

A COMPARISON OF COAL MINING AND INDIANA BAT POPULATION TREND¹

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Abstract. Bat population census information shows a dramatic decline in the number of Indiana bats (*Myotis sodalis*) since 1965 nationwide. On a regional basis, however, the populations are increasing in the northern States and decreasing in the southern States. More recent data shows that the population has been steadily increasing from 2001-2007. This report compares the data on changes in populations of the Indiana Bat with data representing coal production from the same States and over the same time period. The result of this comparison indicates there are no data that would suggest a correlation between the Indiana Bat population trends and: (1) total coal production, (2) rate of growth or decline in coal mining as indicated by percent change in coal production, or (3) surface mining or underground mining methods. This conclusion would be supported by a comparison of the data from the Forest Service that there are 384 million acres of forest cover in the eastern U.S. with the 3.07 million acres of total permitted acreage of surface coal mines in the 14 States within the Indiana bat habitat (OSM 2004), that results in a maximum of 0.8% of the eastern forest cover that could be impacted by surface coal mining.

Although the regional changes in bat population may be suggestive of changes in climate (a uniform increase in the temperature in winter hibernacula could make hibernacula in southern States too hot and in northern States more suitable), the most likely reason for the decline of the species is tied to human disturbance of their underground winter habitat during hibernation. The current emphasis of the U.S. Fish and Wildlife Service on mitigation of impacts due to coal mining is to protect and enhance summer habitat. This may not be effective when the limiting factor in sustaining a healthy Indiana bat population is having an adequate supply of suitable winter hibernacula. Investigations are needed to determine what, if any, impact coal mining and reclamation is having on the bat populations and what mitigation activities are appropriate and effective. The challenge before the States, USFWS, OSM, the coal mining industry, and bat conservationists is to coordinate these concerns in a way that is both protective of the species and appropriately efficient in terms of mitigation requirements that bring proven positive results for this species.

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Trends in Indiana Bat (*Mysotis sodalis*) Populations

At the Indiana Bat and Coal Mining Forum, Richard Clawson of the Missouri Department of Conservation elaborated on the trends in population decline over the last 40 years for the Indiana bat as follows.

The current total population is estimated to number slightly below 400,000 bats; this compares to an estimated population of nearly 900,000 bats in the same hibernacula 30 to 40 years ago, when surveys first began (Table 1). The observed decline is not uniformly distributed throughout the range of the species, however. Hibernating populations in the southern part of the range have declined by 82% in the past 40 years, while those in the northern Midwest and Northeast have increased by 35%. Cumulatively, the total population of Indiana bats has declined by 56% since regular surveys began (Fig. 1 and 2). (Clawson, 2004)

Known and Suspected Causes of Decline

Human disturbance of hibernating Indiana bats has long been recognized as a factor in the decline of populations of this bat (U.S. Fish and Wildlife Service 1983). Arousals caused by repeated disturbance force bats to burn their fat reserves during the critical winter hibernation season. A single arousal requires as much fat as 68 days of uninterrupted hibernation (Thomas et al. 1990). Improper gates or other structures at hibernacula have rendered some sites unavailable to the bats, or altered the microclimate sufficiently that winter temperatures became so warm that Indiana bats were unable to survive through winter on their fat reserves (Humphrey 1978, Richter et al. 1993, Tuttle and Kennedy 2002). Natural hazards such as freezing, flooding, and ceiling collapse also have killed hibernating Indiana bats (Hall 1962, Humphrey 1978, Richter et al. 1993).

Population declines may also be caused by factors that affect Indiana bats in summer. Pesticides, for example, may be a factor in survival and reproduction (O'Shea and Clark 2002). Studies of sympatric species indicate that Indiana bats may be exposed to residual levels of banned chlorinated hydrocarbons and currently applied chemicals such as organophosphates and carbamates (McFarland 1998, Schmidt et al. 2002). It also is possible that changes to the landscape affect summer habitat for the species. Land-use practices that alter the extent and quality of riparian, bottomland, and upland forests

may have profound effects, either negative or positive, on the roosting and foraging habitat for the Indiana bat. (Clawson, 2004)

It is important to note that Indiana bats are capable of occupying newly available sites. In Illinois and Ohio, large hibernating populations have become established in mines in which mining activities have ceased in only the past 15 years. (Clawson, 2004)

Table 1. The size of hibernating populations of the Indiana bat by region and State, based upon estimates nearest to the year indicated (Clawson, 2007)

	State	1965	1980	1990	2001	2007
Southern Region	Alabama	350	350	350	250	250
	Arkansas	15,000	15,000	4,500	2,500	1,800
	Illinois South	14,700	14,700	14,500	19,500	40,000
	Kentucky	248,100	102,200	78,700	50,050	68,800
	Missouri	399,000	342,000	150,100	73,000	65,550
	Oklahoma	0	0	0	5	5
	Tennessee	20,100	20,100	16,400	10,200	8,400
	Virginia	3,100	2,500	1,900	850	750
	Subtotal	700,350	496,850	266,450	156,355	185,555
Northern Region	Illinois North	100	100	400	1,550	1,800
	Indiana	160,300	155,200	163,500	173,100	238,200
	Michigan	0	0	0	20	20
	New Jersey	0	0	0	100	650
	New York	20,200	21,100	26,800	29,750	54,000
	Ohio	150	3,600	9,500	9,800	7,600
	Pennsylvania	700	700	400	700	750
	Vermont	0	0	0	150	300
	West Virginia	1,500	1,200	6,500	9,750	14,600
	Subtotal	182,950	181,900	207,100	224,920	317,920
	Grand total	883,300	678,750	473,550	381,275	503,475

Information provided by Clawson (2004) during the Indiana Bat and Coal Mining forum showed a dramatic decline in the number of Indiana bats from 1965-2001 nationwide. However, on a State specific basis populations are increasing in the northern States and decreasing in the southern States (Fig. 1 and 2). Information provided by Clawson (2007) during the Indiana Bat and Coal Mining Revised Recovery Plan workshop showed a steady increase in the Indiana bat population from 2001-2007 nationwide.

Range-wide Population of Indiana Bats

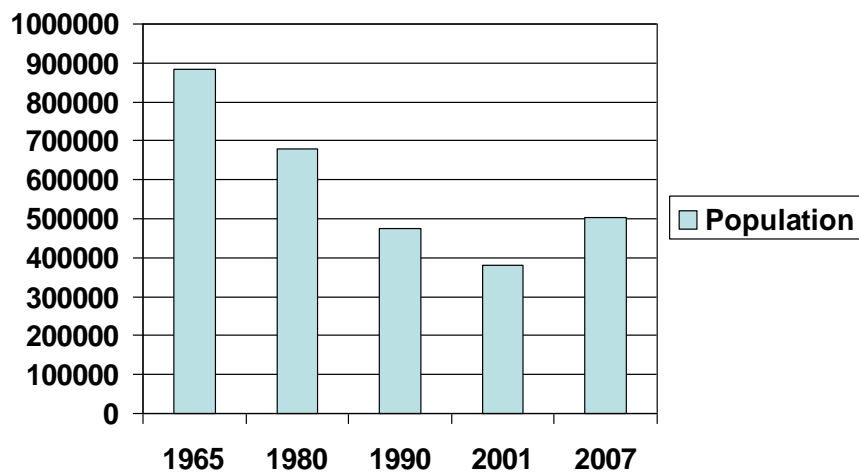


Figure 1. Range Wide Population Trends based on estimates and surveys from 1965 to 2007 for the Indiana Bat (Clawson, 2007)

Overlap of the Eastern Coal Fields with Indiana Bat Habitat

The range overlap of Indiana Bat habitat with coal fields in the Eastern United States (Fig. 3). Of the fourteen States included in either the summer or winter range of the Indiana Bat, twelve are actively involved in coal mining including: Alabama, Arkansas, Illinois, Indiana, Kentucky, Missouri, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, and West Virginia. The State of Iowa is involved with reclamation of abandoned coal mines but no longer has active coal mining.

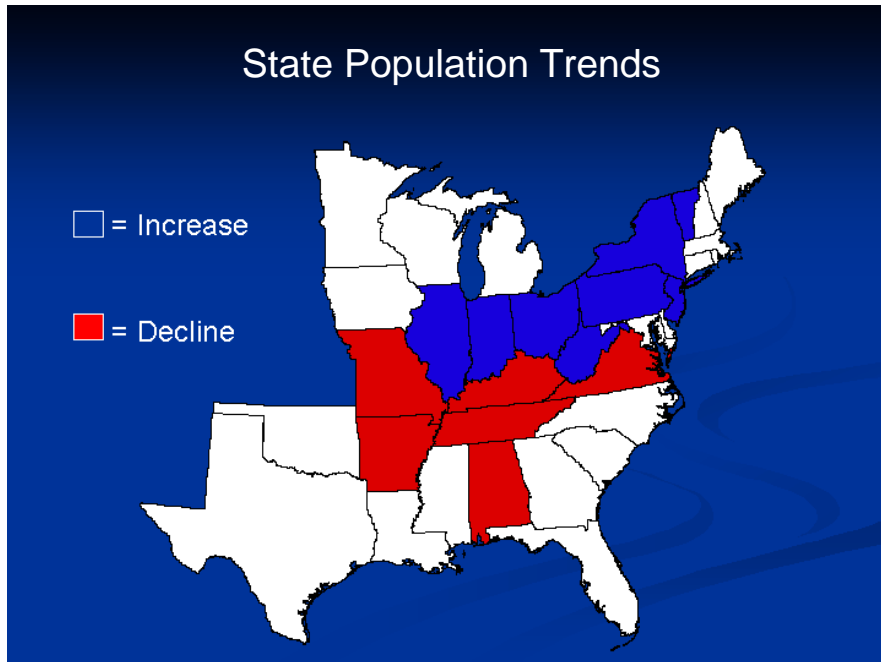
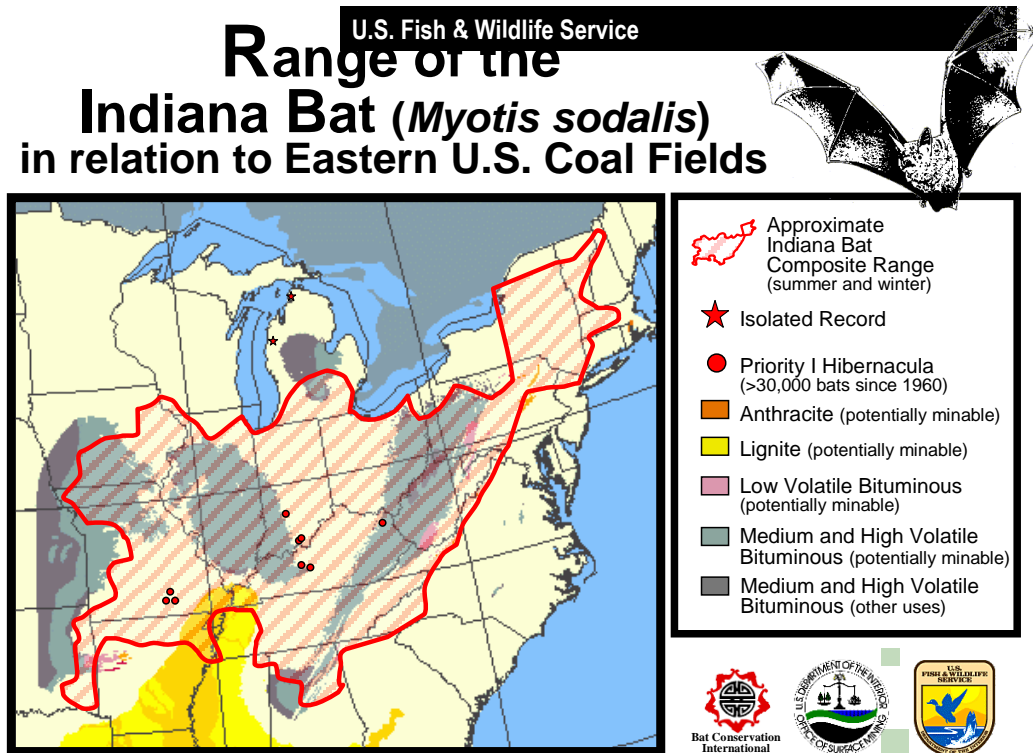


Figure 2. State Population Trends for the Indiana bat from 1960 to 2003 (Clawson, 2004)



Coal field and Indiana bat range (based on data compiled by Bat Conservation International) boundaries were accessed via The National Atlas of the United States (<http://nationalatlas.gov>). Map prepared by Andrew King, Bloomington, Indiana Field Office, U.S. Fish and Wildlife Service.

Figure 3. Coal Field and Indiana Bat range. (based on data compiled by Bat Conservation International) boundaries were accessed via “The National Atlas of the United States.” (<http://nationalatlas.gov>) Map prepared by Andrew King, Bloomington Indiana Field Office. U.S. Fish and Wildlife Service.

Coal Production Data and Trends

In order to better understand the relationship between Indiana Bat populations and coal mining activity in the eastern United States, coal production data were obtained from the U.S. Department of Energy, Energy Information Administration Website at www.eia.doe.gov/fuelcoal.html. The coal production data from 1970, 1980, 1990, and 2006 (U.S. Department of Energy(a)) was determined from the States where Indiana Bat populations and coal reserves overlap (Fig. 3). These data were then compared to trends in the Indiana Bat populations presented by Clawson (2007). The total coal production in millions of tons (Table 2) for each decade from 1970 to 1990 and then from 2006 was the most recent data available and was as comparable as possible to the data from Clawson. The southern States where the Indiana

Table 2. Coal Production Trends in States with Changing Populations of Indiana Bats.

State	Coal Production in Millions of tons*				
	1970	1980	1990	2006	% Change
ALABAMA	15.5	21	19	21	+35%
ARKANSAS	0.35	0.4	0.15	0.01	-97%
KENTUCKY	100	140	175	127	+27%
MISSOURI	3.3	5	2.5	0.6	-82%
OKLAHOMA	1.0	5.0	1.8	2.3	+130%
TENNESSEE	No data	No data	2.6	2.6	0%
VIRGINIA	35	35	46	31.6	-10%
Illinois	64	60	60	32	-50%
Indiana	18	27	33	36	+100%
Ohio	51	38	35	25	-51%
Pennsylvania	85	90	70	68	-20%
West Virginia	135	120	155	159	+17%

(*www.eia.doe.gov/fuelcoal.html) (Southern States with Declining Populations of Indiana Bat in are shown in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in are shown in Lower Case Blue Letters)

Bat populations are declining are shown first in capital red letters followed by the northern States where the Indiana Bat populations are increasing in lower case blue letters. The percent change in coal production for this time period is obtained by calculating the difference in total coal production from 1970 to 2006 and dividing it by coal production in 1970 resulting in either a positive or negative change in coal production for that time period. The data in Table 3 compares the positive or negative change in bat population with the positive or negative percent change in coal production for the same time period.

Table 3. Comparison of Changes in Indiana Bat Populations with Changes in Coal Production.

State	Total Change in Indiana Bat Population 1965-2007	% Change in Coal Production 1970-2006
ALABAMA	-100	+35%
ARKANSAS	-13,200	-97%
KENTUCKY	-179,300	+27%
MISSOURI	-333,450	-82%
OKLAHOMA	+5	+130%
TENNESSEE	-11,700	0%
VIRGINIA	-2,350	-10%
Illinois	+27,000	-50%
Indiana	+77,900	+100%
Ohio	+7,450	-51%
Pennsylvania	+50	-20%
West Virginia	+13,100	+17%

(Southern States with Declining Populations of Indiana Bat in are shown in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in are shown in Lower Case Blue Letters)

Comparison of Bat Population Trends with Growth or Decline of Coal Mining Activity in a State

The author assumes that if coal mining activity had a negative impact on Indiana bat populations, then you would expect a correlation between declines in bat populations associated

with an increase in coal production or vice versa. The data in Fig. 4 illustrates a comparison of the positive or negative change in bat populations with the positive or negative changes in percent coal production. Actual bat population changes are shown in green and actual coal production changes are shown in blue. Fig. 4 is arranged from left to right by the State of Missouri with the greatest total decline in bat population to the State of Indiana with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The red dashed line would be the expected trend line in coal production if a positive percent change in coal production had a negative impact on bat population. The red line is an arbitrarily projected line that would be an expected to mirror image the bat population trends where a large percent increase in coal production would result in a large decrease in bat population and large decrease in coal production would result in a corresponding large increase in bat population.

IN BAT POPULATION CHANGE (Thousands) VERSUS (%) CHANGE IN COAL PRODUCTION

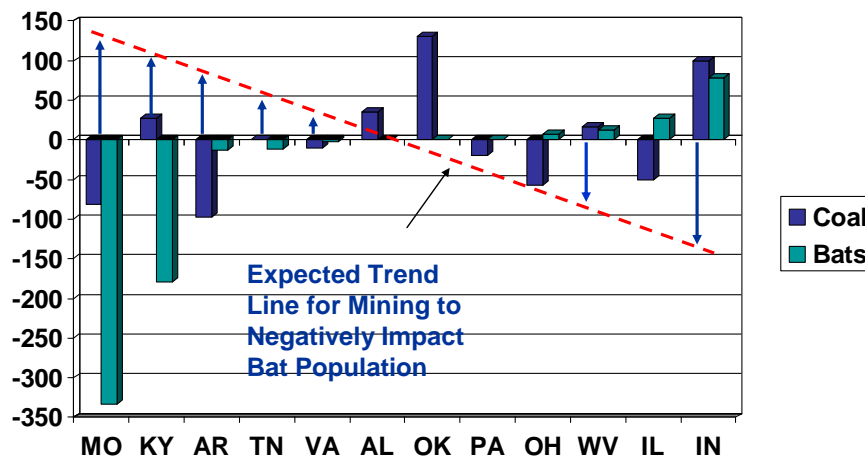


Figure 4. Indiana Bat population change versus Percent Change in Coal Production.

Indiana Bat Populations with Significant Population Decline

Missouri is the State with the greatest percent decrease in Indiana bat population from 399,000 in 1965 to 65,550 in 2007. This population decline of 333,450 represents an 84% reduction. If there was a correlation with coal mining, then you would expect to see a significant increase in coal production during the same time period. Instead, Missouri has experienced a dramatic decline in coal production (negative 82%). The current total coal production in Missouri (0.6 million tons per year) is so small that it can not be a contributing factor to the bat population trend. A similar case could be made for Arkansas. The population has decreased from 15,000 in 1965 to 1,800 in 2007. This population decline of 13,200 represents an 88% reduction in numbers of Indiana bat. Yet during the same time period, Arkansas has experienced a 97% decrease in coal production resulting in a total current coal production of 0.01 million tons per year which again is so small that it is can not be a contributing factor to the bat population trend.

The State with the second largest decrease in bat population is Kentucky from 248,100 in 1965 to 68,800 in 2007. This population decline of 179,300 represents a 72 % reduction. In the case of Kentucky, there has been a significant increase in coal production (positive 27%). Coal mining in Kentucky, unlike mining in Missouri and Arkansas, is largely by underground mining (61%) and the increase in coal production has been largely due to an increase in underground mining. Although the reduction in bat populations in Kentucky is substantial, there seems to be little mechanism for an increase in impact to summer habitat due to mining when the increase has been largely due to underground mining. The data also shows that the bat population in Kentucky has increased from 50,050 in 2001 to 68,800 in 2007 even though it is a Southern State where populations have been generally in decline.

Indiana Bat Populations with Significant Population Increases

Indiana is the State that has the largest increase in Indiana bat population from 160,300 in 1966 to 238,200 in 2007. This population increase of 77,900 represents a 49% increase. If there was a negative correlation with coal mining, then you would expect to see a significant decrease in coal production during the same time period. Instead, Indiana has experienced a substantial increase in coal production (positive 100%). This is especially significant since the predominant mining method in Indiana is by surface mining (67.5%) that would be assumed to have the greatest impact on bat populations and summer habitat.

The State of West Virginia has experienced an 873% increase in its Indiana Bat population while its coal production has also grown by 17%.

The State of Oklahoma has experienced a 130% increase in coal production while the bat population has increased from 0 to 5 over the same time period.

In conclusion, if changes in the rate of coal production were correlated with changes in corresponding increases or decreases in bat population then a pattern should be evident in Figure 4 as indicated by the dashed red line. Instead, trends in bat populations appear to be totally independent of changes in coal production rather than in any way related to them.

Comparison of Trend in Indiana Bat Populations with the Size of the Coal Mining Industry in a State

The author examined the possible correlation between trends in bat populations as compared to the overall size of the coal industry in a State. The theory being that there may be some threshold for the size of the coal mining industry to have an impact on bat populations. Fig. 5 provides data for a visual comparison of total coal production in 2006 with the positive or negative change in bat population from 1965 to 2007. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right with West Virginia being the State with the greatest total coal production to Arkansas with the least. The States are divided into three sizes of coal mining industries. These categories include a Large coal industry (WV, KY, PA), medium size coal industry (IN, VA, IL, OH, AL), and a small size coal industry (TN, MO, AR). The green arrows indicate the expected direction of bat population increase or decrease if there were a large negative population decrease with a large coal mining industry, a smaller negative population decrease with a medium sized coal industry, and a positive population increase with a coal industry too small to have any negative influence on the bat population. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a large size coal industry would result in a large decrease in bat population, a medium size coal industry would result in a smaller decrease in bat population and a small coal industry would result in a corresponding increase in bat population.

**TOTAL COAL PRODUCTION (Millions of Tons)
VERSUS IN BAT POPULATION CHANGE (Thousands)**

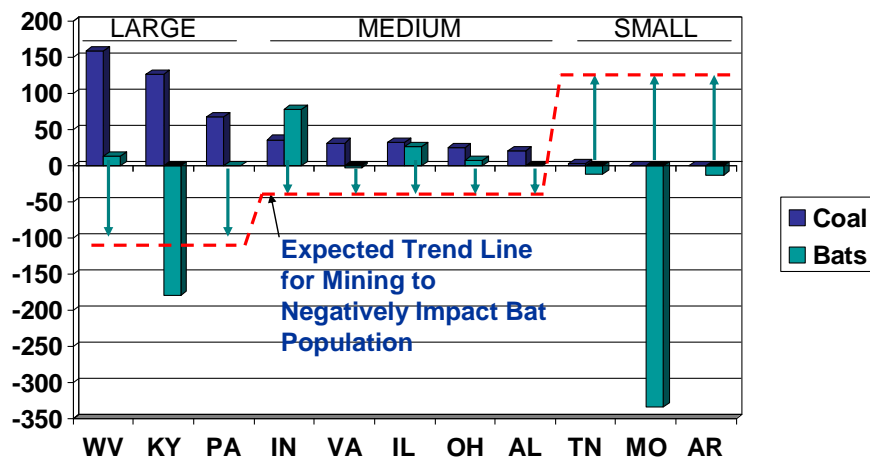


Figure 5. Total Coal Production by State Compared with Change in Indiana Bat Population.

The three States with greatest coal production showed two States, West Virginia and Pennsylvania had gains in bat populations while Kentucky had a substantial decrease in bat population. Of the five States with a medium sized coal industry, three States, Indiana, Illinois, and Ohio, had substantial increases in bat populations while two States had small declines in bat populations. Of the three States that have a total coal production that is too small to have any impact on bat populations, Tennessee, Missouri, and Arkansas, all had substantial decreases in bat populations with Missouri having the greatest decline. These results would suggest that the size of the coal mining industry in a State does not appear to be related to changes in bat population.

**Correlation of Bat Population Data with Coal Production Data Associated with either
Surface Mining or Underground Mining Methods**

The author also examined trends in bat populations as compared to the predominant mining method for the State. If over 60 percent of the coal was produced by surface mining methods in 2005 then the State was categorized as a surface coal mining State. If over 60 percent of the coal was produced by underground mining methods in 2005 then the State was categorized as an

underground coal mining State. Table 4 contains the coal production figures for the predominately surface mined States and shows the coal production figures for the predominately underground mined States (U.S. Department of Energy (b) summarized in Table 5). These tables illustrate that with the exception of the State of Indiana, the major coal producing States within the range of the Indiana Bat are predominately underground mining States.

Table 4. Total Coal Production in Thousands of Tons for States where the Predominant Mining Method was Surface Mining in 2005.

State	Total Coal Production in thousands of tons	Surface Mined	Underground Mined	% Surface Mined
Totals	40,134	27,251	12,878	
ARKANSAS	3	1	0	100
MISSOURI	598	598	0	100
OKLAHOMA	1,858	1,391	465	74.9
TENNESSEE	3,218	1,993	1,224	61.9
Indiana	34,457	23,268	11,189	67.5

(Southern States with Declining Populations of Indiana Bat in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in Lower Case Blue Letters)

Table 5. Total Coal Production in Thousands of Tons for States where the Predominant Mining Method was Underground Mining in 2005.

State	Total Coal Production in thousands of tons	Underground Mined	Surface Mined	% Underground Mined
Totals	436,606	291,744	144,864	
ALABAMA	21,339	13,295	8,044	62.3
KENTUCKY	119,734	73,702	46,032	61.5
VIRGINIA	31,596	21,225	10,371	67.2
Illinois	32,014	26,343	5,671	82.2
Ohio	24,718	15,823	8,896	64.0
Pennsylvania	67,494	54,563	12,931	80.8
West Virginia	139,711	86,793	52,919	62.1

(Southern States with Declining Populations of Indiana Bat in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in Lower Case Blue Letters)

Correlation of Coal Production Data with Indiana Bat Population Data from Predominately Surface Mined States

The percent change in coal production compared to changes in Indiana bat populations from 1965 to 2007 for Predominately Surface Mining States (Table 6).

Table 6. Percent Change in Coal Production from 1970 to 2006 for Predominately Surface Mining States.

Surface Coal Mining State	Total Change in IN Bat Population	% Change in Coal Production
ARKANSAS	-13,200	-97%
MISSOURI	-333,450	-82%
OKLAHOMA	+5	+130%
TENNESSEE	-11,700	0%
Indiana	+77,900	+100%

Correlation of Percent Change in Surface Mined Coal Production with Change in Indiana Bat Population

In Fig. 6, the percent change in coal production is compared with bat population trends for States that are predominately mined by surface mining methods. Actual bat population changes are shown in green and percent change in coal production is shown in blue. The figure is arranged from left to right by the State of Missouri with the greatest total decline in bat population to the State of Indiana with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The dashed red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a high percent change in coal production would result in a large decrease in bat population and small percent change in coal production would result in a corresponding large increase in bat population.

The data from Missouri and Arkansas show a dramatic reduction in surface coal mining that is occurring at the same time as the population of Indiana bats are dramatically decreasing. The data from Oklahoma shows a substantial increase in surface coal mining with a very small increase in Indiana bat population. The Indiana data illustrates a substantial increase in bat populations occurring at the same time as a substantial increase in surface mining activity. The author could not find data to support any connection between the level of surface coal mining activity with trends in the Indiana bat population.

**IN BAT POPULATION CHANGE (Thousands)
VERSUS (%) CHANGE IN COAL PRODUCTION
FOR SURFACE MINED STATES**

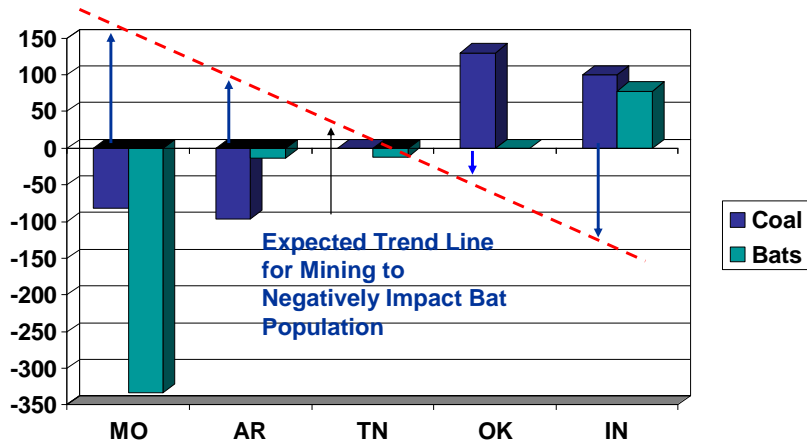


Figure 6. Change in the Population of Indiana Bats versus the percent Change in Coal Production for Surface Mined States.

Correlation of Total Coal Production in States with Surface Mining as the Predominant Mining Method with Change in Indiana Bat Population

In Fig. 7 the total coal production is compared with bat population trends for States that are mined predominately by surface mining methods. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right by the State of Indiana with a medium sized coal industry with the other four states with a coal industry too small to be of any significant influence on bat populations. The green arrows indicate the expected direction of bat population increase or decrease if there were a negative correlation with the size of the coal industry in the State. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a medium sized total coal production level would result in a moderate decrease in bat population and small total coal production would result in a corresponding large increase in bat population.

These data suggest that Indiana with a medium sized coal production where the bat population has substantially increased in comparison to Missouri, Arkansas, Oklahoma, and Tennessee with very small coal production and yet the bat populations in Missouri and Arkansas

are still decreasing dramatically. The trend in data does not support a connection between levels of surface coal mining activity with trends in the Indiana bat population.

**TOTAL COAL PRODUCTION (Millions of Tons)
FOR SURFACE MINED STATES VERSUS
IN BAT POPULATION CHANGE (Thousands)**

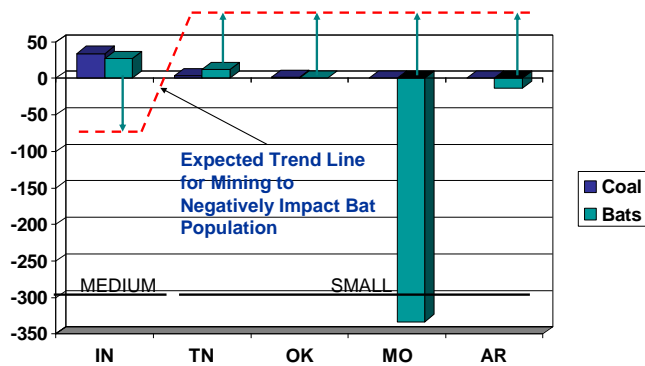


Figure 7. The Indiana Bat Population Change versus the Total Coal Production for Surface Mined States.

Correlation of Coal Production Data from Predominately Underground Mining States with Indiana Bat Population Data

The percent change in coal production from 1970 to 2006 for Predominately Underground Mining States is summarized in Table 7. Kentucky has the most dramatic decrease in bat population whereas Illinois shows the most significant increase in bat population that occurred at the same time as a 52 percent decrease in coal production.

Table 7. Percent Change in Coal Production for Predominately Underground Mining States.

Underground Coal Mining State	Total Change in IN Bat Population	% Change in Coal Production
KENTUCKY	-179,300	+27%
VIRGINIA	-2,350	-10%
ALABAMA	-100	+35%
Pennsylvania	+50	-20%
Ohio	+7,450	-51%
West Virginia	+13,100	+17%
Illinois	+27,000	-50%

In Fig. 8, the percent change in coal production is compared with bat population trends for States where coal is mined predominately by underground mining. Actual bat population changes are shown in green and percent change in coal production is shown in blue. The figure is arranged from left to right by the State of Kentucky with the greatest total decline in bat population to the State of Illinois with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The dashed red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a high percent change in coal production would result in a large decrease in bat population and small percent change in coal production would result in a corresponding large increase in bat population.

IN BAT POPULATION CHANGE (Thousands) VERSUS (%) CHANGE IN COAL PRODUCTION BY UNDERGROUND MINED STATES

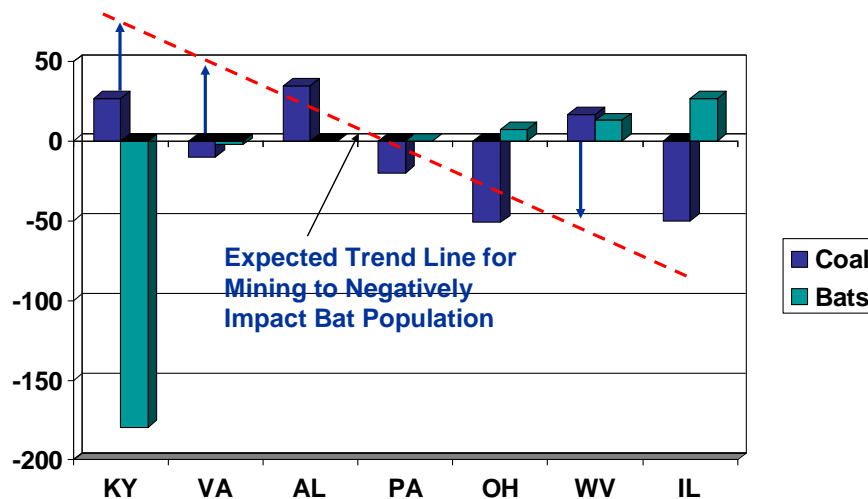


Figure 8. Indiana Bat Population Change versus the Percent Change in Coal Production for Underground Mined States.

In this case, five of the seven underground mining States KY, AL, PA, OH, and IL would seem to support the expected trend if increased coal mining activity resulted in a decrease in bat populations. The data from Virginia and West Virginia would contradict this trend because Virginia has a decreasing coal production along with a decrease in bat population while West

Virginia has an increase in coal production along with an increase in bat population. In addition, since the majority of mining is underground, increases in coal production would not be expected to affect surface habitat of the bat.

The data in Fig. 9 compares the total coal production data with bat population trends for States that are mined predominately by underground mining methods. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right by the State of West Virginia with the greatest total coal production to the State of Alabama with the least. The States of West Virginia, Kentucky and Pennsylvania would be classed as having a large sized coal industry while the other States Virginia, Illinois, Ohio, and Alabama would be classes as having a medium sized coal industry. The green arrows indicate the expected direction of bat population increase or decrease if there were a negative correlation with total coal production levels. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a State with a large coal industry should result in a large decrease in bat population and State with a medium sized coal industry would be expected to would result in a smaller decrease in bat population.

**TOTAL COAL PRODUCTION (Millions of Tons)
FOR UNDERGROUND MINED STATES
VERSUS IN BAT POPULATION CHANGE (Thousands)**

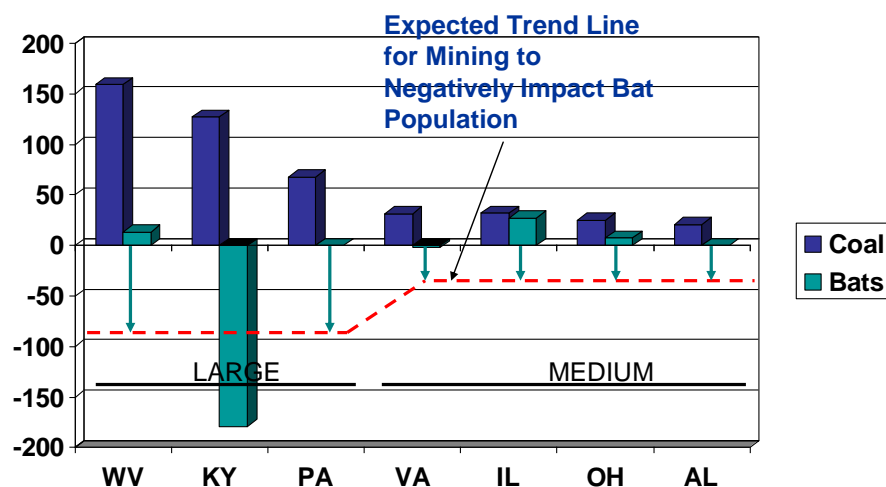


Figure 9. Indiana Bat Population Changes versus Changes in Total Coal Production for Underground Mined States.

Of the States with a large coal industry, the State with the highest total coal production is West Virginia that had an increase in bat population. The State with the second highest total coal production was Kentucky that had a substantial decrease in bat population. Of the States with a medium coal industry three showed a significant increase in bat population with one a very small decrease. Based on these data there does not appear to be any trend to support a connection between levels of underground coal mining activity with trends in the Indiana bat population.

Conclusion

Information provided by Clawson (2004) during the Indiana Bat and Coal Mining forum showed a dramatic decline in the number of Indiana bats from 1965-2003 nationwide. Information provided by Clawson (2007) during the Indiana Bat and Coal Mining Revised Recovery Plan workshop showed a steady increase in the Indiana bat population from 2001-2007 nationwide. Coal production data from 1970, 1980, 1990, and 2003 (U.S. Department of Energy(a) and (b)) was determined from the States where Indiana Bat populations and coal reserves overlap.

Over the time period from 1970-2006, coal mining activity in these States has ranged from a negative 97% in Arkansas to a positive 100% in Indiana and 130% in Oklahoma. Total coal production ranges from 10,000 tons/year in Arkansas to 159 million tons/year in West Virginia. They include five States where surface mining methods predominate and seven States where underground mining methods predominate. Coal production has increased significantly in the States of Alabama, Indiana, Kentucky, Oklahoma, and West Virginia.

Over the time period from 1965-2007, bat populations are decreasing in the six coal mining States of Alabama, Arkansas, Kentucky, Missouri, Tennessee, and Virginia and increased in the six coal mining States of Illinois, Indiana, Ohio, Oklahoma, Pennsylvania, and West Virginia. More recently from 2001 to 2007, bat populations have been increasing in seven of the coal mining States including Alabama, Illinois, Indiana, Kentucky, Oklahoma, Pennsylvania, and West Virginia.

There does not appear to be any consistent pattern or trend in data between coal mining and bat population related to changes in levels of coal mining activity, total coal production (size of the mining industry), or mining method (surface versus underground). This conclusion would be supported by a comparison of the data from the Forest Service that there are 384 million acres of

forest cover in the eastern U.S. with the 3.07 million acres of total permitted acreage of surface coal mines in the 14 States within the Indiana bat habitat (OSM 2004), that results in a maximum of 0.8% of the eastern forest cover that could be impacted by surface coal mining.

While total forest area has been relatively stable for the last 100 years (currently about 747 million acres), there have been significant regional shifts in the area and composition of the nation's forests. Reversion of marginal farmland in the east, large scale planting in the South, and fire suppression have contributed to increases in forest area. Urbanization, conversion to agriculture, reservoir construction, and natural disasters have been major factors contributing to loss of forests. Eastern forests cover about 384 million acres and are predominantly [broadleaf](#) (74%), with the exception of extensive [coniferous forests](#) and plantations in the southern coastal region. These are largely in private ownership (83%) (Smith, W. B. et al.1997).

Although some of the changes in bat population are suggestive of changes in climate (a uniform increase in the temperature of winter hibernacula could make hibernacula in southern States too hot and in northern States more suitable), the most likely reason for the decline of the species is tied to human disturbance of their underground winter habitat during hibernation. Coal mining operations do not have any impact on underground winter habitat of the species. Recent observations in the extreme northeastern U.S. has turned up bats infected with “white nose” disease, but it is too early to tell what impact it will have on the population. The current emphasis of the U.S. Fish and Wildlife Service on mitigation of impacts due to coal mining is to protect and enhance summer habitat. This may not be effective when the limiting factor in sustaining a healthy Indiana bat population is having an adequate supply of suitable winter hibernacula.

Investigations need to be undertaken to determine what, if any, impact coal mining and reclamation is having on the bat populations and what mitigation activities are appropriate and effective. The challenge before the States, USFWS, OSM, the coal mining industry, and bat conservationists is to coordinate these concerns in a way that is both protective of the species and appropriately efficient in terms of mitigation requirements that bring proven positive results for this species.

The recovery of the species will depend upon our ability to detect, restore, and protect key caves and mines that provide adequate and suitable winter hibernacula (Tuttle, 2007).

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