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Nine-Year Performance of a Central Oklahoma Planting of Ponderosa Pine Provenances



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Nine-Year Performance of A Central Oklahoma Planting of Ponderosa Pine Provenances¹

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Ponderosa pine (*Pinus ponderosa* Laws.) has not been widely used as a conifer component in shelterbelt and urban plantings in Oklahoma. Reasons given for not using ponderosa pine were shade intolerance, low survival, and particularly, slow early growth (Afanasiev, 1948, 1949). These experiences may reflect use of seed sources not well adapted to the Great Plains region of Oklahoma. Ponderosa pine does have an extensive natural range and possesses substantial genetic variability (Squillace and Silen, 1962). Considering this adaptation to a wide variety of sites, and its successful use in Kansas, Nebraska and the Dakotas, selection of the proper seed sources may provide trees suitable for Oklahoma conditions.

To identify those provenances of ponderosa pine which are best suited to the relatively harsh environments of central and western Oklahoma, a 40 origin seed source test of the species was established in central Oklahoma at the Norman State Nursery (see location, Figure 1) in 1968. Survival and height for the first nine years after planting, and tip moth damage of this provenance test are reported below.

Materials and Methods

The planting was established using seedlings derived from 40 of the 80 seed source collections assembled by the Rocky Mountain Forest and Range Experiment Station, U.S.D.A. The origins of these seed source collections are shown in Figure 1. Each seed collection contained the bulked seed of from 10 to 20 dominant or codominant trees at a specific location. Collections were

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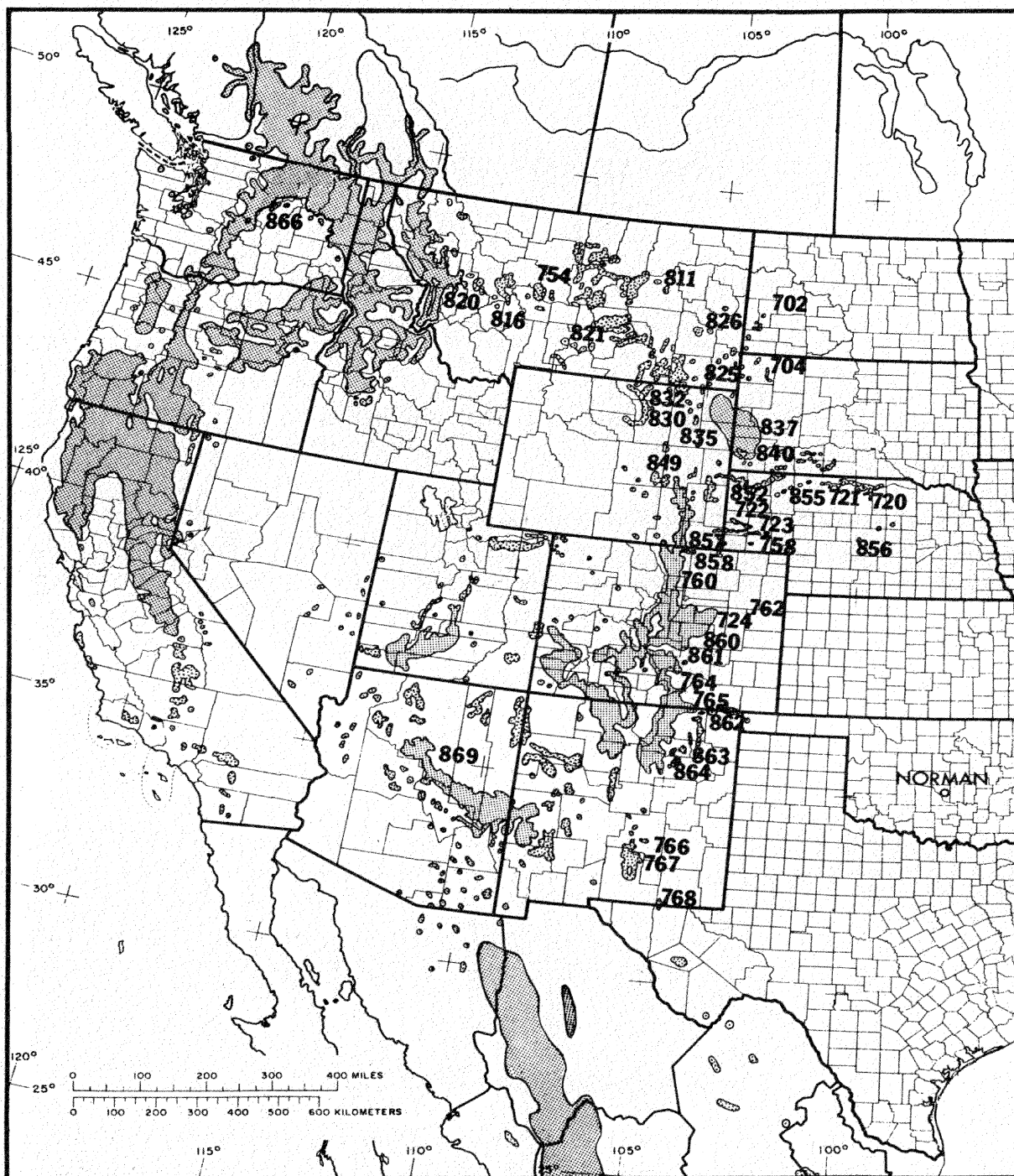


Figure 1. The range of ponderosa pine (by Little, 1971), showing collection locations for the central Oklahoma planting near Norman, Oklahoma.

concentrated in the eastern part of the species range, covering the range of the interior variety of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) from the high plains west to the foothills of the Rocky Mountains. Two far western sources (var. *ponderosa*) were included.

The central Oklahoma planting was established with 2-1 seedlings received from the U.S. Forest Service Bessey Nursery in Halsey, Nebraska. The plantation contains 15 replicates in a randomized, complete block design. Each replicate contains a 4-tree row plot of each source. Trees were planted at 12 × 12 foot spacing with one border row. First year mortality was replaced with 2-1-1 stock in early 1969.

Prior to planting, the grassland site was plowed and harrowed. The planting was cultivated annually to reduce weed competition until 1973 when the trees were tall enough to remain above competing vegetation.

Tree height and survival data were collected three, five and nine years after planting. At these times the presence of damaging agents was also noted. Pine tip moth (*Rhyacionia* sp.) activity in the plantation had caused considerable damage by age five, and a damage summary is included in the following discussion for the five and nine year data.

Results and Discussion

Percent survival, tree height and percent tip moth damage data for the three measurement years are summarized in Table 1. The table also includes seed origin data, and the seed sources have been grouped by geographic ecotype³. Percent survival is based on the total number of trees planted, including replacements. Percent tip moth damage was determined by recording those trees with obvious infestation as damaged. As there was little change in source rankings by growth and survival from three to nine years, most of the following discussion will concern itself with the nine year data.

Overall plantation survival was 62 percent, which is relatively high compared to some of the other NC-99 Great Plains plantings of these ponderosa pine provenances. Most of the mortality occurred during the first summer after planting (26 percent), and only 17 percent of the trees have been lost since replacement.

Analysis of variance of the nine year survival data indicated that differences among seed sources and geographic ecotypes were significant (.05). Duncan's multiple range test was used to delineate differences among sources. This test showed that the best eight sources (81-91 percent survival) were significantly better than the plantation average, but that there was no difference among those eight.

For planting in Oklahoma on the basis of nine year survival data, it would seem best to avoid all sources west of the Continental Divide, the Central

³This is a tentative grouping based on cluster analysis of 3 year data by R. A. Read (personal communication, 1977).

Table 1: Origin, height, survival and tip moth damage of Ponderosa pine in central Oklahoma for the first nine years of plantation growth.

| Ecotype and Origin Number | Source Data | | | Survival (%) | | | Height (% of Plantation Mean) | | | Tip Moth Damage (%) | | 9 Year Ecotype Means (%) | |
|---------------------------|-------------|--------------|-------------|--------------|------|------|-------------------------------|------|------|---------------------|------|--------------------------|--------|
| | °N Latitude | °W Longitude | m Elevation | 3 yr | 5 yr | 9 yr | 3 yr | 5 yr | 9 yr | 5 yr | 9 yr | Survival | Height |
| <u>Far West</u> | | | | | | | | | | | | | |
| 866 | 48.3 | 111.9 | 488 | 63 | 59 | 57 | 97 | 91 | 93 | 20 | 2 | | |
| 820 | 46.2 | 114.0 | 1372 | 35 | 34 | 34 | 76 | 92 | 101 | 5 | 0 | 46 | 96 |
| <u>Transition</u> | | | | | | | | | | | | | |
| 816 | 46.6 | 111.8 | 1372 | 81 | 79 | 76 | 100 | 92 | 96 | 17 | 0 | | |
| 754 | 47.1 | 110.8 | 1372 | 72 | 71 | 71 | 93 | 90 | 96 | 2 | 0 | 74 | 96 |
| <u>Central Montana</u> | | | | | | | | | | | | | |
| 821 | 45.8 | 109.0 | 1158 | 91 | 91 | 91 | 104 | 106 | 103 | 15 | 0 | 91 | 103 |
| <u>Central Rockies</u> | | | | | | | | | | | | | |
| 830 | 44.6 | 107.1 | 2134 | 51 | 50 | 50 | 60 | 68 | 76 | 2 | 2 | | |
| 849 | 42.8 | 105.0 | 1584 | 60 | 60 | 56 | 88 | 85 | 88 | 7 | 7 | | |
| 857 | 41.2 | 105.3 | 2347 | 76 | 75 | 73 | 78 | 77 | 77 | 3 | 2 | | |
| 760 | 40.2 | 105.5 | 2560 | 52 | 50 | 49 | 65 | 67 | 69 | 5 | 0 | | |
| 764 | 37.9 | 105.2 | 2682 | 69 | 66 | 67 | 100 | 94 | 89 | 7 | 4 | 58 | 80 |
| <u>Southern Rockies</u> | | | | | | | | | | | | | |
| 765 | 37.3 | 104.7 | 2134 | 69 | 68 | 65 | 107 | 110 | 99 | 33 | 12 | | |
| 862 | 36.9 | 104.3 | 2240 | 63 | 60 | 59 | 90 | 89 | 83 | 28 | 14 | | |
| 863 | 35.8 | 105.0 | 1951 | 66 | 64 | 61 | 107 | 108 | 106 | 40 | 8 | | |
| 864 | 35.5 | 105.3 | 1951 | 72 | 67 | 68 | 110 | 109 | 106 | 33 | 6 | | |
| 766 | 33.3 | 105.6 | 2225 | 62 | 58 | 54 | 107 | 94 | 94 | 60 | 7 | | |
| 767 | 33.0 | 105.4 | 1951 | 54 | 51 | 48 | 111 | 106 | 109 | 37 | 14 | | |
| 768 | 32.2 | 104.8 | 1768 | 68 | 68 | 69 | 139 | 143 | 132 | 45 | 4 | | |
| 869 | 35.2 | 111.8 | 2134 | 42 | 42 | 42 | 121 | 111 | 94 | 30 | 29 | 57 | 104 |

Table 1. (cont.)

| Ecotype and Origin Number | Source Data | | | Survival (%) | | | Height (% of Plantation Mean) | | | Tip Moth Damage (%) | | 9 Year Ecotype Means (%) | | |
|---|-------------|--------------|-------------|--------------|------|------|-------------------------------|------|-------|---------------------|------|--------------------------|--------|--|
| | °N Latitude | °W Longitude | m Elevation | 3 yr | 5 yr | 9 yr | 3 yr | 5 yr | 9 yr | 5 yr | 9 yr | Survival | Height | |
| <u>Black Hills & Northern High Plains</u> | | | | | | | | | | | | | | |
| 811 | 47.6 | 106.9 | 884 | 89 | 88 | 88 | 112 | 113 | 111 | 7 | 0 | | | |
| 722 | 42.7 | 103.1 | 1311 | 82 | 88 | 88 | 112 | 106 | 108 | 10 | 2 | | | |
| 852 | 42.5 | 102.5 | 1158 | 61 | 58 | 58 | 96 | 91 | 96 | 17 | 4 | | | |
| 826 | 47.0 | 104.7 | 838 | 73 | 72 | 69 | 97 | 95 | 91 | 13 | 4 | | | |
| 702 | 46.9 | 103.5 | 762 | 72 | 68 | 68 | 98 | 95 | 89 | 15 | 8 | | | |
| 825 | 45.7 | 106.0 | 1097 | 85 | 85 | 85 | 132 | 130 | 116 | 10 | 0 | | | |
| 704 | 45.6 | 103.2 | 1052 | 76 | 76 | 75 | 105 | 102 | 101 | 12 | 2 | | | |
| 832 | 44.9 | 105.6 | 1189 | 77 | 85 | 83 | 103 | 92 | 87 | 15 | 9 | | | |
| 835 | 43.9 | 104.2 | 1548 | 72 | 69 | 65 | 91 | 85 | 85 | 17 | 4 | | | |
| 837 | 44.3 | 103.8 | 1920 | 88 | 88 | 85 | 112 | 106 | 95 | 10 | 4 | | | |
| 840 | 43.7 | 103.4 | 1280 | 57 | 57 | 53 | 94 | 90 | 90 | 27 | 6 | | | |
| 723 | 41.8 | 103.8 | 1402 | 58 | 54 | 55 | 91 | 94 | 95 | 10 | 2 | 72 | 98 | |
| <u>Low Elevation East Plains</u> | | | | | | | | | | | | | | |
| 855 | 42.8 | 101.7 | 975 | 52 | 48 | 48 | 107 | 129 | 129 | 0 | 0 | | | |
| 721 | 42.9 | 100.6 | 823 | 65 | 62 | 65 | 121 | 140 | 144 | 0 | 0 | | | |
| 720 | 42.7 | 99.8 | 701 | 91 | 91 | 89 | 136 | 159 | 158 | 0 | 0 | | | |
| 856 | 41.4 | 100.0 | 884 | 50 | 49 | 49 | 108 | 124 | 138 | 2 | 0 | 61 | 144 | |
| <u>Colorado & Foothills</u> | | | | | | | | | | | | | | |
| 758 | 41.2 | 103.2 | 1372 | 54 | 53 | 51 | 96 | 92 | 97 | 18 | 2 | | | |
| 858 | 40.5 | 105.1 | 1615 | -- | 55 | 50 | -- | 68 | 73 | 17 | 0 | | | |
| 762 | 39.4 | 103.8 | 1798 | 51 | 51 | 49 | 85 | 84 | 83 | 17 | 2 | | | |
| 724 | 39.1 | 104.6 | 2256 | 59 | 53 | 50 | 84 | 91 | 87 | 18 | 2 | | | |
| 860 | 38.6 | 104.9 | 1981 | 62 | 57 | 57 | 90 | 91 | 96 | 7 | 2 | | | |
| 861 | 37.9 | 104.9 | 2012 | 84 | 82 | 81 | 97 | 89 | 90 | 27 | 7 | 56 | 89 | |
| Plantation Means | | | | 64 | 64 | 62 | 1.53 | 2.59 | 6.22 | ft. | 16 | 4 | | |
| | | | | | | | 46.6 | 79.0 | 189.6 | cm. | | | | |

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Rockies sources, and most sources south of Wyoming. Provenances from the Black Hills and northern high plains, central Montana, and transition ecotypes survived the best in central Oklahoma. In addition source 720 from the low elevation east plains ecotype and source 861 from southern Colorado showed exceptionally high survival rates.

There were significant (0.5) differences in nine year growth rates among provenances and among ecotypes. As with survival, the fastest growing sources were from east of the Continental Divide in Montana, Wyoming and Nebraska. In addition the Carlsbad, New Mexico source (768) grew fairly fast, and can be recommended for use in Oklahoma. The low elevation east plains ecotype had the best average growth rate, but due to low survival of some sources only sources 720 and 721 of that ecotype appear suitable for planting in Oklahoma.

On the basis of both survival and growth rate, the best areas from which to collect seed for planting in Oklahoma appear to be the central Montana and northern high plains ecotypes, and northeastern sources of the low elevation east plains ecotype. These sources have shown promising performance in the Black Hills (Van Deusen, 1974), Kansas (Deneke and Read, 1975) and Minnesota (Tauer, et al., 1974), as well as Oklahoma. Such apparent general adaptability suggests that collections from these locations should perform well in most of the prairie regions of Oklahoma.

Duncan's multiple range test was applied to delineate differences among individual sources for nine year height. Results for the ten fastest growing sources are shown below.

| | | | | | | | | | | |
|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Source Number | 720 | 721 | 856 | 768 | 855 | 825 | 811 | 767 | 722 | 863 |
| Percent Survival | 89 | 65 | 49 | 69 | 48 | 85 | 88 | 48 | 88 | 61 |
| Average Ht. (ft.) | 9.8 | 8.9 | 8.6 | 8.2 | 8.0 | 7.2 | 6.9 | 6.7 | 6.7 | 6.6 |
| Range Test for Ht. ⁴ | | | | | | | | | | |

Source number 720, from the extreme eastern edge of the range of ponderosa pine in northern Nebraska, is significantly faster growing than all other sources. It also showed high survival (89 percent), and therefore appears to be the best individual seed source for use in central Oklahoma, based on nine year data. Its performance in Oklahoma, coupled with the fact that it also looks promising in tests in the Black Hills (Van Deusen, 1974), Kansas (Deneke and Read, 1975) and Minnesota (Tauer, et al., 1974), suggests that source 720 possesses wide adaptability, and can probably be used successfully throughout much of Oklahoma. Source 721 seems to possess the same wide adaptability as 720, but showed lower survival in Oklahoma. Other individual

⁴Duncan's Multiple Range Test: Means within the same bracket do not differ at the .05 probability level.

sources of scattered origin which can be recommended for planting in Oklahoma are 722 from Nebraska and 768 from extreme southern New Mexico.

Visual examination of tip moth damage data shows the low elevation east plains ecotype virtually unaffected by tip moth. Southern Rockies sources suffered the most damage. While the fastest growing sources (720 and 721) suffered no damage from tip moth activity, there is little apparent relation between seed source growth rate and tip moth activity ($r = .20$). This is also suggested by the fact that the Southern Rockies sources, while suffering the most damage, still grew faster than the plantation average. The data does suggest, however, a relation between seed source origin and tip moth activity.

To examine relationships between seed source origin and performance, simple correlations of seed source growth, survival and tip moth damage with latitude, longitude and elevation of origin were computed (Table 2). Sources 866 and 820, which belong to the distinct and separate variety *ponderosa* were excluded from these correlations.

The correlations of seed origin data with height and survival suggest a general relationship between seed origin and performance. The greatest survival is obtained from sources of northern, low elevation origin, and the best growth is demonstrated by northeastern origins of low elevation. At nine years of age, seed origin elevation accounted for 30 percent of the variation in growth rate, and latitude accounted for 20 percent of the variation observed in survival. Height was also negatively correlated with longitude and survival with elevation, but not as strongly. Similar correlations have been reported by others for ponderosa pine (Mirov, et al., 1952, Squillace and Silen, 1962). These correlations probably reflect climatic differences between seed source origins, as discussed by Squillace and Silen (1962).

The correlations of seed origin data with tip moth damage suggests that northern sources from low elevations suffer less damage than other sources. At plantation age five, when tip moth activity was highest, latitude of origin accounted for 50 percent of the observed variation in damage. In view of the similar relation observed between growth and seed origin, and tip moth damage and seed origin, it should be possible to obtain sources well suited to

Table 2. Simple Correlations of Ponderosa Pine Seed Source Origin Data With 9-Year Growth, Survival and Tip Moth Damage in a Central Oklahoma Plantation

| Seed Source | Height | | | Survival (%) | | | % Tip Moth | |
|-------------|--------|--------|--------|--------------|--------|--------|------------|--------|
| | 3 yr. | 5 yr. | 9 yr. | 3 yr. | 5 yr. | 9 yr. | 5 yr. | 9 yr. |
| Latitude | -.155 | -.003 | -.027 | .424* | .447* | .448* | -.706* | -.499* |
| Longitude | -.136 | -.298 | -.426* | .077 | .082 | .073 | .189 | .295 |
| Elevation | -.358* | -.378* | -.552* | -.311* | -.334* | -.352* | .377* | .359* |

*Significant at .05 probability level or lower.

the central Oklahoma environment with minimal susceptibility to tip moth damage. These relationships may, of course, reflect to some degree the impaired growth of those sources heavily infested.

Summary

Acceptable survival percentages and growth rates of ponderosa pine in shelterbelt and urban plantings in Oklahoma should be obtainable if seed is collected from native stands in Montana east of the Continental Divide. The best performance should be from seed collected from the extreme edge of the range of the species in north central Nebraska, near the origin of provenance 720. Other promising sources include 721 in Nebraska and 768 in extreme southern New Mexico. Use of sources of northern origin and low elevation should also minimize the possibility of serious tip moth damage.

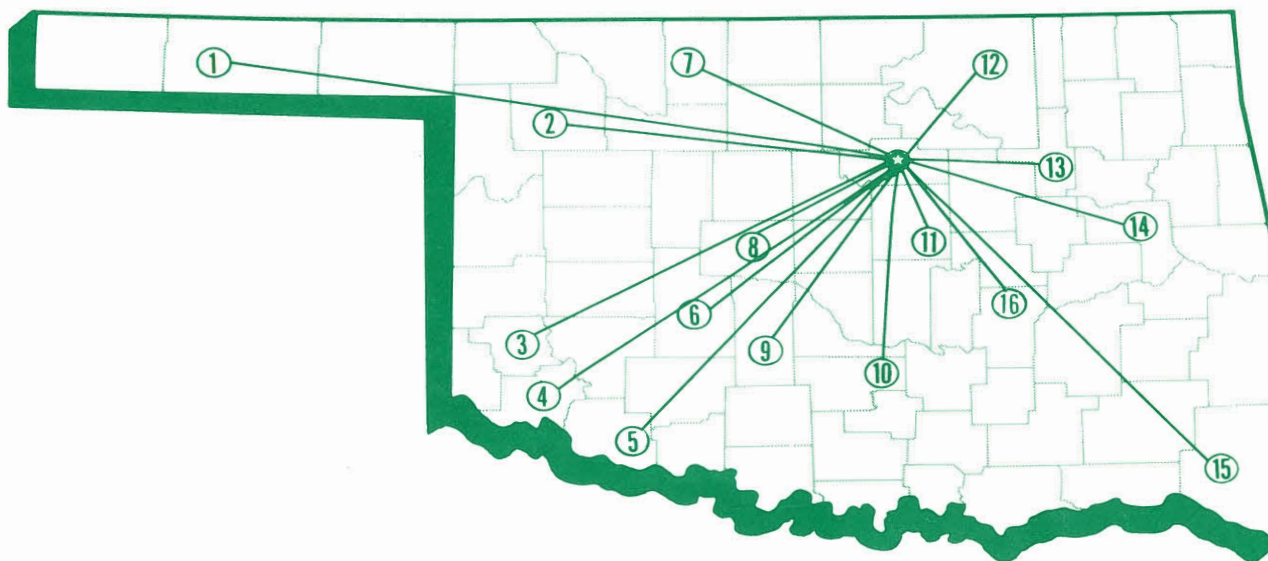
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