United States
Department of
Interior - Office of
Surface Mining

Assessment of Reforestation on Reclaimed Indiana Surface Coal Mine Sites

A Review of Forest Land Uses Released from Bond for Analysis of Reclaimed Indiana Bat Habitat Conditions

Indiana Department of
Natural Resources -
Division of Reclamation

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1.0 Introduction

The Indiana bat (*Myotis sodalis*) was among the first species to receive formal recognition and listing as an endangered species by the United States government. The range of this federally endangered species spans 17 active and inactive coal mining states. Within this range, the hardwood tree species associated with a patchwork of forest, water, and agricultural ground in the coalfields of southwestern Indiana provide important habitat for the endangered bat. Surface mining within the region has caused temporary and extensive disturbance to the local environment and, in some cases, has effected Indiana bat's summer and winter (hibernacula) habitat. Often the activities of coal mining companies can conflict with efforts to protect Indiana bat habitat.

Early conservation efforts focused on the preservation of known Indiana bat hibernacula. Limestone caves and even some abandoned underground mines were closed from human intrusion with bat friendly gates. Current focus has shifted towards protecting the bat's summer habitat particularly its summer roosting and maternity sites. Efforts have been taken to minimize disturbing Indiana bat habitat such as protection of closed canopy stream corridors. Reclamation efforts have focused on creating future habitat suitable to the Indiana bat, namely establishing forested areas fragmented by open fields and water features.

Reforestation is a common post-mine land use option utilized by mining companies for reclamation. Forests and forested edge are important to the Indiana bat for both foraging and roosting. Additionally, roost suitable tree species are often planted in accordance with a permit specific species protection plan. Mine companies in Indiana have used reforestation as a restoration alternative for as long as reclamation efforts have existed. Few studies have provided insight into the status of these reclaimed forests after bond release. Rathfon and others (2004) found that sites reclaimed as forest in Indiana between the years of 1988 and 1995 showed lower than average productivity levels even though tree stocking appeared to be adequate. However, the study was not designed to quantify the number of sites originally reforested that still have trees on them. No study to date has examined the frequency of tree survival related to human land management activities on reclaimed lands after bond release.

1.1 Indiana Bat and Foraging Habitat Selection

The Indiana bat exists in pocket populations throughout most of the eastern United States. Recent population estimates of 400,000 are down from 900,000 individuals 30 to 40 years ago (Clawson 2004). Population declines have been attributed to disturbances at hibernation sites and loss of summer habitat.

Usually in mid-April when hibernation is complete, Indiana bats migrate to summer habitats where they prefer to roost under the bark of dead or dying trees. Preference is given to tree species which exfoliate bark in large sheets as they die such as ash, oaks, elms, hickories, poplars and maples. Additionally, a few live trees which exfoliate bark as they grow are also suitable roost sites such as the shagbark (*Carya ovata*) and shellbark hickories (*Carya lacinosa*). Generally, a roost tree is larger in diameter (greater than 22 cm) than surrounding seemingly

suitable trees. Primary roost sites are usually in the openings or edges of forest stands. Females can form maternity colonies of up to 100 or more individuals on a single or small cluster of trees and utilize as many as 20 trees in a single season switching between them frequently. Males share the same roosting preferences; however, they usually roost alone in trees or in small groups within caves (Kurta 2004).

Once considered a riparian specialist, the Indiana bat is now known to commonly roost in upland forests and in some wetland habitats as well. Roost sites typically exist in deciduous forests fragmented by agricultural areas. The Indiana bat prefers to travel and forage forested corridors and edges and will purposely avoid large open areas absent of forested cover. However, the Indiana bat will actively forage agricultural fields and old fields adjacent to suitable forests. They have also shown an affinity for canopy covered aquatic habitats particularly wooded riparian corridors. Indiana bats do not typically form colonies in areas of extensive forest (Kurta 2004).

Most Indiana bats travel less than three miles from their roost to forage and foraging area size varies greatly from 15 to over 7,000 acres (Sparks et al. 2004). The Indiana bat is a long lived species (up to 20 years) and is believed to return to the same roost trees, travel corridors, and foraging sites year after year.

1.2 Purpose and Need

The 1996 United States Fish and Wildlife Service (FWS) Biological Opinion addresses the Indiana bat. Regulatory authorities, acting in accordance with the Surface Mining Control and Reclamation Act (SMCRA) must require compliance with any species specific protective measures developed by the FWS field office and the regulatory authority.

Over recent years, the FWS, the Indiana Department of Natural Resources, Division of Reclamation (IDNR-DOR), and the Indiana Division of Fish and Wildlife have attempted to reach consensus on issues to be included in the species-specific protective measures document. The interagency agreement lacks only resolution regarding the FWS advocacy for mandatory long-term conservation easements. While the IDNR-DOR has no issue with conservation easements, they do not believe the authority exists under SMCRA to demand them.

The FWS maintains conservation easements are necessary because landowners often destroy reforested post mine areas for utilization of other land uses such as grazing and residential development. The IDNR-DOR believes this to be a rare occurrence. Federal and State agencies recognize the need to study forested sites for which the mine permittee had been released from final reclamation liability at least five years ago. Anecdotal information has led to the thought that restored forested resources are eliminated by landowners after the mining company's period of responsibility ends. The purpose of this study is to determine the existence/persistence of planted forest resources after complete bond release.

To meet these objectives, United States Department of the Interior, Office of Surface Mining (OSM) Mid-Continent Region personnel have teamed with both IDNR-DOR and IDNR-DFW

and developed site specific methodologies, procedures, and sampling to determine the existence of postmine forested acres on Indiana mine sites. Forested sites reviewed in this study have met postmine obligations and received termination of jurisdiction by the regulatory authority. Team goals included a review of the existence and status of post-mine forested resources on mine sites which received final bond release between 1/1/1996 and 7/31/2002. A land use analysis of how many acres of forested habitat are cleared and how much remains after bond release will assist OSM, the State of Indiana, and the FWS in ensuring the sufficient measures for protection of the Indiana bat are implemented. The end result of this process will aid in the development of an Indiana bat protective measures document approved jointly through the FWS and IDNR-DOR with OSM oversight. Using this information, the protective measures document will minimize permitting delays, provide for additional regulatory certainty, and further streamline permitting processes while providing adequate protection for the endangered species.

1.3 Post Mine Land Use

Recent research has suggested that Indiana bats may prefer a habitat mosaic of forests, open areas (pastureland and cropland), and water features (Kurta 2004; Sparta et al. 2004). This combination of land use creates substantial amounts of forested edge utilized by the Indiana bat for foraging and roosting. The post mine land uses of recently reclaimed lands may fit this mosaic pattern. Acres designated specifically for fish and wildlife use accounted for 25% of land released from bond between 1996 and 2002. Twelve percent of the reclaimed land was released as forest. Agricultural cropland and pastureland account for 24,138 acres (42%) of the post mine land use. Water features accounted for 8% of the acres released from bond. New ponds, lakes and water courses created during the mining and reclamation make up the majority of the 3,642 acres released from bond as water. Roads, residential, commercial and other developments accounted for just 4% of the total released acreage. The highly fragmented mix of forest, agricultural lands, fish and wildlife habitat, and water features produced as the result of mine reclamation in Indiana has the potential to provide critical summer foraging and roosting opportunities for the federally endangered Indiana bat. Figure 1 illustrates the proportions of various post-mine land uses of property released between 1996 and 2002.

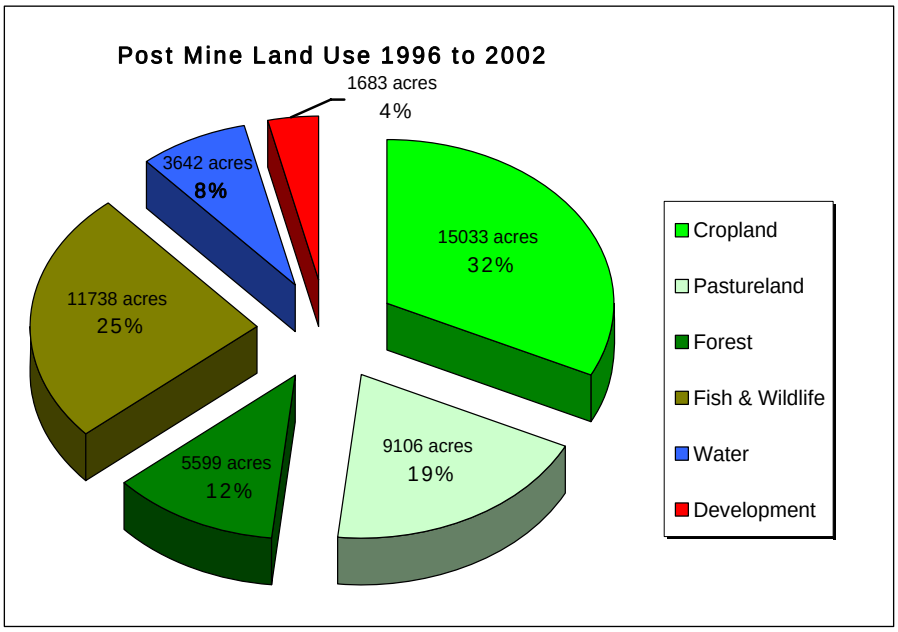

Figure 1. The annual combined post mine land uses of Indiana mines released from bond between 1996 and 2002.

2.0 Study Area

The study area is within the coalfields region of southwestern Indiana. Historically, southwestern Indiana was dominated by expansive grassland prairies and oak-hickory forests. As part of the Central Lowland Plains, most of southwestern Indiana is low rolling hills, knolls and low ridges stretching from the Wabash and Ohio rivers confluence in the south throughout the majority of the White River basin to the north. The geology of the area consists of a mantle of glacial deposits over subsurface sedimentary formations. The eastern parts of southwest Indiana contain steep cliffs and valleys where the land begins to rise into the foothills of the Cumberland Mountains of eastern Kentucky and the Interior Low Plateau Province. Southwestern Indiana's land use today is dominated by agriculture with some remaining forest remnants.

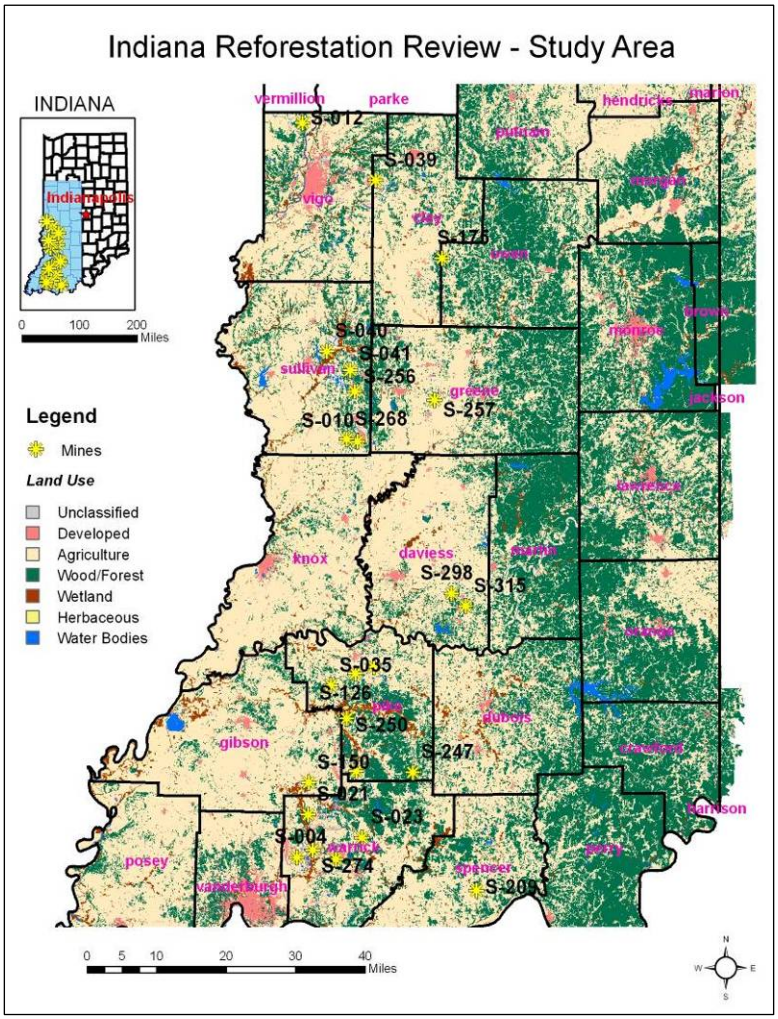

Figure 2. The 24 permitted areas evaluated in this study.

Mining is an active component to southwestern Indiana's economy and its people. According to 1999 estimates, coal mining employed over 3,000 people statewide. In Pike County, 16% of the total workforce is employed in the coal industry. The coal mining industry accounts for 1% of the workforce within the 15 coal mining counties of Indiana (IBRC 2000)

This study examined reclaimed coal mine sites at least part of which had been forest when the State returned the bond to the permittee. Forty-eight sites within 24 permit areas fit the criteria set by this study. The sites spanned ten of southwestern Indiana's 15 coal mining counties (Figure 2).

3.0 Methods

3.1 Site Selection

Mine surveys were conducted to assess the existing condition of forested land that had been included in final bond release actions from 1/1/1996 to 7/31/2002. Land use information was collected across 24 separate mines with 48 tracts having a post mining land use of forest. Forested land uses within the mine sites were selectively (not randomly) sampled. Sites were chosen from a database maintained by IDNR-DOR. This database contains all bond release and land use information for Indiana mines. The database was queried to show all forested units with final release dates between 1/1/1996 and 7/31/2002 (5351.99 acres). That acreage total was further reduced to 3062.96 acres where records were in long–term storage and not easily accessible. This timeframe was chosen to allow analysis of the conditions of the forested sites after they had been under the control of private landowners from four to ten years. Likewise, database records for post-mine land uses and related bond releases originating from 1/1/1996 until 7/31/2002 were readily and accurately obtained through database queries. These sites were then visited by either OSM and State team members or Indiana State Mine Inspectors.

A total of 3,063 acres of forest had been included in a final bond release action between 1/1/1996 and 7/31/2002. Investigators examined 2,971 forested acres. Approximately 92 acres could not be inspected because of problems associated with gaining access to the land. Overall, 97 percent of reclaimed forest identified by the database query was inspected for this study.

3.2 Site Measurements

During the surveys, inventories were accomplished and site conditions were noted for each forested unit. Investigators measured forested acres, estimated acres lost, assessed the number of trees present and evaluated the condition of trees, and identified adjacent land uses. Also, management activities such as mowing and tree thinning on each parcel of reclaimed forest were annotated on the data collection sheets. At many of the sites, tree species and photographic information were collected for reference. Site information was obtained through the use of non-quantitative methods. Visual assessments estimating acreage, condition, and the health of the forested stands was the sampling procedure used during the surveys. This study did not use inferential and descriptive statistical techniques which measure stand and individual tree condition, density, or areal arrangement of tree species.

The methodology was chosen to classify the existence and condition of potential habitat selection for the Indiana bat for several reasons. Published studies have demonstrated that the Indiana myotis preferentially uses woodlands as foraging and commuting areas. Other land types such as cropland and fallow pasture provide additional habitat for the bat species. Forested environments on reclaimed mine sites are commonly associated with other areas creating an assorted land use pattern. In many cases, preferred bat habitat is along forested edge, near water courses, and along wooded corridors that serve as connectivity routes and travel matrixes. Site measurements determine whether conditions favor long-term bat foraging and roosting activity at reclaimed Indiana mine sites. Similarly, site management practices and land use patterns affect

the suitability of the land for the Indiana bat. Many of the sites surveyed are in the early seral ecological stage. A mosaic land use pattern, combined with the amount and condition of healthy restored forest resources, can indicate the effectiveness of reclaimed areas to provide future habitat. A review of these considerations can lead to a better understanding of the regulatory mechanisms designed for bat habitat protection.

4.0 Results

4.1 Forest Conditions

Overall, the survey found that forested mine ground continues to be well wooded with only minor disturbances having occurred after bond release. Out of 2,971 acres inspected, 2,940 acres (99%) have trees stocked at acceptable rates with healthy forest conditions (Appendix A). The 31-acre total of cleared forest was limited to three mine permits, and in each case the land was converted to either a commercial or residential use. An entire 20-acre permit had been mowed and thinned of trees to become home sites. Landowners cleared trees from two other permits, affecting eight acres of one and three acres of another. Reforestation efforts within the coalfields of southwest Indiana have yielded desirable conditions that have persisted 10 years after the state granted final bond release. Figure 3 shows a typical forested tract and the photos in Appendix B demonstrate a variety of postmine forested resources inventoried during the site inspections.

This high success rate can be attributed in-part to the revegetation standards of the IDNR-DOR. The state's stocking and tree species survival rates require coal mining and reclamation operations to maintain forested species at minimum of 450 tree plantings per acre. Mining companies within the region will often use even higher stocking rates to ensure successful bond release. Additionally, other considerations generated through the SMCRA permitting process such as Section 7 Consultation with the FWS and regulatory actions under the Army Corps of Engineers Section 404 permitting process require compensatory mitigation. On reclaimed mines, mitigation work can involve tree plantings and stream and riparian development—actions that promote habitat for the Indiana bat.

Figure 3. Indiana mine site showing healthy forest conditions.

4.2 Adjacent Land Use Analysis

Land having assorted uses was distributed in various patterns around forested mine ground. Among 44 surveyed sites, 33 contained parcels designated for use as fish and wildlife habitat. The next most common associated land use was cropland followed by developed water resources. Pasture and commercial/residential developments were the least frequently encountered land uses adjacent forested tracts. Table 1 gives the associated land uses in relation to the forested units surveyed.

Table 1. Most commonly encountered land uses adjacent to reclaimed forest among sites included for final bond release during the period 1996 to 2002

Land Use Type	***Frequency***
Fish and Wildlife Habitat	33
Cropland	23
Water	22
Roads	19
Pasture	12
Residential	10
Commercial	01

Land use and available forested habitat play an important role in the landscape ecology of the Indiana bat. Research suggests that forested landscapes with a high density of quality roost trees interspersed with fragmented open areas provide critical roost and foraging range. These conditions frequently occur among the reclaimed coal mines of southwestern Indiana. Indiana land designated for use by fish and wildlife range from native grasslands to wetlands to restored hardwood forest. In many cases, wildlife habitat is re-established along drainage ways constructed during mine reclamation. Studies have shown that once Indiana bats arrive in their forging areas, they make multiple loops through a relatively small portion of that area. Bats forage around and within forested areas and prefer forested edge and corridors as primary commuting habitat. The mosaic of wildlife habitat, cropland, water resources, and forested areas potentially increases the available commuting and foraging range for the species. Figure 4 is an aerial view of a typical mine site in southwest Indiana.

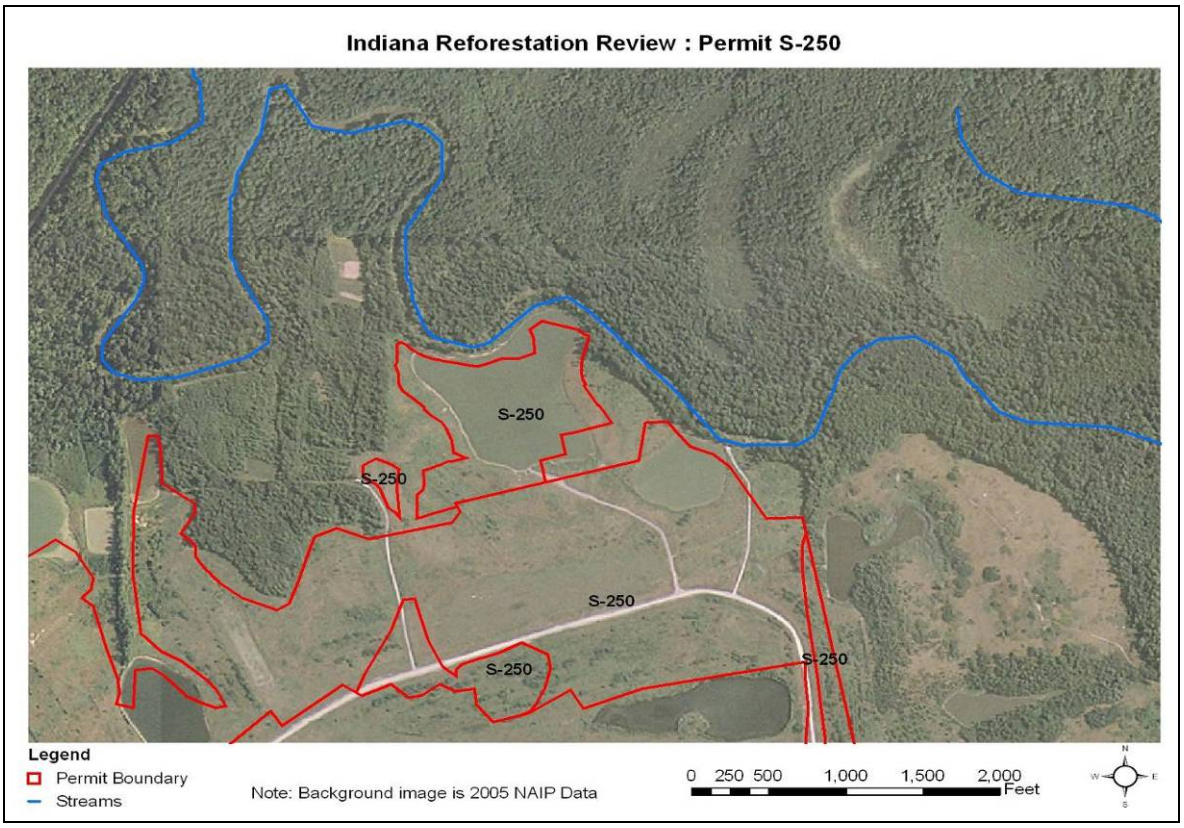

Figure 4. Aerial photo of Indiana Permit S-250 showing a mosaic land use pattern.

4.3 Tree Species

Over 30 species of tree have supplied roosts for female Indiana myotis and their young (Clawson 2004). Bats in southwest Indiana use common trees such as ash, elm, hickory, maple, cottonwood, and oak. The Indiana bat seems to prefer oaks and hickories. At one time, it was generally believed that the type of tree used by the Indiana bat had a direct relation to the geographical range of the species. However, more recent work shows that tree selection is related more to local availability than broad regional preference (Clawson 2004). Nonetheless, the Indiana bat may rarely or never roost in some common trees such as beech, basswood, black cherry, box elder, and willows.

The present study included a qualitative analysis of tree species at 25 of the forested sites. Most tree species noted during the surveys had been planted by mining companies; however, some species were volunteers. The most common trees found on the sites were ash, oaks, sycamore, locust, walnut, pine, and cottonwood. A wide array of other less-frequently encountered woody species were interspersed among the common trees (Appendix C). Most roost trees selected by female Indiana bats are dead or nearly so and tend to be those of larger diameter. Reclaimed mine sites present a temporary loss of desirable habitat because of early forest conditions and limited number of suitable snags. However, maturing forests will provide increasing availability of summer bat habitat. The fact that less than 2% of post mine forested land uses are cleared

after bond release indicates a positive trend that future summer habitat will only improve on reclaimed mine sites.

5.0 Conclusion/Recommendations

This study supports efforts by the IDNR-DOR and FWS to create habitat conservation measures that will maintain compliance with the 1996 Biological Opinion. Through nonquantitative analysis, the study demonstrates that Indiana private landowners have not engaged in wholesale clearing of trees from reclaimed mine sites after the state released the permittee from reclamation liability for those wooded lands. The most common uses for land adjacent to forested reclaimed mine ground are compatible with, and promote, quality bat habitat. Reforested areas consist of healthy, diverse stands of trees. Conservation measures such as employing improved reforestation techniques and designing the reclaimed site to have a mix of water features, open areas, and wooded corridors will help promote the long-term viability of the Indiana bat. This study does not support the contention that long-term conservation easements will provide any further protection of forested resources replanted after mining.

6.0 References

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7.0 Team members

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Appendix A

Forest acres released between 1996 and 2002 where permit is still active or files are still in the J-ville file room.

No.	Permit#	Mine name	Inspector	Release Date	Ac/Released	#Acres unable to inspect	Field Check Data Inspector	Date of Inspection	Forest Area Checked	Was release area accessible?	Are the trees still in place?	Does acreage appear correct?	How many acres removed?	How many acres remain?
1	P-005*	Area	Sellers	11/5/99	0.00	21.90	NA	NA						
2	P-023*	Dugger 8900 Deadhead	Sellers	5/14/02	0.00	4.60	NA	NA						
3	S-004*	Ayrshire - Millersburg	Good	7/16/98	4.79		Good	8/24/06		Y	Y	Y	NA	4.79
4	S-004	Ayrshire - Millersburg	Good	11/24/98	38.79		Good	8/24/06		Y	Y	Y	4.00	34.79
5	S-004	Ayrshire - Millersburg	Good	10/20/00	35.34		Good	8/24/06		Y	Y	N	4.00	31.34
6	S-004	Ayrshire - Millersburg	Good	12/14/01	2.44		Good	8/24/06		Y	Y	Y	NA	2.44
7	S-009*	Squaw Creek South	Mangum	1/27/00	33.60		Briggeman	7/10/06		Y	Y	Y	NA	33.60
8	S-009	Squaw Creek South	Mangum	12/14/00	279.90		Briggeman	7/10/06		Y	Y	Y	NA	279.90
9	S-010*	Hawthorn 2570	Sellers	8/18/98	49.00		Walters	7/28/06		Y	Y	Y	NA	49.00
10	S-010	Hawthorn 2570	Sellers	9/8/99	112.60		Walters	7/12/06		Y	Y	Y	NA	112.60
11	S-010	Hawthorn 2570	Sellers	9/6/00	149.20		Walters	7/12/06		Y	Y	Y	NA	149.20
12	S-010	Hawthorn 2570	Sellers	11/8/01	67.40		Walters	5/31/06		Y	Y	Y	NA	67.40
13	S-012*	Universal Shepardsville A	Kraus	12/17/98	5.70		Kraus	6/2/06		Y	Y	Y	NA	5.70
14	S-017*	Dugger 8900 Area	Good	12/9/99	0.00	33.70	Good	NA		N	NA	NA	NA	0.00
15	S-021*	Lynnville 1150 #1	Good	4/4/02	208.60		Loveless	6/1/06		Y	Y	Y	NA	208.60
16	S-023*	Lynnville 5761 Eby	Corn	3/12/98	64.40		Loveless	6/1/06		Y	Y	N	3.00	61.40
17	S-032*	Kindill No. 1, Hardy Yager	Langer	1/16/01	33.30		Langer	6/6/06		Y	Y	Y	NA	33.30
18	S-034*	Kindill No. 2, Alford Field	Langer	1/29/98	257.20		Langer	6/13/06		Y	Y	Y	NA	257.20
19	S-034	Kindill No. 2, Alford Field	Langer	7/31/00	68.60		Langer	6/13/06		Y	Y	Y	NA	68.60
20	S-034	Kindill No. 2, Alford Field	Langer	11/20/01	202.70		Langer	6/13/06		Y	Y	Y	NA	202.70
21	S-035*	Kindill No. 2, Petersburg	Langer	1/18/01	486.40		Langer	6/5/06		Y	Y	Y	NA	486.40
22	S-039*	Chinook West	Swihart	6/5/02	52.60		Swihart	8/2/06		Y	Y	Y	NA	52.60
23	S-040*	Kindill No. 3, Glendora	Langer	12/17/98	12.00		Langer	6/14/06		N	Y	Y	NA	12.00
24	S-041*	Pit	Sellers	4/6/00	182.50		Mayes	8/15/06		Y	Y	Y	NA	182.50
25	S-126*	Prides Creek	Langer	10/19/98	57.60		Langer	6/1,6/06		Y	Y	Y	NA	57.60
26	S-126	Prides Creek	Langer	8/28/00	9.00		Langer	6/1/06		Y	Y	Y	NA	9.00
27	S-150*	Enterprise	Dayson	6/4/01	0.70		Dayson	7/16/06		Y	Y	Y	NA	0.70
28	S-175*	Coal City #2	Lorenzo	4/30/98	66.60		Lorenzo	6/20/06		Y	Y	Y	20.00	46.60
29	S-209*	Foertsch #2	Mangum	6/10/97	11.60		Mangum	7/18/06		Y	Y	Y	NA	11.60
30	S-240*	Tretter Pit	Sellers	2/25/00	0.00	9.40	NA	NA						
31	S-247*	Deer Ridge	Corn	11/14/00	1.60		Team	6/14/06		Y	Y	Y	NA	1.60
32	S-247	Deer Ridge	Corn	1/18/01	23.50		Team	6/14/06		Y	Y	Y	NA	23.50
33	S-247	Deer Ridge	Corn	2/22/01	68.70		Team	6/14/06		Y	Y	Y	NA	68.70
34	S-247	Deer Ridge	Corn	6/5/01	8.70		Team	6/14/06		Y	Y	Y	NA	8.70
35	S-247	Deer Ridge	Corn	11/14/01	23.20		Team	6/14/06		Y	Y	Y	NA	23.20
36	S-247	Deer Ridge	Corn	6/24/02	11.10		Team	6/14/06		Y	Y	Y	NA	11.10
37	S-250*	Columbia	Dayson	6/17/97	38.70		Good	6/1,6/06		Y	Y	Y	NA	38.70
38	S-250	Columbia	Dayson	12/18/98	0.00	4.70	Good	6/1,6/06						0.00
39	S-250	Columbia	Dayson	3/7/01	5.30		Good	6/1,6/06		Y	Y	Y	NA	5.30
40	S-256*	Sullivan #1 Mine, Penndiana	Sellers	5/10/01	110.40		Mayes	8/31/06		Y	Y	Y	NA	110.40
41	S-257*	Switz City / Holtsclaw	Voigt	6/19/98	2.60		Voigt	7/28/06		Y	N	NA	RELO	2.60
42	S-257	Switz City / Holtsclaw	Voigt	3/17/00	49.40		Voigt	7/28/06		Y	Y	Y	RELO	49.40
43	S-268*	Hawthorn 1250 West	Sellers	12/18/00	17.70		Walters	7/27/06		Y	Y	Y	NA	17.70
44	S-268	Hawthorn 1250 West	Sellers	12/7/01	3.00		Walters	7/27/06		Y	Y	Y	NA	3.00
45	S-273*	Britton	Sellers	4/4/02	0.00	17.50	NA	NA						0.00
46	S-274*	Lynnville - South Millersburg	Good	1/19/01	113.70		Loveless	6/1/06		Y	Y	Y	NA	113.70
47	S-298*	Cannelburg	Davis	2/8/02	0.30		Davis	7/20/06		Y	Y	Y	NA	0.30
48	S-315*	West Fork	Davis	5/14/02	0.70		Davis	7/20/06		Y	Y	Y	NA	0.70
		Total Acres			**2971.16**	91.80							**31.00**	**2940.16**

No.	If removed what is current landuse?	**What are the adjacent Landuses?**	Cropland	Pasture	Residential	Water	Commercial	Roads	Wildlife	Other(write in)	**Condition of Standing Trees**	Most appear healthy(grown or leafed out)	Most appear dead(stunted or no leaves)	Has any partial thinning of the trees occurred?	Is the understory being mowed?	Photos Taken	Species Present	Other Comments	Notes:
1																			
2																			
3	NA								x			Y	N	N	N	N	**Y**		
4	Res/Com							x	x			Y	NA	N	N	N	**Y**		Residential/Commercial
5	Com							x	x			Y	NA	N	N	N	**Y**		Commercial
6	NA				x			x				Y	NA	N	N	N	**Y**		
7	NA							x	x			Y	N	N	N	N	**Y**		
8	NA							x	x			Y	N	N	N	N	**Y**		
9	NA		x	x		x			x			Y	N	N	N	N	**Y**		
10	NA		x	X		x		x				Y	N	N	N	Y	NA		P7120134, P7120133
11	NA			x		x		x	x			Y	N	N	N	Y	**Y**		P7120132, P7120132
12	NA		x						x			Y	N	N	N	Y	**Y**		P7120128, P7120129
13	NA		x	x		x				FOR		Y	N	N	N	N	**Y**		Forest
14	NA											NA	NA	NA	NA	NA	NA		
15	NA			x		x			x			Y	N	N	N	Y	NA		
16	Res					x		x	x			Y	N	N	N	Y	NA		Residential
17	NA		x						x			Y	N	N	N	Y	**Y**		
18	NA								x			Y	N	N	N	N	**Y**		
19	NA								x			Y	N	N	N	N	**Y**		
20	NA		x						x			Y	N	N	N	N	**Y**		
21	NA		x						x			Y	N	N	N	Y	**Y**		
22	NA			x			x					Y	N	N	N	N	NA		
23	NA		x									Y	N	N	N	N	**Y**		
24	NA				x	x			x			Y	N	N	N	N	NA		
25	NA		x									Y	N	N	N	Y	**Y**		
26	NA		x						x			Y	N	N	N	Y	**Y**		
27	NA		x						x			Y	N	N	N	N	NA		
28	Res			x	x	x				x		Y	N	Y	Y	N	NA		Residential
29	NA		x	x								Y	N	N	N	N	**Y**		
30																			
31	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
32	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
33	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
34	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
35	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
36	NA		x		x	x		x	x			Y	N	N	N	Y	NA		
37	NA		x			x		x	x			Y	N	N	N	N	**Y**		
38																	NA		
39	NA					x			x	FOR		NA	NA	NA	NA	NA	NA		
40	NA		x			x		x	x			Y	N	N	N	N	**Y**		
41	Residential		x	x	x	x			x			NA	NA	NA	NA	Y	NA		Relocated to another mine
42	Residential		x	x		x			x			Y	N	N	N	Y	NA		Relocated to another mine
43	NA			x		x		x	x			Y	N	N	N	Y	**Y**		
44	NA			x		x		x	x			Y	N	N	N	Y	**Y**		
45																			
46	NA					x		x	x			Y	NA	N	N	Y	NA		
47	NA		x									Y	NA	N	N	N	Y		
48	NA								x			Y	NA	N	N	N	Y		

Appendix B

Appendix C

	#	S-209 6/10/97	S-250 6/17/97	S-034 1/29/98	S-004 7/16/98	S-010 8/18/98	S-126 10/19/98	S-004 11/24/98	S-012 12/17/98	S-040 12/17/98	S-009 1/27/00	S-034 7/31/00	S-126 8/28/00	S-010 9/6/00	S-004 10/20/00	S-009 12/14/00	S-268 12/18/00	S-032 1/16/01	S-035 1/18/01	S-256 5/10/01	S-010 11/8/01	S-034 11/20/01	S-268 12/7/01	S-004 12/14/01	S-298 2/8/02	S-315 5/19/02	Pecentage of Final releases where species occurred
Tree species																										
Ash	18	x	x	x		x	x	x		x		x	x		x		x	x	x	x		x	x	x		x	72.0%
Oak	18	x	x	x	x		x	x		x	x	x	x		x	x		x	x	x		x		x		x	72.0%
Sycamore	15				x	x		x			x		x	x	x	x	x		x		x		x	x	x	x	60.0%
Locust	13	x		x		x				x	x	x	x			x	x	x	x			x	x				52.0%
Walnut	9			x			x			x		x	x					x	x	x		x					36.0%
Pine	8	x		x							x	x				x		x				x				x	32.0%
White Pine	8		x		x	x	x	x						x			x						x				32.0%
Cottonwood	8		x		x	x		x							x				x				x	x			32.0%
Sweet gum	7				x	x	x							x						x	x		x				28.0%
Black Locust	7							x	x					x	x					x	x			x			28.0%
Red Oak	5					x								x			x				x		x				20.0%
White Oak	5					x								x			x				x		x				20.0%
Sumac	5		x						x		x					x								x			20.0%
Red Pine	5		x											x						x	x		x				20.0%
Bald cypress	5	x	x												x					x	x						20.0%
Persimmon 1	5			x					x		x	x				x											20.0%
Autumn Olive	4		x								x			x									x				16.0%
Popular	4					x								x			x								x		16.0%
Willow	4																		x				x	x	x		16.0%
Alder	4			x			x					x								x							16.0%
Maple	3					x											x						x				12.0%
Green Ash	3								x					x							x						12.0%
Dogwood 1	3		x													x	x										12.0%
Virginia pine 1	3								x					x			x										12.0%
Black cherry 1	2						x						x														8.0%
Crabapple 1	2					x								x													8.0%
Hawthorn 1	2		x						x																		8.0%
Tulip 1	2		x				x																				8.0%
Hazelnut	2																x						x				8.0%
Black alder 1	2		x												x												8.0%
White Ash 1	2				x				x																		8.0%
Bayberry 1	1													x													4.0%
Black walnut 1	1		x																								4.0%
Bur Oak 1	1								x																		4.0%
Catalpa 1	1		x																								4.0%
Pecan 1	1								x																		4.0%
Red osier 1	1		x																								4.0%
Redbud 1	1		x																								4.0%
River birch 1	1								x																		4.0%
Red cedar 1	1				x																						4.0%