# LIFE AND DEATH IN AN OIL BOOM

by

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Oscar Salazar Rodriguez

## ABSTRACT

The local communities will do better to consider oil booms unpredictable. For local planning in anticipation of an oil boom can be a very risky proposition. Unlike other forms of energy resource devlopment, petroleum development can be a highly random and mobile process. The sites of operation are not really known until after exploration and extraction activities are already in their advanced stages. The center or concentration of these activities shifts from one cluster of newly discovered oilfields to another. Other than the petroleum itself, all other factors figure very little into the oil industry's location and production function. Thus as wildcatters, pipeliners and roustabouts move from one "completed" field to a new field, so too the epicenter of the boom will move from one area to another. A local community that invests heavily in public capital in the hopes of averting the shortages and crowding conditions associated with boom-type growth, may a sadly find later that their investments were made in vane. Depending upon where they are located with respect to the natural distribution of petroleum deposits and to where the oil industry happens to strike oil, local communities can either (1) boom then bust after a short period of time, or (2) boom indefinately without interruption, or (3) not boom at all.

Much of the present literature on boomtowns discounts this element of uncertainty in planning. They focus instead on resource allocation in preparation of the boom. That is, they assume that the boom is coming and try to accomodate it in the most efficient way possible. This approach to planning in boomtowns derives from the experience with mining and construction projects. As such, it is not very helpful to the planner working in an oil boomtown.

Looking back now at the oil boom that occurred in the Permian Basin during the 1920's, it is evident that its outcome could not have been predicted. Population settlement and economic growth cannot be explained by what seem to be the most rational and economically outstanding motivations or factors. The towns that boomed the most were neither the most established, nor the significant centers of economic agglomeration, nor even the most endowed with petroleum deposits. Midland-Odessa, the growth center that emerged in the oil boom, could not have been identified as a likely boomtown even ten years into the boom. Big Spring and Wink, on the otherhand, were likely candidates, and they did boom at first, but by the 1940's they stopped growing and even lost population.

Thesis Advisors: Karen Polenske
Ron Trosper
Lisa Peattie

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To the angels of the "last hour", Mary Grenham, Carol Escrich, and Jackie LeBlanc for their patience and skill. Without them, this work certainly would not have been ready.

To my people, past and present, from whose blood, sweat, tears, and dreams I am but one of many products, and to whom this work is dedicated.

Oscar S. Rodriguez

# INTRODUCTION

A regional oil boom is by the very nature of the resource base highly unpredictable. Unlike the development of other types of energy resources, petroleum development covers a vast areas, and its sites of operation are not known until after extraction activities are already in their advanced stages. Faced with this uncertainty, the workforce who arrive to take up the jobs created by the oil boom are forced to make their settlement decisions almost completely in the dark. Moreover, neither the state of the local economy nor the location of labor markets figure into the petroleum industry's production function nearly as significantly as the location of the crude itself. As a result, the distribution of population occurs so much at random that the planner is unable to trace any outstanding factor which serves to explain and, therefore, anticipate where growth will or will not be seen.

The current aim in much of the literature on boomtowns is that of developing efficient resource allocation schemes which anticipate the quantity and quality of the eminent increase in demand for public capital stock by in-migrating workers. But this approach may not apply to oil boomtowns. Much of the research on which these models have been based has taken place around job booms brought on by coal mining or the construction of large power stations in the West. Mining and construction operations are localized and fixed. That is, they occur in one precise place, and they become with a difinite time-table for completion. Thus, the type of policy that might be appropriate under these conditions is inappropriate in the case of an oil boom. Some communities will make good use of the new infrastructure during the boom, but others will either not see a boom at all or they will only experience a few years of growth followed by a final bust. The no-growth communities who overcapitalize stand to lose twice in the boom. They will have to absorb not only the repre-cussions of their squandered investments, but also whatever social and eocnomic problems the boom leaves behind when it has subsided in the region, such as social disruptions, flight of the community's work-force to the oil industry from traditional jobs, and environment change.

# ABOUT THE PAPER

## The Thesis

The thesis presented here is twofold. It argues that (1) local economic growth in an oil boom cannot be projected on the basis of industrial location nor on the ability of the local economy to service the oil industry and the incoming workforce, and (2) that for the most part one cannot predict the outcome an oil boom. To make this argument, four types of hypothetical scenarios of economic development and population settlement in the Permian Basin will be analyzed:

1. droves of incoming workers ascending on the region and settling in the established towns and cities;

2. the emerging oil economy running into bottlenecks, and key actors in the economy queing up in the only two or three town that have the sought-after services;

3. the boom reworking the spatial organization of the regional economy, with growth and settlement concentrating in the regional crossroads and in the communities located closest to the most active oilfields;

4. the centers of production and growth being known beforehand through the information collected by oil prospectors.

The aim here is to show that the outcome of the boom could not have been anticipated: that the actual outcome of the oil boom in the Permian Basin contradicts all four of the scenarios above.

Area of Study

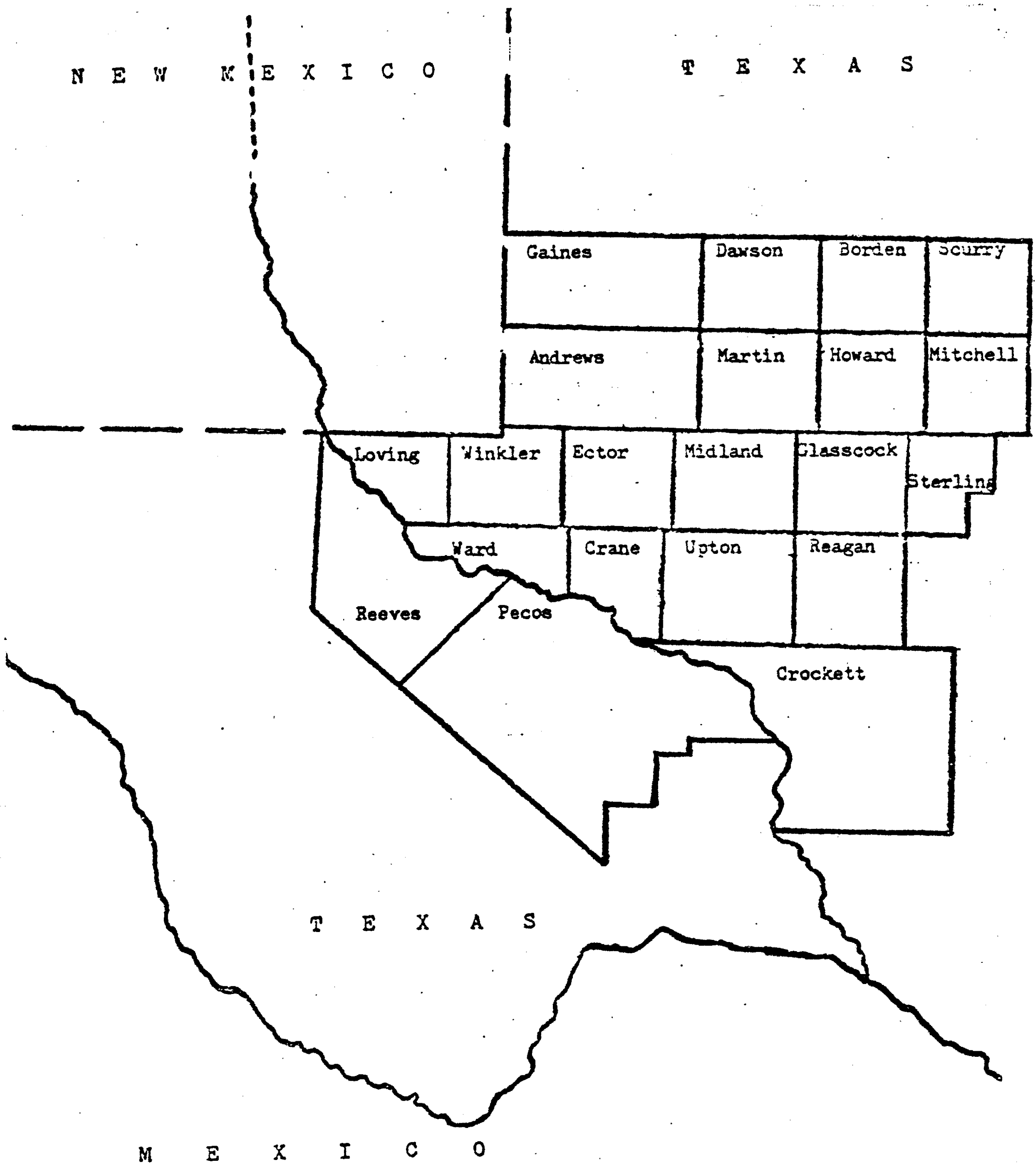
The scope of the paper will focus on twenty-one counties in West Texas:

1. Andrews
2. Borden
3. Crane
4. Crockett
5. Dawson
6. Ector
7. Gaines
8. Glasscock
9. Howard
10. Loving
11. Martin
12. Midland
13. Mitchell
14. Pecos
15. Reagan
16. Reeves
17. Scurry
18. Sterling
19. Upton
20. Ward
21. Winkler

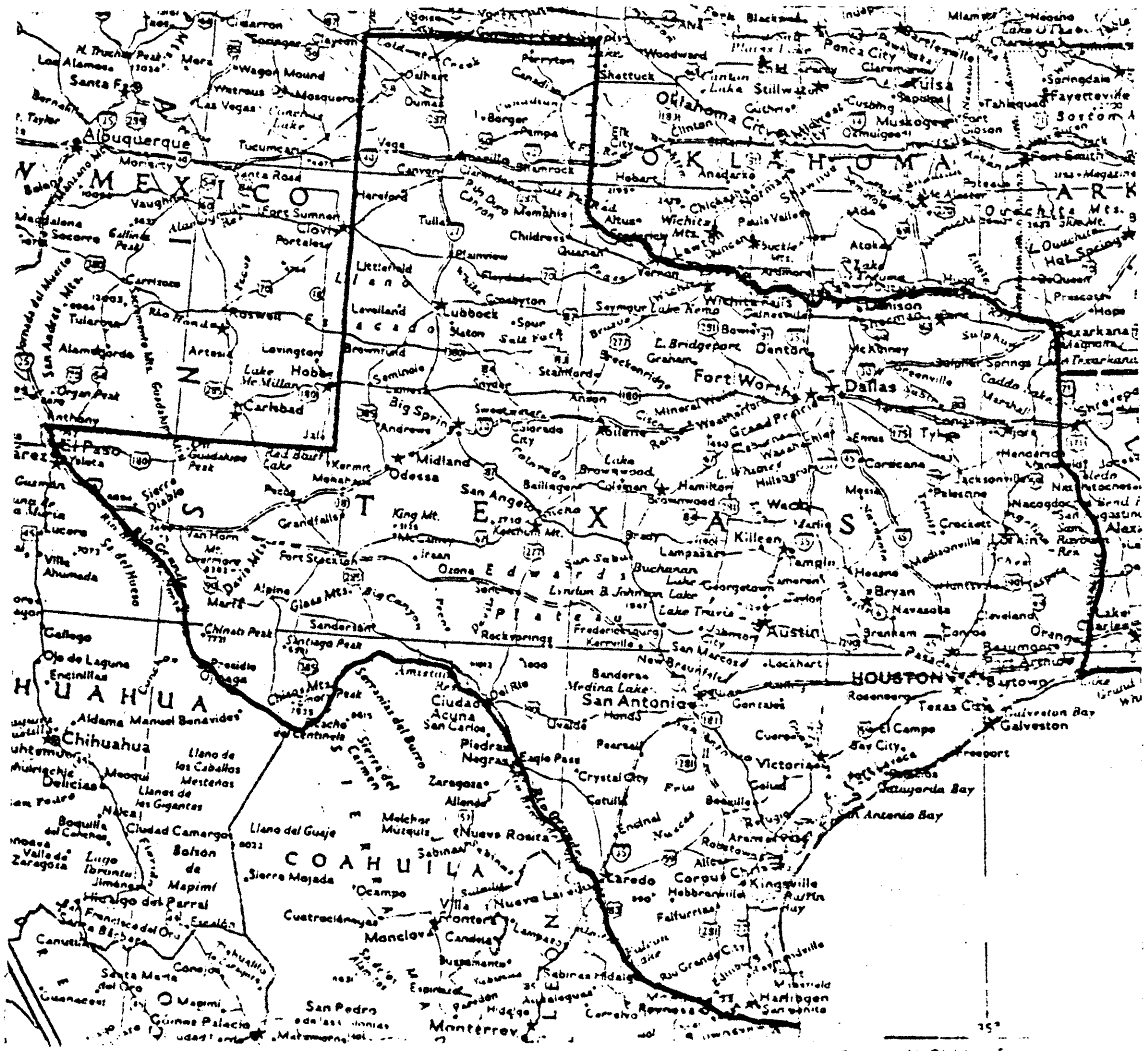
(see Maps I, II)

The region covered by the aggregate surface area of these counties will be referred to as the Permian Basin. The term permian basin describes a geological formation -- an ancient sea -- buried far beneath the surface of West Texas and Southeastern New Mexico. In strictly formal terms, it can be said that the Permian Basin actually extends over a greater area than that covered by the twenty-one counties in this study. However, the Permian Basin is significant in real life only because many reserves of oil and gas have been found within its formations. Given this, the Permian Basin is a smaller, more discreet place. It is therefore proper to think of it as that region of West Texas and Southeastern New Mexico circumscribed by major oil-producing counties. The twenty-one counties listed above encompass this petroleum-rich region in its past and present produc-

Map I: Counties of Permian Basin



Map II: Southeastern, New Mexico,
Texas and Oklahoma




*Compiled and Drawn in the Cartographic Division of*
The National Geographic Society
*Albers Conical Equal-Area Projection, Standard Parallels 29° 30' and 45° 30'*
SCALE 1:7,800,000 OR 123 MILES TO THE INCH

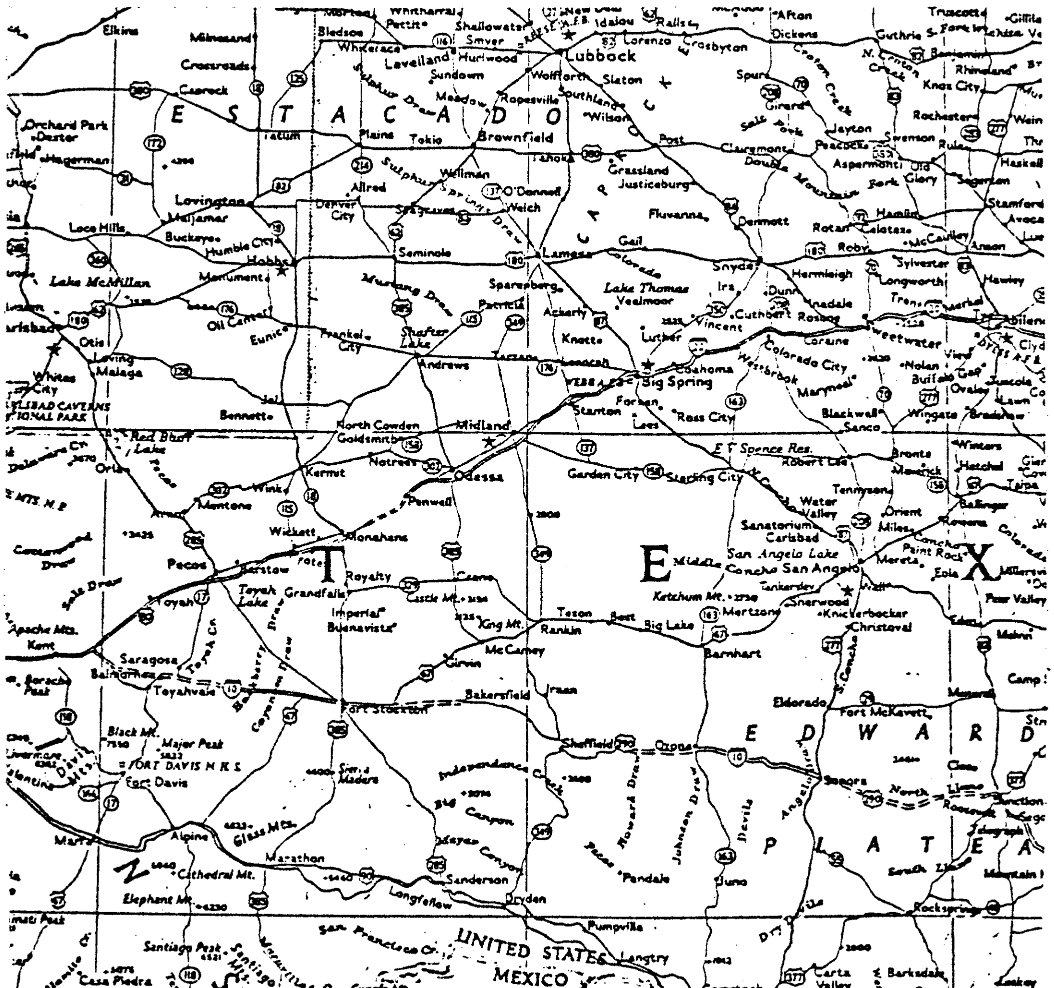
Source: <u>National Geographic Atlas</u>

tion status (See Exhibit A,B, and C in Appendix).

The Time Period

The time frame for this study will begin circa 1921 when oil was first struck, and it will end in the mid-1940's when Midland City and Odessa had surged ahead of all the other communities in the region to become the dominant population centers (see Map III). The assumption here is that at the beginning of the boom, it was not apparent that Midland City and Odessa would grow as rapidly as they did, but that by the mid-1940's their prominence in the region was clear. While the rationale for the bottom time-boundary of the boom (1921) is obvious, the upper boundary (1945) may be less clear. In actuality, the Permian Basin has seen more than one oil boom. Presently it can be said that the Permian Basin is in the midst of at least its third economic peak in terms of oilfield activity rate of increase in region population. Based on different variables, the case can be made that the Permian Basin in the 1940's had gone through more than one boom, or that it has not yet passed its first boom. But based on the change in population for both Ector and Midland as compared to the Permian Basin as a whole, it can be seen that a very significant demographic milestone had been reached by 1950 (See Tables I,II,III). Whatever happened after the 1940's would have been superfluous to the planner trying to predict the direction of the boom. The fact by then was already established that the boom had come and that Midland-Odessa would be the largest growth center in the region (see Diagram I, II).

Map III: Cities and Towns

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The National Geographic Society

Albers Conical Equal-Area Projection. Standard Parallels 29° and 35°

SCALE 1:2,980,000 OR 47 MILES TO THE INCH

STATUTE MILES

KILOMETERS

Railroads — Roads — Construction — Super Highways — Airports ★ Canals

Source: National Geographic Atlas.

TABLE I: County Populations 1920-1980

| | Y'20 | Y'30 | Y'40 | Y'50 | Y'60 | Y'70 | Y'80 |
|---|---|---|---|---|---|---|---|
| Andrews | 350 | 736 | 1277 | 5002 | 13450 | 10372 | 13284 |
| Borden | 965 | 1505 | 1396 | 1106 | 1076 | 888 | 857 |
| Crane | 37 | 2221 | 2841 | 3965 | 4692 | 4172 | 4597 |
| Crockett | 1500 | 2590 | 2809 | 3981 | 4209 | 3885 | 4588 |
| Dawson | 4309 | 13573 | 15367 | 19113 | 19185 | 16604 | 16194 |
| Ector | 760 | 3958 | 15051 | 42102 | 90995 | 92660 | 115204 |
| Gaines | 1018 | 2800 | 8136 | 8909 | 12267 | 11593 | 13199 |
| Glasscock | 555 | 1263 | 1193 | 1089 | 1118 | 1155 | 1308 |
| Howard | 6962 | 22888 | 20990 | 26772 | 40139 | 37796 | 33286 |
| Loving | 82 | 195 | 285 | 227 | 226 | 164 | 91 |
| Martin | 1146 | 5785 | 5556 | 5541 | 5068 | 4774 | 4705 |
| Midland | 2449 | 8005 | 11721 | 25785 | 67717 | 65433 | 82311 |
| Mitchell | 7527 | 14183 | 12477 | 14357 | 11255 | 9073 | 9082 |
| Pecos | 3857 | 7812 | 8185 | 9939 | 11957 | 13748 | 14641 |
| Reagan | 377 | 3028 | 1997 | 3127 | 3782 | 3239 | 4126 |
| Reeves | 4457 | 6407 | 8006 | 11745 | 17644 | 16526 | 15788 |
| Scurry | 9003 | 12188 | 11545 | 22779 | 20369 | 15760 | 18176 |
| Sterling | 1053 | 1431 | 1404 | 1282 | 1177 | 1056 | 1209 |
| Upton | 253 | 5968 | 4297 | 5307 | 6239 | 4697 | 4645 |
| Ward | 2615 | 4599 | 9575 | 13346 | 14917 | 13019 | 14024 |
| Winkler | 81 | 6784 | 6141 | 10064 | 13652 | 9640 | 9961 |
| Total | 49356 | 127919 | 150249 | 235488 | 361134 | 336254 | 381276 |
| Mean | 2350 | 6091 | 7155 | 11213 | 17197 | 16012 | 18156 |
| Median | 1053 | 4599 | 6141 | 8909 | 11957 | 9640 | 9961 |
| Standard deviation | 2685 | 5620 | 5734 | 11009 | 22905 | 22995 | 28394 |

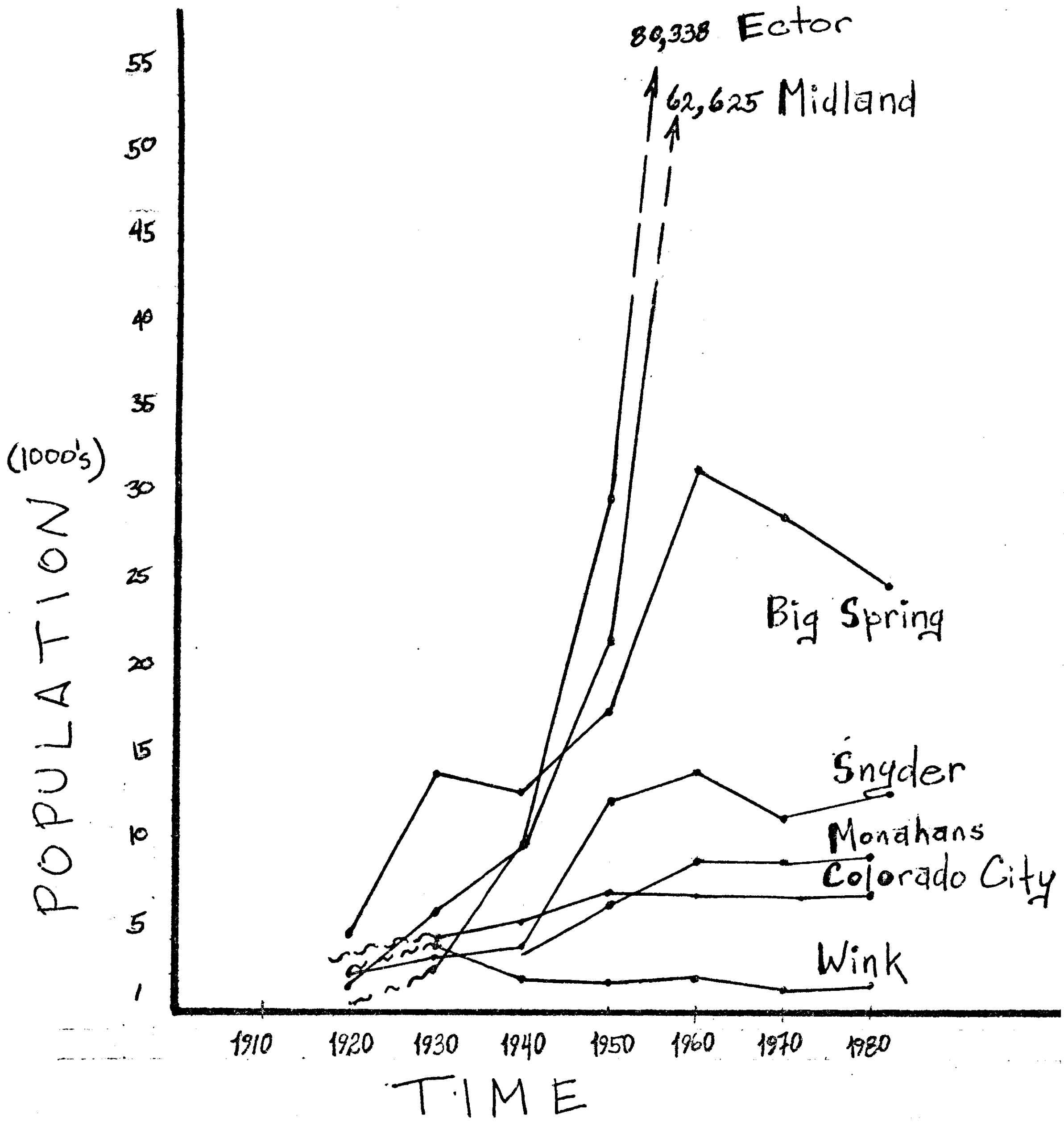
Source: U.S. Census of Population .

TABLE II: Population Rates of Change, 1910-1980 for Counties

| | Y'20 | Y'30 | Y'40 | Y'50 | Y'60 | Y'70 | Y'80 |
|---|---|---|---|---|---|---|---|
| Andrews | -64.103 | 110.286 | 73.505 | 291.699 | 168.892 | -22.885 | 28.076 |
| Borden | -30.375 | 55.959 | -7.243 | -20.774 | -2.712 | -17.472 | -3.491 |
| Crane | -88.822 | 5902.703 | 27.915 | 39.564 | 18.335 | -11.083 | 10.187 |
| Crockett | 15.741 | 72.667 | 8.456 | 41.723 | 5.727 | -7.698 | 18.095 |
| Dawson | 85.733 | 214.992 | 13.217 | 24.377 | 0.377 | -13.453 | -2.469 |
| Ector | -35.484 | 420.789 | 280.268 | 179.729 | 116.130 | 1.830 | 24.330 |
| Gaines | -18.884 | 175.049 | 190.571 | 9.501 | 37.692 | -5.494 | 13.853 |
| Glasscock | -51.444 | 127.568 | -5.542 | -8.718 | 2.663 | 3.309 | 13.247 |
| Howard | -21.603 | 228.756 | -8.293 | 27.308 | 50.210 | -5.837 | -11.932 |
| Loving | -67.063 | 137.805 | 46.154 | -20.351 | -0.441 | -27.434 | -44.512 |
| Martin | -26.017 | 404.799 | -3.959 | -0.270 | -8.536 | -5.801 | -1.445 |
| Midland | -29.301 | 226.868 | 46.421 | 119.990 | 162.622 | -3.373 | 25.794 |
| Mitchell | -15.956 | 88.428 | -12.028 | 15.068 | -21.606 | -19.387 | 0.099 |
| Pecos | 86.239 | 102.541 | 4.775 | 21.429 | 20.304 | 14.979 | 6.495 |
| Reagan | -3.827 | 703.183 | -34.049 | 56.585 | 20.947 | -14.357 | 27.385 |
| Reeves | 1.480 | 43.751 | 24.957 | 46.702 | 50.226 | -6.336 | -4.466 |
| Scurry | -17.585 | 35.677 | -5.276 | 97.306 | -10.580 | -22.628 | 15.330 |
| Sterling | -29.471 | 35.897 | -1.887 | -8.689 | -8.190 | -10.280 | 14.489 |
| Upton | -49.501 | 2258.893 | -27.999 | 23.505 | 17.562 | -24.715 | -1.107 |
| Ward | 9.460 | 75.870 | 108.197 | 39.384 | 11.771 | -12.724 | 7.719 |
| Winkler | -81.674 | 8275.309 | -9.478 | -60.110 | 30.665 | -29.388 | 3.330 |
| Region | | | | | | | |
| Mean | 20.594 | 937.98 | 33.747 | 42.495 | 86.404 | -11.439 | 6.619 |
| Median | -26.017 | 137.8 | 4.8 | 24.4 | 17.56 | -11.1 | 717.0 |
| Standard deviation | 44.982 | 2133.658 | 76.287 | 78.764 | 256.927 | 11.002 | 16.427 |

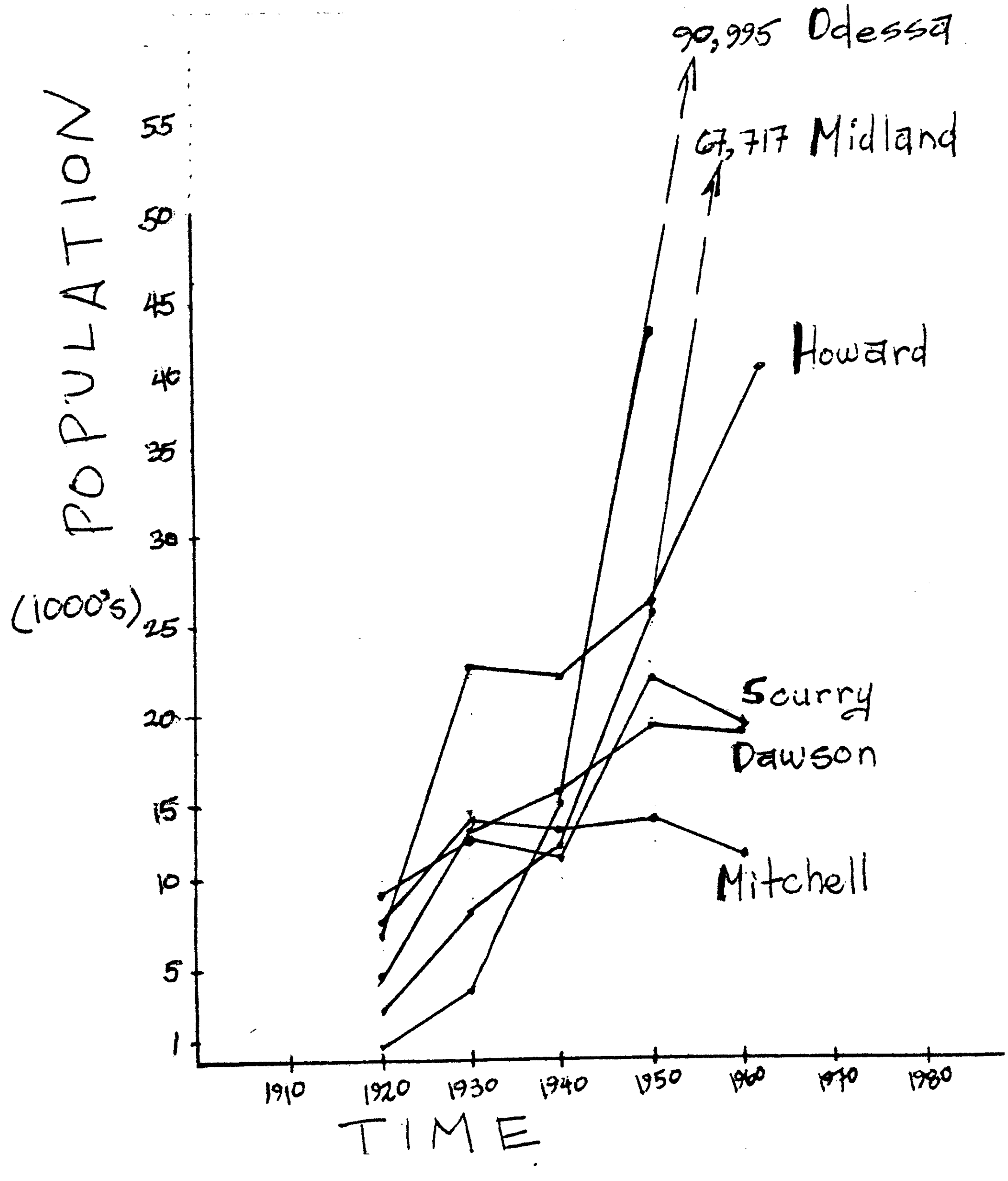
Source: U.S. Census of Population.

DIAGRAM I: County Population Growth
1920-1960




SOURCE: U.S. Census of Population

DIAGRAM II: Municipal Population Growth
1920-1980




SOURCE: U.S. Census of Population

TABLE III: Municipalities 1920-1980

| Municipality | County | 1920 | 1930 | 1940 | 1950 | 1960 | 1970 | 1980 |
|---|---|---|---|---|---|---|---|---|
| Abilene | | 10,274 | 23,175 | 26,612 | 45,570 | 90,368 | 89,653 | 98,315 |
| Lubbock | | 4,051 | 20,520 | 31,853 | 71,747 | 128,691 | 149,101 | 179,379 |
| San Angelo | | 10,050 | 25,308 | 25,802 | 52,093 | 58,815 | 63,884 | 73,240 |
| Andrews | (Andrews) | U | U | 611 | 3,294 | 11,135 | 8,625 | 11,061 |
| Barstow | (Ward) | U | U | 558 | 683 | 707 | 614 | 637 |
| Big Lake | (Reagan) | U | U | 763 | 2,152 | 2,668 | 2,489 | 3,404 |
| Big Spring | (Howard) | 4,273 | 13,735 | 12,604 | 17,286 | 31,230 | 28,735 | 24,804 |
| Coahoma | (Howard) | U | U | 574 | 802 | 1,239 | 1,156 | 1,069 |
| Colorado City | (Mitchell) | U | 4,671 | 5,213 | 6,774 | 6,457 | 5,227 | 5,405 |
| Crane | (Crane) | U | U | 1,420 | 2,154 | 3,796 | 3,427 | 3,622 |
| Fort Stockton | (Pecos) | U | 2,695 | 1,295 | 4,444 | 6,373 | 8,283 | 8,688 |
| Grandfalls | (Ward) | U | U | 653 | 915 | 1,012 | 622 | 635 |
| Iraan | (Pecos) | U | U | U | 1,196 | 1,255 | 996 | 1,358 |
| Kermit | (Winkler) | U | U | 2,584 | 6,912 | 10,465 | 7,884 | 8,015 |
| Lamesa | (Dawson) | 1,188 | 3,528 | 6,038 | 10,704 | 12,438 | 11,590 | 11,798 |
| McKamey | (Upton) | U | 3,446 | 2,595 | 3,121 | 3,375 | 2,647 | 2,436 |
| Midland | (Midland) | 1,795 | 5,484 | 9,352 | 21,713 | 62,625 | 59,463 | 70,525 |
| Monahans | (Ward) | U | U | 3,944 | 6,311 | 8,567 | 8,333 | 8,397 |
| Odessa | (Ector) | U | 2,407 | 9,573 | 29,495 | 80,338 | 78,380 | 89,797 |
| Ozona | (Crockett) | U | U | U | 2,885 | 3,361 | 2,864 | 3,766 |
| Pecos | (Reeves) | U | 3,304 | 4,855 | 8,054 | 12,728 | 12,682 | 12,844 |
| Pyote | (Ward) | U | 1,907 | U | U | 420 | 155 | 382 |
| Rankin | (Upton) | U | U | 672 | 1,139 | 1,214 | 1,105 | 1,216 |
| Seagraves | (Gaines) | U | U | 3,225 | 2,101 | 2,307 | 2,440 | 2,596 |
| Seminole | (Gaines) | U | U | 1,761 | 3,479 | 5,737 | 5,007 | 6,080 |
| Snyder | (Scurry) | 2,179 | 3,008 | 3,815 | 12,010 | 13,850 | 11,171 | 12,671 |
| Stanton | (Martin | U | 1,384 | 1,245 | 1,603 | 2,228 | 2,117 | 2,314 |
| Sterling City | (Sterling) | U | U | U | U | 854 | 780 | 915 |
| Wink | (Winkler) | U | 3,963 | 1,945 | 1,521 | 1,863 | 1,023 | 1,182 |

U--unorganized

Source: U.S. Census of Population.

## MODEL BOOMS

The boomtown phenomenon is an increasingly popular topic of discussion in the energy resource-rich lands of western North America. From the Prudhoe Bay to the Bay of Campeche, Federal policy analysts and local officials are having to wrestle with the impacts that energy resource development is landing on the communities located in the vicinity of these resources. Uncertainty is one of the most foreboding hinderences to planning in these boomtowns. Attempts are being made to cross this barrier by modeling boomtown development. However, after having started out in a very pricise fashion, boomtown modeling has evolved into a very general and imprecise area of research. All boomtowns are assumed to have pointed growth curves and to undergo the same general process of economic development. But what is most disturbing about this movement in the study of boomtowns is its gross negligence of uncertainty. Once the impacts of energy development are eminent, local communities are thought to be set irreversably on the road to typical boomtown development.

Commings _et al_. have published a plan for "optimal municipal investment in boom towns, whereby the taxpayers of a boomtown trade off a fraction of their wages for a corresponding increase in per capita stock in public infrastructure.[7] The benefits of alternative levels of infrastructure are measured according to a definite pricing scheme based on a survey of worker's perferences. The goal here is, at least in theory, to keep the individual worker at the level of per capita infrastructure that he or she is willing to accept in the way of less take-home pay. While allowing for different tenures of residency in the municipality. For the natives, Cummings discounts the cost of having to put up with crowding during the peak period of the boom against the benefit of not having to maintain an oversized stock of infrastructure after the peak when wages and population size begin to decline. From the side of the incoming worker-consumers, the inconvenience of crowded municipal infrastructure is put off through less take home pay. The result of all this is a market-oriented resource allocation scheme that attempts to bridge the impasses between the boom-bust nature of energy boomtowns and the long-term obligations of public infrastructure.

The Cummings approach to municipal investment is, of course, only one of the many approaches to the matter. The case has been made for the employment of other allocative strategies than pricing, such as rationing or the establishment of minimum consumption levels (or alternatively of maximum tax levels).

Susskind and O'Hare have proposed a different way of approaching the conflicts between energy development and planning in the impacted local communities.[8] Based upon the experience of energy boomtowns in Wyoming, Colorado, North Dakota and Texas, Susskind and O'Hare developed an auctioning concept for site location in energy development. They argue that since the costs and benefits associated with a given location decision accrue differently to the different parties touched by the project, the decision making process should allow for greater participation from all the concerned parties (e.g. industry, private individuals, local government, stae and federal government, etc.). Once at the negotiating table, the interested actors are encouraged to review each others' costs and benefits and bid on the site of the project with the understanding that certain conditions and bonuses are to be demanded of the project where ever it is finally based. In this way wherever the project goes, the impacts will be easier to mitigate and society will spend fewer resources to compensate the local community for the local externalties of the project.

It is hard to see how the Cummings or the Susskind approach to the boomtown phenomenon is applicable to oil booms. With mining and plant construction booms the matter of undercertainty really only involves matching the appropriate lump-sum capital stock to the needs of a fair-weathered population. In other words, the task for the planner in these types of boomtowns is to smoothen out the peaks of rapid growth by accommodating the boom in the most efficient way possible. In oil booms, however, the point of impact is uncertain and too broad to prepare for before the actual fact. Although oil has been found in the immediate area oa a given community, it cannot be known until after enough time has passed where or if alot of oil and, therefore, a lot of jobs will be found in the vincinity. The planner in a given boom does not have beforehand enough information to say when, how much, of if in fact rapid growth will occur. Thus, in an oil boomtown the uncertainty lies not only in how to allocate resources to meet the needs of the boom, but rather whether or not a boom will actually materilize--where not to spend resources.

Another question that haunts planners in a boomtown concerns the type of quality of demand, once it has been determined that a boom is upon the region. Most of the work being done on this question has been carried out though the refinement of projection models. The Los Alamos

Scientific Laboratory was pioneer in this area in 1976 they constructed the BOOM I MODEL. The researchers here made no mistake of specifying where their model was to be applied.

> The model, titled Boom 1, simulates the socio-economic development of small towns affected by the construction and operation of large-scale energy facilities....
>
> The model can be used to test the effectiveness of a broad range of policies designed to alleviate the adverse condition that can accompany the construction of large energy facilities near small towns.[9]

After Boom 1 was published, other models began to proliferate which expanded the domain of boom projection. Keeping in touch with the policy of energy resource diversification of the Carter Administration, the boom modelling that followed was aimed at the general boomtown case instead of the specific case of energy plant construction. The Argonne National Laboratory offers a model which greatly increases the scope of Boom 1, the Social and Economic Assessment Model (SEAM):

> The data and models of SEAM can be used to evaluate the social and economic effects of energy or industrial development on any county, communities within counties, or combination of counties in the continental United States.[10]

Within this model are contained several submodels which project the different aspects of the boom in question. For example, the Spatial Allocation Model (SAM) simulates the settlement preferences of the incoming workforce.

> The allocation model is used in specialized applications of SEAM when detailed information on housing demands and settlements patterns of in-migrating workers is required at the community level. SAM projects the manner in which new residents will distribute themselves among the communities within communting distance of the site and computes the housing need of these new residents at each location....

> The Spatial allocation model is preference-maximizing, income constrained linear programming system for determining how different segments of the in-migrating population will distribute themselves within the affected county.[11]

It can be inferred from this, boomtowns are but a single family of rapid growth and the political and economic features of development in one boom are taken to be governed by the same principles and dynamics that form all boomtowns. Supposedly, only the actors, skills, and energy products change. Given better information concerning the labor market that is required by the given energy industry, and the character of the existing infrastructure and economy, the outcome of the boom can be anticipated more accurately. Most recently, Tischelr, Montasser and Associates, Inc., have begun to market and impact projection model which serves not only the needs of government planners but also private business as well, the Social and Economic Impact Assessment Model (SEIA):

> The SEIA forecasts the impacts of a projected plant on a large number of parameters which characterize the region (e.g. population and employment levels infrastructure, human needs, and governmental services and finances). On the basis of the SEIA and analyses of other considerations, a specific proposal may be evaluated. The evaluation may suggest the plan is acceptable or it may lead to the consideration of alternative. The alternative then becomes a subject for analysis.[12]

Centaur Management Consultants, Inc., outlines all energy development according to the following phases:[13]

.exploration
.site preparation
.extration/development/mining
.preparation/processing/conservation
.transportation
.reclamation
.power generation
.transmission
.distribution

In their study of the financial impacts of energy development in Colorado, the Department of Local Affairs describes the "uniqueness of energy-impacted boomtowns; and the following claim about the fixed and local nature of energy development:

> One additional unique characteristic of energy-impacted boomtowns deserves mention. The development of energy resources is site specific. An energy industry must go where the natural resources are located--ther are very few if any alternative locations.

It is sad that these models focus on the obvious problems facing boomtowns, while failing to take stock of the structure and dynamics of energy booms and, therefore, the more profound aspects of the boomtown phenomenon. Local growth is taken to be motivated primarily by the demand for and supply of labor, housing, and public and private capital stock in the boom. Furthermore, the boom is understood to begin at the commencement of construction, peak at the height of development, and bust at the completion of operations. Of peripheral concern to models like these is the possibility that the center of the boom sloshes around the region from one area to another, or the case where there is no growth peak but instead an upward slopping curve, or that the traditional spatial organization of the regional economy becomes reorganized. (See Diagram II).

To be sure, many of the boom projection models in existence today have evolved from studies of either mining operations or plant construction projects, which clearly resemble the sine-curve pattern of growth they invoke. But in the race to improve the power of their projection models, the distinction between these types of booms and other booms has faded. The study of the energy boomtowns has not graduated from its primary stage of development where the classification of phenomena takes place.

Nevertheless, it is already being promoted as an almost complete science. For, when invoked, the term boomtown is meant to refer to all boomtowns. It is not common in the literature to precede 'boomtowns' with such caveats as coal or uranium or petroleum.

With the term energy boomtown being used with little qualification, the planner in an oil boomtown may be led to apply the same planning techniques for his situation that have been developed for, say, coal or oil shale boomtowns. But as he or she will surely find out eventually, what happens in those booms will not necessarily happen in an oil boom.

# THE PERMIAN BASIN

## The Non-Human Environment

The term permian basin derives from the geological description of a particular formation underlying central West Texas and the southeastern corner of New Mexico. More specifically, 'permian' describes a particular period of geological time, and it corresponds to the thickest layer of rock found under the region. During the Permian Period, a sea was formed there (hence the Permian Basin) and with the passing of eons, this ancient sea dried up and was covered over with formations which developed mostly during the Permian Period, but also during later periods. Since the largest geological layer is from the Permian Period, most of the petroleum extracted from the Permian Basin is found between and within (the distinction will come up later) permian structures. Very large deposits of oil and gas have been found also in the structures of other periods however.

## Life Without the Boom

The character of the world above the Permian Bsin can hardly be described as having anything to do with a large body of water. Relative to the surrounding regions, the Permian Basin is very arid. On the average, it receives about fifteen inches of rainfall on its northern counties, five inches on the central counties, and downward from ten inches on its southern and southwestern counties.[1]

On an imaginary line that cuts roughly through the middle of the region from northeast to sourtheast, the Southern Great Plains and the steps of the Southern Rocky Mountains meet. In Andrews, Borden, Dawson, Gaines, Martin, and Midland, the land is generally flat and covered with flora typical to the Great North American Prairie. Crane, Ector, Loving, Upton, Ward and Winkler are characterized by desert-like features, such as rocky surfaces, craggy rills and barren rolling hills which in some places turn into white sand dunes. The land is really only suitable for grazing in these counties.[2] The southern counties, Crockett, Pecos, and Reeves are taken up mostly by sierras and dry inter-mesa flats. The Pecos River trickles through this part of the Permian Basin, but since it is naturally very salinated, it really gives no sustenance to the vegetation in the area. In the eastern counties, Glasscock, Howard, Mitchell, Reagan, Scurry and Sterling, the land is the most humid in the region. It is drained by the northern reaches of the Colorado River (of Texas) and the Concho River systems. The soil there is suitable for thick vegetation, and thus it is the most cultivated part of the Permian Basin.[3] Before the boom, this area was also the most populated are of the region.

Midland-Odessa

Midland City and Odessa are the places where oilmen in the region go to hire the services of wildcatters, to take bids on the construction of pipelines, to arrange for a trucking company to haul equipment and materials to the oilfields, or simply to spend a wild weekend away from the sound of drilling rigs. Every Monday morning, work crews drive out from Midland City and Odessa and deseminate throughout the Permian Basin, sometimes taking up to four hours to reach their actual job sites.

Midland City and, fifteen minutes away, Odessa make up the largest population center between Dallas-Fort Worth and El Paso-Juares. In that part of Texas, the major population and trading centers other than Midland-Odessa are Lubbock, Abilene, and San Angelo (see Table III). Of these three cities, the one closest in distance to either Midland City or Odessa is San Angelo, approximately three hours driving time away from Midland City. Odessa is larger than San Angelo in terms of Population. Then, if counted as one, Midland-Odessa add up to a larger population center than Abilene. Only Lubbock, 140 miles north, is larger than Midland-Odessa.

Most of the consumers from the twenty-one counties in this paper, shop in Midland-Odessa (see Table IV and V). About 55% of all wholesale, 61% of all manufacturing, and 45% of all retail establishments in the Permian Basin are located in either Ector County or Midland County (see Table VI). Of all the major market centers of significant size in Southeastern New Mexico and West Texas, Midland-Odessa, with 274,600 consumers, rank second only to Lubbock, with 372,300 consumers (see Table V).

The history of the region shows that Midland-Odessa has been one of the fastest growing areas in the Permian Basin since the boom. From a population of 2,407 in 1930, Odessa grew into a booming town of 89,797 people in 1980 (see Table III). During this same period, Midland increased from 5,484 to 70,525 inhabitants. At different points in time, both cities have experienced more than once a growth in population of more than 100% (see Table II). Odessa virtually came on to the map as a full-fledged city -- without having gone through any real infancy stages. In fact, in 1920, no more than 760 people were enumerated in all of Ector County. But in 1940, it had become the second largest town in the Permian Basin, with 9,573 residents. By 1950, it was the largest city in the region with 29,495 people. Midland City went from a population of 1,795 in 1920 to one of 5,484 people in 1930; and 9,352 people in 1940. By 1950, it had surpassed Big Spring and was the second largest city in the region.
Big Spring, although it was the largest city in the Permian Basin at the start of the boom and peaked at 31,320 inhabitants in 1960, today has only

TABLE IV: Basic Trading Area, by County

| County | Basic Trading Center |
|---|---|
| Andrews | Midland-Odessa |
| Borden | Big Spring |
| Crane | Midland-Odessa |
| Crockett | San Angelo |
| Dawson | Lubbock |
| Ector | Midland-Odessa |
| Gaines | Lubbock |
| Glasscock | Big Spring |
| Howard | Big Spring |
| Loving | Midland-Odessa |
| Martin | Big Spring |
| Midland | Midland-Odessa |
| Mitchell | Abilene |
| Pecos | San Angelo |
| Reagan | San Angelo |
| Reeves | Midland-Odessa |
| Scurry | Abilene |
| Sterling | San Angelo |
| Upton | Midland-Odessa |
| Ward | Midland-Odessa |
| Winkler | Midland-Odessa |

Source: 1981 Commercial Atlas and Marketing Guide. Rand McNally & Company, 1981

TABLE V: Current Population and Sales Data for Basic Trading Area, 1980

| | Population | Households | Total Retail sales ($1,000's) | Shopping goods sales ($1,000's) |
|---|---|---|---|---|
| TEXAS | | | | |
| Abilene | 207,200 | 77,500 | 764,555 | 137,645 |
| Big Spring | 40,600 | 14,700 | 179,590 | 30,440 |
| Lubbock | 372,300 | 127,100 | 1,416,897 | 256,626 |
| Midland-Odessa | 242,600 | 83,200 | 1,126,651 | 197,610 |
| San Angelo | 164,000 | 60,000 | 611,932 | 98,997 |
| NEW MEXICO | | | | |
| Carlsbad | 48,000 | 17,100 | 153,711 | 25,657 |
| Hobbs | 55,000 | 19,100 | 186,157 | 30,330 |
| Roswell | 51,000 | 17,900 | 187,682 | 31,091 |

Source: *1981 Commercial Atlas and Marketing Guide*, Rand McNally and Company, 1981.

TABLE VI: Number of Business Establishments Registered, by County, 1972

| | Manufacturing | Wholesale | Retail | Mineral | Number Employed In Minerals |
|---|---|---|---|---|---|
| Andrews | 7 | 20 | 134 | 164 | 1400 |
| Borden | 0 | 0 | 5 | 48 | 100 |
| Crane | 4 | 7 | 49 | 106 | 800 |
| Crockett | 1 | 5 | 55 | 102 | 600 |
| Dawson | 18 | 64 | 220 | 81 | 300 |
| Ector | 145 | 360 | 1104 | 385 | 5000 |
| Gaines | 8 | 37 | 157 | 105 | 8000 |
| Glasscock | 0 | 1 | 10 | 52 | 500 |
| Howard | 26 | 77 | 458 | 115 | 500 |
| Loving | 0 | 0 | 1 | 39 | 100 |
| Martin | 3 | 11 | 37 | 76 | 400 |
| Midland | 79 | 171 | 736 | 356 | 5000 |
| Mitchell | 10 | 15 | 108 | 40 | 100 |
| Pecos | 10 | 28 | 200 | 182 | 2100 |
| Reagan | 1 | 12 | 42 | 96 | 700 |
| Reeves | 14 | 39 | 209 | 72 | 300 |
| Scurry | 19 | 42 | 231 | 108 | 1100 |
| Sterling | 0 | 2 | 15 | 30 | Not Available |
| Upton | 2 | 25 | 78 | 90 | 600 |
| Ward | 12 | 24 | 174 | 147 | 1400 |
| Winkler | 6 | 21 | 114 | 106 | 800 |
| REGION Total | 365 | 961 | 4137 | 2500 | |

Source: County and City Data Book, U.S. Department of Commerce (Washington, D.C.: U.S. Government Printing Office, 1977).

24,804 people and is the third largest city in the region. Thus of the three largest cities in the Permian Basin, the largest town today used to be one of the smallest communities in the whole region at the onset of the boom, and the smallest of the top three cities today used to be the largest town at the beginning.

What is perhaps the most outstanding thing about both Midland and Odessa is, however, that neither Ector County nor Midland County are as well endowed with petroleum as their position in the region seems to indicate. The two largest petroleum fields in the Permian Basin, Yates and Kelly-Snyder (respectively the fifth and eighth most productive fields in the United States) are not located in or adjacent to Ector or Midland.[4] Although almost 52% of the entire population of the Permian Basin lives in either Ector or Midland, but less than 25% of both the value added and the total receipts from all mineral-related industries in the twenty-one counties (see Table VII). As for agriculture, the only economic activity in the region which is not dependent on the petroleum boom for its sustenance, has figured least significantly in Ector and Midland than in most of the other counties in the region.[5] This is consistent with the fact that the land has always been the least arable in this area than most of the rest of the Permian Basin.

Thus, in terms of the obvious economic bases that would seem to be critical for a strong local economy there, Ector and Midland do not have between them a clear advantage over the average county in the region. Beyond the fact that they do serve as the point of rendezvous for the petroleum industry in the region, a planner is left with no apparent explanation for why these two counties out of all the rest have come to assume the central position in the regional economy. A more complex

TABLE VII: Establishments, Employed and Transactions in Mineral Industry, by County, 1977

| | Petroleum Extraction | | | | | 1977 | | 1972 | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Establishments | Crude and Gas | Number Employed (1,000's) | Establishments with 20 or more workers | Other Mineral Industries | Value Added | Capital Expenditures | Value Added ($1,000's) | Value of Shipments and Receipts ($1,000's) |
| Andrews | 164 | 87 | 0.8 | 10 | 0 | 430.0 | 55.7 | 238.1 | 282.0 |
| Borden | 42 | 36 | 1.0 | 1 | 0 | 73.7 | 4.9 | 0 | 35.6 |
| Crane | 114 | 57 | 1.2 | 21 | 2 | 381.8 | 48.1 | 183.7 | 228.6 |
| Crockett | 107 | 69 | 0.3 | 2 | 0 | 132.4 | 48.1 | 48.9 | 58.6 |
| Dawson | 80 | 45 | 1.0 | 3 | 0 | 83.0 | 15.2 | 39.1 | 46.3 |
| Ector | 341 | 89 | 6.8 | 19 | 2 | 721.2 | 125.6 | 353.9 | 430.5 |
| Gaines | 114 | 66 | 0.6 | 10 | 0 | 424.0 | 56.9 | 107.6 | 127.9 |
| Glasscock | 65 | 42 | 0.1 | 2 | 0 | 38.3 | 21.2 | 8.8 | 9.9 |
| Howard | 132 | 83 | 0.8 | 2 | 8 | 120.1 | 19.5 | 54.3 | 64.4 |
| Loving | 45 | 30 | 0.1 | 1 | 0 | 117.0 | 14.1 | 13.3 | 10.4 |
| Martin | 64 | 41 | 0.2 | 4 | 21 | 67.9 | 16.0 | 33.0 | 41.2 |
| Midland | 454 | 268 | 6.3 | 61 | 2 | 309.4 | 76.4 | 125.9 | 159.0 |
| Mitchell | 47 | 30 | 4.0 | 3 | 40 | 51.2 | 10.5 | 13.0 | 15.5 |
| Pecos | 167 | 93 | 1.7 | 20 | 0 | 837.8 | 98.1 | 276.9 | 341.3 |
| Reagan | 97 | 60 | 0.7 | 10 | 0 | 83.6 | 17.1 | 30.3 | 52.4 |
| Reeves | 78 | 41 | 0.7 | 7 | 3 | 180.9 | 30.5 | 46.9 | 47.6 |
| Scurry | 123 | 52 | 1.5 | 23 | 6 | 435.3 | 25.0 | 323.1 | 368.7 |
| Sterling | 49 | 32 | 0.2 | 3 | 1 | 39.4 | 11.1 | NA | NA |
| Upton | 104 | 57 | 0.7 | 14 | 0 | 136.7 | 25.6 | 0.6 | 77.2 |
| Ward | 148 | 61 | 0.3 | 21 | 3 | 245.3 | 38.5 | 0.2 | 136.0 |
| Winkler | 114 | 67 | 0.9 | 16 | 4 | 237.2 | 28.9 | 0.8 | 101.6 |

NA--not available.

Source: U.S. Census of Mineral Industries.

explanation must lie in the development process of the petroleum boom. The question that arises here is, how could anybody have predicted at the onset, that the boom would leave the regional economy organized this way? Could the planner have known that Midland City and Odessa and not, say, Big Spring, or Midland and Big Spring, or the combination of any other two or more communities, or soley Midland or Odessa, would experience the main thrust of the boom?

If at the start of the oil boom in the early 1920's, had planners applied the boom models that have been developed for other forms of energy resources development, many communities other than Midland City and Odessa might have been advised to gear up for an eminent increase in demand for housing, social services, infrastructure and other public and private forms of capital stock. The older agriculatural towns like Colorado City, Pyote, Snyder, and Wink would have been prompted by the Texas state and United States federal government to invest heavily in roads, water and sewer mains, and extra public service personnel, only to sadly find out later that instead of coming to them the oil industry was locating in the new town of Odessa or in the relatively insignificant community of Midland City. Ambitious private developers might have risked fortunes in order to construct residential and office space in time to wring profits from the incoming workers and service oriented firms. In Midland City, for example, private developers completed a twelve-story office building -- a rarity in the region before the 1960's -- in 1929, thinking that surely a lot of business from the oilfields would pass through Midland.[6] As it turned out, after a brisk period of growth, the Petroleum Building was idle during the 1930's. Colorado City, after two decades of fast growth, ended up in 1950 with only 2,000 new residents (see Diagram II).

Snyder, after having grown by 1,000 people every ten years from 1929 to 1940, and having leaped to 12,010 people in 1950, saw no more growth. As for Pyote and Wink, along with McKamey and other smaller boomtowns, they declined in population after the first decade of the boom.

# PROJECTING THE OIL BOOM

A rationalistic view of how populations settle in a region does not explain what occured in the Permian Basin. For the method of operation in petroleum development allows the worker-consumer neither a clear picture of the costs and benefits involved in location nor a promise of where the market center will be for him or her in the future. Since workers do not know where their jobs will be in the future, they cannot calculate where to settle in order to cut transportation costs, how to enhance their employment opportunities, or where to make other types of trade-offs between their residential location and the location of their jobs. The planner who projects the spatial development of region experiencing an oil boom based upon what exists before the boom, or upon the immediate needs and actions of the workers-consumer will not be much better off than the roughneck who has to move on to a new location when the oilfield "matures."

What follows is a study of four different categories and hypotheses which the planner might have been tempted to use to predict the pattern developed of the boom:

1. The Most Outstanding and Established Population Centers.
2. Corners of the Regional Economy
3. Crossroads, Mid-points and Hotspots of the Oilfields
4. Most Promising Geological Factors

The methods of analysis will be that of first recreating the scenario that the hypothesis seems to paint, and then presenting the actual outcome according to history.

The Established Population Centers?

Hypothetical. In the findings from their study on the impacts from the development of coal, uranium, and petroleum in New Mexico, the Governor's Energy Impact Task Force (EITF) offered the following observations as characteristic of all energy boomtowns in the state:

> 1) one of more energy based project is planned within commuting distance of the town; (2) the total of construction, operating and local service employees coming into the community causes a significant population increase; (3) the present population base is less than 50,000; (4) the economic base of the community becomes heavily dependent on the new energy based project; (5) the community's need to provide public services and facilities go far beyond their financial and managerial resources; (6) critically important public facilities, such as water and sewer systems, cannot be readily expanded to accomodate anticipated growth; (7) a serious shortage of permanent and mobile housing develops; (8) school classroom capacity becomes inadequate to handle the additional load. (Managing the Boom)[5]

Having put them forth, EITF proceeds with the rest of the report to describe in detail how the regional boom shows up in each of the eight characteristics above. Given this approach to the question of boomtowns, it follows that the most growth should occur in those communities that are best able to meet the needs of the incoming population. The incoming workforce will choose to settle where they can find the best accomodations within driving distance of their jobs. They will settle in the communities that have the largest stock of housing and public infrastructure, along with the most complete service sector. All the existing housing stock will immediately be taken at the beginning of the boom, regardless of the size of the community. But as time goes on and shortages start to develop, the people who are left out will tend to look first at the largest population and economic centers in the vicinity of their job sites.

A larger town means a higher probability of accommodation than in a smaller town. Although the housing turnover rate in the big town may be no higher than that of a smaller town, the absolute number of vacancies can be higher. Even if an opening cannot be found outright, there may still be a greater chance in the large towns of finding people who are willing to share their shelters with new arrivals through boarding or house-sharing arrangements, or by building and renting new house additions or trailer space.

Then once absolutely all the existing housing opportunities have been taken, those in-migrants who decide to build homes will tend to build them in the larger towns. In the short-term, the workers who come with families will prefer to drive longer distances than settle in relative wilderness. In the smaller towns they will see fewer of filling stations, movie theatres, and other forms of recreation outlets. The streets will be less likely to be paved. The capacity of water and sewer and other utility mains will be suited for a smaller population size; hence growth will be limited.

Large towns will have, furthermore, an advantage over the smaller towns with regards to the provision and expansion of their public infrastructure. They enjoy in their present state support from a larger tax base and a greater enconomy of scale in infrastructure. A given lump sum of capital required for say, the construction of a new water-treating plant, it can be borne more easily by a greater number of taxpayers than by fewer taxpayers. Also, given a rapid increase in demand for such infrastructure as streets, power lines, and water mains, the existing stock serving a big town can service more new people than can that of a small town. The crowding threshold in a larger system is greater in a large town than in a smaller town. In a small town where the volume of traffic is relatively small, a system of unpaved residential streets may be the most appropriate, most cost-effective way for the municipality to meet the need of its constituency. It pays the local residents to bear the costs of gradual wear on their vehicles and to support a tractor and a driver to scrape the streets very other month, than to pay for paved streets which will not be used at near their capacity levels. But if traffic increases to the point where the roads deteriorate more frequently and the tractor has to be called out every other week and after even brief showeres, then it will be more efficient to pave the streets. Once the streets are paved, the asphalt will make them wear better. Then only a truly fantastic increase in traffic will tax the town's street system in a way that will force the city to take further measurers to meet the community's needs in the area of streets. Other than build more streets or regulate traffic in some way, there is not much more that can be done in this area, however. In any case, the larger communities should have more options in this regard. The smaller communities will have fewer options in the short-term because they will still be at the point of paving streets or adding on to Main Street--that is, the only paved street in town.

Large cities have a further advantage with regards to the expansions of public capital, since they do not have to start from scratch. A large-scale or small-scale power line or a water main system of a given design can service a large or small population. For example, a gridded system of power lines can have Y grids of poles and lines suppored by X central (main) highwire lines which bring in power from the regional electrical generating station. Y can increase until X can no longer carrry enough power to support them, or until they begin to veer away from the layout of the central pylons. The same principle applies to other forms of public capital, such as water and sewer systems, gas lines, and streets. The cost of installing another domestic utility line of standard dimensions to the main can be borne by the individual consumer who orders it. But if demand increases to the point where water pressure or power begins to decline, or where the length of domestic lines conneting to the mains has increased beyond what the consumer can afford, the community as a whole will have to put up the capital to lay a new main extension. Construction will have to proceed in the directions which the existing layout of mains does not head. The town administrators will now have to overcome new financial, political and physical obstacles. The hill at the outskirts of town which the Water Department people had been avoiding will now have to be sçaled and water pumped up to the growing number of people who have built new homes on it. The town will finally have to declare some downtown property public domain in order to open up right-of-ways for the installation of the new mains.

In the face of all these costs, the small towns will delay expansion, and this will inturn hold back residential construction. Growth, in general, will be capped at the existing levels of infrastructure and other capital stock. After a while, people will stop looking toward the smaller towns and begin to settle in the cities. The cities, on the other hand, have the advantage of offering developers more options for adding on to the city at lower costs to city's taxpayers. Since utility mains will be available in greater capacities and will probably run more directions, crowding will be less noticeable. The city administrators will have more time and more manueverability with which to meet a slower rate of deterioration in services and per capita infrastructure.

Outcome. Nevertheless, for all the insights into savings incentives and cost barriers that this view of regional boom development holds, it does not recreate what happened in the Permian Basin during the 1930's and 1940's. The towns that experienced the most growth during that period were not then the largest population centers nor the most outstanding economic centers. On the eve of the oil boom, Ector and Midland were not siginificant in the distribution of population and economic activities in the region. It is hard to imagine how people would have preferred either of these two counties over all the others in the region on account of their existing capacity to accomodate growth.

In 1920 neither Ector nor Midland amounted to anything of a significant population center in the region. Together they accounted for no more than 6.5% of the total population, 9.5% being the random share for each county (1/21 + 1/21). Ector, with a population of 760, stood well below the median population count, 1053, for all the counties in 1920, and it was a little more than one and a half (1.688) standard deviations from the mean, 2350. (See Table I) Midland, with 2449 people, was but an average county in terms of population size. Odessa was not incorporated until 1928. Midland City, which was incorporated by 1920 had only 1975 residents, third behind Big Spring (Howard County) and Snyder (Scurry County).

By 1930, the region had increased by 261.4% and thirty-five major oilfields had been proved throughout the Permian Basin. Three of these fields straddled the Ecotr-Crane County line, but still it did not seem that people were wanting to settle in Ector or Midland over other areas in the region. Ector and Midland even then amounted to no more than 9.4% of the total population, about equal to the random distribution for any two counties. If anything, it seems that in 1930 in-migrants were preferring several other counties than either Ector or Midland. Individually, Howard, Mitchell, Dawson, and Scurry had, in order, 17.9%, 11.1%, 10.6%, and 9.5%, of the population. All of these counties touch the Howard County line. Thus including Borden County, which is situated above Howard between Dawson and Scurry, it can be said at that time that more than 50% of the population of the region had settled in the northeastern area.

In 1930 Big Spring had swelled by 68% to 13,735 inhabitants. Colorado City (Mitchell County) stood at 4671 inhabitants; Lamesa (Dawson County) at 3528; and Snyder at 3008. Odessa by that time had 2407 people, and Midland City had 5484 people. As such, Midland was the second largest city in the region. Odessa, however, ranked tenth. From the point of view of tax sharing and economies of scale, Midland City was not the clear first choice for developers and newly arrived workers looking to build a new house in the region. Big Spring, thirty-five miles northeast of Midland City, was most probably the best competitor in this regard. Odessa, twenty miles west of Midland City, could not have been very competitive. Not only did it rank very low in terms of population size, but it was also situated closely between two larger communities; namely, Midland City and Wink (Winkler County). A worker arriving from outside the region who did not want to live in Big Spring would have looked to settle in Midland or Wink before Odessa, since even ten years into the boom it still showed no obvious signs of being able to provide either shelter or savings to any outstanding scale.

To be sure, there was not much to look at in the way of housing stock in Ector at the beginning of the boom (See Table VIII). In 1920 there were only 173 dwellings in Ector. Midland had 526 dwellings. On the other hand, immediately southest of Ector, Ward County had 548 dwellings. Driving through Texas from Dallas to El Paso in the early 1920's one would hardly have known that the stretch of land between Midland City and Monahans was inhabited. In fact, the whole strip running from north to south through Ector (Gaines, Andrews, Ector, Crane and Upton) was relatively devoid of man-made structures during the 1920's. There only 555 dwellings in that five-county strip, accounting for 5.3% of the total stock--although it takes up almost one third of the total land surface in the Permian Basin (See Map II).

The number of dwellings gives no positive indication of the true relative attractiveness of Ector among new arrivals to the region. For there is the question of critical mass of housing, of comparative worth among all the dwellings enumerated, etc. But what can be grasped with this statistic is the panorama that faced the newly arrived worker and developer. The region having increased by 61.6% between 1920 and 1930, there must have been alot of hasty settlement decisions made by the new arrivals. Keeping in mind that most of the housing stock in the region was located in the northeastern counties, a planner studying the impacts of energy development on the region could not possibly have guessed that Odessa would come to matter very much to the development of the region. One would have thought that most of the impact would be felt where there already were more people and where there appeared to be a longer history of development, and most of this was in the northeastern counties and

TABLE VIII: Number of Dwellings 1920-1950, by County

| | 1920 | 1930 | 1940 | 1950 |
|---|---|---|---|---|
| Andrews | 78 | 193 | 407 | 1692 |
| Borden | 199 | 323 | 366 | 332 |
| Crane | 7 | 745 | 903 | 1309 |
| Crockett | 362 | 659 | 770 | 1281 |
| Dawson | 884 | 2848 | 4606 | 6091 |
| Ector | 173 | 853 | 4677 | 13,358 |
| Gaines | 231 | 607 | 2548 | 2885 |
| Glasscock | 131 | 293 | 399 | 359 |
| Howard | 1390 | 4766 | 5892 | 8243 |
| Loving | 21 | 54 | 97 | 74 |
| Martin | 242 | 1188 | 1514 | 1963 |
| Midland | 526 | 1714 | 3576 | 8194 |
| Mitchell | 1480 | 3042 | 3704 | 4436 |
| Pecos | 904 | 1746 | 2120 | 2962 |
| Reagan | 71 | 840 | 585 | 1098 |
| Reeves | 995 | 1400 | 2232 | 3506 |
| Scurry | 1834 | 2603 | 3313 | 7409 |
| Sterling | 237 | 335 | 406 | 442 |
| Upton | 66 | 1510 | 1424 | 1765 |
| Ward | 548 | 1092 | 2969 | 4171 |
| Winkler | 24 | 1970 | 2088 | 3265 |

Source: U.S. Census of Housing.

Howard.

In terms of their local economy, Midland and Ector did not seem to be outstanding either. Well into the boom in 1930 the Permian Basin had acquired workforce of 45,802 people. Of these workers, 2967 and 1635 lived in Midland and Ector respectively. In Dawson, Mitchell, Pecos, Scurry and Winkler, however, there were 4263; 4557; 32,946; 3863 and 3090 workers respectively. Howard was by far the busiest employment center, with 8552 workers. Surely, at the onset of the boom, Big Spring would have been most people's guess as to where the epicenter of the boom would be. After Big Spring planners would have looked toward counties like Mitchell where the first oilwell in the region was completed or to Winkler where a disproportionate number of oilfields had by then been discovered and where one of the largest towns in the region was located. Midland, since it did not have oil but did have the second largest urban population and the sixth largest workforce, might have received a corresponding amount of attention from planners. But Ector, the 12th largest workforce, with one of the smallest communities in the region, would not have been diagnosed as an area about to be heavily impacted by oil boom had planners based their projections on the existing distribution of population, housing stock and agglomeration of public capital stock. Based on these variables, one would have predicted that Big Spring would remain, and if anything, increased its position as the center of the regional economy.

Corners of the Regional Economy?

Hypothetical. Would it have been correct to expect that growth would occur where there was specialization in the oilfield service sectors? The argument here is that the oil companies found in Ector and Midland some form of oil-related expertise which for one reason or another could not be found in the other counties. That for this reason the oil industry patronized Ector and Midland more than the other local eonomies, thereby concentrating there the boom's demand for labor and service. The oilfield service areas which come to mind in order for the argument above to hold are primarily five:

1. Transportation
2. Warehousing
3. Welding and Oilfield Construction
4. Miscellaneous Business Services
5. Public Utilities

Outcome. Several facts contradict the argument that between them Ector and Midland had cornered any of these five areas, however. Firstly, the petroleum industry could not have purchased very many services from a small local economy like the one that existed in Ector and Midland in the 1920's and 1930's. The oil industry has always been a capital intensive industry. Perhaps more labor was used in the oilfields in the 1930's but certainly fewer services were employed in the oilfields because it is only recently that new technologies have begun to enter into the production picture in a significant way. By far the largest expense that the oil industry makes toward production goes toward meeting property and mineral rights obligations (e.g. lease payments, royalty payments, contract bonuses, etc.). (See Table IX) Even by the 1970's when secondary and tertiary recovery technologies and other more capital intensive

TABLE IX: Commodity-by-Industry
Direct Requirements

| Commodity | Crude, Petroleum and Natural Gas Industry |
|---|---|
| Crude Petroleum and Natural Gas | .03346 |
| Maintenance and Repair Construction | .04123 |
| Primary Iron and Steel Manufacturing | .00658 |
| Construction and Mining Machinery | .00660 |
| Electrical industrial Equipment and apparatus | .00681 |
| Transportation and Warehousing | .00605 |
| Electric, Gas and Sanitary Services | .01321 |
| Finance and Insurance | .00636 |
| Real Estate and Rental | .15222 |
| Business Services | .02209 |
| Compensation of Employees | .11930 |
| Property-type Income | .47695 |

Source: The Input-Output Structure of the U.S. Economy, 1972, U.S. Department of Commerce, 1979.

production techniques were introduced, it was still estimated that approximately 48 cents on every dollar put into production went to cover property right costs. After property rights, the largest expense is incurred with real estate and rental services, fifteen cents on every dollar. Third in order is employee compensation, approximately twelve cents. This is to say that at least 75% of the petroleum industry's costs in inputs are made in areas which could not have been unique to any single county. The remaining 25% of purchases by the oil industry are divided among the many other producers in the economy. The highest oilfield-related service on the list is maintenance and repair construction which receives only four cents on every dollar. Thus for being such a small factor of production, oilfield services and all forms of service in general does not mean very much to the petroleum industry. Several other things matter much more. The two most prized factors, mineral rights and labor were clearly not cornered nor most abundant in Ector or Midland at the beginning of the boom. On the contrary, at that time they seemed to be located elsewhere in the Permian Basin. By 1930 almost all of the new oilfields were located in the northeastern and southwestern counties. As for labor, the nature of the boom is such that the demand for labor is met by an outside workforce who comes into the region. And telling simply from the relatively low number of people that already lived or seemed headed to Ector and Midland in 1920 and 1930, it seems that labor was less abundant there then in other areas of the Permian Basin.

Could there existed some special function of production in Ector or Midland which the oil industry sought out no matter if it was a tiny part of the overall cost of production? It is highly unlikely that this situation existed. For, ten years into the boom, Ector and Midland had comparatively fewer people who were engaged in oil-field activities. (See Table X) Ector had 361 oilfield workers, 6.9% of the total. Midland had 147 such workers, 2.8% of the total. On the other hand, Winkler alone had 1283 oilfield workers, which accounted for 24.6% of the total workforce; Pecos, with 785 oilfield workers, had 15% of the total; and Howard, with 698 oilfield workers, had 13.4% of the total. In fact there were six counties that had more people employed in the oilfields than Ector. If there was a pattern of technical agglomeration and specialization in the region during the first decade of the boom, the local oilfield workforce totals would have indicated that Ector and Midland played a very minor role in that pattern.

The argument from agglomeration of oilfield factors and services, rather than pointing to Odessa and Midland City, would have led the planner to look away from that part of the region. Then had the communities invested their resources in the hope that growth would occur in their vicinity because there was an abundant supply of experienced oilfield labor, some of the smallest counties today would have met a sad fate.

The Mid-Point or Hot Spots of the Oilfields

Hypothetical: A more farsighted view of the boom would have been to expect settlement during the boom to proceed in a way that would maximize everybody's access to (or alternatively, that would minimize travel time between) all the "hot spots" in the oilfields. In this way, after having

TABLE X: Persons 10 Years and over Engaged in Gainful Occupations by selected Industry Groups for Counties, 1930

| | Total Employed | Agriculture | Oil and Gas | Wholesale and Retail | RANK Total Employment | RANK Oil and Gas |
|---|---|---|---|---|---|---|
| Andrews | 212 | 140 | 26 | 17 | 20 | 15 |
| Borden | 512 | 458 | 3 | 4 | 18 | 21 |
| Crane | 895 | 30 | 491 | 81 | 15 | 4 |
| Crockett | 906 | 352 | 46 | 73 | 14 | 12 |
| Dawson | 4263 | 2693 | 10 | 340 | 3 | 18 |
| Ector | 1635 | 166 | 361 | 163 | 12 | 7 |
| Gaines | 802 | 525 | 9 | 58 | 16 | 19 |
| Glasscock | 424 | 272 | 38 | 6 | 19 | 14 |
| Howard | 8552 | 1772 | 698 | 847 | 1 | 3 |
| Loving | 91 | 12 | 45 | 5 | 21 | 13 |
| Martin | 1791 | 1216 | 15 | 94 | 10 | 17 |
| Midland | 2967 | 931 | 147 | 279 | 6 | 10 |
| Pecos | 2946 | 769 | 785 | 184 | 7 | 2 |
| Reagan | 1191 | 150 | 417 | 77 | 13 | 5 |
| Reeves | 2272 | 605 | 64 | 240 | 9 | 11 |
| Scurry | 3863 | 2175 | 25 | 267 | 4 | 16 |
| Sterling | 587 | 316 | 4 | 35 | 17 | 20 |
| Upton | 2409 | 116 | 396 | 254 | 8 | 6 |
| Ward | 1787 | 466 | 178 | 183 | 11 | 8 |
| Winkler | 3090 | 33 | 1283 | 307 | 5 | 1 |

Source: U.S. Census of Population, 1930.

started off in the oilfield or truckstops in Mitchell, then having moved to Crane, then later to Pecos and Winkler, the incoming workers eventually move to settle in Midland-Odessa. From either of these two points they could commute to the job site almost anywhere in the Permian Basin, instead of constantly relocating everytime the drilling rate dropped off. Similarly, the drilling firms, welding and tooling outfits, the trucking companies, the "roustabout" crews, etc., decided to locate their terminals in Midland City or Odessa in an effort to cut their transportation and maintenance costs. Retailers and wholesalers and the non-oilfield service sectors, upon seeing a crossroads emerging, moved to Midland-Odessa, too.

Outcome. Conceivably, while planning for a long-term, all the actors might have seen a greater benefit in starting out from scratch in the small town of Midland City or in Odessa instead of locating in, say, Fort Stockton (Pecos County) or Lamesa (Dawson County) or Colorado City (Mitchell County). All three of these towns are situated on the periphery of the Permian Basin. In 1920 and 1930 they were all bigger than Odessa and approximately the same size as Midland City, and they were located in or adjacent to one of the clusters of new oilfields. However, they all stood on the opposite end of the region from the other clusters. (See Exhibits D,E,F, Appendix). From there they were slowly cut off from the mainstream of activity in the region as a whole. Then when the number of annual well completions fell locally, employment went down, and growth was stunted. The workers and service managers who had located in these towns found they were no longer living in a "hot spot" in the oil industry. Other hot spots had developed in the other corners of the region, but because of the transportation costs and because of their relative isolation from the networks of information, the people in Fort Stockton, Snyder, and Colorado City were cut off from the new developments in the region.

A further question arises with respect to the several communities in the central counties of the region. How could anybody have anticipated which of these communities would be the most eligible from the point of view of minimizing travel time? When was it time to settle? When was it time to ride out the lull in the oilfields?

Through the 1920's thirty-seven new fields were opened up througout the Permian Basin, but it was not until 1931 that oil was struck in Ector County. (See Table XI) No oil at all was found in Midland and until the late 1940's. In Crane, immediately south of Ector, five fields were discovered by the 1930. Immediately southwest of Ector, Ward County also saw five new fields by 1930. Directly above Ward and bordering Ector, Winkler County had three new fields by 1930. Each of these counties could have been a hot spot from the point of view of the planner. In terms of oilfield activity they were at the very least as hot as Ector, and they all stood the same distance from each other--that is from each other's oilfields. (See Exhibits D,E,F, Appendix).

Nevertheless, these counties did not grow as much as Ector. Although it was connected to the same highway that runs through Odessa from Lubbock, Crane saw very little sustained growth. The same happened in Ward, which is connected to the same inter-state highway that runs through Odessa and Midland and Big Spring. Ward County had a higher population than Ector ten years before during and ten years into the boom. The number of people in Ward almost doubled from 1920 to 1930, and from 1930 to

TABLE XI: Number of New Fields Discovered, 1915-1944, by County

| | Winkler | Ward | Upton | Sterling | Scurry | Reeves | Reagan | Pecos | Mitchell | Midland | Martin | Loving | Howard | Glasscock | Gaines | Ector | Dawson | Crockett | Crane | Borden | Andrews | Total not Double Counting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1915-1924 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 1925-1934 | 4 | 7 | 4(2) | 0 | 0 | 0 | 1 | 10 | (1) | 0 | 0 | 1 | 3 | (1) | 0 | 6(3) | 0 | 1 | 7 | 0 | 4 | 47 |
| 1935-1944 | 14(1) | 8 | 0 | 0 | 1 | 1 | 1 | 16 | (1) | 0 | 0 | 1 | 6 | 1 | 8 | 3(1) | 1 | 11 | 9(1) | 0 | 10 | 91 |
| Total Double Counting | 19 | 15 | 6 | 0 | 1 | 1 | 3 | 26 | 3 | 0 | 0 | 2 | 9 | 2 | 8 | 13 | 1 | 12 | 17 | 0 | 14 | 140/153 |

(-) plus fields which straddle boundary from another county

Source: U.S. Crude Oil Data 1866-1944 (Compiled by the Petroleum Administration for War 1945, Vol. II, I) National Petroleum Council 1970.

1940. But in 1940 Ward was behind Ector by almost 5000 people--Ward having started with 2615 people and Ector with 760 people.

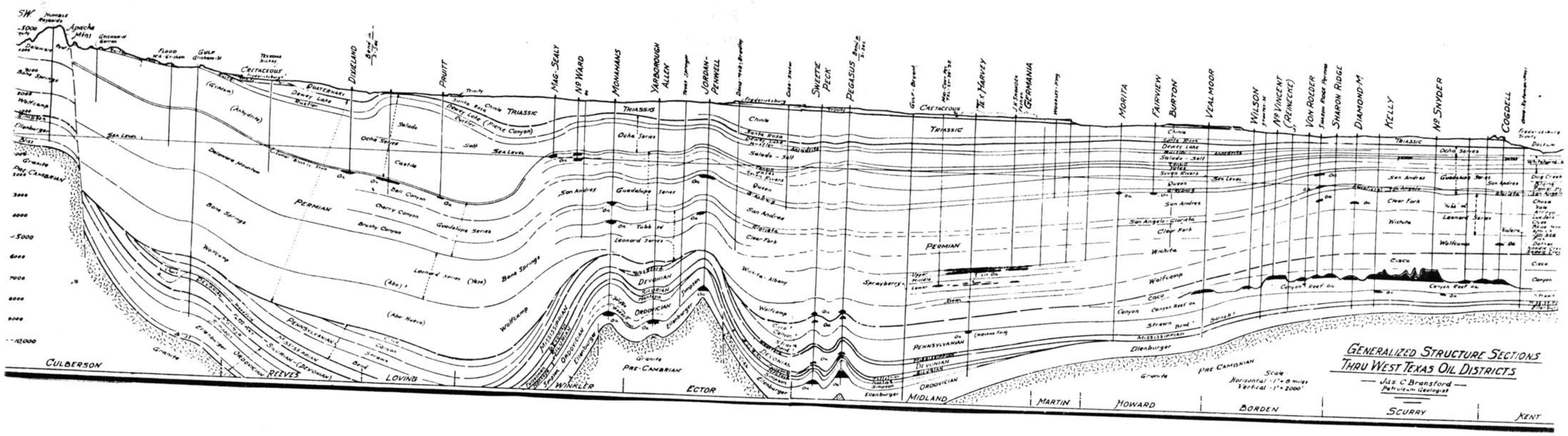
Winkler, although for a while it boomed more than any county in its vicinity, also fell rapidly behind Ector in the 1930's and 1940's. (See Table II). What is most remarkable about the case of Winkler is, however, that above Winkler in New Mexico, Lea County was also in the midst of an oil boom. Thus unlike Ector, which was bordered by an "oil-less" county, Midland, Winkler was (and still is) surrounded on all sides by big oil-producing counties. The fact aside that by 1930 alot more oil producing activities were occuring in Winkler than Ector, Winkler was always a crossroads in the oilfields. Workers and service firms based in Winkler would have had an advantageous access to all oilfield activity in that area. Nevertheless, after having boomed from 81 people in 1920 to 6784 people in 1930, Winkler's population count went on to 6141 in 1940.

From the perspective of strategic access to oilfield activity, the people moving to Ector in 1920's and early 1930's would have been an anomaly. At best their settlement decisions would have seemed temporary in scope, since most of the activity appeared to be occuring in the counties neighboring Ector. But as it turned out, this trend continued until Ector was the county with the largest population, although the comparable oil-worthness of Ector in that area never changed.

Geological Factors?

Hypothetical. Possibly what caused to a great extent the redirection of oilfield activity away from Howard and the northeastern counties toward

MAP IV: Regional Geology




SOURCE: <u>Internationa Oil & Gas Development Review</u>

Ector and the western counties was the emergence of a definite pattern of oil strikes.

Over time, more oilfields were being opened in the western counties than in the eastern counties. It turns out that Ector and Midland sit above a unique geological formation within the Permian Basin. (See Map IV) The nature of the geology underlying Ector and Midland is such that it is easier to find petroleum there than the rest of Permian Basin. This explains the greater frequency of strikes in the strip of counties between Andrews and Pecos. However, even with this insight it would have been unfair to pick Odessa over all the other communities on that strip as the community that was going to be most impacted by the oil boom.

As Robert R. Wheeler explains, oil is not where you find it, but "how you find it."[16] Beneath Ector from the floor of the Permian Basin there protrudes what is known as a structural uplift. This uplift, named the Central Basin Platform, begins approximately from the southcentral part of the region and traverses northwest across the basin into Southeastern New Mexico.[17]

The interesting thing about this formation is that it provides oil prospectors with what are still the best conditions for predicting the existence and location of oil and gas.[18] Within the geological domain of Central Basin Platform are buried a countless number of oil and gas deposits in what are known as structural traps. These structural traps look like big or small ripples (domes or anticlines) in the layered profile of the ground. This feature allows for them to be located by studying the structural character of the entire region. In the early 1900's this was done by studying the geological features of the surface and by analyzing the drilled core samples from different depths throughout the region. What is also ideal about platform formations like the Central Basin Platform is that the more it is drilled into, the more is known about the whereabouts of its petroleum deposits. A region suspected of containing pretroleum will be drilled into many times, at many different depths and in many different areas. Information accumulates for the region over time. Thus as time passes and exploration crews, wildcatters,and development drillers continue to drill into areas, more and more structural traps of all sizes are found.

There is another type of petroleum trap which forms quite differently than structural trap; namely, stratigraphic traps. Stratigraphic traps are formed when two strata (structural layers) shift and through the friction "pinch out" and localize the oil which may be saturating the area of the friction. These traps leave little or no profile or relief for oilmen to trace. They are discovered through a random and costly exploration process in which wildcats are sunk in what is really a hit or miss fashion.[19]

It follows, therefore, that stratigraphic fields are both less common and on the average larger than structural oilfields. For the smaller of these "obscure and subtle traps" are hidden even farther away, and usually only the largest stratigraphic traps are found.[20] At least nine of the largest oilfields in the Permian Basin are stratigraphic traps. The largest field there today, Kelly-Snyder (Scurry, Mitchell and Howard Counties), is contained in a stratigraphic trap.

The Central Basin Platform does not run under Howard and the northeastern or eastern counties, where the first two oil wells were struck.

# DISCLAIMER

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This is not to say that the fields there are predominately stratigraphic, nor that the oil industry has ever seen less potential in the east than elsewhere in the Permian Basin. Rather, what should be understood here is that over the long-term oil tended to be found more frequently on and around the two platforms than in the eastern part of the region. This means that although the first oil strike was made in Mitchell, and although there were sporadic strikes in Howard, Dawson, Glasscock and Scurry, more fields tended to be found in the counties resting on top of the two platforms. (See Exhibits, D,E,F, in Appendix), In fact, the top five counties with the most oil fields by 1944 were, in order, Pecos, Winkler, Ward, Crane and Ector. And all of these counties rest on top of the Central Basin Platform. (See Table XI)

Outcome. Could this information have helped point out the new growth centers? Or, could it have signalled that Big Spring or the communities in the vicinity of Midland City and Odessa would not experience sustained rapid growth? No.

The Central Basin Platform underlies at least seven counties. The planner studying the situation to find which of them would be impacted would have had to turn back to the other hypotheses for projecting the boom. Seven counties still encompass enough space and demography to make the matter of prediction as uncertain as prediction without geological factors. With what was known about the region's geological features, the planner still would have been deciding between Wink, Crane and Monahans--not necessarily Odessa. Moreover, at the beginning of the boom, the Central Basin Platform only had as much oil as was known about up until that time. The fields that were found there in the 1940's may have been easier to find or larger in size than the fields in the eastern counties. (See Table XII) But in the 1920's and 1930's when the first exploration crews sunk their bits into the region, the deposits of the Central Basin Platform could not have been too much easier to locate than those of the eastern counties. It was only after operations had been taking palce for many years that a patern began to emerge. The ultimate question in an oil boom can only now be answered with the benefit of hindsight: since the fact of the formation does not guarantee the existance of oil, is there or is there not oil under the ground where the well is being drilled--is Big Spring the best place to settle?

TABLE XII: Ultimate Maximum Yielded Indicated, Aggregated by County, 1944

| | (1000's Barrels) | | |
|---|---|---|---|
| | 15-24 | 25-34 | 34-44 |
| Andrews | 0 | 75540 | 199100 |
| Borden | 0 | 0 | 0 |
| Crane | 0 | 583635 | 37355 |
| Crockett | 0 | 14400 | 26071 |
| Dawson | 0 | 0 | 100 |
| Ector | 0 | 512213 | 116083 |
| Gaines | 0 | 0 | 706991 |
| Glasscock | 0 | 0 | 3780 |
| Howard | 0 | 206500 | 5840 |
| Loving | 0 | 18780 | 1120 |
| Martin | 0 | 0 | 0 |
| Midland | 0 | 0 | 0 |
| Mitchell | 1600 | 0 | 0 |
| Pecos | 0 | 1504233 | 56820 |
| Reagan | 119029 | 1000 | 64000 |
| Reeves | 0 | 0 | 4 |
| Scurry | 0 | 0 | 11000 |
| Sterling | 0 | 0 | 0 |
| Upton | 99052 | 0 | 0 |
| Ward | 0 | 189787 | 28248 |
| Winkler | 0 | 285710 | 437601 |

Source: U.S. Crude Oil Data 1866-1944 (Compiled by the Petroleum Administration for War 1945, Vol. II,I) National Petroleum Council, 1970.

# CONCLUSION

## Summary

The local impacts of a regional oil boom cannot be projected with labor and local consumer markets as the only independent variables. Petroleum development can be a highly mobile and random process, and the center or concentration of activities in the region will tend to shift from one cluster of oilfields to another. As wildcatters, pipeliners and roustabouts move from one completed field to a newly discovered field, so too the epicenter of the boom will move from one area to another as job locations are moved and the suppliers of consumer goods and services shift in pursuit of a better crossroads for economic activity.

In the Permian Basin at the beginning of the boom the most impact was felt among the established communities who stood closest to the new fields. Since the first strikes were made in the eastern counties of the region, Colorado City and Snyder experienced a lot of growth. Big Spring boomed the most since it was the regional trade center before the discovery of oil in the region. Later, oil was found in the western counties, and the impacts of the boom started landing on the communities of those counties as well. But as time went on, oilfields were discovered in the western counties and more frequently than in the east. With this the eastern towns saw no more rapid growth, and in the west growth narrowed down to only a few communities. Some communities there waned, while other increased tremendously in population.

True to the nature of the act itself, when new fields were first being opened in the counties of the Central Basin Platform there was no indication that Odessa would grow as much as it did, nor that communities like Pyote or Wink or McKamey would lose population. Nevertheless, as the regional boom matured, Midland-Odessa became the growth center and replaced Big Spring as the regional trade center. In fact, the entire regional distribution of population before the boom was reorganized, no matter the convenience of the old settlement scheme and no matter that it all had to be started from scratch.

So What?

Although the four hypothese tested in this paper do not jibe with what is now known about the region, it cannot really be said that the outcome of a regional oil boom is definitly unpredictable. As the Law of Undecideability agrues, given an unresolved problem, one is unable to decide if the difficulty lies in one's lack of training or investment of time in the problem, or if the problem by nature is unsolvable. The case can always be made that with more time or the benefit of some future enlightenment in the sciences, planners will someday be able to accurately predict the outcome of an oil boom. No doubt, future research will yield interesting and useful insights into the matter. In the mean time, however, it should suffice the planner to know that predicting local growth in an oil boom is a very, very risky proposition. Understanding this, the task of planning in an oil boom becomes more an exercise in managing and strategizing in the midst of uncertainty, than an exercise in putting form on all the random variables contributing to the boom. Instead of charting the river, the planner should develop ways for staying afloat in the rapids if and when they come.

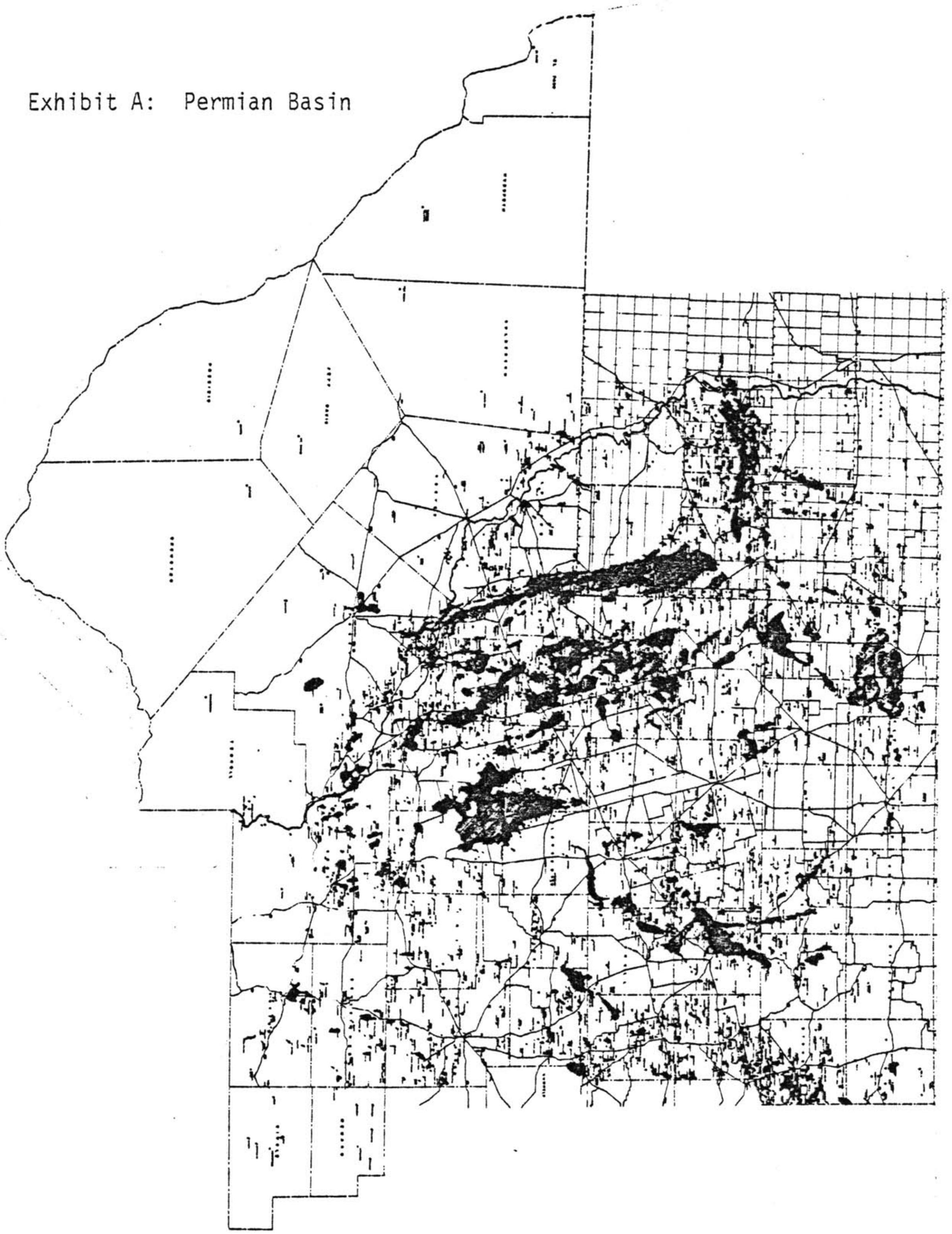
The costs and benfits of a boom do not have to be taken as given. It may be preferable to follow the traditional Community's perference in-spite of or until the boom is guaranteed. For the town stands to be impacted if and only if business activities intensify in the vincinity and the incoming workforce decides to locate precisely in one's town. And it may happen that neither of these determining factors materializes.

Then if the oil boom does come and catches the community unprepared, it may still be preferable to bear the immediate impacts and keep the doors closed to the most transcient elements of the incoming population through discriminating tax codes and regulations and by not increasing the stock of public capital very much beyond what was projected before the boom. In this way, an early test is made of the local boom--whether or not it will remain there--and the temporary epicenter of the boom is deferred to a neighboring town. As a result, the local community avoids long-term disruption while still avialing itself the benefits of the job opportunities and business brought in by the boom.

In West Texas, Monahans serves as the case in point. Although it was surrounded by oil strikes at a very early date, it has managed to grow at a manageable rate. Nonetheless, its people have found well-paying jobs in the surrounding oilfields. And with Odessa booming only thirty-five miles away, the community has access to the conveniences of having the regional market center even though they never made any major accomodations for growth and change.

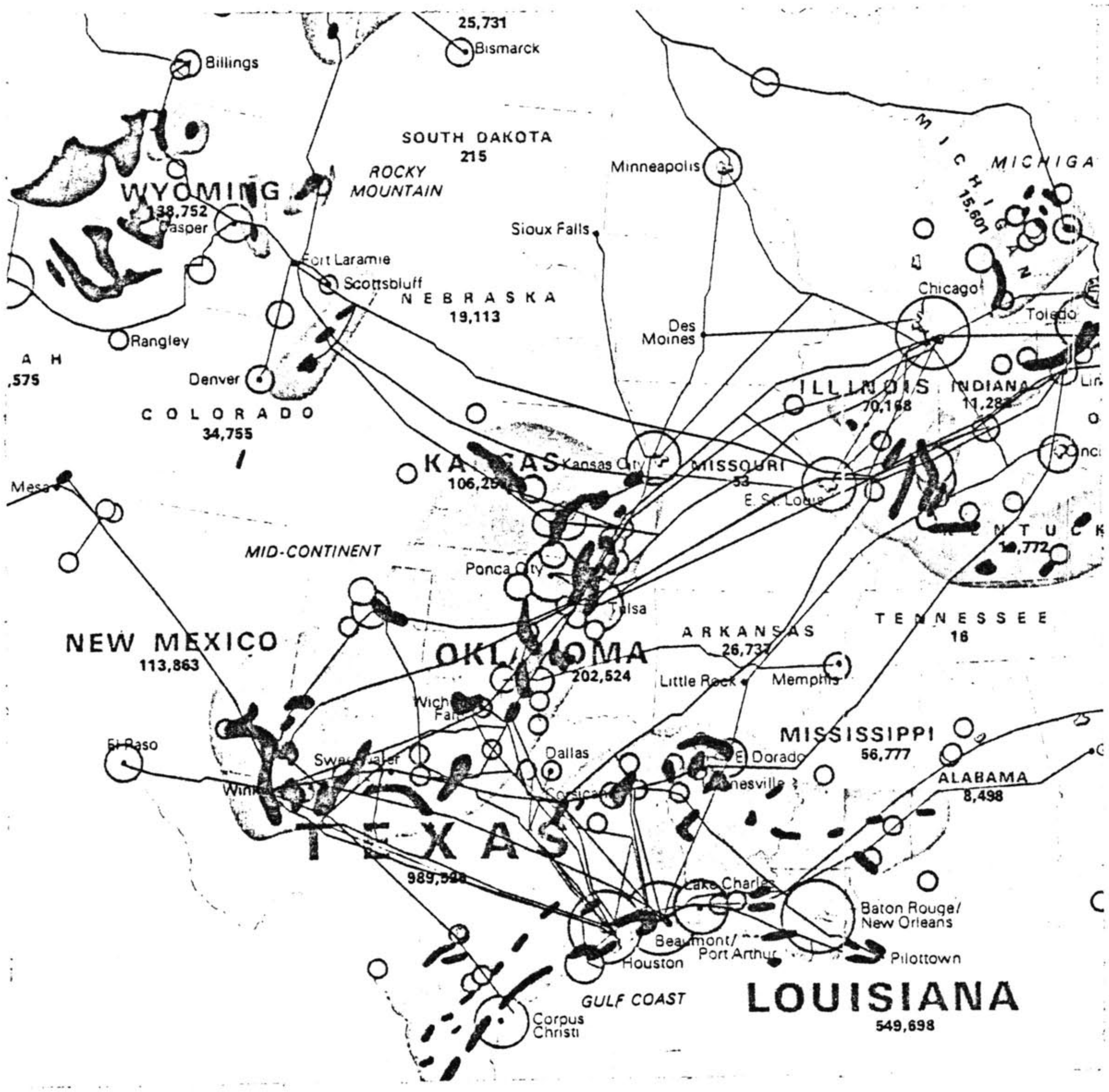
# APPENDIX

Exhibit A: Permian Basin



Source: International Oil and 1959 Gas Development Review, 1959.

Exhibit B: Oil Pipeline and Production Areas

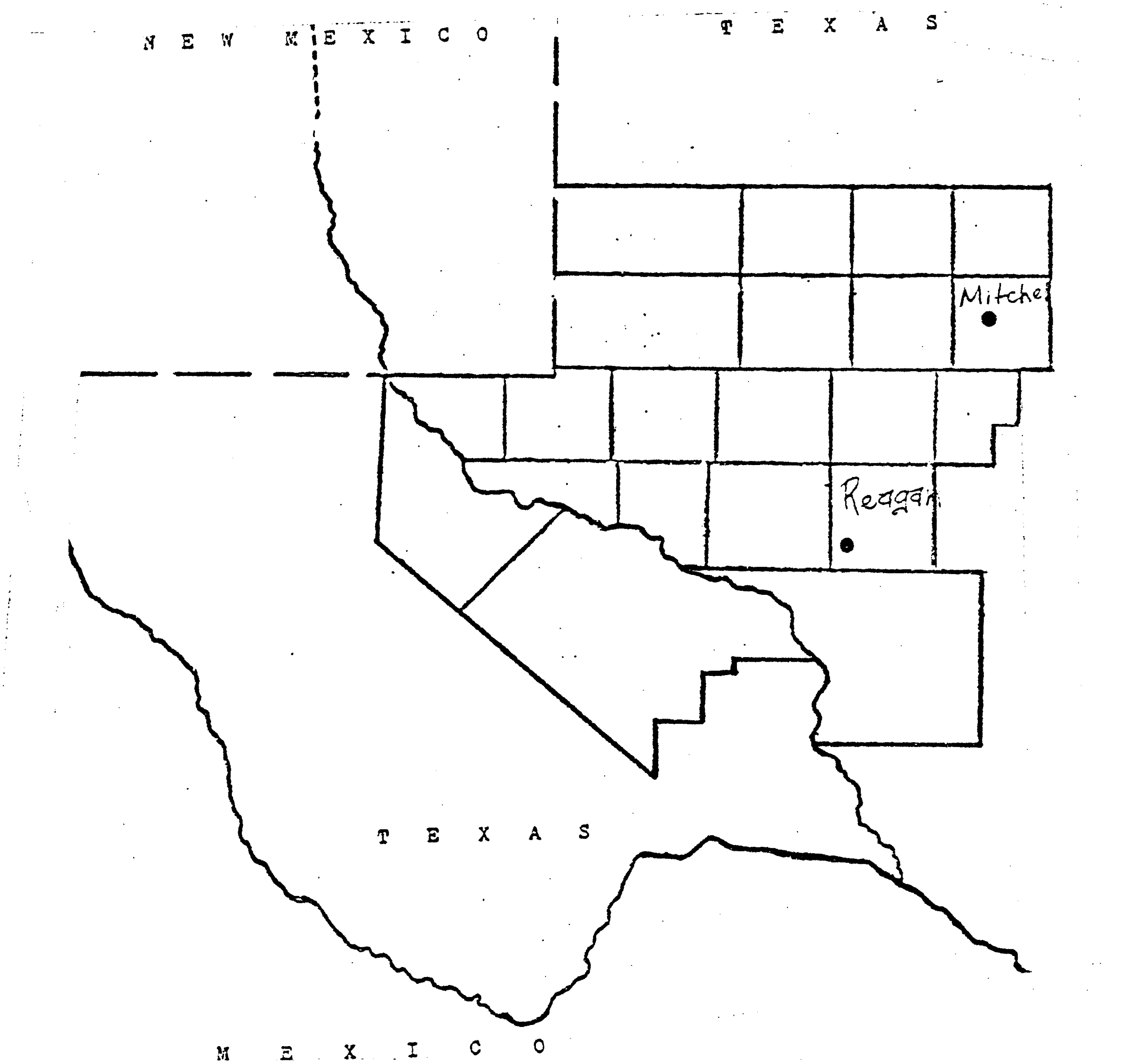



Source: <u>Oxford Regional Economic Atlas of United States and Canada</u>, Oxford: Clarendon Press, 1962

Exhibit C: Natural Gas Pipeline

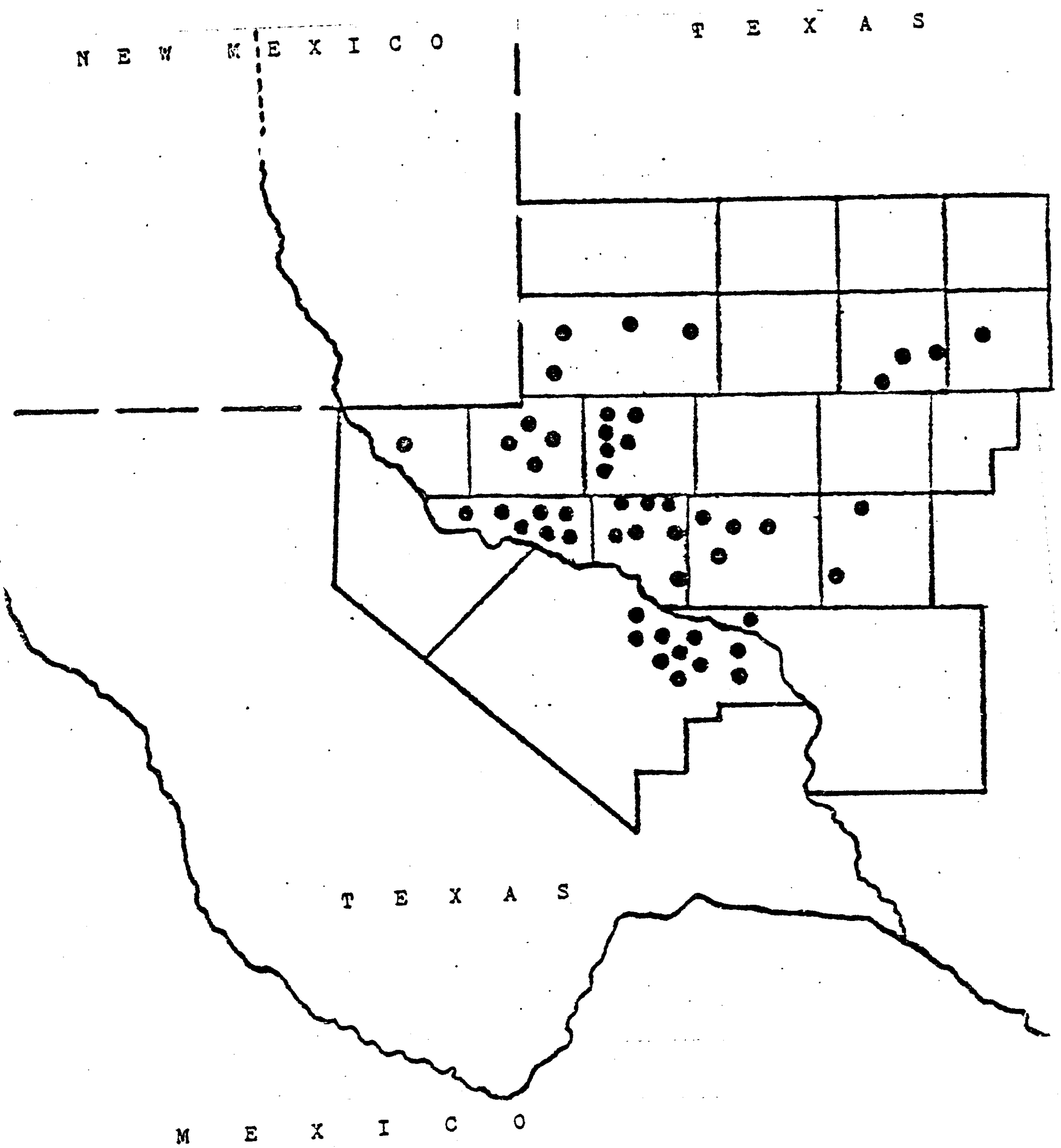

Source: <u>Oxford Regional Economic Atlas of United States and Canada</u>, Oxford: Clarendon Press, 1962

Exhibit D: Cumulative Distribution of New Fields, 1915-1924



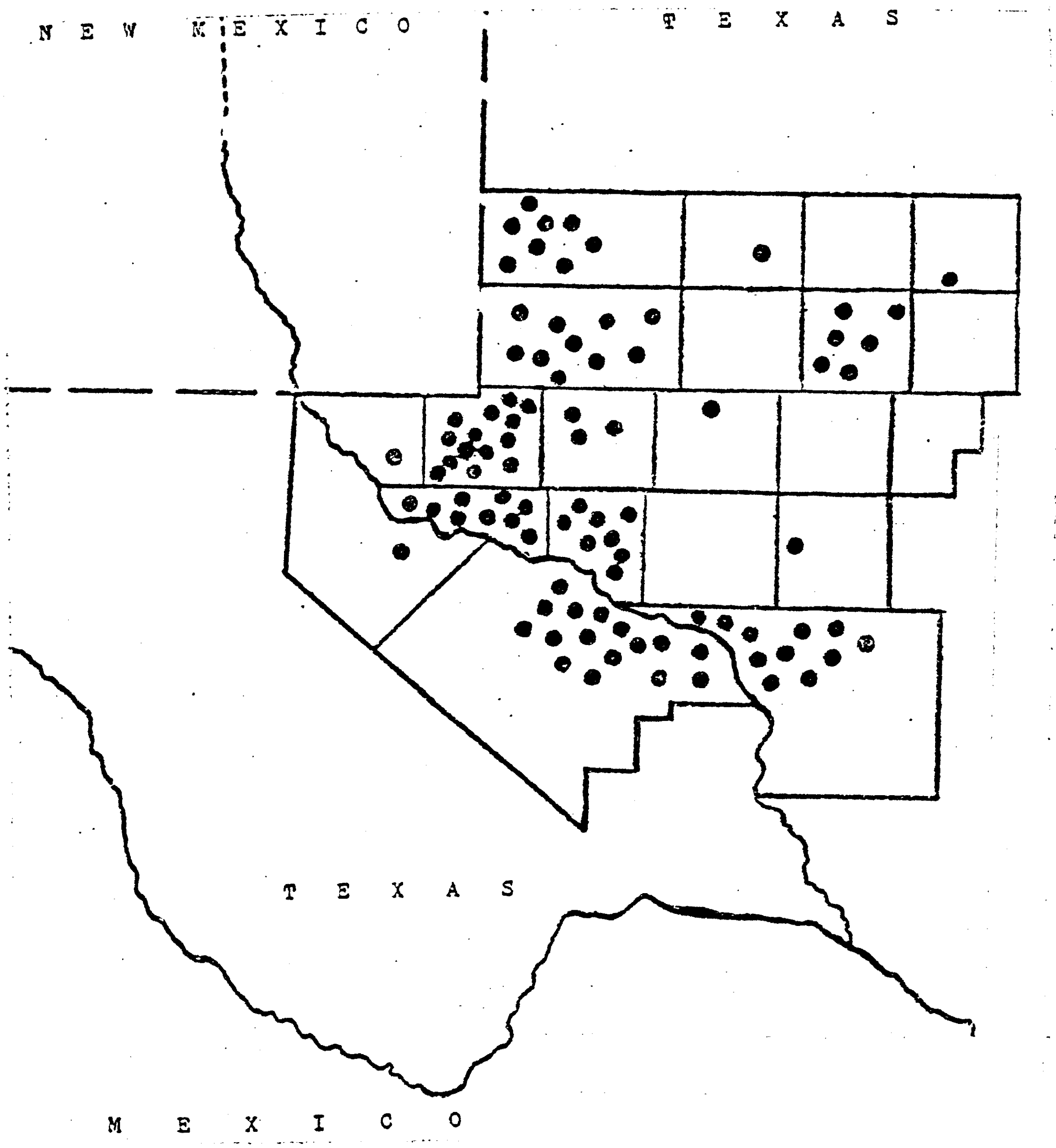

Source: U.S. Crude Oil Date, 1860-1945

Exhibit E: Cumulative Distribution of New Fields 1915-1934




Source: U.S. Crude Oil Date, 1860-1945

Exhibit F: Cumulative Distribution of New Fields
1935-1944




Source: U.S. Crude Oil Data, 1860-1945

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