easement (WRE) projects within the MAV in the last three years (2020-2023) to define grid square blocks of 150 acres for each PBG. Each fishnet grid square was then clipped to available restorable lands. Therefore, virtual reforestation blocks (i.e., grid squares) range in size from 1 to 150 acres. For each analysis, we aimed to virtually restore approximately 1.5 million acres (roughly ten percent of the restorable land area in the MAV). Due to the randomized approach in selecting grid squares for virtual reforestation and the varying size of each individual grid square following clipping, total area of virtual reforestation varied slightly for each analysis, although each approximated roughly 1.5 million acres.

To randomly select grid squares for each virtual reforestation analysis, we exported the attribute table for the fishnet grid layer and used the random number function in Microsoft Excel v1808 to sort and select blocks to retain for virtual reforestation. This process was applied to PBGs 1 through 10. Following the selection of virtual reforestation blocks in Excel, we joined this table to the fishnet grid layer and used the

Feature Select tool to generate a new layer containing only the grid cells selected for virtual reforestation. For each PBG analysis, we then joined this virtual reforestation layer with the extant 2011 Forest Cover classification layer (Mitchell et al., 2016) to generate a final virtual forest layer. This process was repeated five times for each PBG in order to attain a mean result.

Forest Core Analysis

To calculate the area of forest core for each PBG analysis, we first combined the virtual forest layer with habitats that are known to be non-hostile to birds (as defined by Twedt et al., 2006) and then we removed 250 meters of "edge" from each non-hostile habitat / forest combination using an inverted buffer analysis in ArcPro 3.1.2. The cumulative sum of remaining forest in each grid cell represents the total forest core in the MAV. To determine the area of forest core gained through each PBG analysis, we repeated the inverse buffer process for the 2011 MAV Forest Cover classification layer to calculate extant forest core area. We then subtracted the 2011 forest core value from the forest core value calculated for each priority band analysis to determine the area of forest core gained through each approach (Table 1).

RESULTS

The 2011 MAV Forest Cover classification layer estimated roughly 7.8 million forested acres (Mitchell et al., 2016), with about 2.1 million of those acres defined as forest core. Through this series of virtual reforestation analyses, we estimated the potential total forest cover, including forest core, within the MAV under virtual reforestation scenarios based on 10 virtual landscapes, ranging from most strategically targeted (PBG 10) to fully opportunistic (PBG 1). The greatest benefit to forest-breeding birds (i.e., acres of forest core) was achieved when virtual reforestation strategically targeted the top 10th percentile of priority areas defined by the FBBDSM (PBG 10; Figures 2 & 3, Table 1).

Table 1. Mean total area of forest core gained (represented in raw acres and percent increase) in the Mississippi Alluvial Valley based on 1.5 million acres of virtual reforestation for each Priority Band Group (PBG).

Priority Band Group	Forest Core (acres gained)	Forest Core (% increase)
10	**1,743,802**	**82**
9	1,295,993	61
8*	1,190,067	56
7	1,144,784	54
6	1,110,362	52
5	1,086,605	51
4	1,061,349	50
3	1,055,266	50
2	1,034,966	49
1	1,033,397	49

*One outlier replicate was detected and subsequently dropped from the PBG 8 analysis.

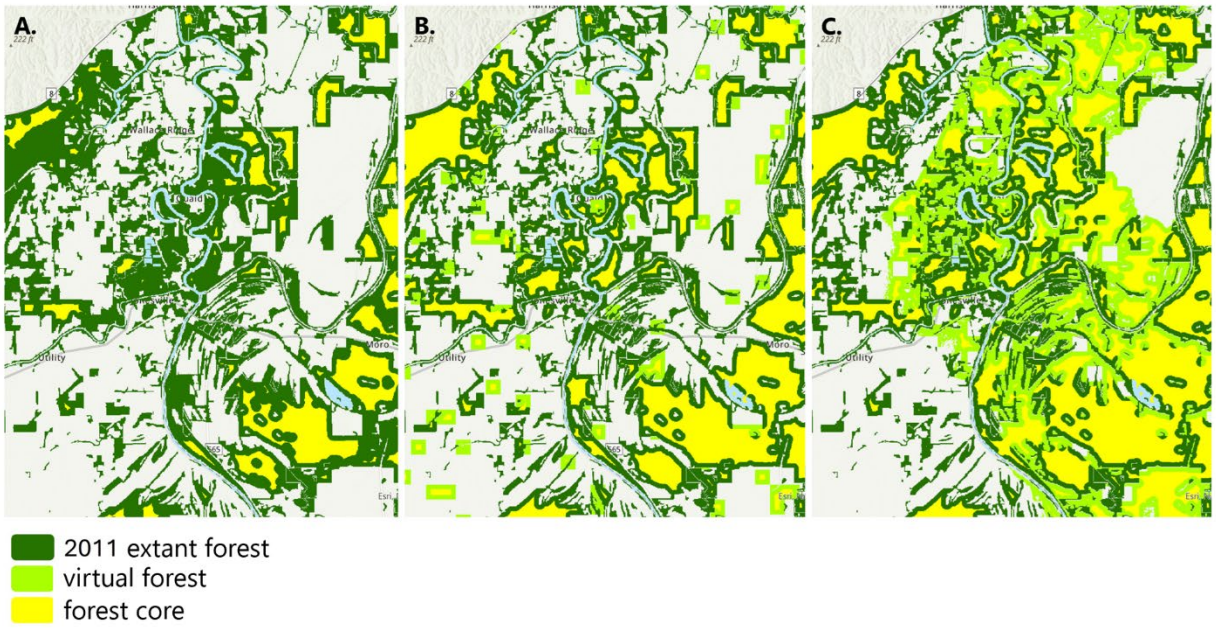

Figure 2. Visual comparison of (A) 2011 extant forest cover (including forest core) with potential forest cover and forest core gains under (B) the most opportunistic reforestation scenario (Priority Band Group 1), and (C) the most strategic virtual reforestation scenario (Priority Band Group 10).

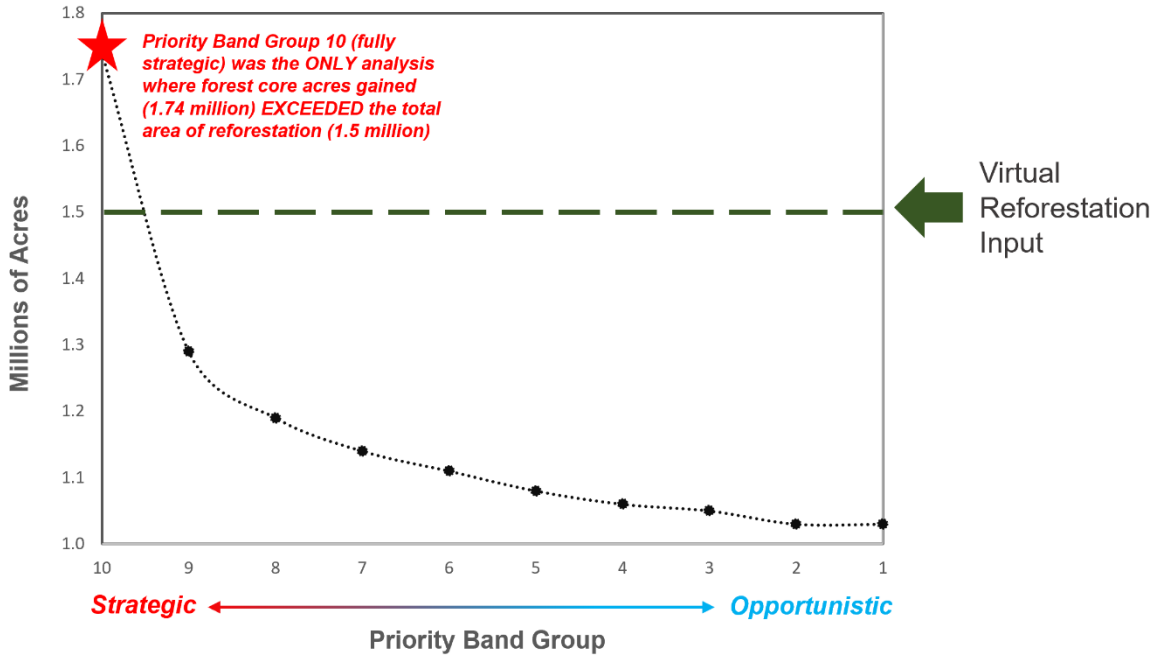

Figure 3. Mean number of forest core acres gained in the Mississippi Alluvial Valley during the virtual reforestation analysis for each Priority Band Group (PBG), representing five repetitions for each PBG. PBG 10 is the most strategic, whereas PBG 1 is the most opportunistic. The dashed green line represents the 1.5-million-acre target for our virtual reforestation.

DISCUSSION

This analysis successfully demonstrates the efficacy of strategic versus opportunistic reforestation. The maximum benefit of increased forest core is achieved within the first priority band of reforestation (e.g., the top 10th percentile). By focusing reforestation efforts on the top 10th percentile according to the FBBDSM, we can substantially increase our return-on-investment regarding benefits to forest-breeding birds. Not only does targeting the top 10th percentile increase the area of forest core by over 80% (Table 1), but the acres of forest core gained during the analysis of PBG 10 (1.74 million acres) exceeded the total number of reforestation acres (Figure 3). ***Thus, we strongly recommend that application of the FBBDSM for strategic reforestation target the top 10% of priority bands, which will yield the greatest conservation benefit to forest-breeding birds in the MAV****.*

Compared to Twedt et al. (2006; page 108, Figure 4), we note that, crucially, the top priorities are similar between the analyses. However, there are small differences between the analyses that could be driven by different forest core definitions, the implementation of over 2 million acres of reforestation on the landscape since the previous analysis, and the fact that our current analysis is a randomly generated process. By generating several replicates of PBGs and demonstrating the average and range of gain in forest core, we believe that this current analysis provides a better, more replicable model for future updates.

Other recent findings support the overall success of reforestation efforts within the MAV in recent history (Michel et al., 2023), which have been guided by the FBBDSM. In a step-down of the “3 Billion Birds” analysis (Rosenberg et al., 2019), researchers analyzed bird population trends within the Southeast region. The goal of this study was to compare avian population trends for the Southeast region with all North America. The analysis included eight Bird Conservation Regions (BCRs) within the Southeast, which are ecologically distinct regions within which there are similar bird communities, habitats, and resource management issues. Overall, the results indicate that trends in the Southeast region follow the continental pattern - with about 50% of all species analyzed in decline. However, of the eight BCRs assed in this analysis, the MAV (BCR 26) yielded the lowest rate of decline among forest-breeding birds, with only 30% of species analyzed experiencing a decline.

Notably, the stabilization of population trends of forest birds within the MAV appears around the same time (mid-1990’s) that conservation delivery programs - particularly Wetlands Reserve (initially Wetlands Reserve Program [WRP], currently Wetlands Reserve Easements [WRE]) - began to be implemented across the landscape (Figure 4). Since this time, forest area in the MAV has increased by well over one million acres – half of which now represent established stands over 20 years old (Michel et al., 2023). Importantly, WRP/E has employed the LMVJV’s FBBDSM as a component of project ranking, resulting in disproportionate strategic placement of WRP/E restoration within the highest priority FBBDSM bands. While we hesitate to blindly associate causation with correlation, the abundance of documented literature demonstrating a positive response in forest birds to reforestation efforts allows us to infer that this alignment

between stabilizing population trends and the establishment of significant, strategically targeted, large-scale reforestation efforts in the MAV indicates a positive, biological response. Therefore, we suggest that the reforestation efforts initiated in 1990's (e.g., WRP) have provided demonstrable benefits to forest-breeding birds in the MAV.

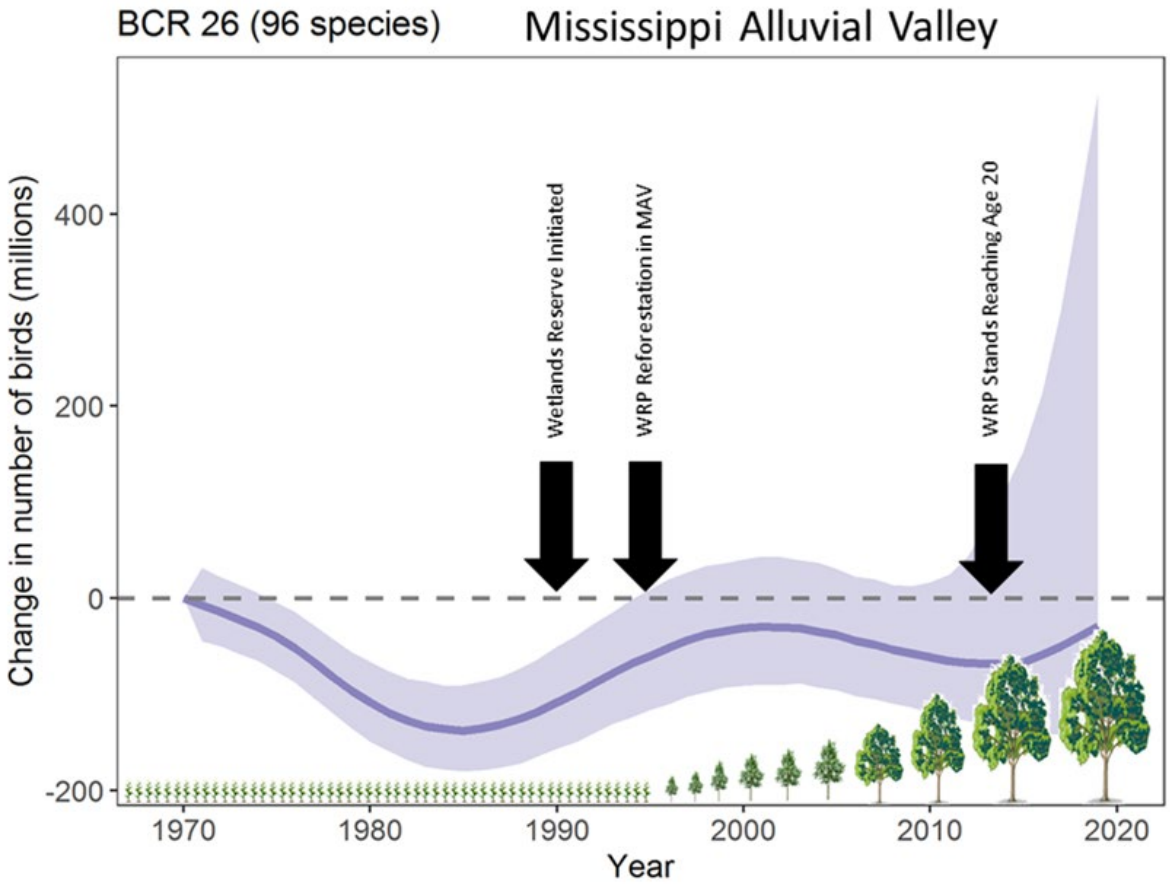

Figure 4. Chronological progression of Wetland Reserve Easement (formerly known as WRP) implementation and the subsequent stabilizing population trend estimated for forest-breeding birds in the Mississippi Alluvial Valley (Michel et al., 2023).

While the recent southeast bird trend analysis indicates that our efforts within the region are, in fact, having a positive effect on forest-breeding birds, it is important to recognize that our work is not done. To maintain a stabilizing trend (or potentially see an increasing trend), we must continue to maximize our impact through strategic application of habitat delivery. The analysis presented here supports the use of the FBBDSM in ranking and scoring proposed reforestation projects within the MAV and crucially demonstrates the importance of focusing habitat delivery within the highest priority areas.

Acknowledgements
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Appendix A. Relative value of Priority Band Groups to virtual creation of Forest Core based on a 100-point scale.

Priority Band Group	Relative Value
10	100
9	37
8	22
7	16
6	11
5	7
4	4
3	3
2	0
1	0