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COOPERATIVE EXTENSION SERVICE—GREAT PLAINS STATES

GREAT PLAINS
BEEF CATTLE FEEDING HANDBOOK

GPE-5100

Consider Prevailing Winds in Feedlot Site Selection

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Confined feeding of cattle in feedlots inevitably leads to odor production. Although certain steps can be taken in feedlot design and management to reduce odor levels, these measures may not be completely or continually effective.

Consequently, the most important element of a feedlot odor abatement program consists of judicious site selection, this involves a study of local climatic factors to minimize the probability of odor drift into nearby population centers. Beyond this, other abatement measures can be adopted as necessary to complement the odor control program.

This publication illustrates the use of published data on wind direction in comparing alternative locations for confined feeding facilities.

Wind Direction Frequency

In most cases, feedlots should be located away from population centers and nearest neighbors in the direction of least probability of wind occurrence. This criterion may not apply where irregular terrain or thermal convections patterns create unusual air currents. The least probable wind direction can be determined from climatic data available from the National Climatic Center, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, (Asheville, North Carolina 28801). For each major weather station, a separate publication "Summary of Hourly Observations: Decennial Census of United States Climate" has been prepared. This contains 5 and 10-year weather summaries that can be used to determine the following information:

(a) Probability of wind from a given direction ("wind direction frequency")—monthly and annual averages

(b) Wind speed from each direction—monthly and annual averages

(c) Occurrence of winds of specific direction and velocity

Wind direction frequencies also can be determined from "wind rose" diagrams (Figure 1) for representative cities in the Great Plains. The probability of wind from a given direction is proportional to the corresponding length of the "spike" on the wind rose diagram. The numbers in the center of the wind rose are the percent of time calm conditions prevail.

Directional probabilities vary widely with season. The most critical period insofar as minimizing odor transport to downwind receptors is May through September when temperature and rainfall are highest in most parts of the Great Plains (Figure 2). For this period, the July wind rose diagram (Figure 1) can be helpful in feedlot site selection. It reveals for example that Southeast through Southwest wind directions are most prevalent in the Southern Great Plains during summer, while other wind directions are less likely. Therefore prospective livestock feeders can usually take advantage of low summer wind direction frequencies (e.g. 2 percent or less) in selecting a feedlot site. Data for all months should be examined, however, before making the final site determination.

Wind Velocity

Average monthly and annual wind speeds, reported for each wind direction, should be considered during feedlot site selection along with wind direction frequency. Odor concentrations downwind from a confined feeding facility vary in inverse proportion to wind speed. For instance, when the wind speed doubles, the odorant concentrations will be halved,

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since the spacing between molecules in the air stream becomes twice as great. However, odor *intensities* as detected by humans are much less responsive to wind speeds than are odorant *concentrations*. In fact, odor intensity is proportional to the logarithm of odorant concentration.

Nevertheless, climatic conditions in the Great Plains are favorable for the dispersion of odors. This region experiences greater wind speeds throughout the "turbulent mixing layer" (altitudes of 0-6000 feet) than other parts of the United States. Meteorological potentials for air pollution are very low, annual forecast days of high pollution potential from air stagnation total almost zero throughout most of the region. Temporary thermal inversions, which can serve as a "lid" in confining odors to near the ground surface, sometimes present a problem, but inversions of this type usually dissipate by late morning.

Both surface wind speed and mixing layer height vary tremendously with time of day, being greatest in the early afternoon and least at night. Thus, the worst conditions for concentrated odor drift usually exist from early evening through early morning hours when most people are enjoying home life.

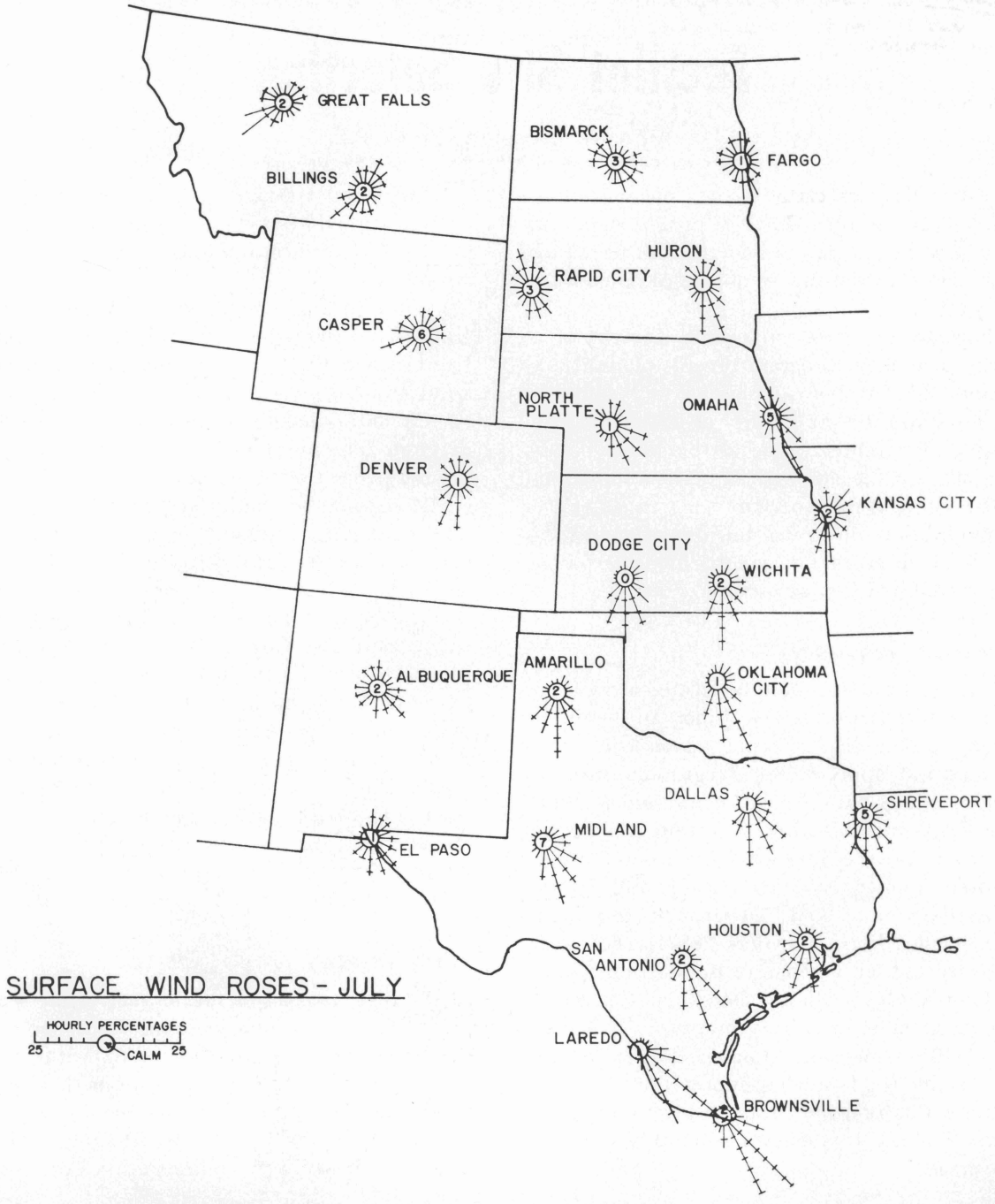

Figure 1. Surface wind roses show percentage of time the wind blows from the 16 compass points (July, 1951-60). The longer spike in a given direction, the greater is the probability of receiving wind from that direction.

Use of Rainfall Frequency Data

An ideal criterion for feedlot site selection would be to select a location that has the least chance of an adverse wind direction occurring in conjunction with or soon after a rainfall event. Although probablistic data of this type is not yet available from research, it is possible to make certain estimates along these lines that can be useful in feedlot planning.

On a given day, the chance of rain exceeding 0.01, 0.05, and 0.10 inches for parts of the Great Plains was reported in "Probability of Wet and Dry Days for Eleven Western States and Texas" (see references). From this information along with the wind direction frequency values discussed earlier, the chance of both rainfall and a given wind direction occurring simultaneously can be estimated by multiplying the two probabilities.

To illustrate, typical rainfall and wind direction probabilities for Midland, Texas, have been plotted in Figure 3. In August, the probability of a west wind is 0.4% while the likelihood of rainfall exceeding 0.10 inches averages 10%. Thus, the combined probability

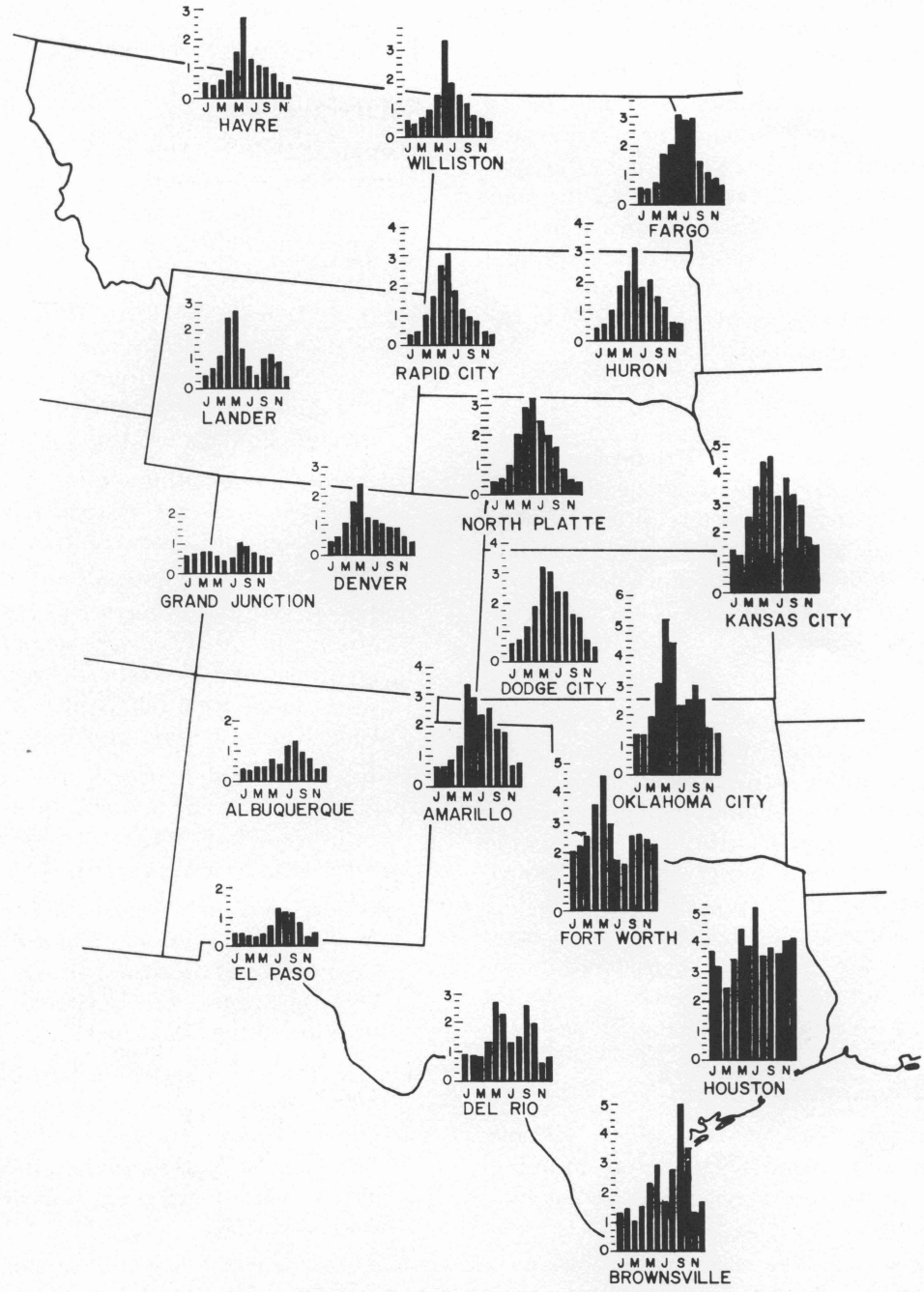

Figure 2. Normal monthly precipitation in inches for the Great Plains States, 1931-1960.

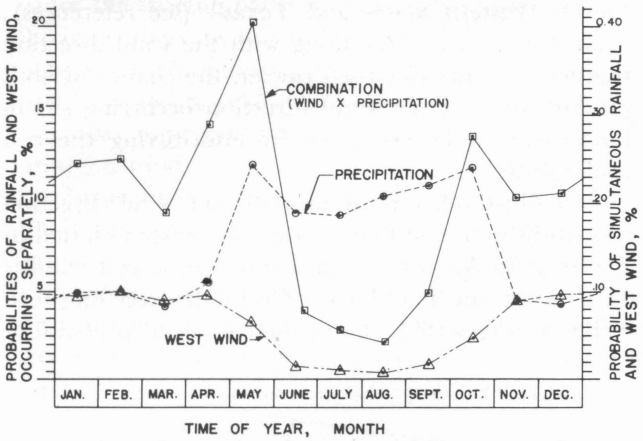

Figure 3. Relationship between frequency of west wind and precipitation greater than 0.10 inches for the Midland, Texas area.

of both these climatic events occurring together is only 0.04%, or four chances in ten thousand. Furthermore for the 8-month period of October to May, this likelihood is almost four times as great as for the June through September periods. Therefore, on the basis of this analysis, it may appear feasible to locate a feedlot west of the city. Of course, nearness to other population centers or dwellings as well as other land use factors should also be examined.

Local Climate Patterns

In rugged terrain, the wind direction may change over short distances. Cool nighttime air may flow downhill by gravity in a completely different direction from the wind flow aloft. Also, the prevailing wind may be split into up-drafts or down-drafts which can carry odor in entirely different directions from the prevailing wind direction.

Buffer Zones

In selecting a site, consideration should be given to maintaining a buffer strip of land around the facility. The buffer zone should be approximately egg-shaped, with the feeding facility located near the small end and most of the buffer area lying downwind in the direction of the prevailing breeze. The size of the feeding operation, climate, and waste management practices are important considerations in planning the feedlot location to include a buffer zone.

Summary and Recommendations

From known principles as to the effects of moisture and temperature on odor generation, meaningful conclusions can be drawn regarding feedlot location for odor control.

Feedlots should be located as far as possible away from population centers or closest neighbors in the direction of least probability of wind occurrence. The optimum direction can be determined from published wind rose diagrams or from tabular wind direction data. Wind data for summer months when peak temperature and rainfall (and hence odors) occur in the Great Plains is of particular importance. An alternate objective in feedlot site selection, where sufficient data is available, is to minimize the probability of both a rainfall event and a specific wind direction occurring simultaneously.

If feedlot odors are minimized during the most critical periods of adverse moisture and temperature, the wind speed factor is probably less important than wind direction considerations.

References

Heerman, Dale F., Morris D. Finkman, and Edward A. Hiler. *"Probability of Wet and Dry Days for Eleven Western States and Texas."* Colorado State University Experiment Station, Technical Bulletin 117, December, 1971.

Kreis, R. Douglas and Lynn R. Shuyler. *"Beef Cattle Feedlot Site Selection for Environmental Protection"* National Environmental Research Center, U.S. Enivronmental Protection Agency, Corvallis, Oregon, Publication No. EPA-R2-72-129, 1972.

"Selected Climatic Maps of the United States." Environmental Science Services Administration, U.S. Department of Commerce. U.S. Government Printing Office, Washington, D.C., 1966

Sholtes, R. S. *"The Growth and Decay of Turbulent Mixing in the Planetary Boundary Layer."* U.S. Environmental Protection Agency, National Environmental Research Center, Research Triangle Park, North Carolina, April, 1972.

Smith, M. E. (ed). *"Recommended Guide for the Predicition of the Dispersion of Airborne Effluents."* American Society of Mechanical Engineers, New York, New York, 1968.

"Summary of Hourly Observations—Midland, Texas: Decennial Census of United States Climate." Climatography of the United States No. 82-41, U.S. Department of Commerce. U.S. Government Printing Office, Washington, D.C., 1963.

Tucker, Joseph E., and John Griffiths. *"Precipitation Distribution and the Probability of Receiving Selected Amounts Over Texas."* Texas Agricultural Experiment Station. Publication No. MP-794, Texas A&M University, College Station, Texas, December, 1965.

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