

NEW MEXICO Climate

Prepared by:
Graphic Design:

Ted Sammis
Jessica Phillips



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Office of the State Climatologist | Department of Plant and Environmental Sciences
College of Agriculture and Home Economics | Agricultural Experiment Station



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Cover Photo: “Flood irrigation pecan orchard” by Southward

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About NMSU’s Climate Center

NMSU’s Climate Center is home to the state climatologist who helps New Mexicans understand the impact of climate changes on the environment, human health, and agricultural production.

The state climatologist is responsible for archiving weather data and distributing climate information to the public. Unlike meteorologists, climatologists do not provide weather forecasting or up-to-the-minute bulletins. Instead, they use a computerized data collection system to provide statewide weather reports for previous days, as well as for historical information.

The state climatologist puts climate data into a form people can use to make decisions about their lives. During fire sea-

son, people use climate data to assess potential fire hazards and to evaluate fire-fighting conditions. Engineers use information about rainfall and flooding to design bridges, culverts, storm sewers, and sanitary sewers.

Business owners use climate data to evaluate new business or relocation sites. Farmers use it to anticipate outbreaks of insect pests or crop diseases. People also use climate data when making their recreation and travel plans.

For more information:
State climatologist Ted Sammis
Phone: (505) 646-2104
Data service: (505) 646-5082
E-mail: webmaster@weather.nmsu.edu
Internet: <http://weather.nmsu.edu>

The office of the state climatologist and its head, the state climatologist, are described in New Mexico Statute 75-4-1 through 75-4-4

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Humidity Affects Crop Growth – and is Humidity Going to Change?

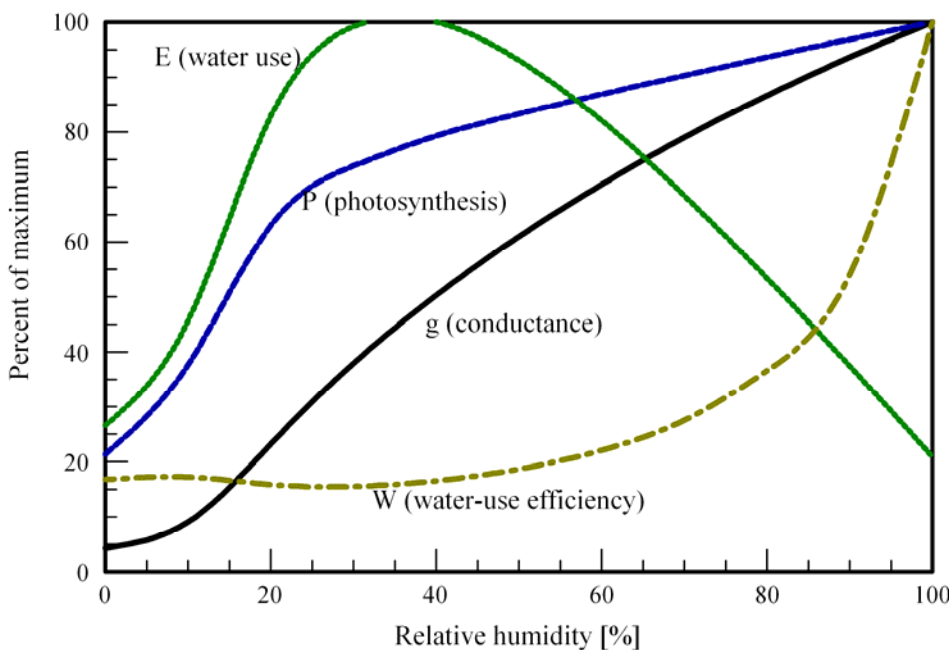
By Dr. Vince Gutschick *

Plant growth is tied to the ability of leaves to make sugars via photosynthesis. These sugars are the basis of all the rest of the biomass that they accumulate. That is, photosynthesis is the basis of growth and yield. The leaves have to capture light over their area displayed to the sun. They also have to open thousands of tiny pores (stomata) situated all over the leaf, letting in carbon dioxide (CO₂) that they'll reduce to sugars using light energy. At the same time, the pores let out, as vapor, water that evaporates from inside the leaf. This is the “cost” of doing photosynthesis – the water loss. Clearly, leaves have evolved very strong controls over the stomatal openings, allowing large openings when conditions are good for photosynthesis and good for low rates of water loss. Thus, they respond to light, temperature, and humidity in the air, as well as windspeed that helps both CO₂ and water vapor move. (They also respond to the availability of water resupply from the roots, but let's consider well-watered plants for now.) The degree of opening of stomata can be viewed with microscopy. More convenient to measure, and more directly relevant to growth is the cumulative effect of all the pores, expressed as the ability to transport water vapor (and thus, CO₂ also, going the other direction). We call this measure the stomatal conductance. How this conductance responds to the environment determines the leaf's rate of photosynthesis, its rate of water loss, and the important ratio between these, the water-use efficiency (more is better here). The rate of water loss also helps determine leaf temperature, which affects water loss in turn; there is a “feedback loop” here that can be important for keeping leaves at viable temperatures.

With all else equal in the environment, low humidity leads to lower stomatal conductance, lower photosynthesis, and lower water-use efficiency. We should expect that growth rate should be lower in dry New Mexico than more mesic (humid) states, and that water use will be higher and water-use efficiency will be lower. Of course, we must compare places with similar temperatures and sunshine; variations in those make a very rich picture of agricultural and ecological variation that we don't have space to consider here. In any event, knowing how plants' growth and water use is set by humidity can be important in deciding what crops to grow. If the average humidity is changing, as with climate change, this can alter our decisions.

There are crops, such as common beans (*Phaseolus vulgaris*) that grow over wide regions, from humid to arid. Surprisingly, it seems that no comparison of growth of any one crop as affected by

humidity has been made across regions. We resort then to models that have been found to represent accurately the experimental results of how leaves respond. The growth estimates will follow. I have assembled models of stomatal conductance, photosynthesis, leaf energy balance (for temperature), and the movement (transport) of CO₂ and water vapor. Each model involves parts of the others, so that the mathematical solution was a refreshing challenge. I will readily share the details with

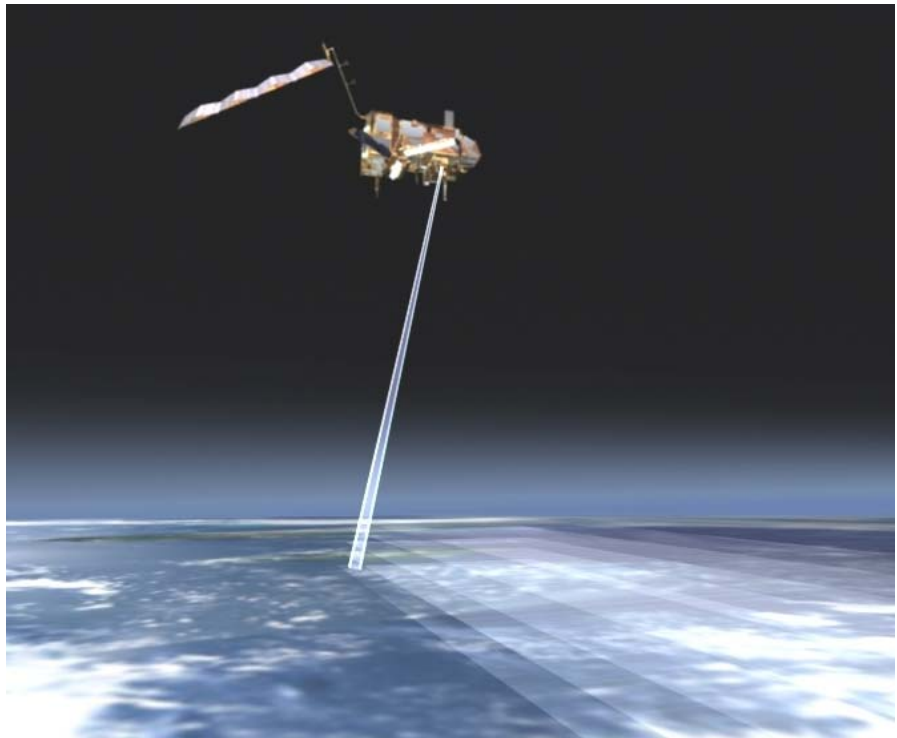


anyone who requests them. Here, let us jump to the results.

I chose to simulate leaves with the photosynthetic capacity of a well-managed bean crop, and I chose good, sunny-day conditions - half of full sun on the average leaf (leaves are at all different angles and get varying amounts of sun), moderate summer temperature (30°C, which is 86°F), a light wind (2 meters per second, or 4.4 mph), clear sky (low thermal radiation coming down to heat the leaf), and the average air pressure at Las Cruces and current CO₂ levels (380 parts per million). I also chose a very common “program” of how stomatal conductance responds to the environment. What I did vary was relative humidity, from 0 to 100%, in steps of 10%. At each humidity, I calculated the photosynthetic rate (P), stomatal conductance (g), water-use rate (E), and water-use efficiency (W). The actual numerical values may be unfamiliar to most people, so that in the graph below I expressed each as a fraction of the maximum value found for each quantity.

There are several interesting points. First, as humidity increases, stomatal conductance and photosynthesis increase, the latter in a somewhat kinked fashion. Water use, however, peaks in the middle range, near 40% relative humidity. This occurs because water use (transpiration) depends on the product (multiplication of) two factors: the conductance, and the difference in water vapor from inside the leaf to outside (the “vapor pressure deficit, or VPD). At low humidity, the leaf strongly reduces its conductance, so that E is low. At high humidity, the VPD is small, making E also small. The water-use efficiency, W, shows a close balance of higher P and higher E over a long range of humidities, from about 0 to 50%, and then it rises sharply. In New Mexico, we’re on that very low range. In Florida, they’re on the very high range....but they have much more to worry about, on fungal diseases and the like! Tradeoffs like these are part of the reason that beans (and some other crops) are grown in both places, despite the big differences in water use. These results closely match experiments done by Jonathan Comstock and Jim Ehleringer and reported in 1993. They did not use different locations but growth chambers in one place maintained at different humidities. They saw the patterns above, so that we can have some confidence in the estimates.

Climate change seems to be upon us. Many things are changing, including temperature and precipitation, and perhaps humidity. Each factor is important for our agriculture and ecology. Keeping to the theme of humidity, will New Mexico get more or less humid? The best climate predictions, from huge computer models, agree about many patterns, both among the different models themselves and the models each with past climate records. However, New Mexico is a place where they are uncertain, in good part from our climate being a result of a “clash” between generally dry weather from the West and wet weather from the East. The best bet is probably that we will have a somewhat lower relative humidity. For a variety of crops, not just beans, we could then expect lower water use and lower growth rates, almost in parallel with each other. Of course, as CO₂ rises and so does temperatures, many other patterns in photosynthesis, nutrient use, water use, and development will change. So, too, will the availability of water. It will not be an easy task to make estimates of the changes and to do agricultural planning, but it should be rewarding both financially and intellectually. - **Department of Biology, NMSU*



MetOp satellite of the European Space Agency, scanning the atmosphere for water vapor.

Frost Depth in New Mexico and the United State

By Dr. Ted Sammis*

Frost forms in soils when the temperature of the soil matrix falls below the freezing point of water, causing the water present in the pore spaces in the soil to freeze. The freezing process occurs gradually and is the result of the loss of heat through the soil surface to the cooler air above. Consequently, the frost depth becomes a function of the thermal conductivity of the soil; and the air temperature and the amount of snow cover that act as insulation to decrease the heat loss from the soil. Freezing of soil can cause water and sewage pipes to freeze if they are located above the frost depth and water is not flowing through them supplying heat to prevent freezing. Frost depth maps (figure 1) can be determined from simulation models using air temperature and snow cover data from the National Climate Data Center. Map one was first published in 1988 by J. E. Bowles and then later by Department of the army U.S. Army corps of Engineers (2008).

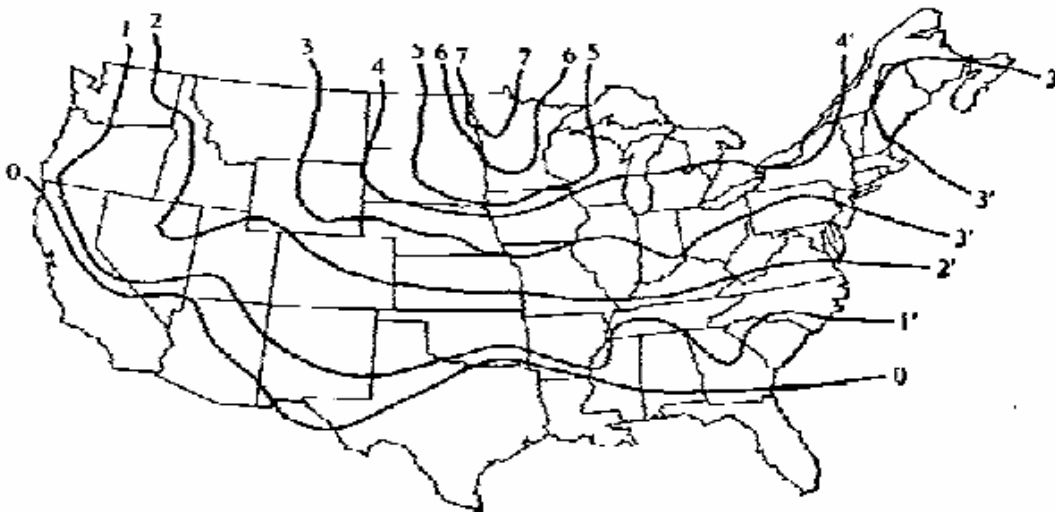


Figure1. Frost depth contours in the United States

Reference for wind map pleas: Department of Energy's Wind Program and the National Renewable Energy Laboratory (NREL). 2008

http://www.eere.energy.gov/windandhydro/windpoweringamerica/maps_template.asp?stateab=nm

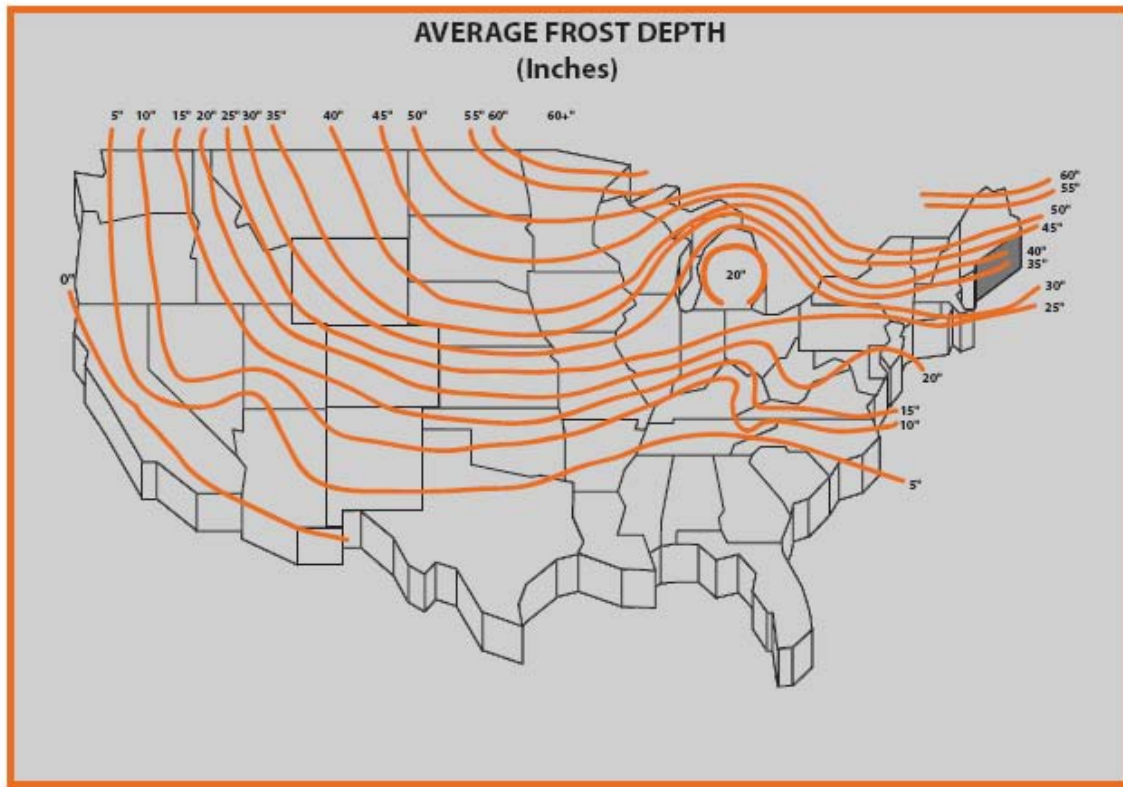


Figure 2. Revised map of frost depth in the United States

The frost depth maps have been revised as better simulation models and additional air temperature data are collected. Map two represents an update of map one. Based on new simulation models developed in 1994, the frost depth may be deeper in some parts of the United States than either map indicates. (Farrington and Gildea 2008).

Frost depth can be measured using a clear tube filled with water and methylene blue solution placed in a 1 inch pvc pipe placed in the ground to a depth 2 ft below the frost depth and above ground to a height above the depth of snow (McCool and M. Molnau. 1984). Each day the clear tube is pulled out of the hole and the depth of frozen water measured. These frost depth gages have been used in research, but they are not as part of a standard climate station setup (Smeal 2008). Consequently, little measured data is available to verify the published maps of frost depth.

In order to protect the water system in a house, all parts of a water system outside the house should be located below the frost depth. The universal plumbing code specifies the Depth of Water Service (Section 305.6) and states that “Water service pipe shall be installed not less than 12 inches deep and not less than 6 inches below the frost line” This code is normally amended by either city or county ordinance to require the depth to be deeper in cold environments. For example the City of Altoona, Iowa modified the code to read “Water service piping shall, whenever feasible, be no less than five feet below the surface of the ground”. This depth represents 15 inches below the estimated frost depth based on map 2. In Santa Fe NM the plumbing code requires water lines be buried from 36 to 42 inches which is 21-27 inches below the frost depth. Consequently, the water lines in Santa Fe will not freeze if installed to code but where the water lines come to the surface and into mobile homes, they will freeze if not properly insulated. Water meters in cold environments should also be placed deep in the soil below the frost depth or in heated enclosures which means general they are located inside the house.

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* *Department of Plant and Environmental Science, NMSU*

Shrinking water supplies in the future call for planning today

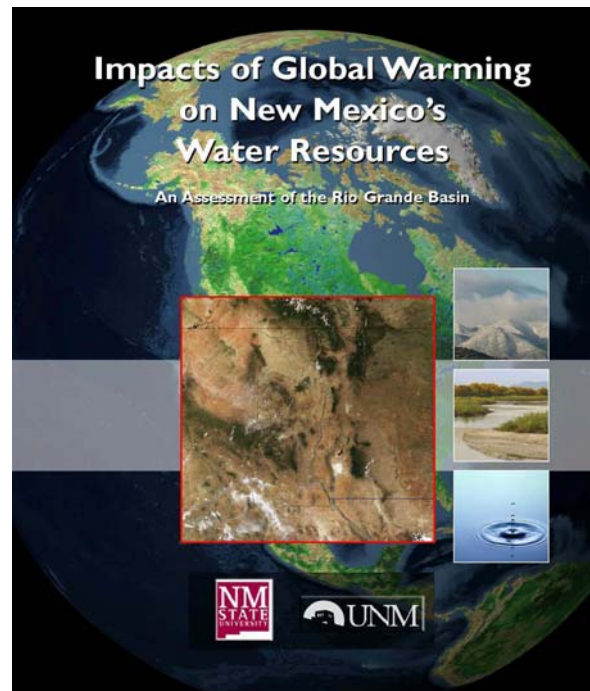
By Dr. Brian Hurd*

The saying “forewarned is forearmed” could be a subtitle for the recently released study entitled “Climate Change and Its Implications for New Mexico’s Water Resources and Economic Opportunities”. The study was a joint effort of Brian Hurd and Julie Coonrod of New Mexico State University and the University of New Mexico, respectively. Hurd is an associate professor in the Agricultural Economics and Agricultural Business Department at NMSU, and Coonrod is a civil engineering professor in the Engineering Department at UNM.

Climate change scenarios were developed from the results of several general circulation models (GCMs), which climatologists use to understand the behavior of the global atmosphere and oceans. Coonrod and her team of graduate students used these scenarios to project the effects of climate changes on streamflow hydrology. Among the key findings is a likely shift from snow to rain in the mountains resulting in less snowpack. Additionally, higher temperatures will bring about an earlier snowmelt and earlier peak runoff, as well as increased evaporation. Together, these effects combine to reduce total streamflows throughout the Rio Grande Valley – even in the event of a potential rise in precipitation.

Using the streamflow and evaporation projections, Hurd assessed the economic impact of the predicted changes. He estimated direct and indirect economic losses ranging between \$13 million and \$115 million by the year 2030 and from \$21 million to more than \$300 million by 2080.

Rising population in the face of shrinking surface water supplies will increase competition for water and increase transfers from agricultural to urban uses. Fewer agricultural acres in production could permanently change the landscape and character of New Mexico. But it is not just agriculture that will suffer. “Irrigated lands support more than crops,” Hurd said. “They provide habitat for wildlife, open



space and scenic vistas for the backdrop to New Mexico's thriving art, tourist, and recreational economies."

Hurd, who has studied climate change and its economic effects for over a decade, believes that the study is a starting point for planning for the future of New Mexico's water use. "Acting proactively may be our best course of action. Forming and transforming policies, planning, and partnerships that are appropriate to the range of anticipated changes may well serve to be the difference between a truly disastrous result and one much less severe."

Articles about this joint research effort have appeared in the Albuquerque Journal, the Santa Fe New Mexican, the Daily Lobo and The New York Times online.

* *Department of Ag Economics and Ag Business, NMSU*

Wind as a Renewable Energy Source in New Mexico

By Dr. James R. Stalker

Director & CTO

Precision Wind, LLC

840 N. Telshor Boulevard, A-415

Las Cruces, New Mexico 88011

In the face of rising energy costs, increasing health concerns with regards to environmental pollution that may be directly resulting from conventional energy generation, wind energy has received national attention over the past several years. Wind energy has been shown to have a stabilizing effect on energy costs and drastically reduce energy generation related pollution. Early pioneer states like California, followed by other aggressive states such as Texas, are still front runners with sizable energy production portfolios from wind farms. New Mexico has joined this national movement when it introduced legislation to have its own renewable energy portfolio standard (RPS) to spur the growth of wind energy in the state. The state RPS mandates conventional energy producers (e.g., utilities) in the state to have a mix of renewable energy source in their respective energy portfolios to meet such standards. Today, New Mexico ranks 10th in the nation as one of the top most wind energy producing states. Not too long ago (at the end of 2006), New Mexico ranked 7th in the country. In just one year (2007), three states (Colorado, Oregon, and Illinois) pushed ahead of New Mexico and Oklahoma in the national ranking, according to the 2007 year-end report from American Wind Energy Association, an active U.S. wind energy trade association.

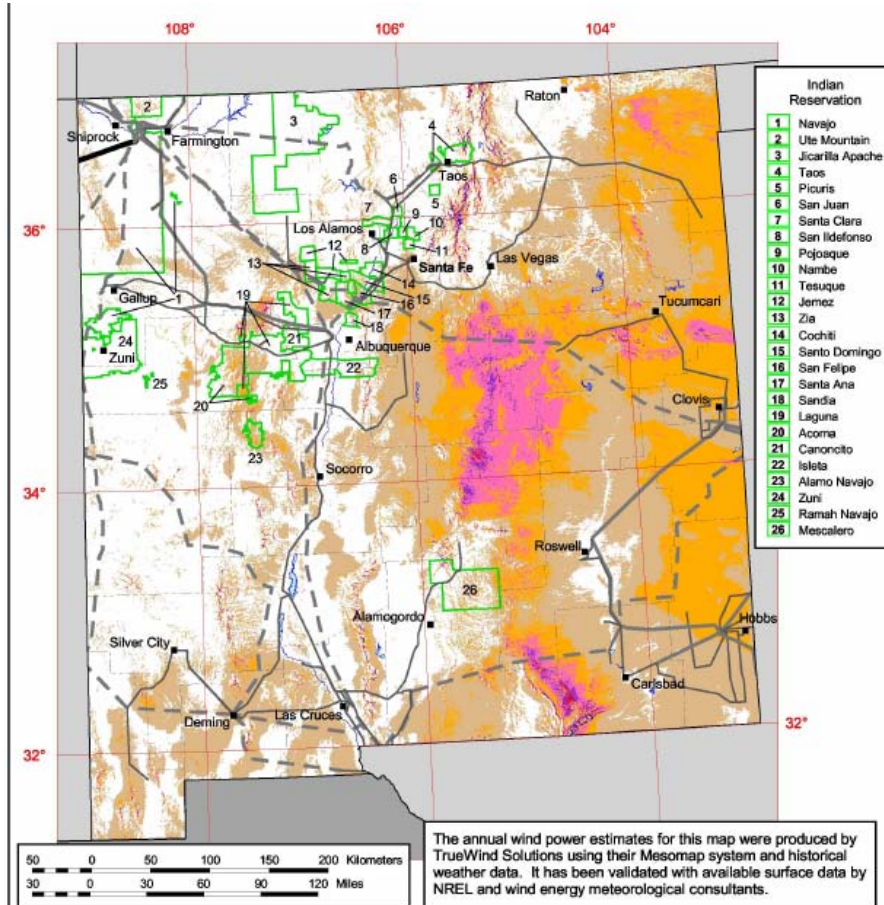
Wind, pushing on wind turbine blades, tends to turn the blades and a rotor attached to the blades thereby generating electricity from moving magnets housed in a generator box. The stronger the wind speed, the more electricity a wind turbine can generate to the extent where the generator and the gearbox are set up to handle such large rotational speeds. In this context, a low wind speed, below which no electricity is produced, (typical range of 2-4 m/s) the cut-in speed, and a high wind speed, above which the wind turbine is stopped, the cut-out speed, (typical range of 20-25 m/s) are defined. These cut-in and cut-out speeds depend on the type of wind turbine and how it is optimized for the environment in which it operates throughout its lifetime.

In terms of the total untapped energy potential, but not the actual installed wind plant capacity, New Mexico ranks 12th in the nation with the top 5 states being North Dakota, Texas, Kansas, South Dakota, and Montana, according to a study by Department of Energy's Pacific Northwest Laboratory. With only 496 MW of wind turbines installed in the state, the energy produced annually from New Mexico wind farms is less than 1 % (~0.35%) of the state potential. That is not atypical just for New Mexico as the U.S., as a nation, taps a very small portion of that high untapped energy available in the entire country. In order to attract more wind project developers and financiers to invest in wind projects the state as a first

priority needs a more quantitative and accurate description of the available wind resource in the state, The state needs to develop state-supported economic policies and incentives to level the field with other subsidized competing energy producers, and the state needs to introduce key legislation to develop new transmission infrastructure, etc.

The current state-wide wind maps of New Mexico (see Figure 1) suggest all the relatively windy areas are predominantly in the eastern half of the state, particularly over the eastern plains.

These maps hardly show any utility-scale wind resource in the entire western half of the state where mountainous areas are prevalent but more accurate and technologically advanced wind mapping tools are available today, and if applied properly could change where wind turbines are currently being installed and increase the amount of wind energy generated in the state. Wind resource is considered utility-scale grade for commercial wind project development when the wind power class is (good) or above (see Figure 1). In other words, if the annual average wind speed at site, at the 50-m height above ground level, is 7.0 m/s or higher, then the site is



4
a

considered to have utility scale wind resource. These newer wind-mapping technologies (weather forecast models coupled with terrain models) make wind resource assessment efforts less-time consuming and cost effective compared to traditional methods of wind assessment, i.e., by erecting wind measurement towers with wind sensors and collecting data for extended periods of time.

Wind Power Classification				
Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ²	Wind Speed ^a at 50 m m/s	Wind Speed ^a at 50 m mph
1	Poor	0 - 200	0.0 - 5.6	0.0 - 12.5
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

^a Wind speeds are based on a Weibull k value of 2.0

◀ Figure 1. New Mexico wind resources at 50 m.

Another issue of relevance to New Mexico and other states is how this newly identified source of energy is being affected on longer time scales (multiple years, decades, etc.), for example, by natural and anthropogenic climate changes. Newer wind assessment technologies may offer the necessary tools to qualitatively and perhaps quantitatively understand such climate change related influences.

The future of wind energy is economically viable in New Mexico, but the industry will need help from the state to be successful.

Questions for the New Mexico Climate Center:



Question: What would the climate be like in Albuquerque 10 years after an atomic bomb had been dropped on the city.

Answer by Dr. Ted Sammis: If only a single atomic bomb were dropped on the city, the climate would not change but the place would not be habitable. After a bomb was set off at Trinity, the first test of technology for a nuclear weapon on July 16, 1945, at a location 35 miles (56 km) southeast of Socorro, New Mexico, the climate in the area did not change.