

# ECOLOGICAL RESTORATION ON SURFACE COAL MINES IN APPALACHIA 2023 REPORT







# GREEN FORESTS WORK'S MISSION

Green Forests Work's (GFW) mission is to re-establish healthy and productive forests on formerly mined lands in Appalachia.

## INTRODUCTION

Since 2010, the US Department of Agriculture - Forest Service (USFS), in cooperation with Green Forests Work, a 501(c)(3) nonprofit organization, and many other partners, has been working to restore red spruce dominated forest on areas of the Monongahela National Forest (MNF) that were disturbed by surface mining. As a part of its commitment to Corporate Social Responsibility (CSR) and the "Komatsu Earth Environment Charter," Komatsu America Corporation began supporting this work in December of 2018. The objectives of Komatsu's support of GFW were to accelerate ecological restoration work on the Monongahela National Forest, and to promote methodologies that would increase native ecosystem restoration on disturbed lands in other countries and continents. Komatsu's initial financial contributions were to assist with the 2020-2025 restoration work on the Monongahela National Forest. This report details the progress that was made on the MNF during the period of May 1, 2019 – November 1, 2023.

In 2022, GFW began discussions with the Komatsu Green Business Promotion Department about the development of machines to aid reforestation efforts and tools for monitoring reforestation success. Those discussions led to the development of a new project in Martin County, Kentucky. Information related to that project is also detailed in this report.

In 2023, the Komatsu partnership has resulted in the planting of nearly **140,000** trees on **211** acres between three planting sites.



A seedling is planted in early May at the Mower Tract.

Table 1 – Summary of ecological restoration efforts that Komatsu has been involved in on the Monongahela National Forest since 2019.

Year	Site	# Acres	# Wetlands	# Trees Planted
2019	Komatsu Earth Day event	3		1,500
2020	Greenbrier RD	200	84	92,318
2021	Komatsu Earth Day event	3		1,650
2021	Greenbrier RD	184	108	119,710
2021	Marlinton RD	47		25,799
2022	Greenbrier RD	189	180	117,252
2022	Marlinton RD	46	78	34,230
2023	Greenbrier RD	160	60	105,215
2023	Marlinton RD	26		14,850
2023	Martin Co. KY	25		19,720
TOTAL		883	510	532,244





Professional tree planters begin to plant on Sharp 23.

## RESTORATION BENEFITS WV RED SPRUCE ECOSYSTEMS

Red spruce (*Picea rubens*) influenced forests have severely declined in West Virginia: The Red Spruce – Yellow Birch Forest (G2S2) and the Red Spruce – Southern Mountain Cranberry Forest (G2S1), which surrounds the Mower Tract, are imperiled<sup>1</sup> and critically imperiled<sup>2</sup> communities within the state, respectively. Protecting and re-establishing these communities is of conservation concern because they support 240 rare species in West Virginia alone. Red spruce have a limited range due to their specific site requirements. They grow best in cool, moist climates, which is why the high elevations of the Appalachian Mountains are one of the few places that can support their growth. Cheat Mountain, where the Mower Tract is located, has been identified by the Central Appalachian Spruce Restoration Initiative and The Nature Conservancy as a key red spruce corridor and top priority for conservation. Corridors connect large communities together, acting as roadways for all the living things within them. Having these connections between large communities allows species to move further north as the southern extent of their range becomes inhospitable due to climate change.



A red spruce settles into its new home on Cheat Mountain.

<sup>1</sup> Imperiled (S2) is a conservation status designated by NatureServe meaning that the species has a high risk of extinction due to restricted range, relatively few populations (80 or fewer), recent or widespread declines, or other factors.

<sup>2</sup> Critically imperiled (S1) is a conservation status designated by NatureServe meaning that the species has a very high risk of extinction due to extreme rarity (five or fewer populations), very steep declines, or other factors.





An excavator begins work on the decommissioning of sediment ponds at Cheat Mountain.

## RESTORATION TECHNIQUES

### REPURPOSING NON-NATIVE SPECIES

Grasslands and plantations of non-native trees, such as Norway spruce and red pine, were created on the mined areas during the reclamation process. The non-native species that were seeded and planted did not provide the same ecosystem services as native red spruce and needed to be cleared before soil decompaction activities could be performed. Although the non-native pines and Norway spruce could tolerate the compacted soil better than many native tree species, they still did not develop healthy roots or grow vigorously.

Since the stunted, non-native trees had little value for lumber or furniture, they were knocked down by a bulldozer or excavator, pushed into piles, and then scattered across the site after ripping. As they decompose, they will provide valuable functions on the site. The dead wood provides a suitable growth medium for mosses, lichens, and fungi, which support a variety of wildlife. The woody debris also provides habitat for a variety of insects, birds, and mammals. As the wood decays, nutrients and organic matter are provided to the soil, increasing the soil's fertility and water-holding capacity. The downed trees also increase the rate of natural regeneration by acting as perches for songbirds such as Dark-eyed Juncos (*Junco hyemalis*), which spread native seed in their droppings. Fire cherry (*Prunus pensylvanica*) is not planted but can be seen growing prolifically amid the piles of downed trees. Colonization of fire cherry and other native species has been attributed to the "perch effect," which increases species richness and the abundance of locally adapted plants.

## SOIL DECOMPACTION

Mitigating soil compaction is the most critical step in putting mined lands on a trajectory toward becoming native forests. Loosening the soil allows native plants to naturally regenerate by providing a suitable medium for root growth, while planting trees facilitates the process. Ripping is typically done in the fall when the soil is dry to maximize soil fracturing. Komatsu America Corp. has been providing equipment and funding to assist with site preparation since 2019. After the non-native trees are cleared by a Komatsu D61 bulldozer and PC210 excavator, local contractors rip the land using a Komatsu D155 bulldozer equipped with dual, rear-mounted ripping shanks that are spaced eight feet apart. After ripping is completed, the D61 and PC210 redistribute downed trees across the site.



## WETLAND CREATION

After the ripping and scattering of downed trees, a contractor is hired to create wetlands and vernal pools of varying depths and sizes. Wetlands are created by an excavator based on observed drainage patterns, evaluation of soils and sub-surface conditions, and previous work. Some of the drainages and sediment ponds that were created by mining companies can be improved and planted with wetland plants. The wetlands are created to intercept and retain precipitation and groundwater and trap sediment. They also provide habitat for amphibians and other wildlife species, and they provide suitable conditions for 145 state rare plant species known to be associated with wetlands in the High Alleghenies, including 60 critically imperiled (S1) species, 56 imperiled (S2) species, and 29 vulnerable (S3) species.

## PLANTING OF NATIVE SPECIES

In the spring following ripping, the reforestation sites and wetlands are planted with a variety of native plants by volunteers and professionals. Depending on the species, plants are established through direct seeding, or by the planting of bareroot seedlings, containerized/potted plants, and seedling plugs. To increase survival, the seeds and plants are purchased or grown from a locally adapted seed source. Red spruce is the largest component of every planting, overall comprising 41% of the total seedlings planted. Other native species are selected based on their benefit to wildlife, their association with red spruce forests and wetlands in the High Alleghenies, and how they compete with red spruce. For example, aspen is the second largest component of the plantings overall, because it is a fast-growing species and provides food and cover for wildlife, helping to quickly establish an early successional habitat. Aspen are also short-lived compared to red spruce and northern hardwoods, so they will not compete with these trees and will eventually be overshadowed by them. The average planting density of upland plants is 536 plants/acre, which leaves sufficient open spaces for natural regeneration. Wetlands are planted at a higher density of approximately 1,000 plants/acre.



Wildflowers and other native plants naturally colonize ripped areas. This bench was ripped in 2021 at Sharp Knob.





Aerial view of the ponds before work begins on their removal.

## POND DECOMMISSIONING

On the Mower Tract are a series of over fifty abandoned sediment ponds that border the downgradient side of our restoration area. Under current SMCRA regulations, these would have to be removed as part of the reclamation process. However, these predated SMCRA and were allowed to remain and today serve little ecological benefit and are a source of thermal pollution to downstream coldwater fish habitat. In an effort to address this problem, we initiated a project in 2023 to decommission the ponds and turn them into a complex of small wetlands with greatly reduced ponded area that can be planted with a mixture of wetland trees and shrubs that will grow and eventually shade the area. An area of approximately 60 acres will be converted at the site. Extensive earth moving and restructuring is required, and the project will likely be implemented in phases. Phase 1, which is ongoing, will eliminate 15 ponds and that area will be planted in spring 2024.



Post removal landscape in an area where one of the ponds was decommissioned.



# MOWER TRACT - GREENBRIER DISTRICT

## *SITE HISTORY AND PROJECT GOALS*

The Mower Tract (40,000 acres) of the Monongahela National Forest was purchased from the Mower Land and Lumber Company in the early 1980s. It is located on Cheat Mountain (4,848 ft elevation) in Randolph and Pocahontas Counties, West Virginia (Figure 1). The Mower Tract and the surrounding high elevation areas were historically dominated by old-growth red spruce and red spruce-northern hardwood forests; but after the industrial logging era of the late 19th and early 20th centuries, the red spruce ecosystem in the West Virginia highlands was reduced by an estimated 90%. Clear-cut slash ignited unnaturally hot wildfires, which eliminated the red spruce seed source and caused former red spruce forests to be replaced by even-aged, hardwood dominated forests. Extensive logging was linked to regional flooding and was key to the establishment of the Monongahela National Forest.

In addition to logging, coal mining further reduced and prevented the re-establishment of red spruce communities in West Virginia. In the Mower Tract, approximately 2,000 acres were surface mined for coal.

Reclamation laws required mining companies to return the site to approximate original contour and to control erosion, which was accomplished by compacting soils and planting non-native trees or seeding aggressive grasses and legumes. The Mower Tract was reclaimed to non-native conifer plantations and pasture and remained this way for over 30 years. Native species could not recolonize the reclaimed sites because of the compacted soils and thick grass cover.

Starting in 2010, the U.S. Forest Service began a partnership with Green Forests Work and the Appalachian Regional Reforestation Initiative (ARRI) to conduct a suite of restoration activities, including non-native species

removal, organic matter loading, soil decompaction, mined land reforestation, and wetland creation. In the short term, the goal is to create an early successional habitat, with the ultimate goal being to establish a forest that is at least 30% red spruce. Ancillary benefits include improved water quality, enhanced wildlife habitat, and improved ecosystem services, such as carbon sequestration.

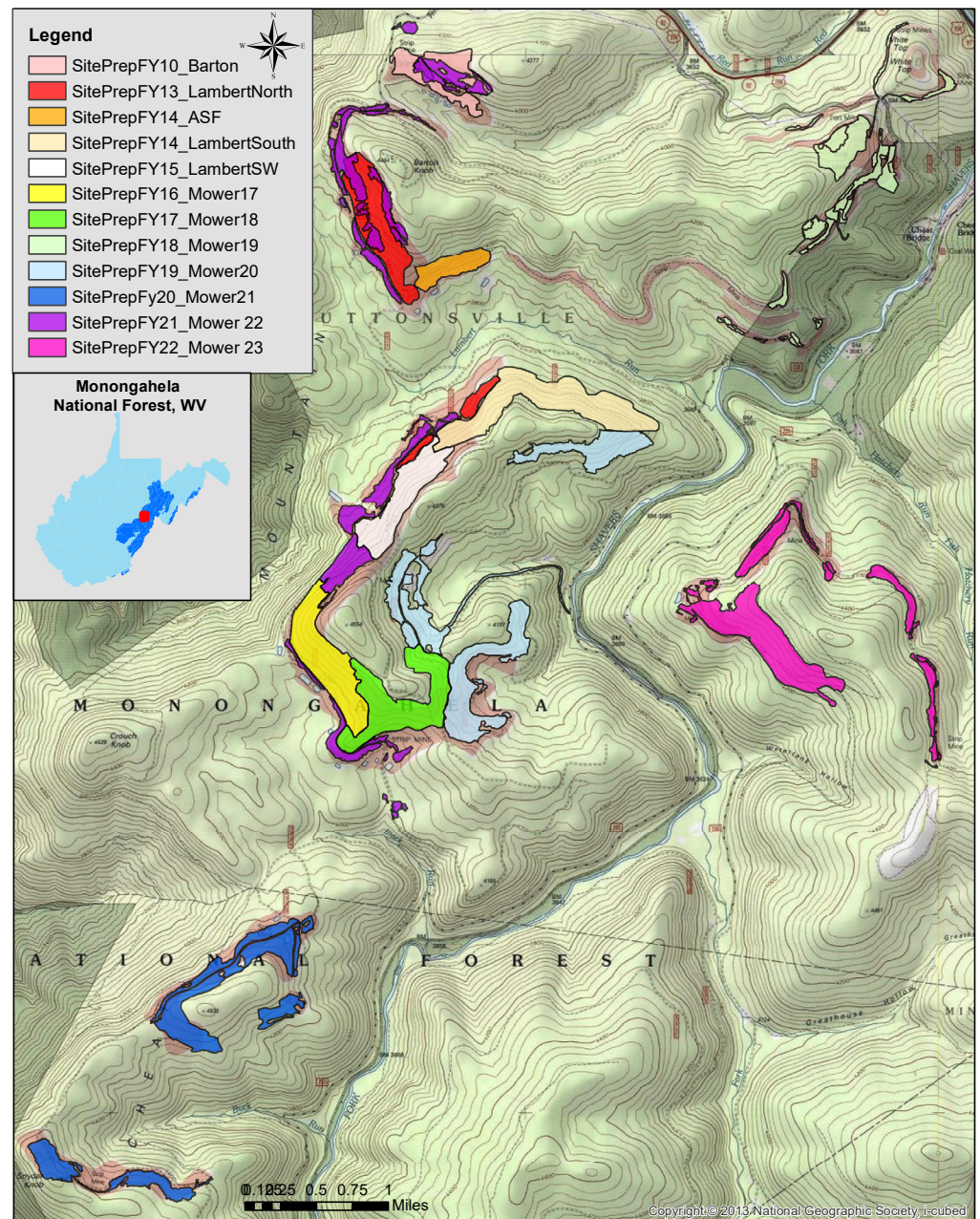


Figure 1. Map of restoration areas by year at the Mower Tract.





Contractors plant large aspen at pond area at the Mower Tract in 2023.

# 2023 MOWER RESTORATION

In 2023, GFW and partners planted 105,215 trees and shrubs and created 60 wetlands. Prior to planting, non-native species were removed and the soil was decompacted. In total, 733 acres have been restored in the Mower Tract since our partnership with Komatsu began. This has included the creation of more than 400 wetlands and the planting of over 400,000 trees and shrubs (Table 2). Although the majority of the planting has been accomplished by professionals, 70 volunteers from Komatsu have assisted us in these efforts since 2019. Table 3 lists the 60 native tree and shrub species and 4 herbaceous species that have been planted on the Mower Tract restoration areas over the years.

Table 2. Yearly summary of restoration activities.  
<sup>1</sup> Komatsu numbers only. Komatsu funding received in 2019 was applied to the 2019-2020 phase.  
<sup>2</sup> In addition to the 192 ripped acres, 8 acres of non ripped slopes were planted.  
<sup>3</sup> In addition to the 171 ripped acres, 18 acres of land ripped in the past project years were planted.  
<sup>4</sup> There is an overlap in the species planted each year. Across all years, more than 60 species of trees and shrubs have been planted, as well as many more species of herbaceous transplants and seeds.

Year Planted	Restoration Area (ac)	Wetlands Created	# Trees and Shrubs Planted	# Species Planted	Volunteers Engaged
2019 <sup>1</sup>	3		1,500	23	50
2020	200 <sup>2</sup>	84	92,318	21	0
2021	184	108	119,718	32	20
2022	189 <sup>3</sup>	180	117,452	31	0
2023	160	60	105,215	20	0
<b>TOTAL</b>	<b>736</b>	<b>432</b>	<b>436,203</b>	<b>60 total<sup>4</sup></b>	<b>70</b>



Table 3. Summary of the native tree and shrub species and herbaceous species that have been planted on the Mower Tract restoration areas over the years, along with their percentages of the total.

Species	Total Planted	% of Total	Species	Total Planted	% of Total
Red Spruce	344,952	43.73%	Maple Leaf Viburnum	1,500	0.19%
Bigtooth/Quaking Aspen	76,609	10.09%	Beech	1,415	0.18%
Speckled Alder	57,698	7.31%	Yellow Birch	1,413	0.18%
Black Cherry	47,201	5.98%	Bush Honeysuckle (Native)	1,384	0.18%
Silky Dogwood	20,643	2.62%	Red Oak	700	0.09%
Mountain Ash	18,807	2.38%	Blackhaw	652	0.08%
Winterberry Holly	17,837	2.26%	Other	432	0.05%
Red Osier Dogwood	18,850	2.39%	Fraser Magnolia	339	0.04%
Arrowood Viburnum	15,607	1.98%	Catberry	312	0.04%
Chokecherry	12,456	1.58%	Pin Cherry	250	0.03%
Serviceberry	14,178	1.80%	Bear Oak	240	0.03%
Sugar Maple	12,471	1.58%	Silky Willow	400	0.05%
Red Maple	13,292	1.69%	Red Raspberry	101	0.01%
Black Chokeberry	18,793	2.38%	Late Figwort	100	0.01%
Balsam Fir	13,780	1.75%	Red Chokeberry	100	0.01%
Hazelnut	10,115	1.28%	Steeplebush, Pipestem	100	0.01%
Black Elderberry	9,515	1.21%	Highbush Cranberry	75	0.01%
Witch hazel	8,150	1.03%	Red Mulberry	75	0.01%
Wild Raisin	4,953	0.63%	Swamp Rose	34	0.00%
Cucumber Magnolia	4,754	0.60%	Black Birch	33	0.00%
Ninebark	4,215	0.53%	Mountain Holly	32	0.00%
American Chestnut	3,558	0.45%	Hemlock	23	0.00%
Willow	3,324	0.42%	Black Raspberry	6	0.00%
Ironwood	2,900	0.37%	Skunk Current	6	0.00%
Red Elderberry	4,846	0.61%	Wild Grape	3	0.00%
Hawthorn	2,313	0.29%	Devil's Walkingstick	1	0.00%
Lowbush Blueberry	2,243	0.28%	<b>TOTAL Trees</b>	<b>788,771<sup>1</sup></b>	
Staghorn Sumac	2,102	0.27%	<b>Herbaceous Plants</b>		
Alternate Leaf Dogwood	2,475	0.31%	Penstemon	280	0.04%
Mountain Maple	2,675	0.34%	Smooth Oxeye	150	0.02%
Basswood	1,597	0.20%	Sweet Fern	100	0.01%
Nannyberry	1,586	0.20%	Milkweed	8	0.00%
American Plum	1,550	0.20%			

<sup>1</sup> Total trees planted 2010 to present.





Equipped with trees, professional tree planters set out on Sharp Knob site on a foggy morning.



A red spruce is planted at Sharp Knob in the early spring of 2023.

## SHARP KNOB - MARLINTON DISTRICT *SITE HISTORY AND PROJECT*

Sharp Knob, also located on Cheat Mountain in Pocahontas County, West Virginia, shares much of the local history of the Mower Tract in that it was also formerly dominated by red spruce forests before being replaced by northern hardwoods after logging and slash fires. In addition to logging, coal mining throughout Appalachia further reduced and prevented the re-establishment of red spruce communities. On Sharp Knob, approximately 700 acres were surface mined for coal. In contrast to the nearby Mower Tract, which was mined after the 1977 mining reclamation law (requiring mining companies to return the site to approximate original contour, compact to control erosion, and revegetate with grasses or plantations), Sharp Knob was mined in the 1960's and early 70's. Before 1977, once mining was completed, the mining companies revegetated the site by seeding non-native grasses and legumes and/or planting exotic tree plantations, and then had no further obligations; the sites were abandoned, leaving mine benches and highwalls. Abandoned mines often had problems such as land instability, erosion, and water issues. Sharp Knob has flat mine benches of exotic Norway spruce and red pine plantations, grasslands, and steep highwalls with large mine



ponds at the base. On the most compacted areas of Sharp Knob, due to soil compaction and thick exotic grass cover, native trees and shrubs are not able to colonize and exotic plantation trees grow stunted with shallow root systems. Roughly 60 years have passed since mining was completed at Sharp Knob, and very few native trees have successfully established on the most compacted areas.

GFW and the USFS intend to continue fundraising for additional Red Spruce Ecological Restoration projects, as well as expand to restoration projects on mined lands in other Forest Service districts, until we’ve reforested as much mining-degraded land in the Monongahela National Forest as possible. The process has begun for restoring mined lands on other districts of the Monongahela National Forest. Conversations between partners have been extensive, preliminary maps have been created, and a portion of the funding has been secured, and we expect to begin work in 2024.

Red Spruce Ecological Restoration on Sharp Knob has been a collaborative effort between GFW, USFS-Monongahela National Forest, Komatsu, Appalachian Headwaters, Argosy Foundation, Snowshoe Mountain Ski Resort, Appalachian Stewardship Foundation, Mennen Environmental Foundation, National Forest Foundation, Appalachian Regional Reforestation Initiative, Office of Surface Mining Reclamation and Enforcement, The Nature Conservancy, AmeriCorps-Appalachian Forest National Heritage Area, Natural Resources Conservation Service-Appalachian Plant Materials Center, Central Appalachian Spruce Restoration Initiative (CASRI), Arbor Day Foundation, West Virginia Highlands Conservancy, University of Kentucky, and many others.



Professional planters load red spruce trees into their bags before planting at Sharp Knob 23.

Table 4. List of native species planted at Sharp Knob each year. A total of 143,290 trees, shrubs, and herbaceous plants of 39 species have been planted from 2018 to 2023.

Trees and Shrubs	Total Planted	% of Total
Red Spruce	54,552	38.07%
Yellow Birch	17,761	12.40%
Black Cherry	15,250	10.64%
Sugar Maple	8,150	5.69%
Red Maple	9,780	6.83%
Quaking Aspen	7,180	5.01%
Allegheny Serviceberry	4,295	3.00%
Red Osier Dogwood	2,670	1.86%
Black Elderberry	1,600	1.12%
Red Elderberry	1,100	0.775
Silky Dogwood	1,525	1.06%
<i>Diervilla lonicera</i>	400	0.28%
Speckled Alder	5,608	3.91%
Alternate-leaf Dogwood	1,070	0.75%
Winterberry Holly	1,539	1.07%
Choke Cherry	701	0.49%
Hornbeam	38	0.03%
Cucumber Magnolia	27	0.02%
Arrowwood Viburnum	1,173	0.82%
American Chestnut <sup>1</sup>	750	0.52%
American Hazelnut	1,183	0.83%
American Plum	200	0.14%
Black Chokeberry	572	0.40%
Butternut	100	0.07%
Fraser Magnolia	11	0.01%
Lowbush Blueberry	25	0.02%
Mountain Ash	3,373	2.35%
White Oak	100	0.07%
Wild Raisin	32	0.02%
Willow	2	0.00%
Witch Hazel	150	0.10%
Hawthorn	318	0.22%
<b>Herbaceous Plants</b>		
Tall Sunflower	325	0.23%
Gray-headed coneflower	300	0.21%
Common Milkweed	30	0.02%
Blue Vervain	350	0.24%
Boneset	350	0.24%
Joe Pye Weed	350	0.24%
Swamp Milkweed	350	0.24%
<b>TOTAL</b>	<b>143,290<sup>2</sup></b>	<b>100%</b>

<sup>1</sup> Backcrosses provided by The American Chestnut Foundation.  
<sup>2</sup> Planted 2018 to present.



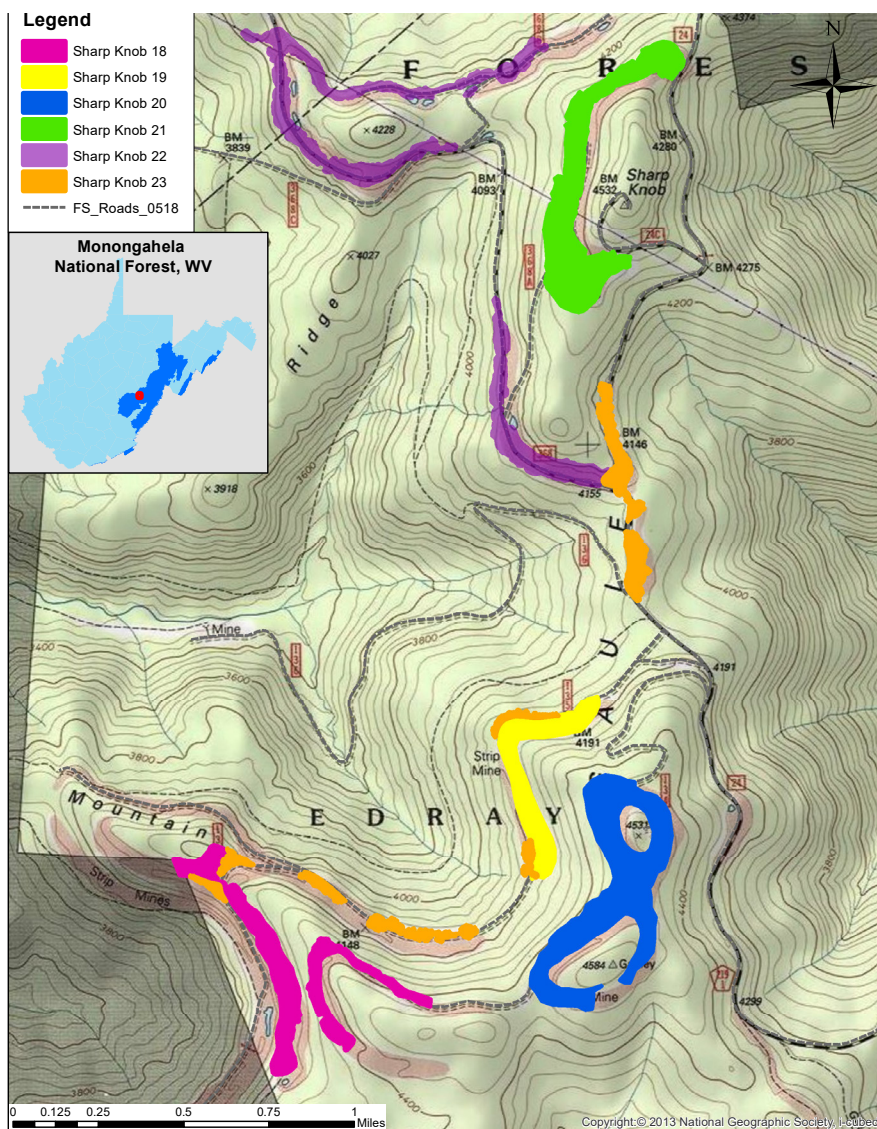


Figure 2. Map of restoration areas by year at Sharp Knob.

## SHARP KNOB RESTORATION ACTIVITIES

Since Green Forests Work began working with the U.S. Forest Service-Monongahela National Forest and Komatsu on Sharp Knob, restoration projects have taken place annually since 2020. Prior to planting, non-native species were removed and the soil was decompacted. So far, 184 acres have been restored, including 119 acres with funding from Komatsu from 2020 through present. 78 wetlands have been created and nearly 75,000 trees and shrubs planted (species are listed in Table 4), as well as over 2,000 native herbaceous plants (Table 4). Seeds of flowering species for pollinators have been spread throughout the restoration area. This past fall 2022, 26 acres were decompacted, and 14,850 trees were planted in the spring of 2023 (Table 5). This completes the mined land restoration on Sharp Knob.

Table 5. Yearly summary of restoration activities with Komatsu partnership.

Year Restored	Acres Reforested	Wetlands Created	# of Trees & Shrubs Planted	# Species
2021	47		25,799	17
2022	46	78	34,230	19
2023	26		14,850	16
<b>Total</b>	<b>119</b>	<b>78</b>	<b>74,879</b>	<b>48*</b>

\* In addition, over 2,000 herbaceous transplants of 7 species planted, and dozens of pollinator species seeded.



# KOMATSU GREEN BUSINESS PROMOTION DEPARTMENT: *MARTIN COUNTY, KENTUCKY*

This project is a collaborative effort by Green Forests Work, Komatsu Global, and the Appalachian Renewal Project (ARP) to test a remote forest monitoring platform on reforestation planting sites. Komatsu will perform R&D of their monitoring platform on a shortleaf pine-upland oak reforestation project in Martin County, Kentucky, USA. The reforestation site is owned by ARP and is located on a large surface coal mine that was reclaimed as pasture.

Site preparation, including deep ripping with a bulldozer and removal of exotic shrubs, was performed to reduce soil compaction and non-native plant competition. A total of 19,720 seedlings were planted on 25 acres during the 2023 planting (Table 6). In addition to the trees, native warm-season grasses and wildflower seeds were sown within the reforestation area. Initial inspection of the planting and spreading of seeds indicated high survival.



Plot layout at the Martin County site.

Table 6. Planted tree species at the Martin Co site.

Trees and Shrubs	Total Planted	% of Total
Virginia Pine	819	4.15%
Eastern White Pine	2458	12.46%
White Oak	4096	20.77%
Chestnut Oak	1639	8.30%
Northern Red Oak	1639	8.30%
Black Oak	819	4.15%
Yellow-Poplar	819	4.15%
Black Cherry	819	4.15%
Shagbark Hick.	696	3.53%
Mockernut Hick.	205	1.03%
Persimmon	410	2.07%
Sweet Birch	410	2.07%
Hackberry	410	2.07%
Red Mulberry	410	2.07%
Sycamore	410	2.07%
Black Locust	410	2.07%
Red Maple	410	2.07%
Sugar Maple	410	2.07%
Wild Plum	410	2.07%
American Crabapple	410	2.07%
Hazelnut	737	3.73%
Gray Dogwood	410	2.07%
Silky Dogwood	410	2.07%
American Chestnut	58	0.29%
Total	19,720	100%



White oak seedling showing its fall colors.

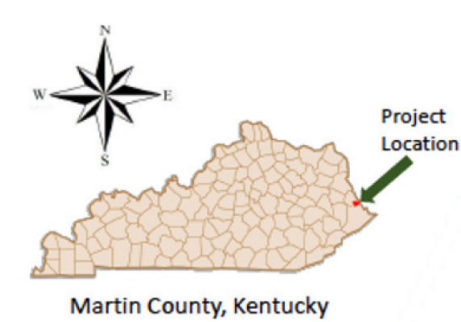




Project partners discuss site preparation prior to project implementation.

# MARTIN COUNTY, KY

The project is on a reclaimed coal mine in Martin County, Kentucky. The site exhibited an early succession habitat dominated by exotic plant species growing in excessively compacted soils. The site was logged in the early 1900s and again in the mid to late 1990s. Subsequently, the site was surface mined for coal from 2005 – 2015. The site was revegetated by 2016. However, the land was not managed, and the high-maintenance forages quickly collapsed and reverted to a landscape of weedy and undesirable species.



Location of Martin County, Kentucky tree planting site. Blue polygon outlines the project area.







Clockwise from top left: A Komatsu 61PX bulldozer removes unwanted vegetation at the site. Freshly ripped and uncompacted soil is ready to be planted. Tree planting crew busy at work.

## PLANNED WORK FOR 2024

Tree and shrub seedlings for upland areas and for wetlands have been ordered for planting in the spring of 2024 on the Greenbrier Ranger District mineland restoration project. A total of 75,000 trees and shrubs have been ordered. An additional 1,500 red spruce seedlings will be set aside for an Earth Day 2024 tree planting event with Komatsu employees. Phase II of the pond decommission work will continue into 2024. A new project site at the New River Gorge National Park, the nation's newest national park, has been identified and similar work may be initiated there in 2024.





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