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THE SPATIAL CHARACTERISTICS OF THREE WYOMING FUELS

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This paper examines the development patterns of Wyoming's petroleum, natural gas and coal resources. The emphasis is on the location of the resources and their movements. The author suggests, through the use of a limited number of measurements, that the spatial characteristics of Wyoming fuels have displayed a mutable nature. It is posited that an examination of Wyoming's past experience might provide the state with a better understanding of the state's current position as a major fuel supplier.

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INTRODUCTION

One of the immediate solutions to the problem of excessive amounts of sulfur released into the atmosphere is the use of low-sulfur fuels such as natural gas or low-sulfur coal. Coal is by far the more abundant of the two fuels even though only a small fraction of the coal reserves in the United States is low-sulfur grade (coal with less than one percent sulfur content). However, of those reserves, "over 80 percent of the total 23.5 billion tons of low-sulfur subbituminous coal is in the Rocky Mountain and Northern Great Plains provinces, with almost 70 percent (13.4 billion tons) in Wyoming."[1] Thus, the Rocky Mountain region, especially Wyoming, begins to take on greater significance in the quest for more electric power and cleaner fuels for power plants.

Since 1868, when coal was mined for the locomotives of the Union Pacific Railroad, fuel production has been a very important factor in Wyoming's economy. In 1970 Wyoming ranked among the top ten states nationally in the production of petroleum, natural gas, coal, and uranium.[2] Already unit trains carrying low-sulfur subbituminous coal from Wyoming to power plants in Wisconsin and Illinois make it possible for previously little-used Wyoming coal resources to compete with Midwestern coal.

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[1] U.S., Department of the Interior, Bureau of Mines, Strippable Reserves of Bituminous Coal and Lignite in the United States (Washington, DC: Government Printing Office, 1971), p. 21.

[2] University of Wyoming, Division of Business and Economic Research, College of Commerce and Industry, Wyoming: Comprehensive Economic Studies To Facilitate Development Through Planning (Laramie: University Press, 1970), p. 8.

Recently, decisions at both national and state levels regarding the quality of air Americans breathe have stimulated a reexamination of Wyoming's abundant fossil fuels. Assuming that Wyoming has both short and long term potentials as a fuel reservoir, one should concentrate on the location and usage patterns of those fuels. This study examines those spatial characteristics through the use of several measurement tools.

It does little good to consider how energy demands are to be met in the future if no assessment is made of the choices available now. To do this requires such basic steps as an inventory of energy sources as they exist in a finite space; the recognition and measurement of the movement of energy resources both within and outside a given region. The author believes that a significant insight into present spatial patterns can be gained by tugging on the thread of historical fact which is woven throughout the present patterns of fuel development. The one unifying methodology is an historical economic geography, with a variety of other analytical tools used to more fully analyze three selected fuels in the resource base of Wyoming.

OTHER PROBLEMS

Also important are forces which play a part in shaping location and usage patterns. The Arab oil embargo is an example of a factor which is not directly related to the site or situation characteristics of Wyoming fuels. As the result of certain political and economic reactions to the embargo, some traditional constraints to development of fuels in particular locations have been altered. The ammouncement of Project Independence[3] did not in itself create new fuel sources; however, given the shortage of fuels and an officially announced policy of domestic self-sufficiency in fuel production, such factors as proximity to markets and transportation costs are somewhat less important than availability.

Furthermore, technologies which may have a deleterious effect on our environment also make it possible for us to utilize their methods and tools to correct as well as monitor the changes in our physical environment. However, one element is basic not only to the eventual solution of the energy/environment conflict, but also in defining the areas of conflict that have often been relegated to a background position. Spatial factors are critical elements which must be considered in understanding any energy problem. Additionally, interaction between geographic areas is not carried out in a vacuum but within the political and cultural milieu at both regional and national levels. It does little good to consider how energy demands are to be met in the future if no assessment is made of the optimum choices available now. To do this requires such basic steps as an inventory of energy sources as they exist in finite space, and the recognition and measurement of the movement of energy resources both within and outside of a given region.

SCOPE AND LIMITATIONS OF THE STUDY

For convenience in obtaining and working with data, this study is limited to Wyoming as a geographical and political unit. Functionally,

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[3] A federal program to achieve energy self sufficiency by 1980 announced by President Nixon in 1974.

as one might expect, there is a great deal of interaction between neighboring political units, and a state as sparsely populated as Wyoming has more external economic ties than internal ones. However, the study also concerns the changing role the State of Wyoming has played over time at both a regional and national level. It is postulated that the cyclical nature of the state's production of fuel resources has been determined largely by external factors. Only recently have the vast reserves of subbituminous coal located within the state been considered important enough, in economic terms, to be exploited by eastern consumers. The following study is oriented toward examining the past and present spatial characteristics of production patterns. Coal, petroleum, and natural gas are chosen for analysis to illustrate current and historical characteristics. Coal's patterns of production and transportation are examined as is the distributive pipeline network of petroleum and natural gas. Additionally, methods of land acquisition and physical and non-physical restrictions placed upon the production of coal are discussed.

THE IMPACT OF MINERAL LEASES ON PUBLIC LANDS IN WYOMING

One of those methods of land acquisition which has had an impact upon coal production in Wyoming has been the leasing of public lands. Public land statistics reveal that over 48 percent of all the land acreage of Wyoming is owned outright by the federal government.[4]

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[4] U.S., Department of the Interior, Bureau of Land Management, Public Land Statistics - 1972, p. 10.

Historically, as Table 1 indicates, Wyoming's rank in terms of patents on public lands has been first in the nation. The fact that 41 percent of all federally owned land in the state and fully 20 percent of the state's entire acreage has been involved with mineral leasing lends credence to any statement pointing out the important role of minerals in Wyoming's development. Traditionally, coal leases have constituted the largest acreage of public land committed to specific mineral exploitation (19 percent through 1948). There is no reason to assume that the pattern has been altered greatly in the 1948-1972 period. However, mere acreage figures belie the value of the mineral produced. Thus in 1972, oil and gas leases produced more revenue for the state and federal governments than coal leases.

For example, during 1972 approximately 80.8 million barrels of petroleum were produced on public lands in Wyoming while slightly over 2.8 million tons of coal were produced during the same period. Assuming very conservative prices of $5 per barrel of oil and $3 per ton of coal (F.O.B. mine), the respective market values are over $400 million for petroleum and only $8.4 million for coal.[5] If the more realistic 1973 prices of $12 per barrel and $7 per ton (F.O.B. mine) were considered, the resulting figures would be enormous. During 1972 alone, $12.26 was received in bonuses[6] for each acre of public land leased for gas and

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[5] Actual Department of Interior figures show a value of $10.5 million for 1972.

[6] The cash consideration paid to the United States by the successful bidder for a mineral lease such payment being made in addition to the rent and royalty obligations specified in the lease.

TABLE 1 PATENTS ISSUED WITH MINERALS RESERVED TO THE UNITED STATES, THROUGH 1972

State	Type of mineral reservation						
	All minerals	Coal	Oil and Gas	Phosophate	Oil and Gas plus other minerals	Miscellaneous minerals and combinations	Total
Through 1948	acres	acres	acres	acres	acres	acres	acres
Alaska	6,501	10,823	1,095		773		19,192
Alabama	4,412	63,586	9,563		2,889		80,450
Arizona	2,547,517	4,403	27,497			101,880	2,681,297
Arkansas	1,107	1,520	15,043	85	40		17,795
California	2,352,070	3,005	156,783		23	1,864	2,513,745
Colorado	4,271,042	1,348,288	215,423		38,494		5,873,247
Florida	1,154		2,304	71,259	520		75,237
Idaho	1,291,163	11,749	4,940	270,036	216,060		1,793,948
Illinois	634	120					754
Iowa	359						359
Kansas	54,384		1,421				55,805
Louisiana	1,223		17,105		3,844		22,172
Michigan	1,935		3,261				5,196
Minnesota	235			8			243
Mississippi	974		10,231				11,205
Missouri	166						166
Montana	3,993,640	6,658,554	987,472	11,290	17,788	150	11,668,894
Nebraska	72,964		3,253				76,217
Nevada	242,717	960	1,119		80	40	244,916
New Mexico	6,378,118	614,779	112,995	680	70,673	2,092,091	9,269,336
North Dakota	134,578	4,636,851	11,915		1,164	40	4,784,548
Ohio	38					744	782
Oklahoma	48,781		10,917				59,698
Oregon	1,639,742	5,598	14,369		480		1,660,189
South Dakota	1,565,802	187,722	6,328				1,759,852
Utah	856,083	215,528	98,922	21,576	8,157	1,680	1,201,946
Washington	262,444	14,535	2,518		384	400	280,281
Wisconsin	1,546						1,546
Wyoming	9,541,179	2,297,363	376,906	32,037	17,341	257	12,265,083

SOURCE: Public Land Statistics, Bureau of Land Management, 1972, Table VI p. 1.

oil on the 40 competitive mineral leases granted by the Bureau of Land Management.[7]

COAL LEASING ON PUBLIC LANDS

Walter Mead's work with petroleum leasing of offshore tracts in the Gulf of Mexico indicated that the competitive bidding on public lands system was affected by several variables which influenced the outcome of the leasing permit. Among the variables examined by Mead was the size of the bidding companies (either one of the largest eight oil producers or a smaller producer), the size of the potential lease tract, the value of oil production from the awarded lease through time, and the depth of the water. Several hypotheses were tested, including a high winning bid value when there were many joint bidders from large firms; the tract was in a highly productive area and the water was shallow. Mead's investigation showed that the most important variable which related to the winning bid was the number of bidders on the tract.

As a consequence of Mead's inquiry into competitive leasing in the petroleum industry, this author hypothesized that the same types of factors may also be functionally important in the leasing of public coal lands in Wyoming which are subjected to competitive bidding. Accordingly, coal lease data were obtained from the Bureau of Land Management files in Cheyenne, Wyoming, and an initial frequency distribution of the number of bidders per coal tract was constructed.

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[7] Public Land Use Statistics - 1972, op. cit., p. 113.

The results showed that only 30 percent of the tracts leased through the competitive bidding process had three or more bidders. A comparable figure of 27 percent was obtained by Mead for oil leases in the Rocky Mountain area. In an attempt to determine which factors seemed to be most important in determining the high bid on public coal lands (which ranged from $505 per acre to $1.00 per acre) a stepwise regression procedure was chosen. One of the advantages of this regression procedure is that any variable which does not make a significant contribution to the regression model is removed and the process is continued until no more variables are admitted or rejected. Thus the process provides a judgment of the contribution of each variable introduced into the model.[8]

COAL LEASE ANALYSIS

Thirty leases in the BLM files were bid on since approximately 1954 which limited the value of the analysis somewhat but still proved to be a workable n size for the statistical procedure. The dependent variable (y) was the high bid on the tract while the following six independent (x) variables were considered: (1) the size of the bidder in which a value of 10 was given to any bidder who was one of the top 25 oil producers or top 10 coal producers; (2) a bidder who did not meet the above criteria was given a value of zero and thus was able to drop out of the equation; (3) the total production from the lease from

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[8] N. R. Draper and H. Smith, Applied Regression Analysis (New York: John Wiley & Sons, Inc., 1966), p. 171.

the time the lease was granted (in tons); (4) the time (in months) that the lease was held; (5) the size of the lease tract in acres; (6) the number of bidders on the lease. The results show that the most important factor contributing to a high lease bid was the number of bidders, with the size of the large companies being the next most important factor.[9] The findings seem to be similar to Mead's analysis of oil lease bidding and certain interesting characteristics of both a spatial and economic nature emerge from such analyses.

Initially the wide range of bids for public coal lands indicates that the greater the number of bidders involved with the lease the more likely the price (or the perceived value) of the lease will increase. The present competitive bidding system is designed so that an increased number of bidders will raise the lease bid level and early production of coal will follow. Unfortunately, just the opposite has occurred. High bids of over $500 and $400 per acre by large petroleum companies such as Sun Oil and Mobil have resulted in absolutely no coal production to date. The two examples cited have been held for 5.6 and 5.7 years respectively[10] and there are no immediate plans to mine coal in the future. On the other hand, coal has been produced by smaller corpora-

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[9] The coefficients of determination (R^2) were number of bidders, Var. 7, (.53658); top 25 producers, Var. 2, (.17254); acres in lease, Var. 6, (.03243); total production, Var. 4, (.02016); time held, Var. 5, (.00724); all other bidders smaller than top 25, Var. 3, (.00076). In all the model accounted for almost 77 percent of the total variability in the high bid.

[10] Bureau of Land Management Coal Lease data; U.S.G.S. correspondence with regional offices.

tions on leases which have ranged from $1.00 per acre to $257 per acre. These data may indicate that the production incentives of the competitive lease bidding system may not be very effective (only 6 of 30 leases have been coal producers) and may in part explain the Department of Interior moratorium on coal leasing since late 1971. It is suggested that the lack of development of coal leases, perhaps for speculative reasons, is an important reciprocal consideration of the more prominent environmentally disruptive elements of exploited coal deposits.

A CONSIDERATION OF SOME PHYSICAL CONSTRAINTS UPON FUEL DEVELOPMENT

In terms of disruptive aspects of mining, a recent report from the Bureau of Mines indicates that only 3.6 million acres or 0.16 percent of the nation's total land area has been used for mining.[11] As a contrast, the report also estimated that the land used for railroads and airports in 1971 roughly equaled the acreage used for mining activities in the 1930-71 period. In comparison, the total national acreage underlain by highways was almost 23 million acres.[12] Because most coal and uranium production in Wyoming is from surface mining operations and will probably be surface mined in the foreseeable future, a considerable amount of land is assumed to be affected by mining activities in the state. For example, even after more than a century

[11] James Paone, John L. Morning and Leo Giorgetti, Land Utilization and Reclamation in the Mining Industry, 1930-1971 (Washington, DC: U.S. Government Printing Office, 1974), p. 1.

[12] Mining Congress Journal, "Mining Newsmonth," August, 1974, p. 5.

of mining it is estimated that approximately 99.4 percent of Wyoming's coal reserves are still untouched.[13]

A recent environmental impact statement developed by the Bureau of Land Management, U.S. Forest Service, U.S. Geological Survey, and the Interstate Commerce Commission[14] indicates that great changes are forthcoming for the Powder River Basin of Wyoming. By 1990 an additional 150 miles of railroad, 225 miles of powerlines, 30 miles of coal slurry pipeline, and at least 24 additional miles of roads are all expected to be constructed in the area. Although the Impact Statement concerns only coal development, this writer believes that some of the same constraints, especially their spatial component, can also be applied to other fuel resources located in Wyoming.

THEORETICAL IMPACTS OF COAL MINING ON A REPRESENTATIVE AREA

It is acknowledged that an impact statement written for one portion of one coal basin does not necessarily apply to all coal basins in the state. However, it is typical of the types of constraints that would be encountered in other areas as well. More importantly, the Powder River Coal Basin with its tremendous coal reserves and generally good accessibility will probably be the first large scale fuel resource development area in the state.

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[13] Gary B. Class, "Wyoming," Coal Age, Western Coal Edition, Mid-April 1973, p. 193.

[14] U.S., Department of the Interior, Bureau of Land Management, U.S. Geological Survey, Interstate Commerce Commission, Draft Environmental Impact Statement, Development of Coal Resources in the Eastern Powder River Coal Basin, Vol. 2, pt. 1, pp. 459-60.

Estimates show that over 29,000 acres of land will be disturbed by mining between 1974 to 1990. When production hits the 118 million tons/year rate between 1974 and 1980, the operation of seven strip mines will disturb approximately 35,000 acres per year. Additionally, the construction of roads and railroads will almost match the amount of land disturbed in the 1974-1980 period. Mining activity alone may reduce the local relief patterns in the vicinity of the coal seams from about 28 to 68 feet depending on the amount of overburden removed and the thickness of the coal seam being mined. In sum, the impact statement estimated that by 1990, rights-of-way for roads, pipelines, transmission lines, and other facilities, will account for an additional 7,500 acres of land being disturbed annually. Mining facilities and housing construction could require another 7,500 acres and, of the 15,000 acres estimated to be disturbed, 9,500 acres (63 percent) will be permanently lost as productive soil surface.[15]

In order to ease the movement of coal out of the region by rail, a new rail line which would link the eastern Powder River Basin coal fields with the main line of the Burlington Northern/Chicago and Northwestern is being considered.

> The railroad as presently proposed will be located above coalbeds which are amenable to mining by surface or underground methods. The right-of-way crosses an estimated 161 million tons of presently economically strippable coal. Should it become economically feasible to strip overburden to depths of 400 feet, then the proposed right-of-way crosses an additional 195 million tons of coal. The spur lines to be

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[15] Ibid., pp. 470-77.

> built into the mines will cross additional large amounts of presently strippable coal (73 million tons to 400 feet of overburden).[16]

In effect, the construction of this one form of transportation link to the mining operations will remove the affected land from production. If one were to include highways, mine support facilities and especially housing requirements, the amount of non-productive coal land created by surface mining is truly enormous.

NON-PHYSICAL ENVIRONMENTAL IMPACTS

Another category of environmental impacts are those which are not physical. They can affect amenities such as historical sites or recreational areas. Although the impact statement being used as an example notes that these types of limitations are not present, the possibility of mining impacts on such sites has caused some concern at the state level. The Bureau of Land Management's State Multiple Use Advisory Board recently passed a resolution that "called for a public education program for preservation...[of sites] known to have historic value."[17] As a precaution against destruction, the resolution recommended that such sites be identified, inventoried and photographed.

Often overlooked are other social and political constraints to fuel resource development. The tourist industry ranks third in the state's economy after minerals and agriculture partly because of the great abundance of public areas reserved for tourism. For example, national parks and monuments constitute 4 percent of the state's total

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[17] "BLM Asked to Protect Historic Sites in Wyoming," The Denver Post, 16 September 1974, Sec. B, p. 21.

land area and national forests also account for an additional 4 percent. Over 73,000 acres are devoted to four wildlife refuges. The State of Wyoming maintains eight recreation areas of almost 152,000 acres plus 17 historic sites (158 acres) and markers. The Wyoming Game and Fish Department operates 11 fishing areas (3,000 acres) and 24 wildlife management areas of almost 34,000 acres. Local parks and monuments constitute an additional 1,024 acres. In all, over 23 percent of the total land area of the State of Wyoming is already devoted to public recreation use and is therefore placed in the non-productive category of fuel resource development.[18] Not all the reserve areas are assumed to contain fuel resources of significant size. However, areas such as the Jackson Hole Coal Field and the Wind River Coal Basin contain considerable amounts of coal, and in the case of the Wind River Indian Reservation, oil and gas as well. Thus, any inventory of fuel resources must also include the cultural and political spatial restrictions placed upon the resource in addition to their mere size and quality.

THE HISTORY OF MOVEMENT OF FUELS WITHIN AND OUTSIDE THE ROCKY MOUNTAIN REGION

PETROLEUM

Another aspect of fuel inventory is the pattern of transportation over time. General trends concerning fuels originating in Wyoming can be discerned from federal data. For example, roughly half the petroleum

[18] U.S., Department of the Interior, National Park Service, Parks For America, A Survey of Park and Related Resources in the Fifty States, 1964, pp. 471-2.

produced within Wyoming is currently exported either as crude oil or refined products. The pattern developed when pipelines were built to Denver in 1938 and across the Continental Divide to Salt Lake City by 1939. Another pipeline to Billings, Montana was constructed during the same period which made it easier to market Wyoming petroleum outside the state. Prior to 1939, over 2-1/2 million barrels per year were moving from the Casper area to the Midwest markets of the Standard Oil Company.[19]

PIPELINES TO MARKETS

A combination of low crude oil prices, pro-rationing programs at state levels, and natural declines in oil field production all contributed to the construction of short trunk lines within several states, including Wyoming.[20] When the Lance Creek Oil Field in west central Niobrara County was developed, Continental Oil Company built a six-inch line to its Denver refinery in order to compete with other independent oil producers who were selling to the Bay Petroleum Company Refinery which was also located in the Denver area.[21]

Movement of petroleum from Wyoming to regional markets rather than extra-regional ones became important during the late 1930s. It was during this period that oil production "booms" in Kansas and Illinois overshadowed an increase in Wyoming's petroleum production and made regional market opportunities more attractive. As population growth

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[19] Harold F. Williamson, et al., The American Petroleum Industry (Evanston: Northwestern University Press, 1963), pp. 571-2.

[20] Ibid., p. 571.

[21] T. R. Ingram, "To Lay 230-Mile 6-Inch Line from Lance Creek to Denver," Oil and Gas Journal, June 1938, p. 24.

continued, a greater portion of Wyoming petroleum was consumed within the region. This trend is especially evident after World War II when the population of the region increased 31.5 percent, 44 percent and 24 percent during the 1950, 1960 and 1970 censuses. During the 1960-70 period the Colorado population increase (26 percent) created an important regional market area for Wyoming petroleum. Not surprisingly, the amount of Wyoming petroleum consumed within the Rocky Mountain Region (Montana, Wyoming, Colorado, Utah) has increased from 22 percent of Wyoming's total production in 1960 to 38 percent in 1972.[22]

GOVERNMENTAL IMPACTS ON PIPELINE MOVEMENTS OF PETROLEUM AND NATURAL GAS

Federal control of pipelines can be traced back to the passage of the Hepburn Act in 1906. This legislative act which placed oil pipelines for the first time under the control of the Interstate Commerce Commission which regarded interstate pipelines as common carriers and therefore subject to the same regulations as railroads. The Act was directed toward the Standard Oil Company which, the ICC believed, used pipelines to its advantage. The ICC report to Congress in 1907 stated that:

> More than anything else the pipeline has contributed to the monopoly of the Standard Oil Company, and the supremacy of that company must continue until its rivals enjoy the same facilities of transportation by this means.[23]

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[22] U.S., Department of Commerce, Bureau of the Census, 1970 General Population Characteristics: Wyoming (Washington, DC: Government Printing Office, 1971), pp. 1-23; and U.S., Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1972, 3 vols. (Washington, DC: Government Printing Office, 1974), Vol. 1, Metals, Minerals and Fuels, pp. 952-3.

[23] Arthur M. Johnson, Petroleum Pipelines and Public Policy, 1906-1959 (Cambridge: Harvard University Press, 1967), p. 235.

The Hepburn Act of 1906, or more specifically, the pipeline amendment to the Act placed the federal government in a position to regulate the operation of the pipelines directly, and to influence the pattern of pipeline development indirectly. The precedent established by a small oil marketing firm in 1922 illustrates government regulation.

The Brundred Brothers Company, which sold oil products to small refiners in western Pennsylvania, sued a pipeline owned by the Prairie Pipeline Company to reduce the minimum tender[24] required to transport oil. The ICC found for the Brundred Brothers and cut the tender requirement to one-tenth of its former amount. Since the Prairie Pipeline Company was engaged in the construction of a 6-inch pipeline from Casper to Missouri (see Figure 1) at the time, the ICC decision had some influence upon petroleum development patterns in Wyoming as well. Because the extremely high and expensive tender requirements (in 1920 a conservative estimate of $350,000 in inventories was placed on a 100,000 barrel tender) were cut by the ICC, small producers in Wyoming and other states were not discouraged in their production and marketing activities.[25] Today the benefits of a federal intervention into the transport of petroleum have helped to create a situation in Wyoming where the small independent producers and refiners are becoming essential to the continued development of the state's petroleum industry.

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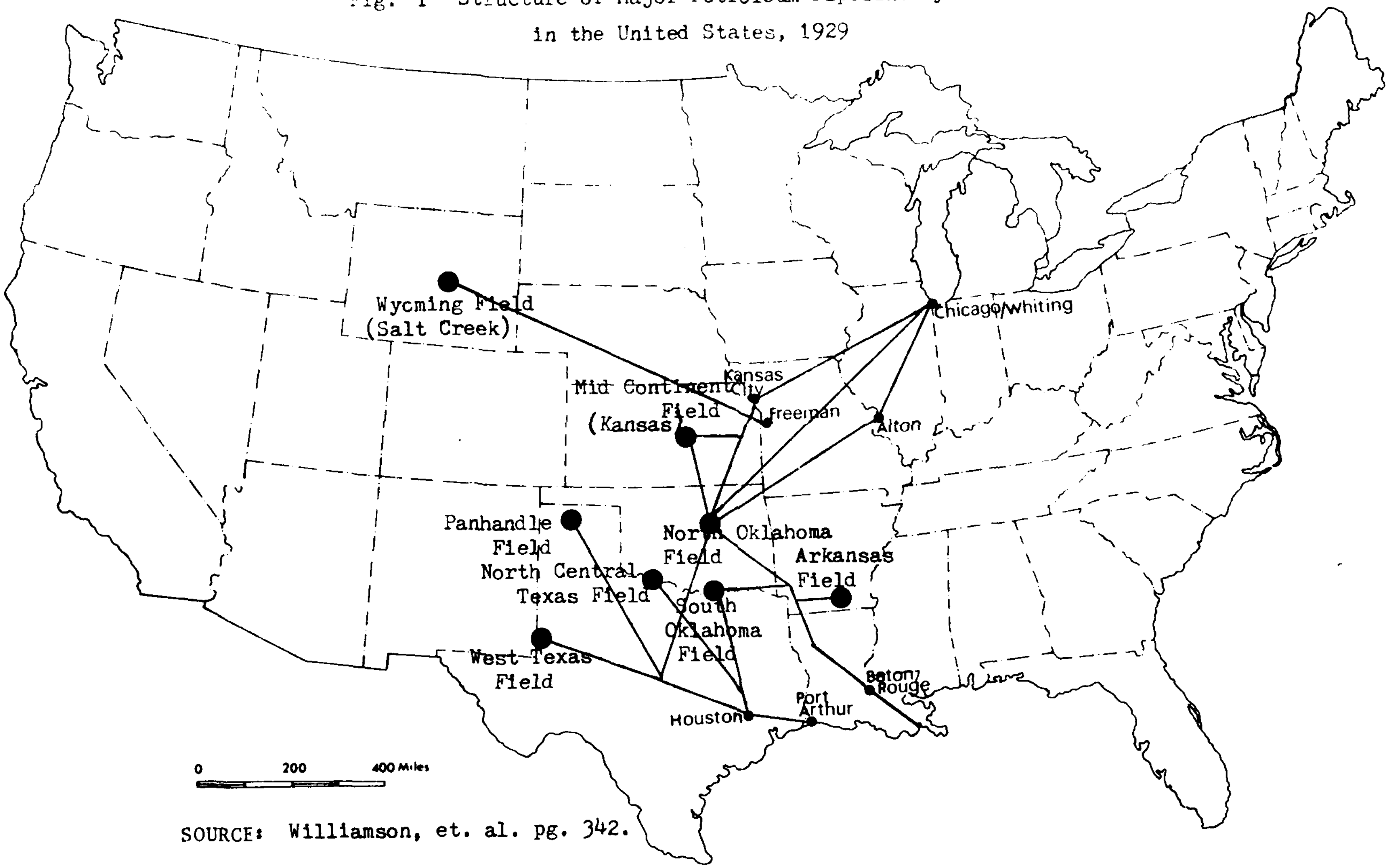
[24] A rate schedule agreement whereby each shipper agreed to ship a certain amount of oil which he had in storage above ground and ready to be shipped to a single point before the pipeline company would move the oil.

[25] Williamson, et al., op. cit., p. 342.

Fig. 1 Structure of Major Petroleum Pipeline Systems
in the United States, 1929



SOURCE: Williamson, et. al. pg. 342.

NATURAL GAS

At the present time Wyoming is playing an increasingly important role as a regional natural gas supplier. In 1972 there were seven interstate natural gas pipeline companies operating in Wyoming which collectively delivered over 3.4 trillion cubic feet of natural gas to 16 states including Wyoming.[26] Approximately 96 percent of all the natural gas produced in Wyoming was marketed, which reflected a trend since World War II when natural gas demand at both national and regional levels was great enough to eliminate the wasteful gas flaring activities of the 1920s and 30s. As Figure 2 illustrates, the largest consumer of natural gas from Wyoming is Colorado which has also experienced the greatest overall population increase in the region during the last twenty years.

Unlike petroleum interstate pipelines, which are under the control of the Interstate Commerce Commission, natural gas pipelines are regulated by the Federal Power Commission. In its regulatory capacity the FPC not only has the power to impose or remove controls on gas prices but can also approve or disapprove pipeline construction. In addition, the FPC may approve or disapprove gas exploration plans presented by individual companies that most often generate the funds for such programs through increased well-head production rates. The federal government's activities in the natural gas industry therefore exert an influence on not only the price structure of natural gas but

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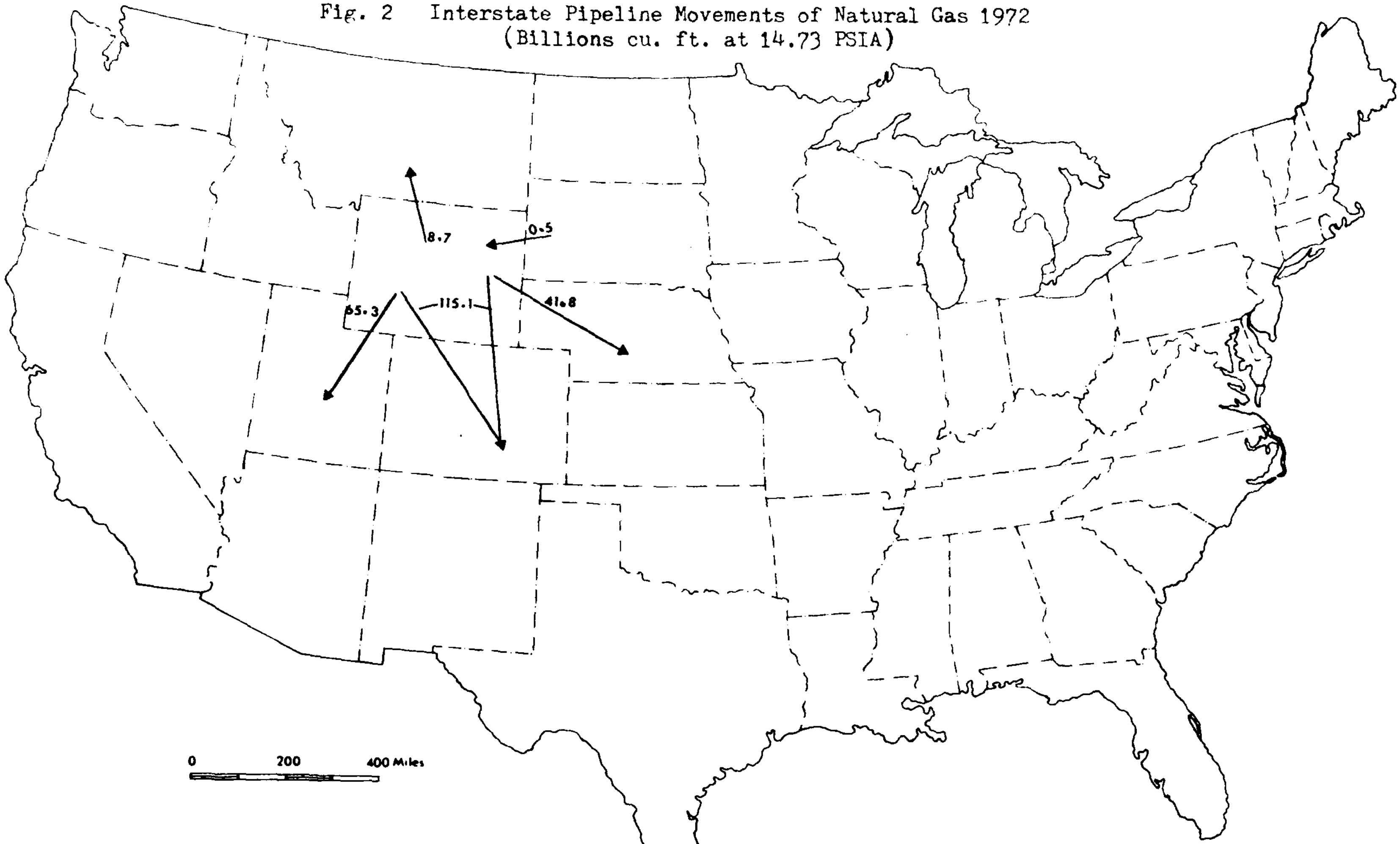
[26] Federal Power Commission, Statistics of Interstate Natural Gas Pipeline Companies 1971 (Washington, DC: Government Printing Office, 1972), pp. 602-708.

Fig. 2 Interstate Pipeline Movements of Natural Gas 1972
(Billions cu. ft. at 14.73 PSIA)



SOURCE: Minerals Yearbook 1972, Vol. I, Metals, Minerals And Fuels, p. 834.

on such locative factors as where new pipelines will be constructed or which new gas supply areas may be tapped. Even with the current FPC plan to deregulate natural gas well-head rates, demand levels have increased greatly in the regional natural gas market. An example of federal intervention which creates an impact upon the movement of natural gas across state boundaries involved the Public Service Company of Colorado.

INCREASED REGIONAL DEMAND FOR NATURAL GAS

The Public Service Company of Colorado, which also operates subsidiaries in the Cheyenne area, supplies both electric power and natural gas to its customers. The company purchases over 90 percent of its natural gas supply from Colorado Interstate Corporation which has major holdings of natural gas producing areas in Wyoming. During the 1973-74 heating season the utilities company was advised that Interstate could not meet the 1974-75 requirements requested by Public Service Company of Colorado. Because of the supply shortages the FPC was called in to establish the maximum daily demand obligations of Interstate to the utilities company.

> The FPC, in certain circumstances, has the authority to allocate the natural gas transported and sold in interstate commerce by natural gas companies regardless of existing contractual obligations.[27]

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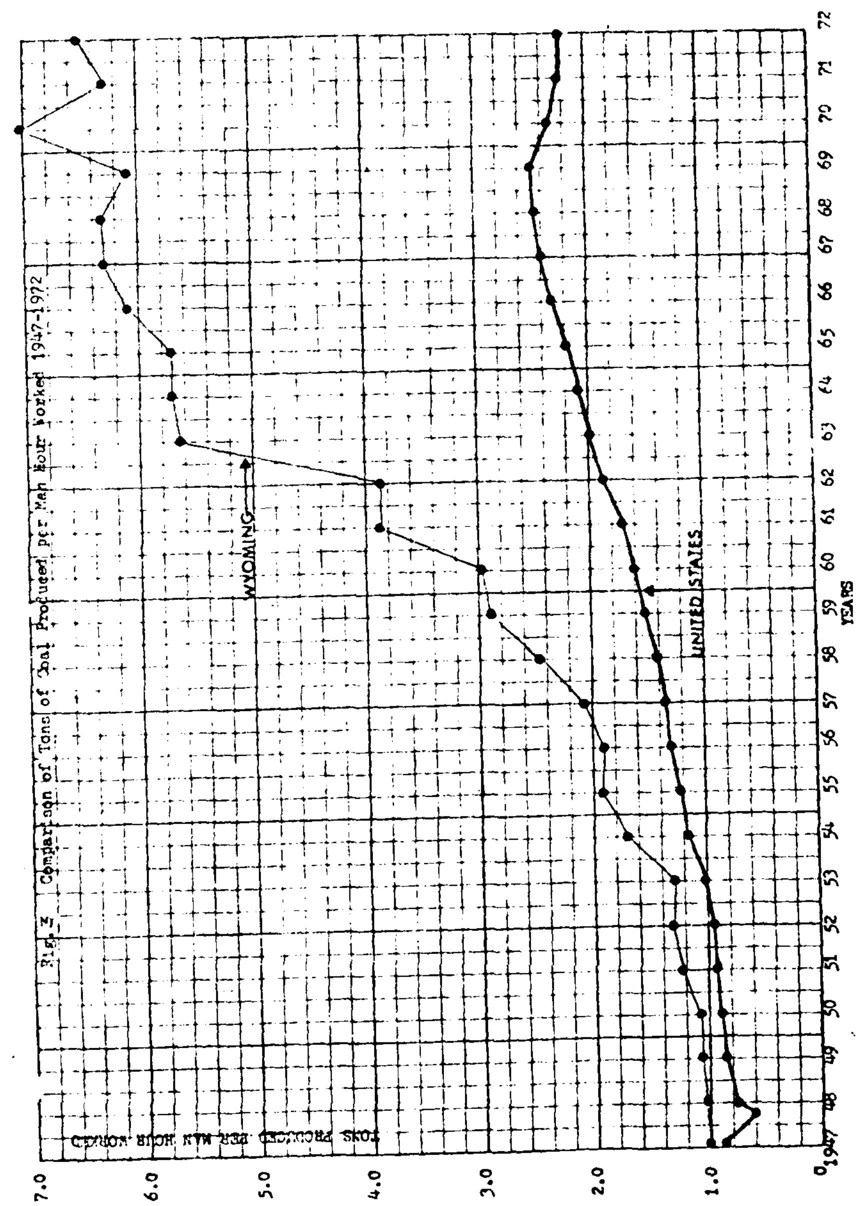
[27] Merrill, Lynch, Pierce, Fenner & Smith, Inc., Prospectus Public Service Company of Colorado (Denver: Merrill, Lynch, Pierce, Fenner & Smith, Inc., September, 1974), p. 15.

PRODUCTION CHARACTERISTICS OF WYOMING COAL PRODUCERS

When surface mining of coal became more widespread after World War II, Wyoming's productivity in coal production also began to increase rapidly. On the basis of coal produced per man-hour worked, a 25 year period from 1947 to 1972 (see Figure 3) shows that productivity in the state has been far above the national average. A particularly sharp increase can be discerned during the 1960s when strip mining became very prominent on both a national and state level. The national peak production point on a national basis was reached in 1969. Later that year the Federal Coal Mine Health and Safety Act was passed. As national production levels began to drop (possibly due in part to the passage of the federal law) after 1969, Wyoming productivity increased rapidly, because restrictions on surface mining operations were not as stringent as those for underground mines. The author believes that the pronounced decline in productivity in the 1970-71 period coincided with the rapid development of the state's coal industry and a corresponding rapid increase in both the total number of employees and the percentage of relatively unskilled miners. An examination of coal production data on a county, rather than on a national level, can also reveal some interesting characteristics.

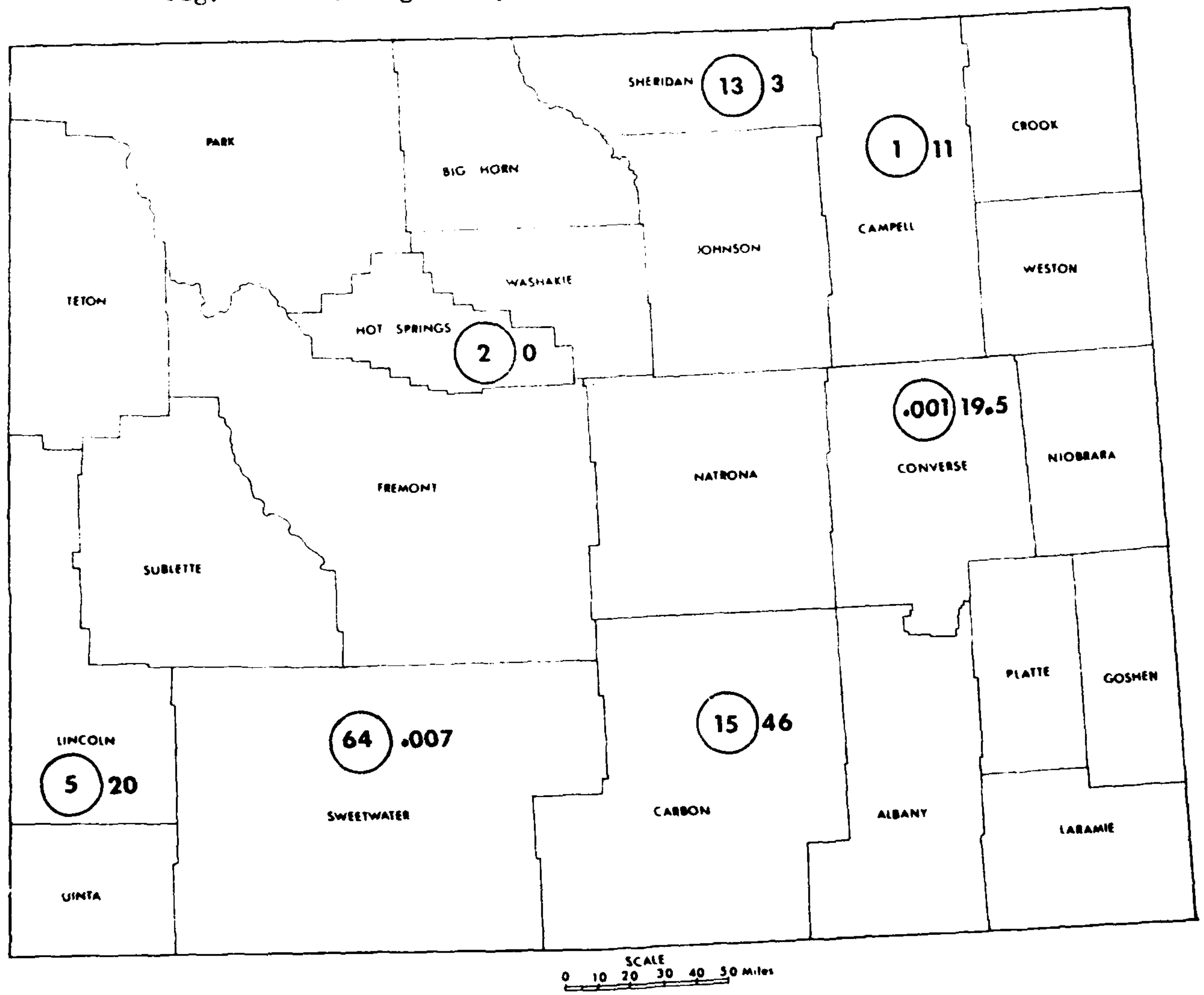
COAL PRODUCING COUNTIES

Production data on a county basis were plotted on a state map to determine county production levels (in percentages) over time. Figure 4 illustrates two peak years of coal production, 1945 (1,836,798 tons) and 1973 (14,800,000 tons). The rather wide variation in production



SOURCE: Computed from Minerals Yearbook 1947-1972

Fig. 4 Percentage of Wyoming Coal Production 1973 V. 1945



(1945) Percentage share of total coal produced

1973 Percentage share of total coal produced percentages over the 28 year period generally reflects the shift away from underground to surface mining. As previously mentioned, by 1973 over 97 percent of all the coal mined in the State of Wyoming was surface mined while in 1945 six strip mines produced only 9 percent of that record year's coal production. As might be expected, each county has a dominant producer but the disparity between the largest producer and the next largest is surprisingly great as Table 2 illustrates.

When an additional step is taken of plotting the rank and type of mine on a map, other patterns emerge (see Figure 5). With the exception of the largest producing county (Carbon) and the smallest (Fremont), there are no more than two coal mines per county. This raises the question of whether an optimal number of mining operations per county may exist. Other studies concerned with coal production at a county scale have also been carried out to examine production characteristics.

ONE METHOD OF MEASURING PRODUCTION CHANGE

The question of change or lack of change in county ranking concerning the production of coal nationwide on a county level was approached by Maresh who used a non-parametric statistical technique as a surrogate measure of change or constancy.[28] In the case of Wyoming alone, the r_s value with an n size of only 11 was .93 (see Figure 6), but when combined with Utah counties, raising the n size to 20, the r_s value declined to .81

[28] Thomas J. Maresh, "On Constancy and Change in the Distribution of Mineral Production," Land Economics, May 1972, pp. 179-83.

TABLE 2 PRODUCER'S PERCENTAGE OF COAL PRODUCTION BY COUNTY (1973)

RANK

1 Carbon County - Hanna Basin

Arch Minerals - 64%
Rosebud Coal Sales - 22%
Resource Exploration & Mining - 09%
Energy Development Corp. - 05%

2 Lincoln County - Hams Fork Basin

Kemmerer Coal Co. - 100%

3 Converse County - Powder River Basin

Pacific Power & Light - 100%

4 Campbell County - Powder River Basin

Amax Coal Co. - 54%
Wyodak Resources - 46%

5 Sheridan County - Big Horn Basin

Big Horn Coal Co. - 96%
Welch Coal Co. - 04%

6 Sweetwater County - Green River Basin

Gunn-Quealy Coal Co. - 100%

7 Hot Springs County - Bighorn Basin

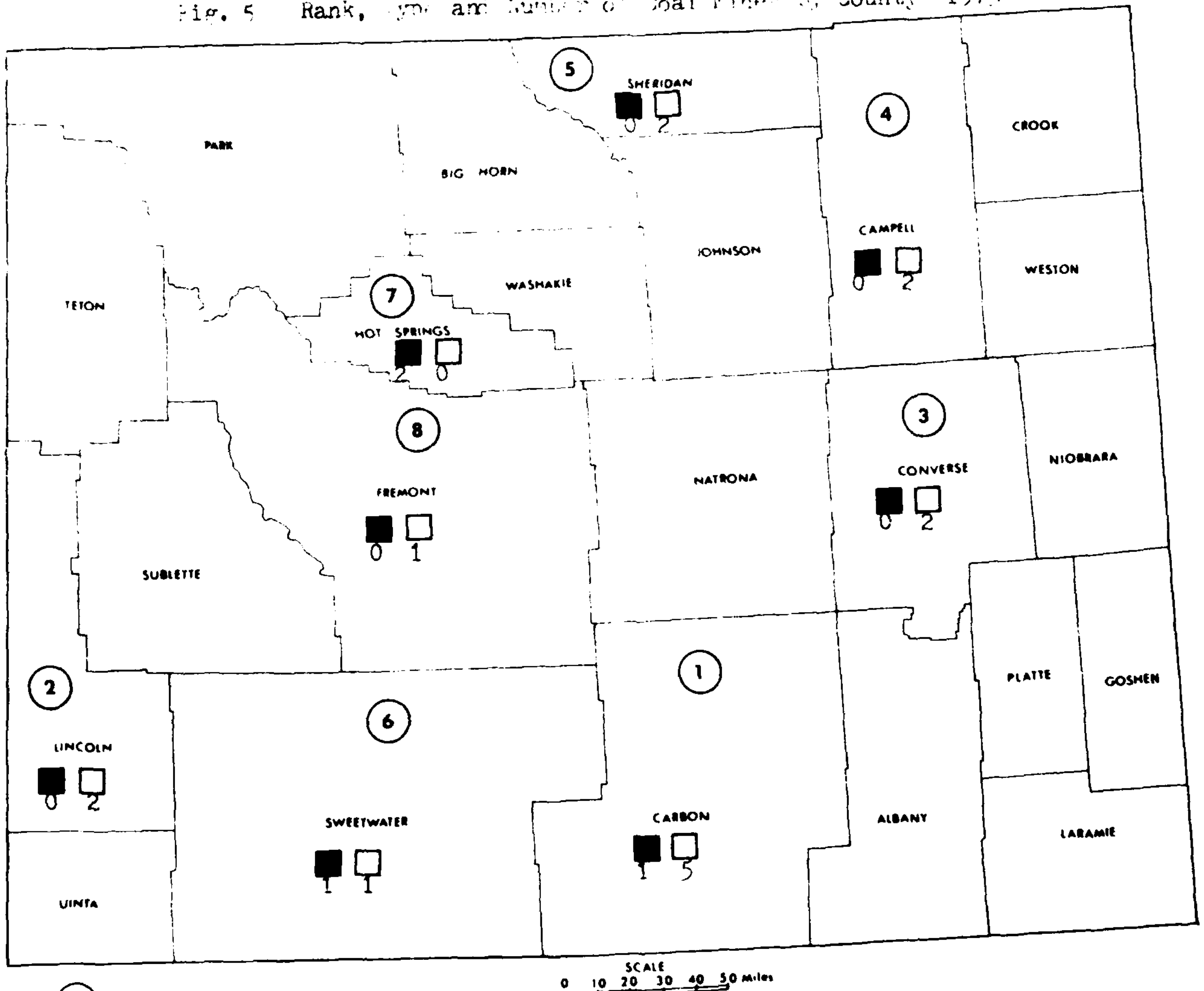
Roncco Coal Co. - 59%
Dusky Diamond Coal Co. - 41%

8 Fremont County

John Gianunzio - 100%

Compiled from Wyoming State Inspector of Mines production data: 1973

Fig. 5 Rank, Type and Number of Coal Mines by County 1973

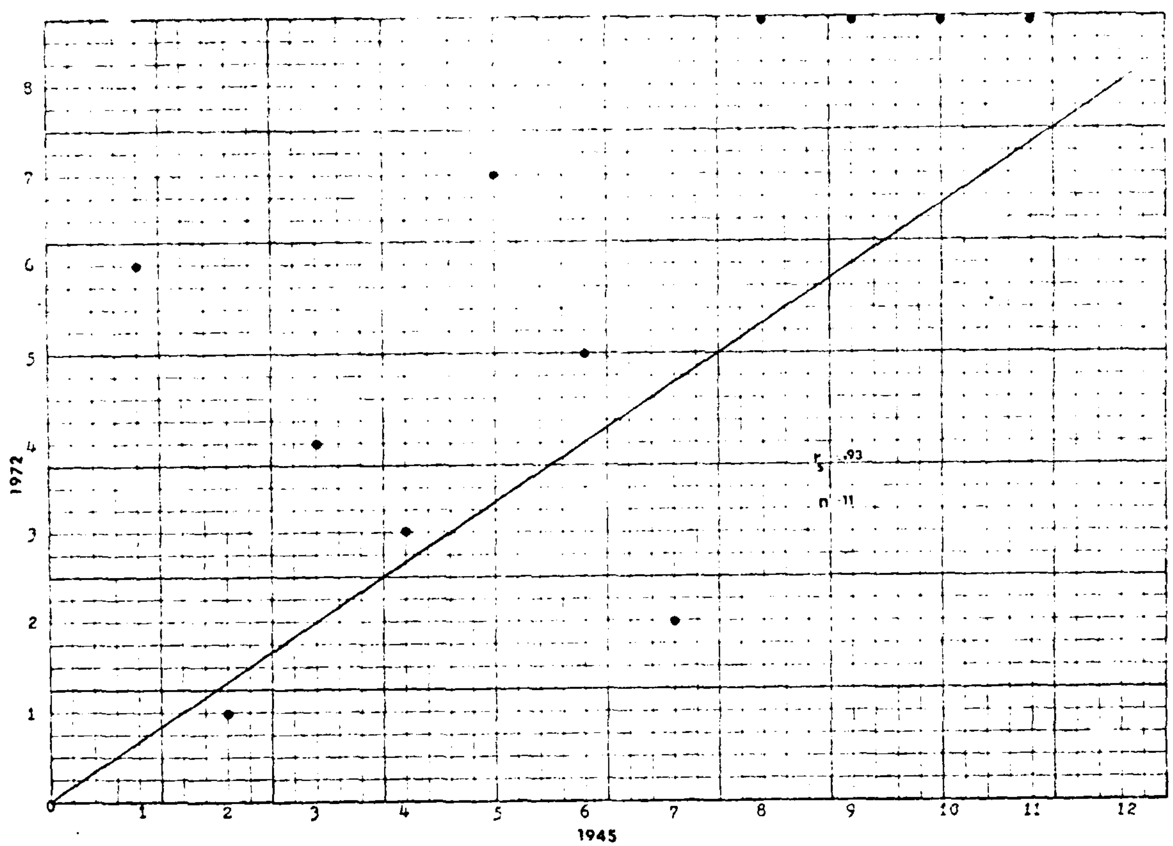


County rank 1973

Number of underground mines

Number of surface mines

Fig. 6 Wyoming Coal Production by Counties



(see Figure 7). These coefficients of correlation indicate that both on a regional and state scale the constancy of coal production by county appears to be fairly great (Maresh found an r_s value of .61 for an n size of 121). Thus, in general, between eight and 11 counties in Wyoming and 10 and 18 counties in Wyoming and Utah combined have been producing coal since 1945 and continued to do so in 1973. Maresh believes that production is "dominated by a small number of the producing counties,"[29] and this appears to be the historic case in Wyoming. In 1945, for example, just three counties (Sweetwater, Carbon and Sheridan) accounted for 92 percent of the state's coal production while in 1973 over 85 percent of the state's coal production was accounted for by the top three counties. However, two of the top three counties in 1973 were ranked fourth and seventh in 1945. Since the advent of strip mining those two counties (Lincoln and Converse) rank number 2 and number 3 respectively.

THE CONSUMPTION OF COAL

Wyoming coal mines have long produced coal for export to markets quite distant from the Rocky Mountain region. For example, in 1910 roughly 15,000 tons of Wyoming coal were consumed annually by the City of Portland while 200,000 tons of Rocky Mountain coal (some of it from Wyoming) were shipped to California.[30] Indeed, by 1918 almost 52,000 tons of coal from southern Wyoming and Utah were shipped to overseas

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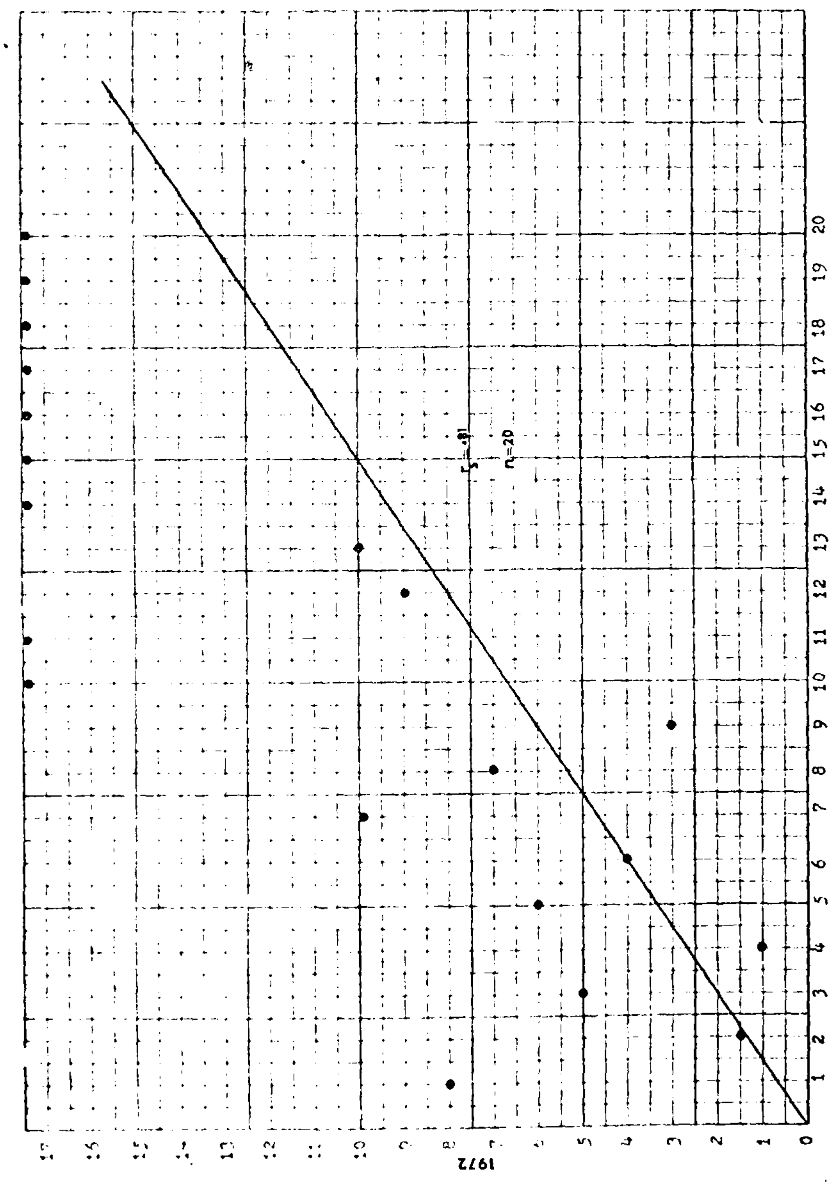
[29] Ibid., p. 183.

[30] U.S., Department of the Interior, U.S. Geological Survey, Mineral Resources of the United States, 1910 (Washington, DC: Government Printing Office, 1910), pt. 2, p. 89.

Fig. 7 Wyoming and Utah Coal Production by Counties



users. Most of the coal was bunker coal for foreign ships taking on fuel at San Francisco. Domestic markets external to the Rocky Mountain region also consumed roughly one quarter of all Wyoming coal produced in the 1917-1918 period. In an itemized report on coal consumption and distribution appearing in Mineral Resources of 1918, no fewer than 14 states received coal shipments from Wyoming. The fact that overall percentages of coal shipped to other states declined from almost 24 percent in 1917 to barely 21 percent in 1918 probably reflects the readjustment to normal peacetime demands for coal. As in the data for foreign exports, almost all Wyoming coal shipped to other states was for railroad fuel.[31] Thus, the pattern of coal export to non-regional markets was set early in this century.

As might be expected, most of the coal produced in Wyoming during the 1920s was consumed by the railroads for fuel. In the 1918-1919 period over half of the coal produced in northern Wyoming and almost half of the coal produced in southern Wyoming were used solely by railroads. During that same period only 3-1/2 percent was shipped to public utilities consumers.[32] This consumption pattern had changed greatly when reexamined 56 years later. In 1973 approximately 92 percent of the coal mined in Wyoming was consumed by electric power producers and none recorded for transportation.[33]

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[31] U.S., Department of the Interior, U.S. Geological Survey, Mineral Resources of the United States, 1918 (Washington, DC: Government Printing Office, 1919), pt. 2, p. 1324-57.

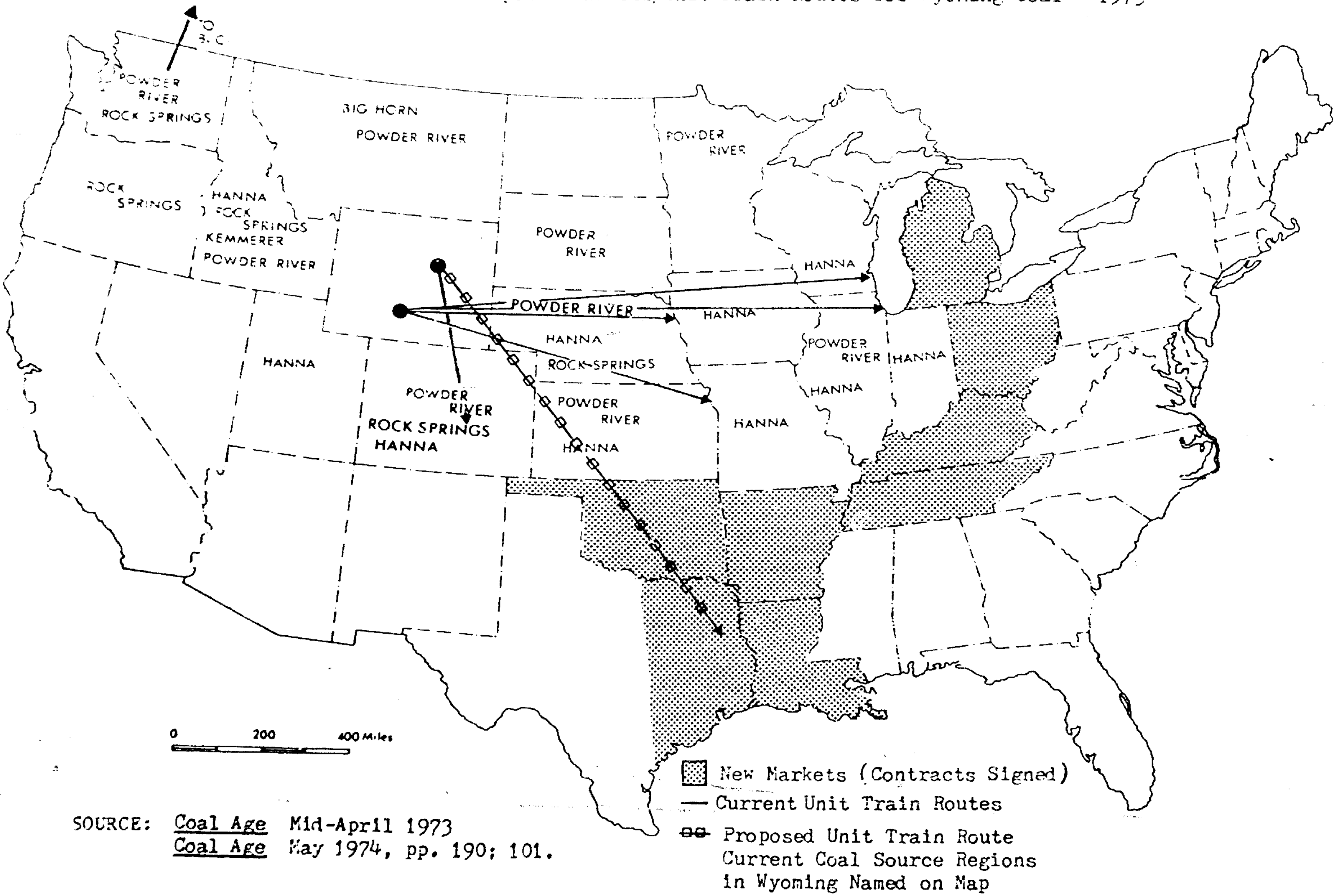
[32] Ibid., p. 1373.

[33] Gary B. Glass, "Wyoming: Production Seen Doubling by 1976," Coal Age, May 1974, p. 107.

Surrogate measures of the consumption patterns of Wyoming coal are current market areas, by state, and the destination of coal unit trains from Wyoming. Figure 8 illustrates the market and the source areas of Wyoming for those particular state markets and coal unit train routes. In all, almost 63-1/2 percent of the coal mined in Wyoming during 1973 was shipped out of state while in-state uses only comprised 36.6 percent. If one were to look at comparable statistics for 1915 (Figure 9), the percentage of coal shipped out of Wyoming (excluding railroad fuel) was 26 percent. In-state use was only 9 percent, and a very high 65 percent of the total out-of-state coal was used by railroads (almost 60 percent of out-of-state use in 1973 was for power plants).

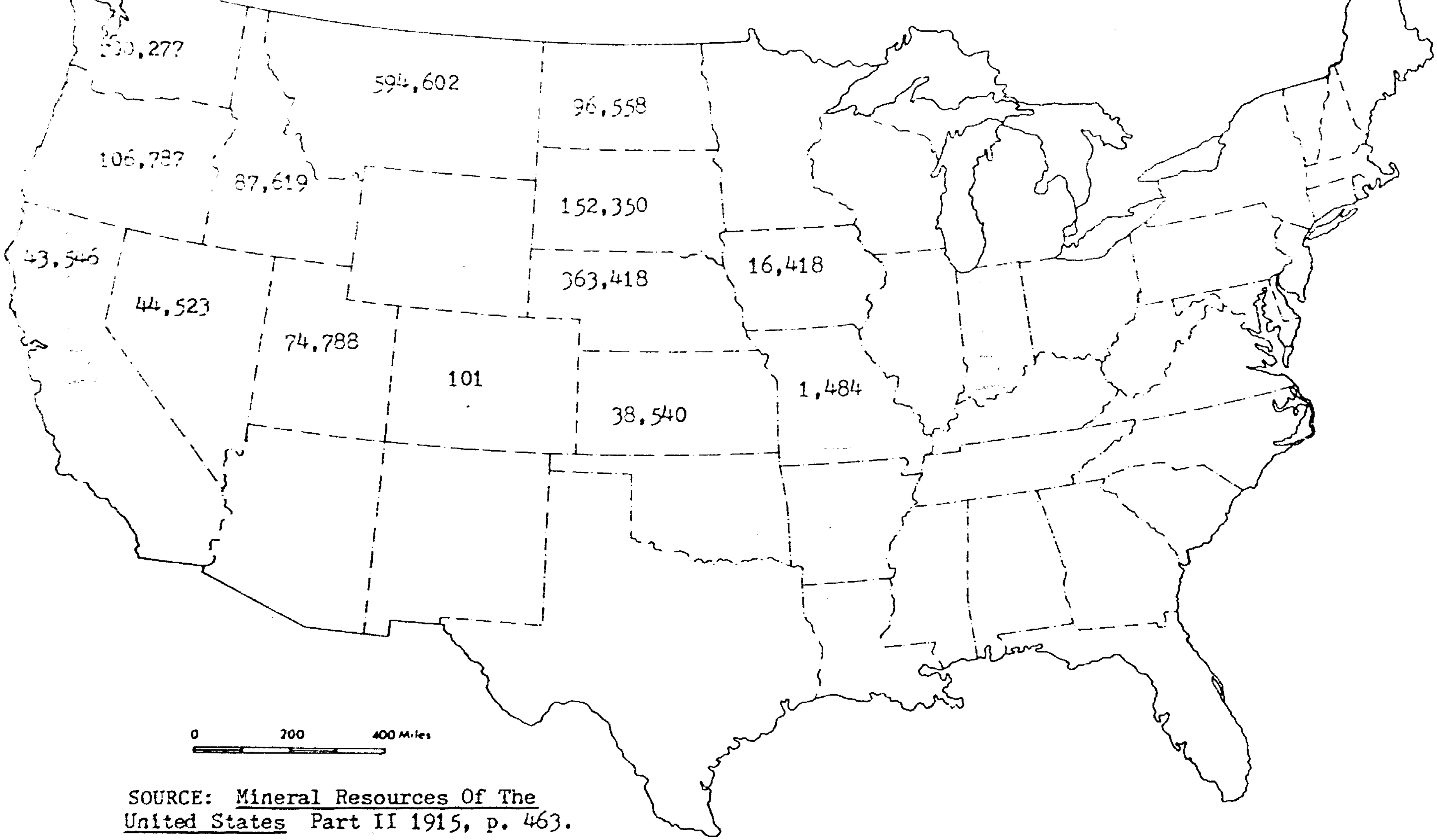
As one can see from the preceding maps, coal from Wyoming has historically moved over a surprisingly extensive area of the United States. Most current market areas still roughly correspond to the markets of 1915 except for the more easterly extent of the markets. Unlike 1915, however, the nature of coal consumers has changed from being almost entirely railroad companies to electric power utilities. One of the historic characteristics and problem areas of Wyoming coal production has been the orientation toward a single use market. In 1915 through the 1940s, the market was for steam locomotive fuel; and in the 1970s, over 90 percent of both in-state and out-of-state markets use coal in power plants. Interestingly, it was the development of a transportation network, especially railroads, which started the coal industry in the state, almost killed, and most recently helped resurrect the importance of the coal industry in Wyoming.

Fig.8 Current and Proposed Markets/Unit Train Routes for Wyoming Coal - 1973



SOURCE: Coal Age Mid-April 1973
Coal Age May 1974, pp. 190; 101.

Fig. 9 Market Areas (by state) for Wyoming coal in 1915 (net tons)



SOURCE: Mineral Resources Of The United States Part II 1915, p. 463.

TRANSPORTATION NETWORK DEVELOPMENT

The effects of transportation development, especially in a traditionally underpopulated area like the State of Wyoming, were especially significant in the 1890s. As part of a grand strategy of the Chicago Burlington and Quincy Railroad to tap the mineral resources of the Black Hills area, new rail lines were built into the Black Hills and beyond. During 1890, tracks were laid from Newcastle, Wyoming, to what became the town of Gillette in 1891. The next year, 1892, CB&Q tracks were extended to Sheridan. The following excerpt from a history of the Burlington Route gives a vivid account of the immediate effects of the railroad's arrival:

> For Sheridan this was like a shot in the arm. Within a month, farmers of the region had paid off loans on which they had been paying interest at the rate of two percent a month. Ranches turned into farms, coal mines were opened, more people went into stock raising, and the economy in general reached a new and higher level. As Gillette, in charge of the railroad's construction, put it: 'Rich soil, the finest supply of good water for domestic and irrigation purposes, the magnificent Big Horn Mountain full of elk and deer, numerous lakes, trout in all the streams, grouse in the valleys, and the whole country underlaid with coal convinced many in the party that this at last was what they had been looking forward to in making their permanent home....'[34]

The present day railroad network was essentially established and functioning in Wyoming by 1913. As Figure 10 indicates, the only significant mainline trackage which was built after 1912 was the stretch between Casper and Thermopolis. When the railroad network of Wyoming is examined using graph theory to determine the relative accessibility of towns (nodes) in the network, the post-1912 system displays a higher

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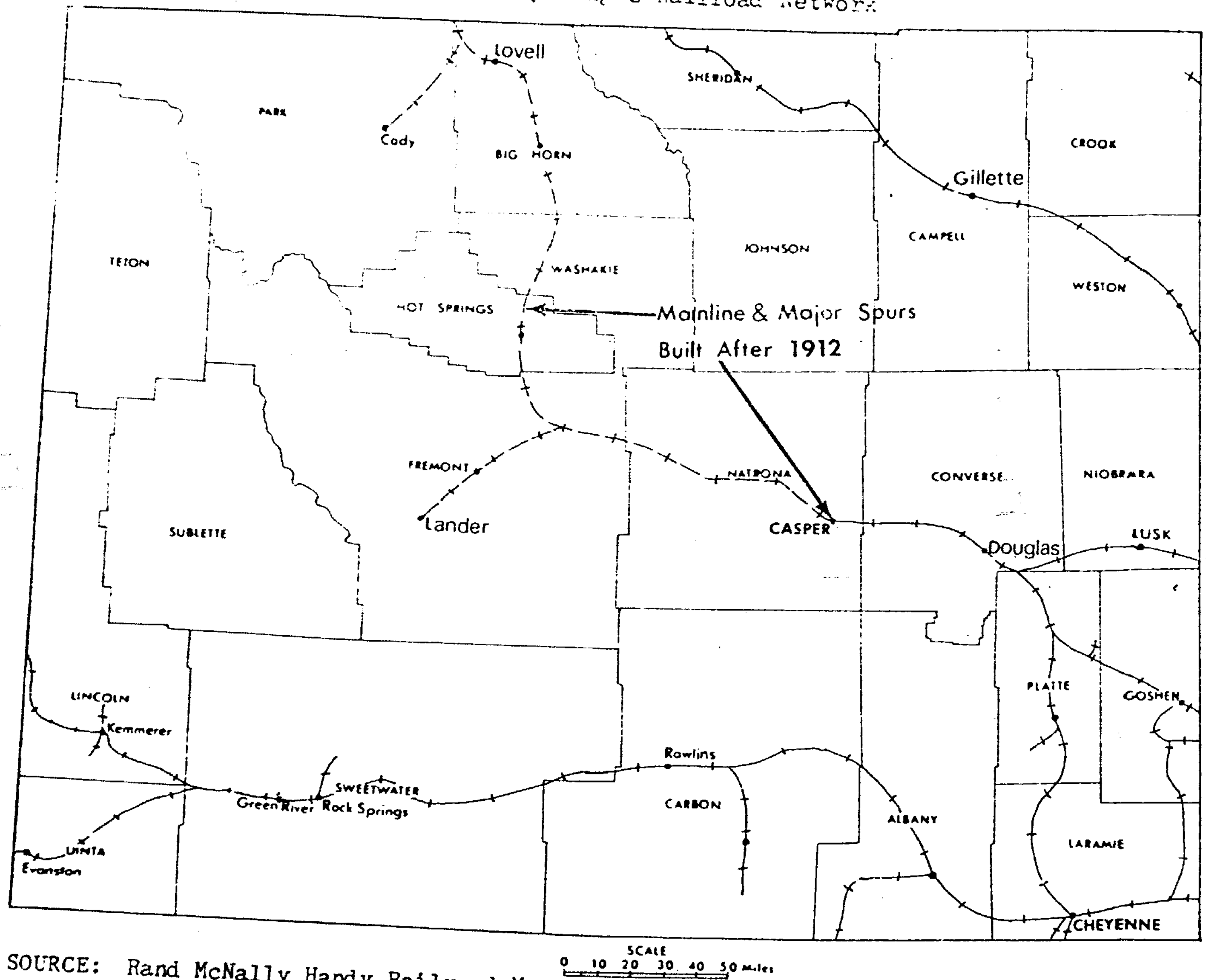
[34] Richard C. Overton, Burlington Route: A History of the Burlington Lines (New York: Alfred A. Knopf, 1965), p. 228.

Fig. 10 Wyoming's Railroad Network



SOURCE: Rand McNally Handy Railroad Map, Wyoming, p. 52.

degree of connectivity. Using Kansky's[35] beta index ($B = \frac{e}{v}$) where e is the number of edges or routes and v is the number of nodes or towns, the calculated value for the 1912 rail network is .71 compared to 1.00 for the post-1912 network. Prior to 1914 Cheyenne and Wheatland were equally central to all other places connected by railroads. After the new route from Casper to Thermopolis was completed in 1913, the most accessible node shifted to Douglas. Table 3 illustrates the ranking of ten places in terms of their degree of connectivity with all other places (nodes) in the rail network. The fact that southern Wyoming towns are found in the pre-1912 rankings indicates the historical development of the Union Pacific Railroad's mainline location and the location of coal deposits. In his dissertation concerning the selection of a route for the Union Pacific Railroad, Grey stated that the presence of known coal deposits along the proposed southern Wyoming route "...seems to have been a rationalization rather than a reason in the choice of a route."[36] Nevertheless, Wyoming coal has been a particularly important freight item for the Union Pacific.

By far the most important carrier of Wyoming coal has been the Union Pacific Railroad which, during the period 1917-1945, was also the largest producer of coal in the state. Figure 11 indicates several features of the two major transporters of Wyoming coal. Aside from the

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[35] E. J. Kansky, Structure of Transportation Networks (Chicago: University of Chicago Press, 1963), p. 17.

[36] Alan Hopwood Grey, "A Railroad Across the Mountains: Choosing the Route of the Union Pacific Over the Eastern Rockies" (PhD dissertation, University of Wisconsin, 1963), p. 147.

TABLE 3 CONNECTIVITY RANKING OF NODES IN RAIL NETWORK

Place	Pre 1912 Rank	Place	Post 1912 Rank
Wheatland	1	Douglas	1
Cheyenne	1	Wheatland	2
Laramie	2	Lusk	2
Lusk	3	Casper	3
Douglas	4	Cheyenne	4
Rawlins	5	Laramie	5
Saratoga	6	Thermopolis	6
Torrington	7	Torrington	8
Rock Springs	8	Newcastle	9
Green River	9	Riverton	10
Casper	10		

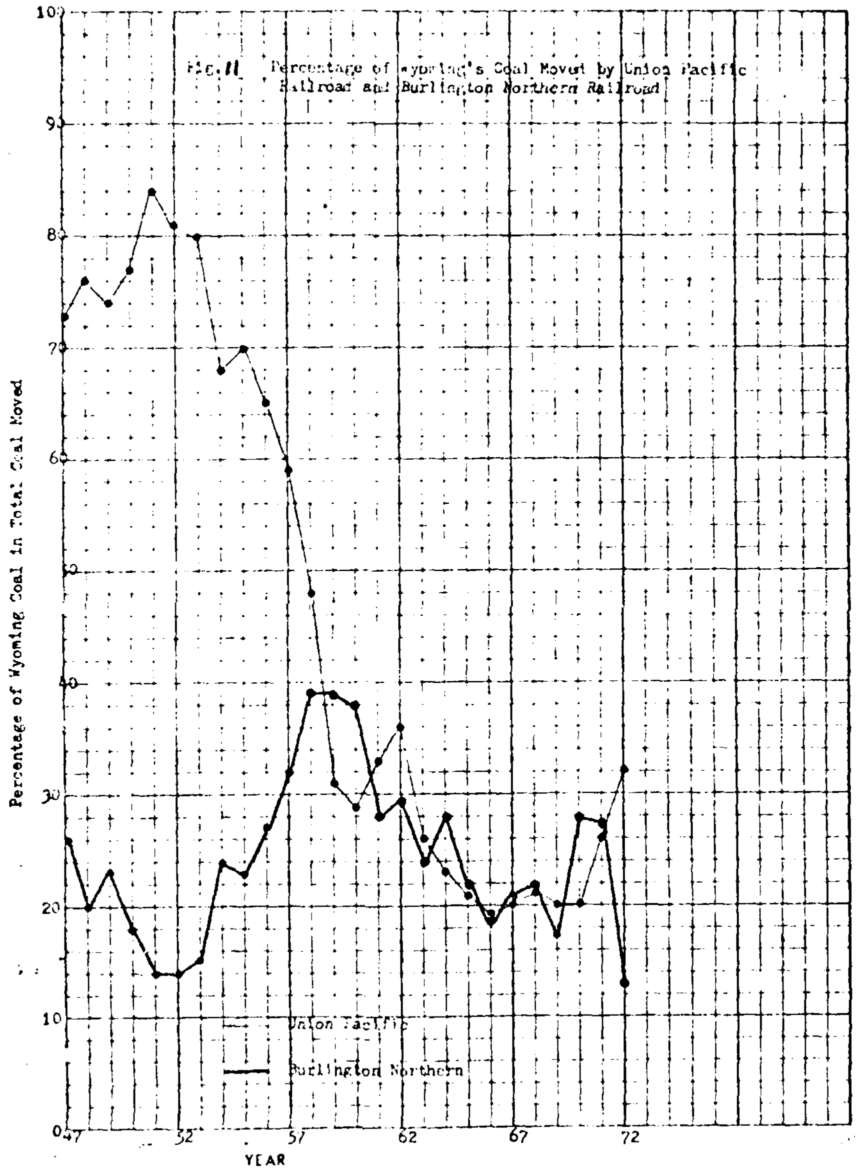

Fig. 11 Percentage of Wyoming's Coal Moved by Union Pacific Railroad and Burlington Northern Railroad

obvious differences in the percentages of coal moved, the switch to diesel-electric motive power is indicated by the decline in coal carried during the middle 1950s. The Union Pacific in particular shows a sharp decline because several of the company's own coal mines, which provided much coal traffic, were closed down. The general trends during the 1970-72 period probably reflect several changing factors. First, other railroads were beginning to carry Wyoming coal to markets. Second, more coal is being burned by power plants located within the state. Third, unit trains, which are sometimes owned by the consumer (such as Commonwealth Edison of Chicago) and are only operated by the railroad, are recent innovations which reduce the share of Wyoming coal carried solely by the Union Pacific and Burlington Northern railroads.

UNIT TRAINS' IMPACT ON MOVING WYOMING COAL

The unit train concept has held down the costs of transporting coal from Wyoming to distant market centers. The concept began in 1959 as a management technique to reduce the transportation cost of moving a bulk commodity such as coal from the mine to market. A variety of new types of equipment and technological innovations such as flood-loading of coal cars have all aided in increasing the efficiency and lowering the costs of operating unit trains. However, it is estimated that one of the best cost reducing innovations which is currently practiced is the consumer purchase of coal cars. The savings of consumer ownership of coal cars are often placed at about $1.00 per ton when all factors are taken into consideration.[37] In general the weight of unit trains is

[37]Mining Informational Services, <u>1971 Keystone Coal Industry Manual</u> (New York: McGraw-Hill, 1971), p. 142.

greater and the train is in continuous motion, not even stopping while being loaded. The resulting shipping costs are often 50 percent lower than conventional railroad owned coal trains.

Almost all the consumers of Wyoming coal are electric power utilities which have generally signed long-term contracts for coal. Not surprisingly, the fuel costs vary between supplier and consumer but some representative costs for coal being supplied from Wyoming may be illustrative of the range of coal costs. Wyoming coal burned by an electric utility in Omaha during 1974, for example, cost 46.18¢ (per million BTU); 53.7¢ in Des Moines; 42¢ (1973) in Genoa, Wisconsin (south central Wisconsin); and 32¢ (1973) in Rapid City, South Dakota.[38] Figure 12 locates the major power plants which have contracted to use coal from Wyoming. Within the last two years a new unit train-to-barge combination transportation system was tested by the Burlington Northern Railroad.

> We made some test rail-to-barge runs early in 1973, hauling coal in unit train quantities to East St. Louis for trial burning in power plants owned by American Electric Power on the Ohio River [sic.]. This coal came from the Belle Ayre mine in Wyoming and from the Decker mine in Montana, and it was transloaded to barges through the dock at East St. Louis, owned jointly by the Illinois Central Gulf and Burlington Northern and operated by Peabody Coal. Barges then took the coal down the Mississippi and up the Ohio as far as Wheeling, W.V. Burning tests were satisfactory and planning is now under way for a new coal dock in the St. Louis area served by Burlington Northern.[39]

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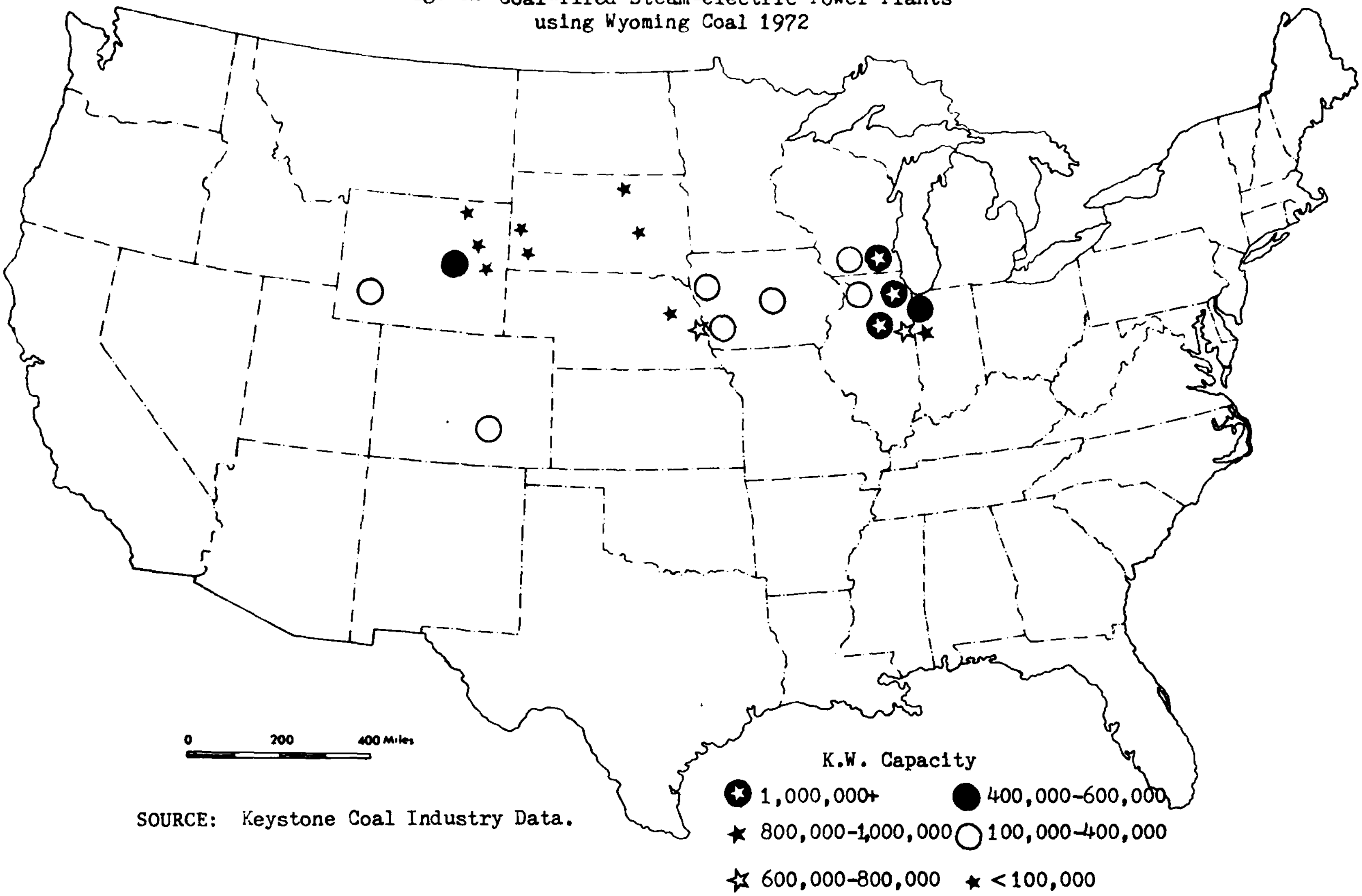
[38] Mining Informational Services, <u>1975 Keystone Coal Industry Manual</u> (New York: McGraw-Hill, 1975), pp. 432-62.

[39] George R. Powe, "Economics of Using Western Coal in Appalachian Markets," <u>Mining Congress Journal</u>, June 1974, p. 20.

Fig. 12 Coal-fired Steam-electric Power Plants using Wyoming Coal 1972



SOURCE: Keystone Coal Industry Data.

The Burlington Northern Railroad believes it can deliver western coal to Appalachia for costs approximating 70¢ per million BTU "...a figure that soon may be competitive with low-sulfur eastern coal."[40]

On a regional scale, the Public Service Company of Colorado again provides an example of the extensive use of fuels from Wyoming. Approximately 64 percent of all the fuel Public Service Company uses is low-sulfur western coal with most of it originating in Wyoming. The company is supplied through seven contracts with mining firms in Colorado and Wyoming. The impact of inflation, higher labor costs and taxes and royalties plus governmental programs (such as the easing of price controls on natural gas) have all been reflected in the increased cost of fuels purchased by the Public Service Company of Colorado (Table 4).

Since the cost of coal has increased at a less rapid rate than other fuels, it seems reasonable to assume that at least the largest utility company in the region will increase its use of coal in the future. The implementation of unit trains, especially to large electric generating plants, like the 350,000KW Comanche Plant near Pueblo, has helped keep the net cost increase in coal purchases to levels below 10¢.

SLURRY PIPELINES

Yet another innovation in coal transportation technology which may have a significant impact on the future development of fuels in Wyoming

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[40] Ibid., p. 23.

TABLE 4 DELIVERED COSTS OF FUELS TO PUBLIC SERVICE COMPANY OF COLORADO

(Cost Per Million B.t.u.)

Twelve months ending 31 December	Coal*	Gas	Oil	Average of all fuels
1969	24.9¢	22.9¢	25.4¢	24.6¢
1970	25.3¢	24.1¢	38.[illegible]¢	2[illegible].5¢
1971	2[illegible]¢	26.5¢	60.7¢	2[illegible].2¢
1972	29.1¢	28.2¢	59.7¢	[illegible].6¢
1973	31.0¢	35.8¢	103.7¢	3[illegible].4¢
June 30, 1974	33.5¢	38.[illegible]¢	140.0¢	39.4¢

*The average cost per ton of coal of the periods shown was $5.56, $5.[illegible], $[illegible].1[illegible], $6.[illegible], $6.72, and $6.[illegible]4 respectively.

SOURCE: Public Service Company of Colorado Prospectus, p. 13.

is slurry pipelines. Shown in Figure 13 are two such proposed slurry lines originating in Wyoming. The State Engineer of Wyoming already has granted approval to a plan by Energy Transportation Systems, Inc. to construct a 1,040 mile, 38-inch coal slurry pipeline from the Powder River Coal Basin in Wyoming to Arkansas. When completed, the pipeline would have a capacity of 25 million tons per year which would require an estimated 15,000 acre-feet of water per year to operate.[41]

THE CONTROVERSY

There is currently a great deal of controversy between railroads and the pipeline interests concerning coal slurry pipelines. The disputes over slurry pipelines focus upon three points: (1) their operating cost; (2) their environmental impact during construction; (3) the amount of water they will require. The following facts should be considered: (1) The cost of coal slurry pipelines may not be less than other transport forms. The Congressional Research Service estimates that a pipeline moving 10 million tons of coal per year would cost about 7/10 of a cent per ton-mile to operate. Transportation by unit train in the western U.S. was estimated at 6/10 of a cent per ton-mile. Transportation costs via coal barge on the Ohio River System are in the range of 4/10 to 5/10 of a cent per ton-mile.[42] (2) According

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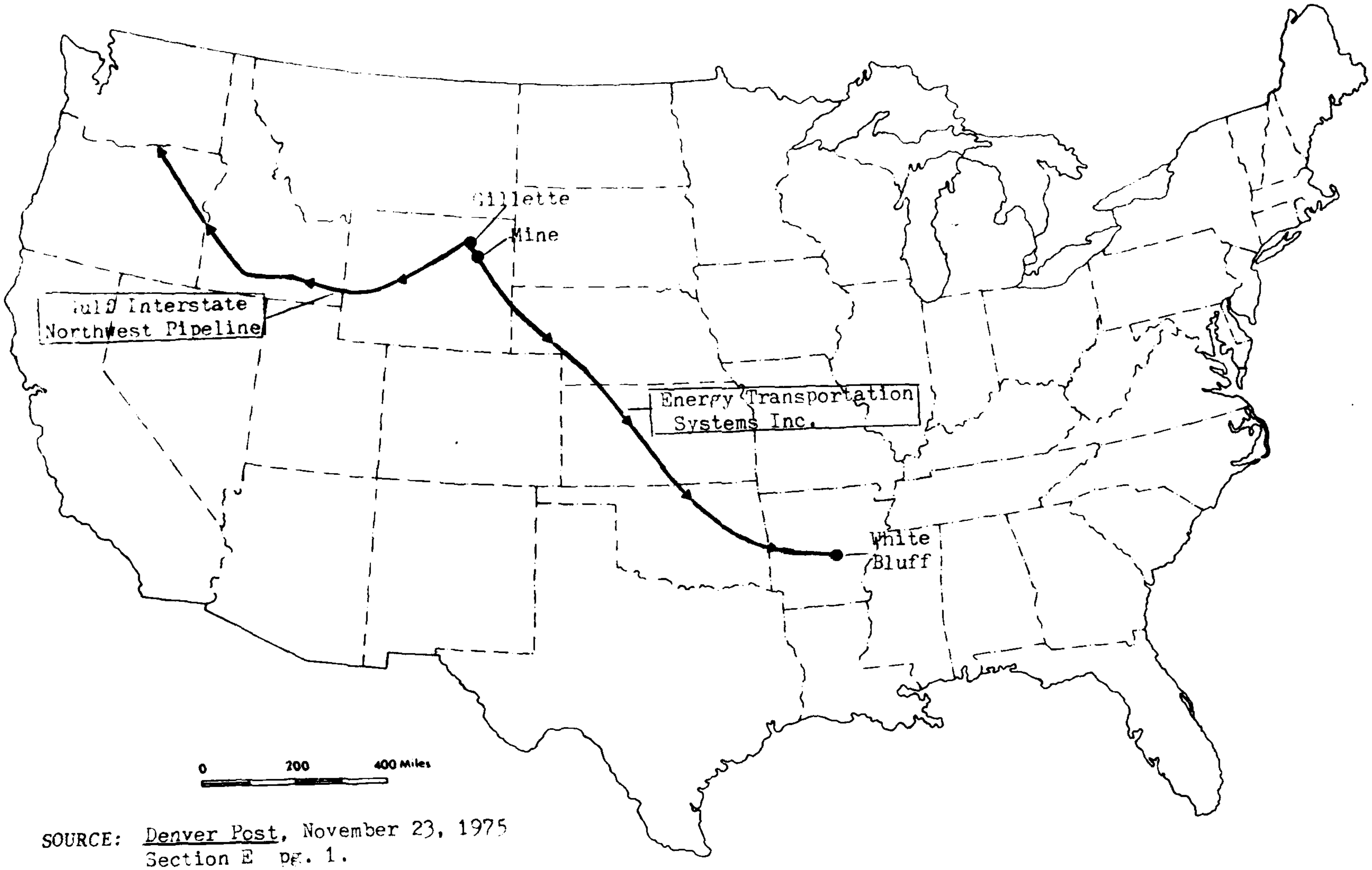
[41] U.S., Department of the Interior, Bureau of Land Management, U.S. Geological Survey, Interstate Commerce Commission, Draft Environmental Impact Statement, Development of Coal Resources in the Eastern Powder River Coal Basin, Vol. 1, pp. 49-50.

[42] U.S., Congress, House, Hearings Before the Committee on Interior and Insular Affairs, Coal Slurry Pipeline Legislation, 94th Cong., 1st sess., 1975, p. 81.

Fig. 13 Proposed Coal Slurry Pipelines - Wyoming Origin Points



SOURCE: Denver Post, November 23, 1975
Section E pg. 1.

to the Federal Energy Administration, 250 gallons of water are required for each ton of coal moved through a pipeline, For example, FEA estimates of a 10 million ton per year line would call for about 7 million gallons of water a day from the coal-producing region.[43] (3) In testimony before a Congressional committee, the State Geologist of Wyoming (D. N. Miller) was quoted as saying that "...there is no assurance that the necessary water supply will be available, i.e., that a withdrawal of 15,000 to 20,000 acre-feet of water per year can be sustained for 10, 20 or 30 years."[44]

CONCLUSIONS

This paper has attempted to examine some of the development patterns of Wyoming's petroleum, natural gas, and coal resources. The emphasis has been on location of the resources and how they move. The author has attempted to indicate through a limited number of measurements that the spatial characteristics of Wyoming fuels have displayed a mutable nature.

For example, because of the high percentage of federally owned land in Wyoming, many acres of mineral lands have been leased via the competitive leasing system. When a leasing program for coal was examined the author found coal bids were really not competitive and that the leasing system encouraged speculation rather than production. The current moratorium on coal leases on public land indicates that the Department of the Interior may be aware of the inequities involved in bidding between large

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[43] Ibid., p. 95.

[44] Ibid., p. 1155.

corporations and individuals with limited financial backing. It is suggested that the competitive bidding system of leasing coal on public lands in Wyoming should be reevaluated.

A considerable amount of well-endowed coal lands will never be productive units for a variety of physical and cultural reasons. Such physical constraints to coal development as highway and railway rights-of-way, supportive structures for mines, and housing areas are just now becoming recognized as significant constraints upon surface mining activities within the state. How these problems will be dealt with is still a matter of conjecture, but the euphoria connected with strip mining vast tracts of thick-seamed low-sulfur Wyoming coal has been tempered by impact studies required by both federal and state governments.

Historically, the development of petroleum and natural gas pipeline systems in Wyoming has been influenced greatly by the federal government. Largely because Wyoming's petroleum and natural gas moves to out-of-state markets, their prices and their development patterns have been dictated by the Federal Power Commission and the Interstate Commerce Commission. Increasingly, even on a regional level, the federal presence has grown so that in at least one case the FPC served as the final arbiter between a natural gas supplier in Wyoming and its customer in Colorado.

In the development patterns of coal production, technological innovations rather than governmental intervention have seemed to be the prime forces of change in Wyoming. The sharp increase in surface mining of coal in the 1960s changed the traditional county ranking in terms of coal production. Counties using underground mining techniques which had been traditional production leaders have been supplanted by counties in which surface mining is dominant. The author found that the changes were generally in rank structure only, not in geographic distribution. Most counties which have always produced coal are still producing it. The number of mines, however, has declined and the disparity between the largest producers and the next rank has increased. With the exception of the most productive and least productive counties, there were no more than two coal mines per county. This suggests that a type of optimal threshold for coal mining counties may exist.

An analysis of the transportation network used to move Wyoming coal to markets showed that the state's coal has historically moved to distant markets. The pattern has only recently changed; the distances coal moves today are even greater than those at the turn of the century. The application of graph theory to Wyoming's railroad network during two different stages of its development showed that the overall efficiency (connectivity) of the system was increased after 1912. With the addition of the unit train concept and the eventual use of coal slurry pipelines, the level of coal transportation efficiency as it relates to coal movement is also likely to increase.

The author has intended to examine the patterns of development as they once existed and how they exist today. Obviously external factors, acting in concert, have affected the patterns of development in at least the three fuels selected for this discussion. Governmental activities, economic conditions, technological capabilities and social-environmental factors all play a part in shaping the patterns of fuel resource development on Wyoming's landscape. Implications for policy decisions concerning energy on a national level are magnified at either a regional or state level. The solutions to environmental, economic and social problems as well as the traditional technological difficulties of mining which are found in Wyoming may be a microcosm of solutions which could be implemented on a national scale. Wyoming has traditionally been an exporter of its fuel resources, and the state's economy has generally been reactive to the national economic and political environment. The state has now begun to assume a role of leadership in energy resource development. Assuming an even greater role as a regional and national supplier of fuels, Wyoming's future role may be more prominent in national affairs. An examination of its past experiences might provide a better understanding of the state's current position as a major fuel supplier.

Much work, especially dealing with the dynamics of fuel movements, needs to be done at the state level. The geographies of energy at such a level are not merely idiographic exercises with no applicative value, but are the incremental pieces required for the formulation of a rational, workable national energy policy. This study has been oriented ultimately at filling a void in that geographic level of analysis of energy.

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