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Economic Impacts of the Implementation of the Missouri Pine-Oak Woodlands Restoration Project at the Mark Twain National Forest, 2012-2019: A Project of the Collaborative Forest Landscape Restoration Program

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Abstract

The Collaborative Forest Landscape Restoration project (CFLRP) “Missouri Pine-Oak Woodlands Restoration” is slated for implementation over 126,000 acres within the Mark Twain National Forest (MTNF). The MTNF-CFLRP area corresponds to about 0.8% of forest land in Missouri, 4% of the regional nine-county timberland area, and 8% of MTNF lands. About \$20 million will be invested to implement the project with one-half funded through the national Collaborative Forest Landscape Restoration Fund and the other half through MTNF matching funds, the Knutson-Vandenberg Fund, and non-governmental sources. By the end of fiscal year 2015 (30 September 2015) project expenditures totaled \$6.3 million in activities conducted on 36,300 acres.

The \$20 million invested in MTNF-CFLRP implementation is expected to support an average of 138 jobs per year and generate \$34 million in labor income as part of a total contribution of \$44 million in value added to the nine-county economy over the 2012-2019 period. These projected values are the results of a regional economic impact assessment using the model IMPLAN (Impact Analysis for Planning), based on past and future project implementation activities and projected forest conditions using the FVS (Forest Vegetation Simulator). Merchantable tree volume within MTNF-CFLRP lands at the end of this period is expected to exceed the initial volume by 14%. Considering that some management practices would be implemented even in the absence of the MTNF-CFLRP, net impacts of the project to the nine-county region were estimated at \$28 million in value added. Given the modest size and scope of the MTNF-CFLRP, this economic impact assessment found no discernable negative effects to the local nine-county wood products industry although impacts on particular industry segments and land management effects on timber quality will need further evaluation.

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Representation of open shortleaf pine woodland in the MTNF-CFLRP (Missouri Pine-Oak Woodlands Restoration Project), Mark Twain National Forest

Credit: Photo by USDA Forest Service

Highlights

- Lands managed under the Mark Twain National Forest Collaborative Forest Landscape Restoration project (**MTNF-CFLRP**) “Missouri Pine-Oak Woodlands Restoration” represent about 0.8% of forest land in Missouri, 4% of the regional nine-county timberland area, and 8% of MTNF land.
- About half of the scheduled \$20 million allocated for MTNF-CFLRP activities is funding conditional on the implementation of the Missouri Pine-Oak Woodlands Restoration project. The other half includes USDA Forest Service matching funding (such as Knutson-Vandenberg funding) and non-governmental sources.
- Economic and vegetation models suggest that **total** MTNF-CFLRP investment and subsequent implementation activities from 2012 to 2019 are likely to result in impacts to the local economy (a nine-county region where the project is expected to have its largest impact) as follows:
 - Over \$44 million in value added
 - Annual average of 138 local jobs supported, representing \$34 million in labor income
 - \$9 million in federal and state tax revenues
 - \$2.22 of value added to the nine-county economy for every \$1.00 invested.
- Considering that some management practices would be implemented even in the absence of MTNF-CFLRP, **net** impacts of the project to the nine-county region are estimated to be:
 - \$28 million of added value
 - 84 jobs supported
 - \$21 million in labor income
- Economic estimates are inherently limited by projections of future MTNF-CFLRP activities based on an assumption of constant economic multiplier effects.
- Merchantable tree volume per acre by the end of 2019 is estimated to be 14% greater with the implementation of the MTNF-CFLRP as compared to initial conditions.
- However, net growth in merchantable tree volume per acre would be higher under a scenario where MTNF-CFLRP was no longer implemented (19% greater in 2019 than in 2012).
- Timber harvesting and processing associated with MTNF-CFLRP is only a small fraction of the regional economic activity in logging and processing wood products because of the project’s small size and scope.
- Understanding of impacts of MTNF-CFLRP on specific segments of the local wood products industry as a result of changes in dominant species or quality of timber supply caused by restoration practices (such as prescribed fire) requires additional evaluation.

**Economic Impacts of the Implementation of the
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Background

The Missouri Pine-Oak Woodlands Restoration project at the Mark Twain National Forest (MTNF) was proposed under the Collaborative Forest Land Restoration (CFLR) Program. This project (MTNF-CFLRP) is currently under implementation to increase landscape diversity by restoring on suitable sites shortleaf pine (*Pinus echinata*) woodlands with a diverse grass/forb groundcover. The total MTNF-CFLRP management area (Figure 1a,b) encompasses some 126,000 acres slated for treatment, or about 0.8% of the total 15.1 million acres of Missouri forests and 8% of the 1.5 million acres of the MTNF (Figure 2).

The focal area for the study of the restoration project's local economic impacts consists of nine counties that have primary wood processing facilities near the MTNF-CFLRP area. The MTNF-CFLRP is located on about 4% of these nine counties' timberland base. Stands of hardwood tree species cover about 57% of the project area, and shortleaf pine stands cover about 43% of the project area. Lands dominated by hardwood species in the MTNF-CFLRP area represent about 2.4% of these nine counties' total timberland (USDA Forest Service 2014a,b). A detailed rationale for pine woodland restoration in the CFLRP area is provided in the 2011 proposal for the Missouri Pine-Oak Woodlands Restoration Project (USDA Forest Service 2011).

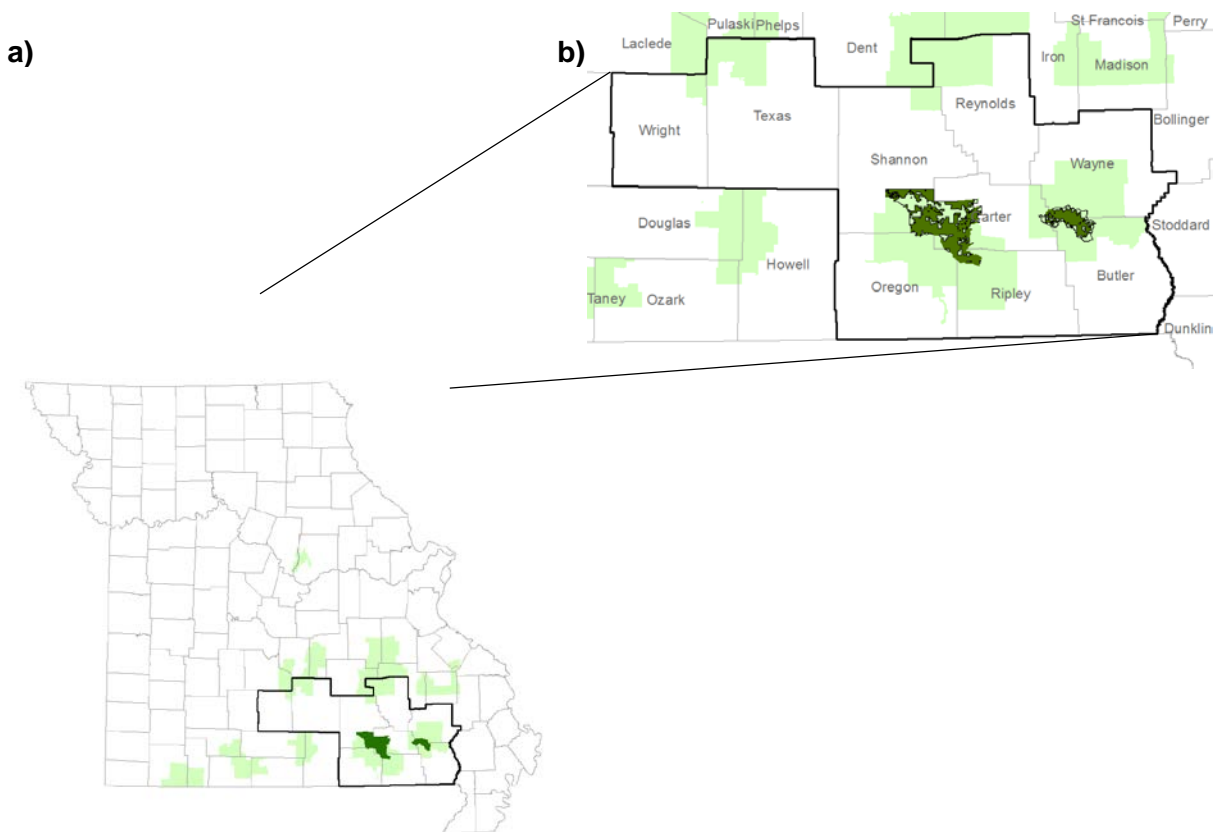


Figure 1. Missouri Pine-Oak Woodlands Restoration Project lands [darker green] (a) within the Mark Twain National Forest, Missouri, and (b) within the nine-county regional focal area for the economic impact assessment. MTNF lands not managed under a the MTNF-CFLRP are represented in lighter color. Source: Data from MTNF, USDA Forest Service (2014a).

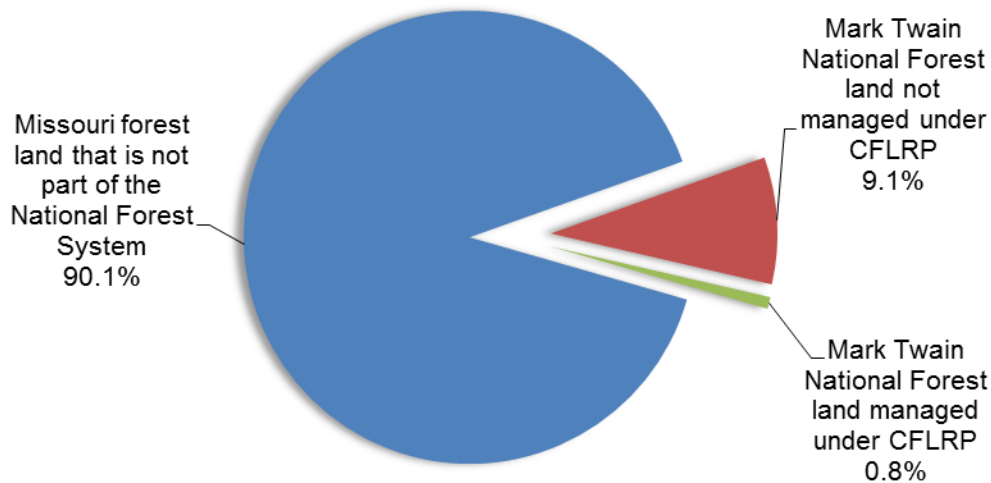


Figure 2. Shares of forest land, by acreage, in the state of Missouri and the Mark Twain National Forest. Source: Data from MTNF, USDA Forest Service (2014a).

Implementation of the MTNF-CFLRP started in 2012 and is expected to require a total of \$20 million in investments through 2019. Estimated financial support from the national Collaborative Forest Landscape Restoration Fund for the MTNF-CFLRP is \$10 million. The USDA Forest Service and other partners will provide an additional \$10 million in cash, materials, and services to match national funding over the same period. Part of the matching funds comes from Knutson-Vandenberg (KV) funding generated through products sourced from MTNF-CFLRP lands; part comes from other non-governmental sources. To date, MTNF-CFLRP partners have contributed \$173,588 through in-kind funding and agreements. Most of these funds have been in the form of labor costs to assist in collaborative monitoring. As of the end of fiscal year 2015 (30 September 2015), some \$6.3 million has been invested in project implementation activities conducted over 36,310 acres.

The nine Missouri counties with primary wood processing facilities near the MTNF-CFLRP area are Butler, Carter, Oregon, Reynolds, Ripley, Shannon, Texas, Wayne, and Wright. Collectively they form the focal area for the economic analysis of impacts associated with the MTNF-CFLRP. The combined population in these counties is 147,000 (about 21 people per square mile). Poplar Bluff is the largest municipality with a population of 17,000. Area statistics point to median household income below state and national averages, mostly rural populations, and a higher unemployment rate and larger contribution of the wood products industry to employment than state or national averages. About 40% of Missouri wood mills are located within the nine counties (Missouri Department of Conservation 2015). These mills employed 1,316 workers in 2012. They produce a wide range of wood products, such as lumber, pallets, poles, ties, cants, pulpwood, charcoal, and firewood. Ownership of forest land in the nine-county region is largely private (67%), followed by federal forest land (24%). **Table 1** summarizes regional statistics, along with state and national averages.

Table 1. Selected socio-economic and forest sector statistics for the nine-county region selected for the economic impact analysis, Missouri, and the United States

| Statistics | Nine-county region | Missouri | United States |
|--|---------------------------|-----------------|----------------------|
| Population (2014) | 143,000 | 6,064,000 | 318,857,000 |
| Percent rural population (2010) | 82% | 30% | 19% |
| Mean annual household income (\$/year, 2013) | 43,588 | 75,926 | 85,588 |
| Unemployment rate (2014) | 8% | 6% | 6% |
| Percent forest cover | 99% | 34% | 33% |
| Percent red oak volume ^a | 30% | 28% | 8% |
| Percent shortleaf pine volume ^a | 16% | 6% | 1% |

| Statistics | Nine-county region | Missouri | United States |
|---|--------------------|----------|---------------|
| Number of primary wood product processing businesses ^b | 155 | 387 | 6,550 |

Source: U.S. Bureau of Labor Statistics (2015), U.S. Census Bureau (2015), and USDA Forest Service (2014c). ^a Percentage based on growing stock of tree species in the red oak group, *Quercus* section *Lobatae*, at least 5 inches in diameter at breast height. ^b As of 2012 for Missouri and 2007 for the United States.



Log landing, shortleaf pine cutting unit, Mark Twain National Forest, Missouri
Credit: Photo by USDA Forest Service

Objectives

The objectives of this study were to (a) examine observed past and simulated future forest dynamics and wood removals as a result of the implementation of the MTNF-CFLRP and (b) assess associated local economic impacts through the end of 2019. Specifically, this study helps to answer the following questions in regard to MTNF-CFLRP implementation:

- (1) What changes in retained and harvested forest volume are expected from 2012 to 2019?
- (2) How many local jobs and how much labor income, value added and total output value are investments in the MTNF-CFLRP likely to support?
- (3) How much tax revenue is expected to be collected as a result of economic activities associated with MTNF-CFLRP implementation?
- (4) What are the expected impacts of the MTNF-CFLRP on the local wood products industry?

This report presents findings from **forest simulations** to answer Question 1, a **regional economic assessment** to address Questions 2 and 3, and preliminary results to answer Question 4.

Methods

Forest simulations were conducted by using annual estimates of forest growth and harvest volume generated from the Forest Vegetation Simulator (**FVS**) (USDA Forest Service 2015) to examine likely future forest conditions resulting from MTNF-CFLRP implementation. Please see **Appendix I** for a summary of forest stand treatments under the MTNF-CFLRP and **Appendix II** for more details on the FVS. Information from a grid inventory of the MTNF-CFLRP area provided initial forest conditions in 2012. Annual projections of tree growth, mortality, and harvest volume in conjunction with simulated treatments scheduled for individual MTNF-CFLRP stands estimated future forest change resulting from implementation. FVS simulation estimates were validated based on actual observed merchantable tree removals from 2012 to 2014. Proportions of the MTNF-CFLRP harvest used for lumber, wood containers, pallets, and woody biomass were based on estimates provided by MTNF management. Projected harvests and the condition of the remaining live trees by the year 2019 were compared to the baseline year (2012) to examine anticipated changes in merchantable and sawtimber tree volumes. Results were used to derive economic impacts on the local forest products industry.

The **economic analysis** was based on annual projections of financial investments in forest management activities and wood removal estimates from FVS simulation of the implementation of MTNF-CFLRP. **IMPLAN** (Impact Analysis for Planning), a computer model designed to assess regional economic impacts, was used to estimate the cumulative impacts of total MTNF-CFLRP investments in forest management and timber sale revenues from MTNF-CFLRP lands. Please see **Appendix III** for more information on IMPLAN. Total and net economic impacts of the project were derived by contrasting a scenario where the MTNF-CFLRP was implemented against an alternative with only partial investments (**Table 2**). The alternative scenario depicts conditions in the absence of additional CFLRP funding. For instance, if MTNF-CFLRP had not been implemented,

then activities on the project lands through 2019 would have dropped to only about 40% of the current implementation conducted by MTNF employees, 30% of the current contracted ecosystem restoration activities, and 20% of current contracted work on facilities, the watershed, roads, and trails.

For this economic analysis MTNF-CFLRP management practices were first categorized and matched to IMPLAN’s list of activities by industries, institutions, and households – the three main actors in an economy. MTNF-CFLRP practices were divided between two main categories: program implementation and monitoring. Impacts of forest management practices by USDA Forest Service employees were captured through the “Support Activities for Agriculture and Forestry” industry category in IMPLAN. Contracted hazardous fuels reduction and forest health improvement treatments were also primary forest management practices that match this category. Impacts of expenditures for CFLRP facilities, the watershed, roads, and trails were evenly split between “Construction of Other New Nonresidential Structures” and “Maintenance and Repair Construction of Nonresidential Structures” industrial sectors in IMPLAN. Forest monitoring activities implemented by the USDA Forest Service or contracted were modeled in IMPLAN through the “Contracted Monitoring” industry category. These CFLRP practices and their corresponding IMPLAN activities are summarized in **Table 2**.

Table 2. Specified MTNF-CFLRP practices, corresponding IMPLAN activities, and level of expected implementation in the absence of the MTNF-CFLRP

| Category of practices | IMPLAN activities (contribution factor)^a | Level of implementation in the absence of the MTNF-CFLRP^b |
|--|--|---|
| Monitoring by USDA Forest Service employees | Contracted monitoring (1.0) | 40% |
| Implementation by USDA Forest Service employees | Support activities for agriculture and forestry, industry 19 (1.0) | 40% |
| Services contracted for monitoring | Contracted monitoring (1.0) | 0% |
| Contracted facilities, watershed, roads, and trails work (FWRT) | FWRT maintenance (0.5) FWRT construction (0.5) | 40% |
| Contracted forest ecosystem management for hazardous fuels (HF) reduction and forest health (FH) | Support activities for agriculture and forestry, industry 19 (1.0) | 20% |
| Sawmills and wood preservation ^c | Commercial sawmill (1.0) | 40% |
| Wood container and pallet manufacturing | Wood container and pallet manufacturing (1.0) | 40% |
| Biomass energy generation | Biomass-Cogeneration (1.0) | 0% |

^a Contribution factors are proportions allocated to each practice. ^b Corresponding management treatment likely to take place in the absence of CFLRP implementation expressed as a percentage of corresponding treatment under CFLRP implementation. ^c Inclusive of logging operations.

Wood removed or projected to be removed from MTNF-CFLRP lands was allocated among three major wood consumption industry sectors: (a) sawmills and wood preservation, (b) wood container and pallet manufacturing, and (c) biomass energy generation. Each unit of wood removed was counted only once in these industry sectors. The number of workers needed to process each additional 1 million cubic feet of wood was based on Morgan et al. (2014) and used to derive total jobs supported by processing wood from MTNF-CFLRP lands. The value added and output impacts of the MTNF-CFLRP on wood processing industries (sawmills, wood preservation, and wood container and pallet manufacturing) were estimated through IMPLAN corresponding industry categories (**Table 2**). A new industry that generates electricity using wood chips in Missouri was created within IMPLAN by using parameters provided by economists on the USDA Forest Service Ecosystem Management Coordination staff.

The integration of the FVS forest simulations and economic analysis using IMPLAN is depicted in **Figure 3**. The analysis was adjusted to incorporate KV funding, defined at 25% of value of timber sales. KV funds generated through timber sales are returned to the National Forest and must be used for the improvement of forest lands from which timber was removed. This funding is part of the MTNF's match funding, and its amount could be different from KV funding included in the proposed budget. Therefore, a KV funding adjustment was added to make the total investment a function of timber removal.

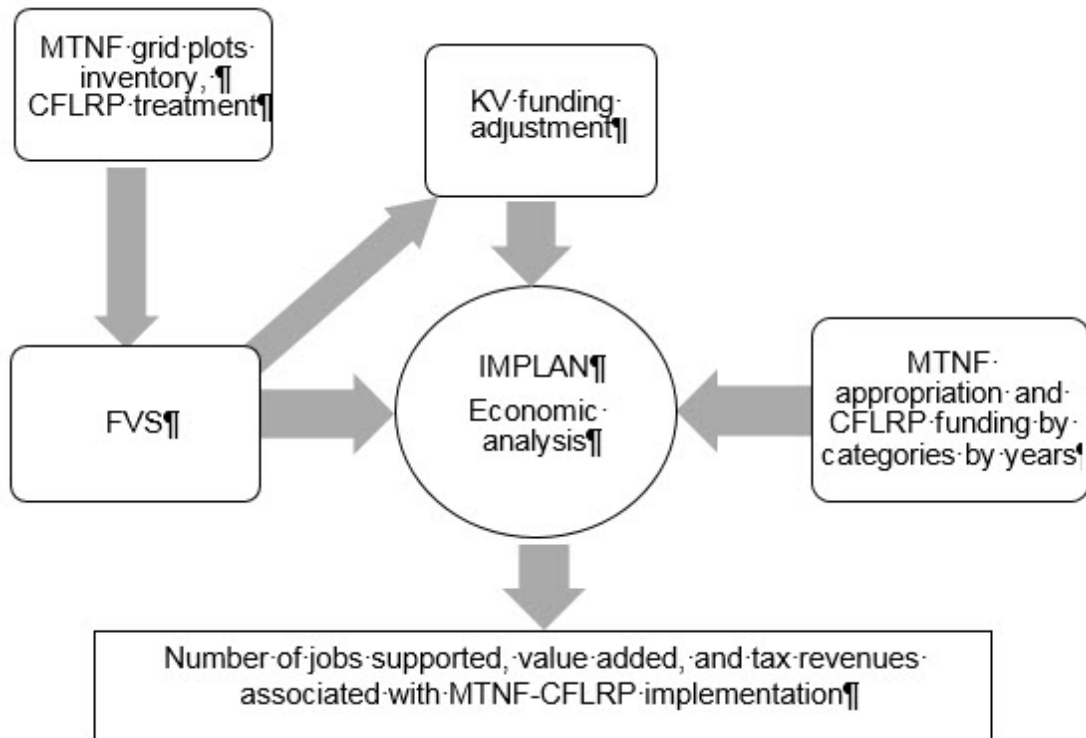


Figure 3. Diagram of steps followed to assess the economic impacts of activities associated with the implementation of MTNF-CFLRP.

Results

Forest simulations using FVS suggest that with additional tree removal in some forest stands (for example, forest thinning) the per acre average total merchantable volume will be 14% greater and sawtimber volume will be 20% greater in the MTNF-CFLRP area by the end of 2019 than in 2012. These increases imply that forest growth will exceed removals within MTNF-CFLRP lands. However, the expected merchantable and sawtimber volume of standing trees in 2019, as compared to 2012, will be about 5% lower than if MTNF-CFLRP had not been implemented. A summary of the simulation results is presented in **Table 3**.

Table 3. FVS simulated average per acre tree volume and removal prior and after MTNF-CFLRP implementation^a, and with no MTNF-CFLRP implementation

| Forest characteristic | Baseline (2012) Prior MTNF- CFLRP implementation (cubic feet/acre) | Evaluation scenarios (2019) After MTNF- CFLRP implementation (cubic feet/acre) | Evaluation scenarios (2019) No MTNF-CFLRP ^b implementation (cubic feet/acre) |
|---|---|---|---|
| Merchantable tree volume | 25.31 | 28.88 | 30.13 |
| Sawtimber volume | 18.29 | 21.89 | 22.80 |
| Total removal of merchantable tree volume in 8 years (2012 to 2019) | | 1.95 | 0.78 |
| Total growth of merchantable tree volume in 8 years (2012 to 2019) | | 5.52 | 5.60 |

^a Average on 126,000 acres of MTNF-CFLRP land. ^b Assumes 60% less removals than under MTNF-CFLRP. See Table 2 for details.

A summary of estimated local employment and economic impacts from the beginning of 2012 to the end of 2019 is presented in **Table 4**. Timber sold from these lands averaged \$0.51 per cubic foot of merchantable wood harvested in recent years. At this price the total projected value of timber removals from the MTNF-CFLRP over the 8 years is \$10.7 million. The \$20 million invested in MTNF-CFLRP implementation over the 2012-2019 period is expected to support an average of 138 local jobs and generate \$34 million in labor income in the regional nine-county economy. Values in **Table 4** suggest that MTNF-CFLRP's \$20 million investment will contribute \$44.3 million in value added (an approximate measurement of GDP increment), effectively resulting in an added-value multiplier effect of 2.22 on the local economy.

MTNF-CFLRP implementation can generate about \$9.2 million in federal and state tax revenues, about 46% of total investment. The \$44.3 million of value added from the project would generate \$6.9 million in federal tax revenue, based on a 15.5% ratio of net federal tax revenue to national GDP (U.S. Bureau of Economic Analysis 2015, U.S. Internal Revenue Service 2015). Likewise, value added would raise \$2.3 million in state

tax revenue, based on a 5.2% ratio of tax revenue to GDP in Missouri (Missouri Department of Revenue 2014).

Because of greater timber removals from MTNF-CFLRP lands, local sawmills will experience higher wood supply than if the MTNF-CFLRP is not implemented through 2019. The net increase in tree volume from 2012 to 2019 also suggests an increasing amount of wood supply beyond 2019. However, evaluation of impacts to particular segments of the wood products industry due to changes in the mix of species and in land management practices (such as prescribed fire), requires more-detailed forest simulations and a more in-depth economic analysis to determine how local businesses could potentially react and adapt to such changes. Landscape-scale shifts in tree species composition and size structure may take decades to materialize. Because the MTNF-CFLRP area corresponds to only 4% of the 3 million acres of timberland in the nine focal counties, 8% of the Mark Twain National Forest area, and only 0.8% of Missouri’s total forest lands, the impact of the MTNF-CFLRP on future forest conditions will be modest.

Table 4. Estimated total impacts on local^a average annual employment, total labor income, total value added and total output value associated with MTNF-CFLRP implementation by funding category

| MTNF-CFLRP funding category | Annual employment (jobs^b) | Total labor income (\$) | Total value added (\$) | Output value (\$) |
|--|---|--------------------------------|-------------------------------|--------------------------|
| Monitoring by USDA Forest Service employees | 0.1 | 33,859 | 39,001 | 63,872 |
| Implementation by USDA Forest Service employees | 21.9 | 2,817,419 | 1,274,147 | 4,050,411 |
| Services contracted for monitoring | 0.1 | 50,189 | 57,811 | 94,677 |
| Contracted facilities, watershed, roads, and trails work | 1.2 | 282,398 | 1,469,220 | 1,975,143 |
| Contracted forest ecosystem management for hazardous fuels reduction and forest health | 3.0 | 381,849 | 172,687 | 548,958 |
| Sawmills and wood preservation ^c | 85.9 | 23,122,914 | 30,896,012 | 131,405,397 |
| Wood container and pallet manufacturing | 21.8 | 6,109,934 | 8,732,402 | 23,480,608 |
| Biomass energy generation | 4.2 | 1,467,613 | 1,654,600 | 3,659,532 |
| KV funding adjustment | 1.2 | 157,242 | 127,180 | 290,396 |
| Local total | 138.2 | 34,266,175 | 44,295,879 | 165,278,598 |

^a Nine-county focal area used to define local economy. ^bRefer to definition of “Jobs” in the Glossary (Appendix IV). ^c Inclusive of logging operations.

Considering that some of the activities on MTNF-CFLRP lands would still occur if the project were not implemented, the **net** impacts of the MTNF-CFLRP were estimated at 84 jobs, \$21 million of labor income, \$28 million of value added, and a total of \$101 million output value. These estimates were derived after assessing overall project effects (**Table 4**) weighted by the percentage of activities likely to take place in the absence of MTNF-CFLRP (**Table 2**).

Conclusions

Simulations of forest dynamics show that forest tree volume in the MTNF-CFLRP area will very likely increase during project implementation, but the expected growth rate is smaller than if the project had not been implemented. MTNF-CFLRP implementation between 2012 and 2019 can support an annual average of 138 equivalent full-time local jobs with a total of \$34 million of labor income. This labor income is part of the \$44 million in value added out of a total value of \$165 million in products and services.

Net impacts of the MTNF-CFLRP, after taking into consideration activities likely to take place even if the project were not executed, were estimated at 84 jobs, with a total of \$21 million of labor income. The labor income is part of the \$28 million of value added from a total of \$101 million output value.

The greater supply of timber due to MTNF-CFLRP implementation will very likely support the manufacturing capacity of the local wood products industry. It is unlikely, however, that the project will have sizable effects on the statewide or regional (nine-county) timber supply because the project lands are only a small percentage of total timberland (about 0.8% of Missouri forests and 4% of the nine-county timberland area). Assessment of changes in tree species composition and timber quality due to landscape management restoration practices (such as prescribed fire) and impacts of these changes on specific segments of the wood products industry will require additional investigation.



Log deck, red oak, Mark Twain National Forest, Missouri.
Credit: Photo by USDA Forest Service

Appendix I. Mark Twain National Forest – Collaborative Forest Land Restoration Project Treatments

Treatments in the Mark Twain National Forest – Collaborative Forest Land Restoration project (MTNF-CFLRP) consist of two broad activity types: prescribed fire and mechanical treatments. Some implementation and monitoring activities are accomplished by MTNF personnel, but most are contracted out to private firms. Prescribed burning and mechanical treatments are used to develop and maintain desired tree species composition and size structure, promote desired understory vegetation, or suppress undesirable understory vegetation. Prescribed burning may have significant effects on tree regeneration and bush control, but it is not expected to affect timber removals over the 8 years of project implementation. Major treatments and their corresponding FVS management categories are listed in **Table A1**. Treatments are explained in more detail in the glossary (Appendix IV).

Mechanical and chemical treatments are used to remove and suppress both small and large plants and trees, mostly older red oak trees. The desired post-treatment stand density of forests in the MTNF-CFLRP ranges from 10 ft² of basal area for savannas (low-density forests with open space under trees) to 100 ft² of basal area for upland forests and woodlands, according to the MTNF Forest Plan. Thinning to reduce stand basal area is often achieved in two entries to avoid dramatic changes in forest structure. The first entry reduces the basal area and canopy cover to a mid-point toward the desired condition, and a second entry reduces the basal area to the target density. About half of the forest stands in the MTNF-CFLRP treatment area (656 out of the sampled 1,223 stands) are expected to be treated mechanically with some type of harvest between 2012 and 2019.

Table A1. Major CFLRP treatments and their corresponding treatment categories modeled in the Forest Vegetation Simulator (FVS)

| Treatment | FVS specification treatment |
|---|--|
| Commercial thinning/oak savanna restoration | Commercial thinning from above, 30% removal by basal area |
| Group selection harvest | Group thinning, default setting in FVS for the Mark Twain area (Central States); group opening size equal to 1.5 times the height of adjacent overstory trees; cutting cycle of 40 years |
| Pre-commercial thinning | Pre-commercial thinning from below, to 70 ft ² of basal area |
| Prescribed burning | Prescribed burning to reduce understory vegetation |
| Salvage/sanitation harvest | Removal of trees in the red oak group or other unwanted trees |
| Seed tree | Removal of all but five overstory seed trees per acre |
| Shelterwood preparatory cut | Preparatory shelterwood cut or shelterwood cut |
| Stand clearcut | Removal of all standing trees |
| Understory treatment | Thinning from below to achieve 70 ft ² of basal area |

Appendix II. Forest Vegetation Simulator (FVS) Software, Sample, and Validation

The Forest Vegetation Simulator (FVS) is software used to model forest stand growth under alternative treatment regimes. It is able to simulate the dynamics of managed forests decades into the future. In this study, simulation functions for growth, mortality, and regeneration were specified for the FVS Central States region. For each year growth, death, and removal (thinning) of sampled trees were simulated. Each tree's species, size, and number of competitors determined the rate of growth and mortality in the prediction. New seedlings were programmed to be added to the stand if conditions were favorable. Numbers of trees, merchantable and non-merchantable volumes, and removal of trees were updated at the end of each year of a simulation period. The inventory database for the MTNF-CFLRP area used to initialize FVS simulation included 1,223 sample plots systematically distributed across a rectangular grid covering the entire MTNF-CFLRP area. Each plot represents approximately 100 acres of forest land. A total of 18,699 sample trees were included in the sample plots.

Merchantable timber removal for economic analysis purposes was predicted by the FVS model. Our simulations showed that commercial thinning was the major source of merchantable wood products from the MTNF-CFLRP area. Existing forest stands designated for commercial thinning in the MTNF-CFLRP area have basal areas ranging from 90 ft²/acre to 200 ft²/acre. Thinning was modeled by removing a predetermined percentage of the total basal area. Past observations of timber removals were used to validate the FVS simulation for commercial thinning. Preliminary simulations with FVS showed that thinnings on average removed 30% of tree volume to yield 2.5 million and 2.1 million ft³ of merchantable timber in 2013 and 2014, respectively. This value was further validated based on MTNF leadership's professional opinions. Hence, a commercial thinning in FVS was modeled as a harvest of 30% of a stand's basal area. The estimated post-treatment basal area of trees ranges from 63 ft²/acre to 140 ft²/acre, high enough for most stands to have another treatment in the future before target stand density is achieved.

Appendix III. Impact Analysis for Planning (IMPLAN)

IMPLAN (Impact Analysis for Planning) is an input-output model that includes a matrix quantifying economic interactions among all industries and economic groups within a given geographic area (Day 2015). The program can estimate the economic impacts of changes in purchasing products and services in an economy. Impacts are derived from direct, indirect, and induced economic effects associated with new investments or activities (please refer to definitions in the Glossary in Appendix IV).

A project such as MTNF-CFLRP will increase purchase of products and services related to its implementation activities and, thus, lead to direct and indirect changes in employment and production in related industries and economic groups. Typically an impact is measured in IMPLAN as the effect of a unit change in production or service on employment, employee income, value added, and output in dollars. An IMPLAN activity represents a change in an industry, an institution's spending pattern, or specified demand for commodities. Each IMPLAN activity may include a combination of one or several industries. For example, each MTNF-CFLRP management practice was modeled by using one or two IMPLAN activities defined by IMPLAN; those activities are linked to numeric impact multipliers that are used in IMPLAN to estimate how changes in one segment of the economy affect others. County-level data matrices for nine counties of Missouri whose wood industry and labor market will most likely be affected by MTNF-CFLRP implementation were included in the IMPLAN analysis. These counties were: Butler, Carter, Oregon, Reynolds, Ripley, Shannon, Texas, Wayne, and Wright. Results in this report capture economic impacts within the boundaries of these nine counties to measure the localized impacts of MTNF-CFLRP implementation.

The impacts of MTNF-CFLRP investments in each industry category on local employment and economic activity were obtained through IMPLAN. These impacts measured changes in direct, indirect, and derived values for annual average employment, total labor income, total value added, and total output. When MTNF-CFLRP funding is used directly by MTNF employees, the expenditure was used for either monitoring or implementation. Funds allocated between monitoring and implementation by Forest Service employees for future years were 7% and 93%, respectively, based on the project budget. The rest of MTNF-CFLRP funding was used for contracted implementation and monitoring activities. Expenditures for these categories of future activities were assumed to be proportional to average expenditures to reflect data from previous years. For instance, it was assumed that the impact of biomass energy generation from wood was shared among the logging industry at 70%, maintenance of the electricity generating facility at 11%, electricity distribution at 10%, and other industries at 9%.

Appendix IV. Glossary

CFLR: The Collaborative Forest Land Restoration, which is a program created under Title IV “Forest Landscape Restoration” of the Omnibus Public Land Management Act of 2009 (P.L. 111-11). The purpose of the CFLR is to encourage the collaborative, science-based restoration of ecosystems in high-priority forest landscapes. MTNF-CFLRP is one of the projects supported by this program.

Clearcut: Regeneration method that removes essentially all trees in a stand. Small size clearcuts are used in the MTNF-CFLRP to make space for developing optimal forests from cleared forest land.

Commercial thinning: Partial removal of standing trees with revenues from product sales used to offset all or part of implementation costs.

Contracted ecosystem restoration: Ecosystem restoration practices such as hazardous fuels reduction and forest health improvement conducted by contracted private firms.

Contribution factor: Ratio between the expenditure for one IMPLAN activity and the total expenditure for a category of empirical practices. The sum of all contribution factors for each practice is 1. In most of the cases there is only one IMPLAN activity for a practice, and the contribution factor is 1.

Direct effect: Direct economic effect resulting from an activity on employment, labor payment, value added, and market output modeled in IMPLAN.

Forest land: Land that is at least 10 percent stocked with trees of any size, or that formerly had such tree cover and is not currently developed for a non-forest use. The minimum area for classification of forest land is 1 acre. The components that make up forest land are timberland and all noncommercial forest land.

FVS (Forest Vegetation Simulator): A computer-based system for simulating forest growth, yield, regeneration, removal, and structure and species dynamics overtime. For more details please go to <http://www.fs.fed.us/fmnc/fvs/>.

Group selection cut: A forest generation method that cut trees in groups mimicking small-scale natural disturbance and natural generation. Groups of about 0.5 acre are cut every 15 to 20 years.

Hardwoods: Dicotyledonous trees, usually broad-leaved and deciduous.

IMPLAN (Impact Analysis for Planning): An input-output software for simulating changes in employment (jobs), production, labor payment, and value added in different industrial sectors, institutions, governments and households. It is commonly used to assess employment and economic impacts of resource policies, conservation programs, and regional plans. For more details please go to <http://implan.com/>.

Indirect effect: Changes in demand for labor and goods that result from purchases and expenditures incurred for producing goods and services to meet the demand from direct purchase and expenditure. Indirect effects are calculated based on the economic data of industries and institutions involved in the production of goods and services needed.

Induced effect: In IMPLAN, it refers to changes in employment and economic measurements as a result of the expenditure of households of employees of companies or institutions that incur both direct and indirect expenditures.

Jobs: A job in IMPLAN is equivalent to the annual average of monthly jobs in an industry (this is the same definition used by Quarterly Census of Employment and Wages, Bureau of Labor Statistics, and Bureau of Economic Analysis nationally). Thus, 1 job lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months each. A job can be either full-time or part-time.

KV (Knutson-Vandenberg Act) funding: A proportion of sales from products from National Forest land allocated to manage the forest where the products are produced. The extraction and uses of the funding are regulated by the Knutson-Vandenberg Act; hence the funding is called KV funding.

Labor income: All forms of employment income, including employee compensation (wages and benefits) and proprietor income.

Merchantable timber: Trees that have market value, usually with diameter of 5 inches or more at breast height.

Multiplier effect: Measurement of a chain of larger or smaller scales of changes in other sectors of the economy as a result of a change in one sector of the economy.

Oak savanna restoration: The restoration of oak forest characterized by low-density crown coverage and open space under trees for wildlife.

Output value: Market value of products and services produced from economic activities.

Pre-commercial thinning: The removal of some trees before they reach merchantable size. The objective of a pre-commercial thinning is to cut some trees in overstocked stands to prevent stagnation and increase the growth of the remaining trees.

Prescribed burning: Also called controlled burning, used as a forest management method to reduce forest fuel load, remove unwanted species, clear ground for wildlife, promote regeneration, and improve soil. Careful monitoring of moisture, temperature, and wind speed is required for performing prescribed burning. Some states require certified prescribed burning managers to supervise a prescribed burning.

Salvage/Sanitation harvest: Removal of dying or dead trees because of age, insect, disease, wildfire or other natural damage.

Seed tree: A harvest method that keeps several standing trees after removal of most trees to produce seeds for regeneration. This method is used in MTNF-CFLRP to regenerate unhealthy forests.

Shelterwood preparatory cut: Thinning of a forest prior to major removals so that smaller trees can grow under the shelter of large trees. This method is used at the MTNF-CFLRP to regenerate trees of optimal species.

Softwoods: Coniferous trees, usually evergreen and having needles or scale-like leaves.

Timberland: Forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization.

Understory treatment: Removal of unwanted small trees and shrubs under forest canopy to make suitable regeneration conditions and wildlife habitats.

Value added: Difference between the value of goods and the cost of materials, supplies, and energy used to produce them. It is the contribution of an activity to overall GDP. It may include wages, salaries, interest, depreciation, rent, taxes, and profit.

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