Modeling the Spread of the West Nile Virus

New Mexico High School
Supercomputing Challenge
Final Report
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Team #019
Bosque School

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Executive Summary

The West Nile Virus is not a new virus, in in that it has been known to exist as a human infection for some time. However, its presence in the United States is recent, and its appearance caused an immediate panic upon its outbreak in New York City in the summer of 1999. It has already spread via the American Crow, its chief host, at a rapid rate along the East Coast, and it has spread in more concentrated areas because of mosquitoes, one the most common mosquito being the *Culex tarsalis.* While various government and health agencies have focused on recording the Virus' movements, little has been done to track its possible spread. Were this movement able to be modeled, even to a very rough degree, scientists would be able to anticipate outbreaks and act accordingly. This project was originally intended to act as a tool for this specific purpose, but has since been modified to concentrate on the population of its vectors in New Mexico.

Introduction

The Problem

The West Nile Virus was first detected in the United States in 1999. This initial outbreak resulted in 62 serious human infections, leading to seven deaths. Two additional deaths and 19 human infections occurred in the United States in the year 2000. By September 2001, the virus had been detected in wildlife populations in 27 states and in Canada. It has spread from its first North American location, New York, and now covers a region from Toronto, Canada, to northern Florida, and it has spread across the Eastern seaboard as far west as Arkansas and Missouri. More recently, several infected crow cases have been confirmed in Tennessee, and precautions are being taken to prevent the virus from spreading into the human population. However, should the virus continue southwest to Texas, a large hub of commerce in the U.S., it would have the potential to spread into the remainder of the country with increased momentum. Government agencies and centers, such as the Centers for Disease Control and Prevention (CDC), monitor the spread of the Virus. The problem with such agencies is that they monitor where the virus has already spread, but do not make any predictions as to future spread or rates of risk in any given area.

The Project

The original purpose of this project was to predict the spread of the West Nile Virus throughout the United States. However, problems with resources, inappropriate model types, and time restrictions prevented us from achieving that goal. The current goal is to create a model that will predict the risk of becoming infected with the West Nile Virus on a county-by-county basis. To begin with, the model will be limited to the state of New Mexico. The current output is a numerical value that will assess the risk of being bitten by an infected mosquito for each county. First, developing an understanding of the dynamics of the disease, such as its vectors and rate of spread, was necessary. Initially, the vectors were limited to mosquitoes and crows, as the migration of the latter is not limited exclusively to this state. Due to a pronounced lack of data, the model for crow migration and interaction is not so complete as that for mosquitoes in terms of how it could be used for modeling the spread of the Virus. With this data, the program can be expanded to include larger geographic areas, broader weather patterns, additional vectors, and migratory fly-ways.

Background Information

The Virus

In 1937, in the West Nile District of Uganda, a woman was ill with what appeared to be a typical fever. Further observation revealed that the woman was afflicted, not with a common cold or flu, but with a new and potentially deadly strain of encephalitis. This virus was first recognized as a cause of severe human meningoencephilitis among the elderly during a 1957 outbreak in Israel, and was detected in horses in Egypt and France in the early 1960s. Meningoencephilits is the inflammation of the spinal chord and brain. In 1999, it was identified and named the West Nile Virus. While scientists are unsure of exactly when the Virus arrived in the United States, it was a string of occurrences in New York that led them to conclude that, indeed, the Virus was present on U.S. soil.

In the summer of 1999, the West Nile Virus manifested itself in New York City in the form of 59 severe cases of encephalitis and meningitis, three less severe cases, and seven deaths. In an effort to determine the initial extent of the disease's spread, the New York City Department of Health and the Centers for Disease Control and Prevention, USA, conducted a household-based survey that consisted of blood tests of 677 individuals from 459 households. Nineteen individuals (2.6%) tested to be seropositive – their blood contained antibodies essential for the virus's incubation – and one third of these individuals reported recent fever-like symptoms. 70 individuals tested to be seronegative.

The initial symptoms can be as mild as a fever and body aches, and sometimes a mild rash and swollen lymph glands, from which patients typically recover fully. In some cases, usually among the elderly and young children, the Virus causes inflammation of brain tissue, the symptom most commonly associated with encephalitis. The most serious cases can result in permanent damage to brain tissue, and rarely in death for about 3 to 15 percent of patients. These critical cases, or additional symptoms, will rarely occur in patients aged 5 to 50 years. Other symptoms include a severe headache, confusion, loss of consciousness, which may induce a coma, and muscle weakness. All members of this virus' genus, Flavivirus Japanese Encephalitis Antigenic Complex, share these symptoms, St. Louis and Japanese encephalitis being among the most widely spread viruses. A flavivirus is transmitted through arthropods, meaning bites from mosquitoes, ticks, etc., and is capable of reproducing within the carrier. The Virus is more widely classified as an arbovirus – <u>Ar</u>trhopod-<u>bo</u>rne virus – and will eventually share the typical trait of arboviral encephilitedes, i.e., existing in a wide-spread geographical region, and capable of being transmitted through most mammalian species.

The most important factors in the spread of this disease are the mosquito population, migration of crows, and these species' interactions with humans. As the mosquito population grows, its contact with humans, horses, and crows increases. This results in the further spread of the Virus. One mosquito's possession of the Virus will lead to its transmission to every organism that it blood feeds on. Crows are considered to be reservoir hosts, meaning that they are both carriers and transmitters of the Virus. Should an uninfected mosquito bite an infected crow, it is likely that the mosquito will receive the pathogen, which in turn could spread it further. If this mosquito goes on to bite a human or another mammal such as a horse, a dead-end host, it is a one-way transmission. A dead-end host refers to the fact it cannot transmit the pathogen any further.

Mosquitoes

Mosquitoes act as the primary vector for the spread of the West Nile Virus, as well as other arboviruses. There are over 2,500 species of mosquitoes in the world, and over 150 in the United States alone. The species modeled in this project is the *Culex tarsalis*, due to its major role in the spreading of the Virus, as well as its prominence in New Mexico. The individual *Culex* species share common traits with one another, and are found throughout the continental United States. Out of the population, only the females of the species blood feed, and perform this through biting a subject. While mosquito bites are a common nuisance among humans, mosquitoes blood-feed on birds three times as often. The purpose of the blood feeding process is to accumulate the proteins that allow the female to produce eggs. Five days following the blood meal, the female lays approximately between 100 and 150 eggs on the surface of a pool of stagnant water, such as a birdbath or clogged gutter. The egg will remain on the surface for two days, after which the larva will hatch, providing that the nighttime temperatures remain above 50 degrees. Mosquito larvae develop into a pupa underwater over a period of about 7 to 17 days, depending on the water's temperature; higher temperatures will result in a shorter developmental period. It will remain in the pupa stage for up to 4 days. At the end of this time, the pupa completes its development into an adult mosquito, and leaves the water to restart the cycle, in the case that it is a female. Because the males do not blood feed, they do not, for the most part, play a large role in the cycle, illustrated in Figure 1.

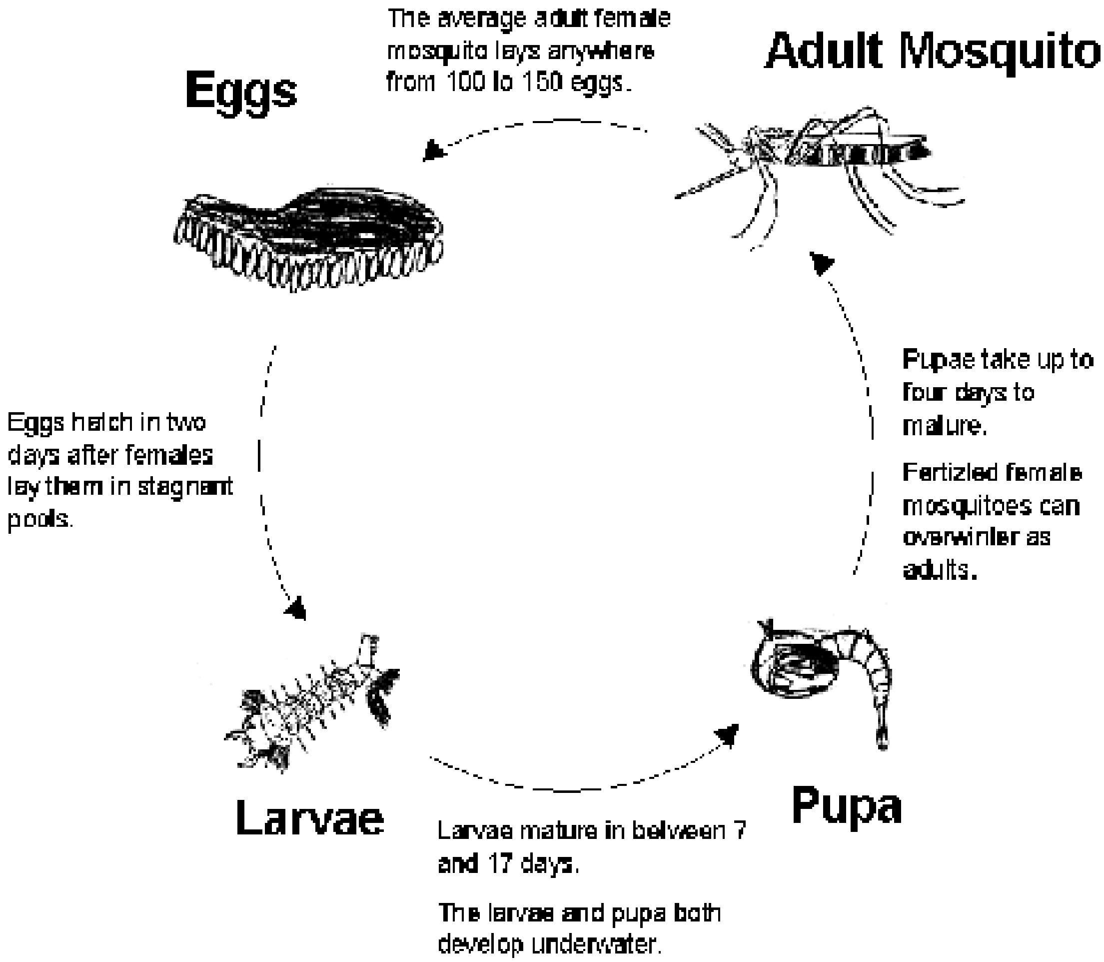

Figure 1. Life Cycle of the *Culex tarsalis*

Crows

In order to accurately model the spread of the Virus, mosquitoes and crows, the most common reservoir hosts of the Virus, must both be modeled. The crow chosen for the model is the *Corvidae brachyrhynchos*, more commonly known as the American Crow. This species was chosen due to its greater numbers in New Mexico, relative to other carrier species, as well as for its capacity for carrying the Virus. Crows are migratory species that, during the fall and winter, seek shelter in the Rio Grande Valley. In 2000, the estimated total crow population in the U.S. was over 3 billion. Because of this species' heartiness, and the fact that it is a scavenger bird with a very broad diet consisting of insects, fruit, carrion, etc., the crow is capable of living year-round in many different climatic zones without migrating. When they do migrate, their fly-ways are much shorter compared with the Canadian Goose, for example, which travels a few hundred miles at most, typically limiting movement between states. A female crow will typically lay 4-6 eggs per year. While its presence in other parts of the nation year-round is common, the American crow was listed as an uncommon transient, in both spring and fall, in the Sandia and Manzanita Mountains within the Cibola National Forest in Bernalillo County. This species is not commonly seen year-round in New Mexico, and breeds during the summer months.

Horses

The Virus' manifestation in horses is similar to that in humans. A horse will contract it from an infected mosquito bite, and symptoms such as disorientation, lack of appetite, and laziness will occur, followed in most cases by lethargy and death. While these symptoms are similar to Eastern and Western Equine Encephalitis, the vaccinations for these diseases have not been proven to be effective against West Nile. In 2001, a vaccine was created to combat the Virus and its high fatality rate among horses, but has not as yet been proven as being effective. However, swift and consistent veterinary treatment to infected horses has provided successful treatment for infections caught early enough.

Project Description

Finding sufficient data pertaining to mosquito population growth and blood feeding habits, crow population growth and migration data, and daily temperature data was of foremost importance because the interaction of the mosquito population with other species is the major factor in spreading the Virus. Using crow populations as the primary “other species,” a program could be created that would model the mosquito population.

Population information was obtained from Dr. Rudy Bueno, the team’s mentor, on the *Culex tarsalis*, the major vector for the spread of encephalitis in New Mexico. Through this data, it was found that the primary factor in determining the mosquito population is the daily temperature. Depending on the temperature, the length of the mosquito’s life cycle changes. During periods of cold weather, the time it takes mosquitoes to develop increases, and their adult lifespan can be as high as 37 days (Table 1). As the temperature increases, a mosquito’s lifespan decreases.

Nighttime Temperature	Adult Mosquito life span
50 F	37 days
68 F	18 days
70 F	17 days
80 F	10 days
88 F	7 days

Table 1. Lifespan of Adult Mosquito

Since the length of a mosquito’s lifecycle changes according to the weather, a logistic growth model would not work. This logistic type of growth model assumes that the population reproduces once after a fixed number of days, but does not incorporate changes in the reproductive cycle based on temperature, which the model requires. Logistic growth models also require the input of a carrying capacity, which is difficult to determine for any species. In order to develop such a model, the average temperature per day from the past 30 years was obtained from the Western Regional Climate Center (WRCC) and used to estimate the average temperature for a one-year cycle in the model. In the model, once the nighttime temperature reaches 50^{o} F, the mosquito population will begin to blood feed and reproduce. When the nighttime low falls below 50^{o} F, the population will begin to decline as reproduction ceases.

Mosquito Population Growth Model

The first step in the project was to develop a mosquito growth model for Bernalillo County. To make this growth compatible for any region used, all of the county-specific weather data from the daily weather file, also provided by the WRCC, was analyzed. This data was used without any modification and can be interpreted directly by the program, meaning raw data in any form can be implemented. The program edits out any irrelevant headers and any unnecessary data.

The mosquito growth equations are designed specifically for the mosquito *Culex tarsalis*. They were developed using the population data collected, and were used to create a graph, from which several trend lines were drawn. Figure 2 shows the length of time that a mosquito spends in the larvae stage, pupa stage and the adult mosquito stage of its life span. When the nighttime temperature is 50^{o} F, a mosquito is a larva for 16 days, pupa for 4 days and an adult mosquito 37 days. As the temperature increases, the length of time that a mosquito spends in each stage decreases.

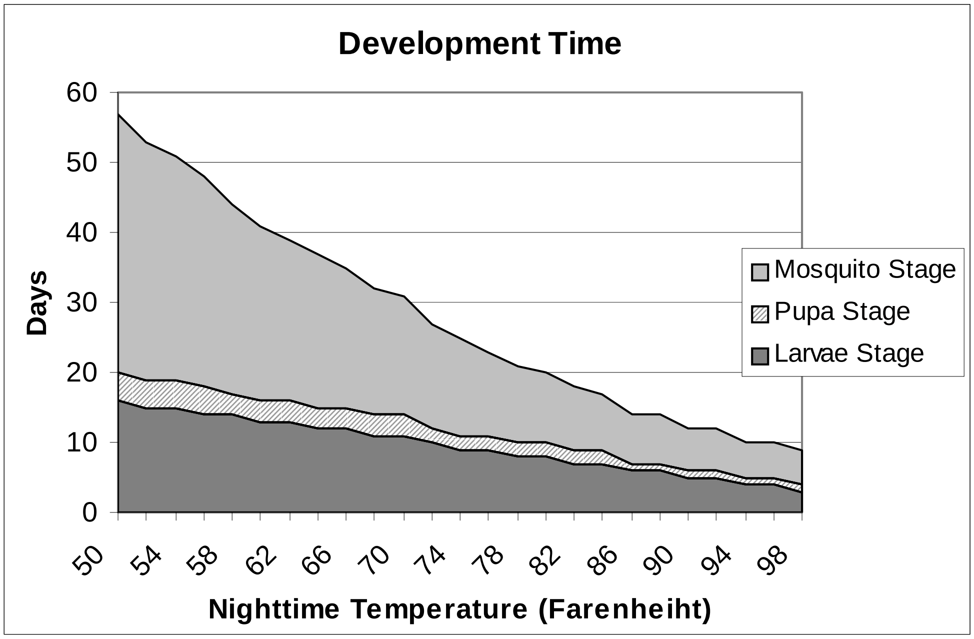

Figure 2. Development Time of the *Culex tarsalis.*

When the nighttime temperature gets over 50^o F in the spring, the over-wintering (i.e., hibernating) *Culex tarsalis* stop their hibernation cycle and begin to blood feed. The model begins with one over-wintering mosquito, which will lay eggs after five days. These eggs take two days to mature, after which they hatch into larvae. Mosquitoes stay as larvae for as many as 17 days during the coldest days and as few as 7 days during the hottest days in summer. During the larva stage and the pupa stage, the mosquitoes are easy prey, which is taken into account with a 5 percent survival rate variable. The remaining 5 percent will grow into the pupa stage, where they will mature for approximately four days, after which they mature into an adult mosquito. The female mosquitoes will then mate and begin the blood feeding process again. The program uses this cycle in order to model the mosquito population growth. The length of time that it takes for the mosquito to develop is calculated and recorded. This program continues until the temperature is lower than 50^o F at night, after which the mosquitoes slowly die off.

The output of this program is the first, second, and third bites. These are important because if the mosquito receives the Virus pathogen, i.e. becomes infected, on the first bite, then its lifespan will allow it to transmit the pathogen to two other hosts, assuming the mosquito will live to its fullest possible age. During times when these second and third bites occur often in a county that harbors the West Nile Virus, the number of infections will increase. The output also contains the population data for the mosquitoes.

Crow Population

Because crows have been the chief carrier of the Virus from state to state, creating a model for their movements and population that works in conjunction with the mosquito model was necessary because with smaller population numbers, the crow population will have more occurrences of the Virus. Once the Virus has thoroughly circulated throughout a mosquito population, the migration of crows becomes a major factor when trying to predict the spread of the Virus. This migration allows for easier transmission of the Virus as the crow population encounters other infected crow hosts and infected mosquitoes. When a crow has been infected with the Virus, it will live for about two weeks before it dies; there is a 100 percent fatality rate among crows.

The Crow Population Model

Because the crow is the most common reservoir host for the Virus, its implementation into the model was essential. However, the data gathered for crow populations in New Mexico is very sparse, as they are not year-round birds, and there are trends within the growths and declines that may indicate skewed data. For example, in San Miguel County, the amount of crows seen doubled in one year, and then dropped by more than half the next year. While this could be seen as a fluke in only one year, there are similar trends in almost every county that data was gathered from; 13 out of 33 counties offered feasible crow data. While many of these counties don't have an acceptable climate for crows, some of them, like Bernalillo County, harbor many crows, although officials collect no records of their populations, perhaps due to the fact the state functions only as their wintering home.

To create the program, the variations in the crow populations over the course of thirty years were computed. The equation created takes the average population in a certain area, and then computes the average variance in the crow population. With this information, a program was created that assumes that the crow population in New Mexico will stay approximately the same over time. Using the variations created in the data, cycles were created that are 14 years long. Within this period of time, the fluctuations of the population fall into a growth and decline that fits a seven-year cycle. This will allow the program to create a relatively accurate representation of the number of crows that are in New Mexico. Although there are counties that have little or no definite crow data, it can be postulated that there are crows present in those areas. Thus, population data from neighboring counties that have similar climate conditions were used to estimate unknown populations.

County Population Profiles

Another important factor in modeling the spread of the Virus is the population profile. If the county is made up of a high percentage of elderly (over 50) or children (under five), the Virus is more likely to cause a serious threat to the population, since its majority will be more at risk of becoming infected. Population data was gathered from the 2000 U.S. Census (table 2). S

County	Total Population	0-5	6-49	50+	At Risk
Bernalillo County	556678	8.3%	65.2%	26.5%	34.8%
Catron County	3543	5.3%	48.8%	45.9%	51.2%
Chaves County	61382	8.7%	62.1%	29.3%	37.9%
Cibola County	25595	9.5%	65.0%	25.5%	35.0%
Colfax County	14189	6.7%	57.5%	35.8%	42.5%
Curry County	45044	10.3%	65.8%	23.9%	34.2%
De Baca County	2240	6.3%	51.1%	42.6%	48.9%
Dona Ana County	174682	9.4%	67.0%	23.6%	33.0%
Eddy County	51658	8.8%	61.5%	29.7%	38.5%
Grant County	31002	8.1%	57.4%	34.5%	42.6%
Guadalupe County	4680	6.6%	64.6%	28.8%	35.4%
Harding County	810	4.2%	48.1%	47.7%	51.9%
Hidalgo County	5932	9.3%	61.4%	29.2%	38.6%
Lea County	55511	9.2%	65.0%	25.8%	35.0%
Lincoln County	19411	6.2%	53.9%	39.9%	46.1%
Los Alamos County	18343	7.0%	59.9%	33.1%	40.1%
Luna County	25016	9.4%	56.4%	34.2%	43.6%
McKinley County	74798	11.1%	70.4%	18.5%	29.6%
Mora County	5180	7.3%	59.2%	33.5%	40.8%
Otero County	62298	9.0%	64.7%	26.3%	35.3%
Quay County	10155	6.5%	55.6%	38.0%	44.4%
Rio Arriba County	41190	8.4%	65.3%	26.3%	34.7%
Roosevelt County	18018	9.1%	66.0%	24.8%	34.0%
Sandoval County	89908	8.9%	66.0%	25.0%	34.0%
San Juan County	113801	9.7%	68.0%	22.3%	32.0%
San Miguel County	30126	7.9%	64.4%	27.7%	35.6%
Santa Fe County	129292	7.4%	63.4%	29.1%	36.6%
Sierra County	13270	5.8%	45.6%	48.5%	54.4%
Socorro County	18078	8.6%	65.2%	26.2%	34.8%
Taos County	29979	7.0%	61.0%	32.1%	39.0%
Torrance County	16911	8.4%	66.3%	25.3%	33.7%
Union County	4174	7.3%	58.2%	34.5%	41.8%
Valencia County	66152	9.2%	65.9%	24.9%	34.1%

Table 2. Population Profiles for New Mexico Counties

Results

Our mosquito population program produced data for every single county in New Mexico. This data contained the total number of mosquitoes and the total number of first, second and third bites (Figure 3).

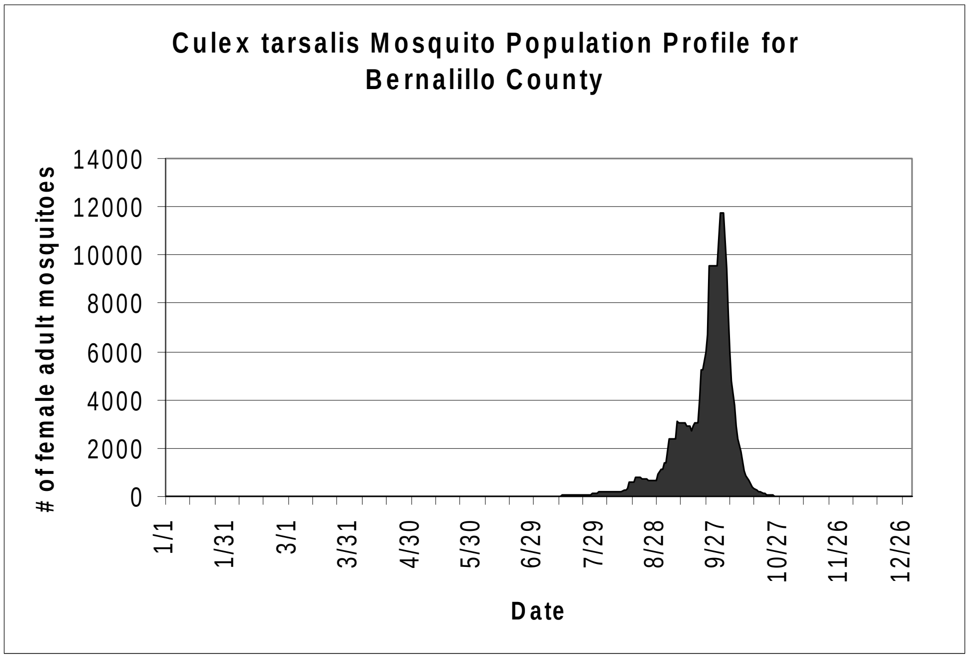

Figure 3. Mosquito Population Profile

Our mosquito population program also produced estimates for second and third blood feeding incidents for each of the adult female mosquitoes. Figure 4 shows the Virus-spreading blood feeding incident (VBI) over one year in New Mexico. This VBI deals with total number of potential bites that could spread the virus. Figure 5 shows the total VBI for each New Mexico county. This VBI is partially similar to the total mosquito population, except that it deals with the total number of mosquitoes in certain stages of their lives. VBIs and total mosquito population are computed based on the assumption that one mosquito over-winters from the previous year.

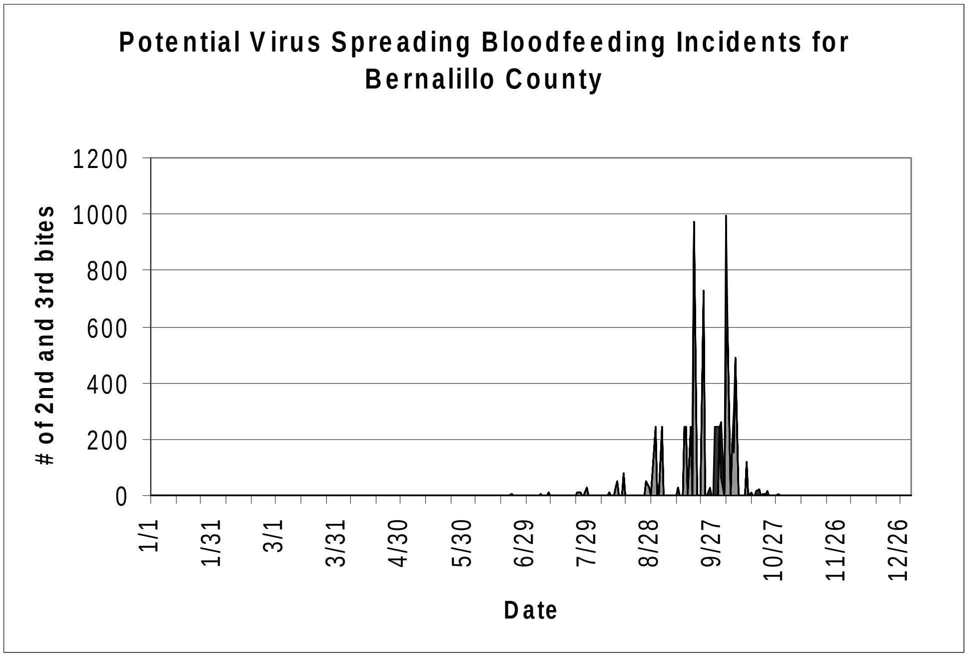

Figure 4. Potential Virus infections

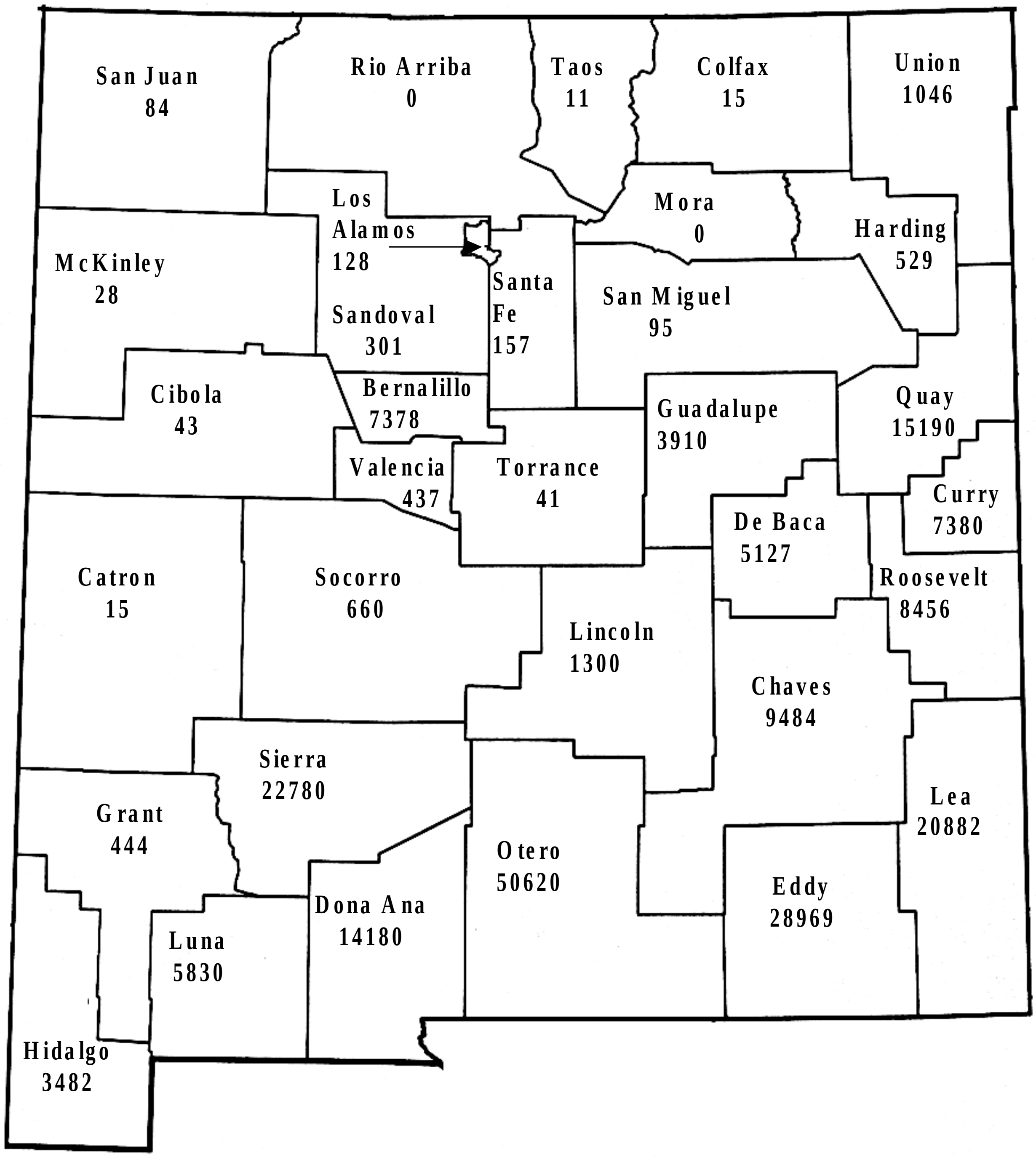

Figure 5. VBI values for each New Mexico County

Conclusions

Even though Figure 5 shows that two counties have a VBI of 0, this only means that the people in that county will not likely get the virus from a *Culex tarsalis*. Then reason they have such a low VBI is because the temperature doesn't get warm enough to support the *Culex tarsalis* population. However, *Culex tarsalis* are one of the most abundant mosquitoes in New Mexico, and they aren't the only ones that spread viruses like the West Nile.

In Bernalillo County, the mosquito population peaks in late September and the beginning of October with a total population of almost 12,000. In this area, between the beginning of September and the end of October; the bite count -- the number of bites from female adult mosquitoes per day -- peaks as well. Since the population and the number of bites are both especially high during this period, people are at a higher risk of getting the Virus, should it be present in the mosquito population.

The crow population peaks every fourteen years in any county. This allows for high numbers of reservoir hosts to be developed. Because of their prevalence in the Rio Grande Valley, which is also a perfect habitat for mosquitoes, there is a greater possibility of interaction. Since the mosquito population peaks during the fall, when crows are in the same region, the Virus can spread easily between the two species.

Because the symptoms of the West Nile Virus are similar to those of the flu, an outbreak might seem to the public like a simple flu season. This creates the potential for an unchecked outbreak. Thus, if the West Nile Virus exists in their region and the risk of getting it is especially high there, people should know to seek treatment for it. Making this knowledge available has become one of the main goals of the program.

All of the models that were created supplied necessary information for the final program. Although the population model that was designed was initially for mosquitoes and crows in the counties of New Mexico, it is possible to provide the basic model with different data. Thus, it is easily possible to model both mosquito and crow populations and the resulting number of VBIs in every county in every state in the United States by simply plugging in available weather data of the county.

The process of entering the data is very straightforward. Using the standard running command "./a.out," and entering the name of the county, the user can obtain the output. The program saves it to a ".data" file automatically. The user must also open the saved .data file in Excel to confirm its transformation into a spreadsheet. For a visual output, the user has to select the third column of data in this spreadsheet, hit the graph, choose the area graph and follow the normal steps for creating graphs in Excel.

After comparing the counties in New Mexico to each other, Rio Arriba County has the lowest risk rate of becoming infected with the West Nile Virus; Otero County has the highest risk. The VBI in Rio Arriba County is 0, because there are no *Culex tarsalis*, and almost no risk of getting infected. In addition, the percentage of people at risk is only 34.7 percent. In Otero County, however, which is located in southern New Mexico, the VBI is 50,626. 35.3 percent of Otero's population is at the risk of becoming infected with the Virus.

This comparison shows the importance of knowing whether or not one is living in an area with a large mosquito population and a consequently high VBI, as well as whether many people in high-risk age groups live in the area, should the West Nile Virus enter New Mexico. The program provides this information quickly and easily for this purpose.

Recommendations

There are many variables within this project that still have the opportunity to be examined. Due to the restrictions created by the lack of variables, the exact spread West Nile Virus could not accurately be modeled.

Crow Model

Because of a lack of data on crow migration and population, a model that could calculate a population's spread accurately enough could not be created. However, the current crow population model could currently be expanded and improved on in order to include crow migration between counties.

Mosquito Model

Mosquito population data concerning the total number of mosquitoes in various areas was also not available. In order to model the mosquito population growth more accurately, the input of rainfall is also necessary. The use of more sites in the state for weather data and population data on a city-by-city basis would also improve the accuracy of the data. The mosquito model can currently model 11 of the western states based on data from the Western Regional Climate Center, though not at the level of accuracy additional weather variables would allow. Currently, the model uses only the *Culex tarsalis,* which is not the only mosquito that transmits the Virus; implementing additional common species into the model, and region-specific vector species is a possibility.

Integrating the mosquito model, the crow model and the population profile would allow for the three basic data types to be created simultaneously. The parallelization of the code would allow for more of the data to be processed by the computer at once; currently, the model needs to be run once for each county and the data then has to be collated and compared. The collective models and program could also be modified to work for different diseases, creating a susceptibility list from the input of the population profile.

Acknowledgements

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Appendix A – The Mosquito Model Code

```
/*************************************************/
//Temperature header file
//Team 19
//Samuel Ashmore, Jessica Behles, Adrienne Cox,
//Geraldine Prashun, Kenny Sutherland
/*************************************************/


class temperature{
 public:
  double hi;
  double low;
  int day;
  int month;
  temperature();
};

/*************************************************/
//Temperature body  file
//Team 19
//Samuel Ashmore, Jessica Behles, Adrienne Cox,
//Geraldine Prashun, Kenny Sutherland
/*************************************************/
#include "temperature.h"

temperature::temperature()
{
  hi=0.0;
  low =0.0;
  day=0;
  month =0;
}
  /******************************************************/
//                 Mosquito Population Growth Model
//                   By Team 19 - Bosque School
//Current Problems: none
//Samuel Ashmore, Jessica Behles, Adrienne Cox,
//Geraldine Prashun,Kenny Sutherland
/******************************************************/
#include "temperature.h"                    //Contains the temperature class
#include <string>
#include <iostream>
#include <fstream>
```

```
//fixed rates
double smrate=.5;
double slrate=.05;
double sprate=1.0;
double hrate=.8;

int main(int argc, char *argv[])
{
  //Temperature infile
  temperature county[366];                    // This is the array of temperatures.
  ifstream infile;
  ofstream outfile;
  string filename=argv[1];
  string end="DT.txt";
  string infilename=filename+end;
  string outfilename=filename+".data";
  infile.open(infilename.data());             // This portion of the code has been
  outfile.open(outfilename.data());           // tested in a test program and worked.
  string line;                                // this string is to clear the header
  string news;                                // The header files have been formated

  //edits out headers of files
  for(int x=0;x<7;x++)                        // so that every files has the same
   {                                          // size header in the file.
     getline(infile,line);                    // The important data is hi and low
   }                                          // temperatures since they effect the
  int doy,mon,day;                            // lifespan of the mosquito in each
  float hi, low, blank;                       // of its stages.

  //reads in data
  for( int x=0; x<366;x++)
   {
    infile>>doy>>mon>>day>>hi>>blank>>low
     infile.ignore(200,'\n');                 // This section reads in only the desired
     county[doy-1].hi=hi;                     // numbers from the weather file and saves them
     county[doy-1].low=low;                   // for later use.  Currently is also
     county[doy-1].month=mon;                 // stores the month and day of the month
     county[doy-1].day=day;                   // in it.  This is an important piece
   }                                          // of the mosquito model.

  //mosquito model
  double done=0;
  // This section creates the variables for mosquitoes growth
  long double eggs[2];
  long double larvae[14],larvaetime;
```

```
long double pupa[4], pupatime;
long double mosquito[37], mosquitotime, hibmosquito=1;
int start=0;

//This sets the values equal to zero.
for(int i=0;i<2;i++)
  {
    eggs[i]=0;
  }
for(int i=0;i<14;i++)
  {
    larvae[i]=0;
  }
for(int i=0;i<4;i++)
  {
    pupa[i]=0;
  }
for(int i=0;i<37;i++)
  {
    mosquito[i]=0;
  }

double temp=0;

//This is the main loop
for(int doy=0;doy<366;doy++)
  {
  if(county[doy].low>50)  //If the temperature is warm enough the mosquitoes breed
  {
// The life span of the mosquito very important
1.    mosquitotime=int(.0121*county[doy].low*county[doy].low-2.46*county[doy].low+
    129.42+.5);

pupatime=int(-0.0526*county[doy].low+5.6842+.5);
larvaetime=int(-0.1579*county[doy].low+19.053+.5);

//The mosquitoes age
for(int a=36;a>0;a--)
  {
    mosquito[a]=mosquito[a-1];
  }
//the mosquitoes that are too old die off
for(int a=36;a>mosquitotime;a--)
  {
    mosquito[a]=0;
  }
```

```
  //Totalp is the total number of pupa that are too old they become mosquitoes
  double totalp=0;
  //Figures out how many old pupa thera are
  for(int a=3;a>pupatime;a--)
    {
      totalp=pupa[a]+totalp;
      pupa[a]=0;
    }
  //old pupa and pupa that are at the end of pupa life become mosquitoes
   if(start==0)
     {
          mosquito[0]=hibmosquito; // The hibernating mosquitoes become active
          start=1;
    }
else
{
   mosquito[0]=(pupa[int(pupatime-1)]+totalp)*smrate;
}
//pupa age
for(int a=int(pupatime)-1;a>0;a--)
    {
      pupa[a]=(pupa[a-1]);
    }

  //Totall is for all of the larvae that are too old
  double totall=0;
  //All larvae are add up
  for(int a=int(larvaetime);a<13;a++)
    {
      totall=larvae[a]+totall;
      larvae[a]=0;
    }
  temp=larvae[int(larvaetime)-1]+totall;
  pupa[0]=((temp)*sprate);
  for(int a=int(larvaetime)-1;a>0;a--)
    {
      larvae[a]=larvae[a-1]*1.0;
    }
  larvae[0]=(eggs[1]*slrate);
//egg advancing
  eggs[1]=eggs[0];
  eggs[0]=(mosquito[5]+mosquito[20]+mosquito[35])*120;
  done=1;
 }
  else
   {
```

```
  if(done==0)//if spring
   {
     for(int i=0;i<2;i++)
      {
           eggs[i]=0;
     }
   for(int i=0;i<14;i++)
     {
           larvae[i]=0;
     }
   for(int i=0;i<4;i++)
     {
           pupa[i]=0;
     }
   for(int i=1;i<36 ;i++)
     {
           mosquito[i]=int(mosquito[i]*hrate+.5);
     }
 }
 else//if fall
   {
 for(int i=0;i<2;i++)
     {
        eggs[i]=0;
     }
for(int a=36;a>0;a--)
{
 mosquito[a]=int(mosquito[a-1]*hrate+.5);
}
//the mosquitoes that are too old die off
 for(int a=36;a>mosquitotime;a--)
  {
   mosquito[a]=0;
  }

//Totalp is the total number of pupa that are too old they become mosquitoes
//remove pupa
for(int a=3;a>0;a--)
  {
    pupa[a]=0;
  }

 //Totall is for all of the larvae that are too old
  mosquito[0]=0;
  //larvae are removed
  for(int a=0;a<13;a++)
```

```
    {
  larvae[a]=0;
    }
     }
  }
 double sum=0;
 for(int i=0;i<37;i++){
  sum=mosquito[i]+sum;//total mosquito population is figured out
  }
  outfile.setf(ios::fixed,ios::floatfield);
  outfile.setf(ios::showpoint);
  outfile.precision(0);
  outfile <<doy<<"\t"<<county[doy].month<<"/"<<county[doy].day<<"\t";
  outfile << sum << "\t" << mosquito[0]<<"\t" <<mosquito[15]<<"\t"<<mosquito[30];
  outfile<<endl;
  }
  return 0;
}
```

Appendix B – Sample Input Data

ALBUQUERQUE WSFO AIRPOR, NEW MEXICO

30 Year Daily Temperature and Precipitation Summary

STATION 290234 AVERAGES FROM AVAILABLE YEARS IN PERIOD 1971 TO 2000 .

DOY	MON	DY	TMAX	#YRS	TMIN	#YRS	PRECIP	#YRS	SD MAX	SD MIN
1	1	1	45.9	30.	22.8	30.	0.017	30.	8.741	7.806
2	1	2	46.0	30.	22.9	30.	0.017	30.	8.750	7.827
3	1	3	46.0	30.	22.9	30.	0.018	30.	8.830	7.863
4	1	4	46.1	30.	23.0	30.	0.018	30.	8.902	7.928
5	1	5	46.2	30.	23.0	30.	0.018	30.	8.966	7.969
6	1	6	46.3	30.	23.1	30.	0.018	30.	8.986	7.946
7	1	7	46.3	30.	23.2	30.	0.018	30.	9.019	7.905
8	1	8	46.3	30.	23.3	30.	0.018	30.	9.023	7.852
9	1	9	46.5	30.	23.3	30.	0.018	30.	9.020	7.811
10	1	10	46.6	30.	23.3	30.	0.017	30.	8.979	7.770
11	1	11	46.8	30.	23.4	30.	0.017	30.	8.907	7.688
12	1	12	47.0	30.	23.5	30.	0.016	30.	8.890	7.629
13	1	13	47.1	30.	23.5	30.	0.016	30.	8.800	7.553
14	1	14	47.2	30.	23.6	30.	0.015	30.	8.748	7.521
15	1	15	47.4	30.	23.6	30.	0.015	30.	8.746	7.434
16	1	16	47.7	30.	23.7	30.	0.014	30.	8.689	7.405
17	1	17	47.9	30.	23.8	30.	0.016	30.	8.677	7.441
18	1	18	48.2	30.	24.0	30.	0.015	30.	8.692	7.414
19	1	19	48.4	30.	24.1	30.	0.015	30.	8.659	7.345
20	1	20	48.6	30.	24.3	30.	0.015	30.	8.550	7.198
21	1	21	48.8	30.	24.4	30.	0.015	30.	8.474	7.108
22	1	22	49.1	30.	24.5	30.	0.014	30.	8.374	6.998
23	1	23	49.2	30.	24.6	30.	0.014	30.	8.421	6.943
24	1	24	49.4	30.	24.8	30.	0.014	30.	8.471	6.919
25	1	25	49.5	30.	24.8	30.	0.015	30.	8.549	6.888
26	1	26	49.7	30.	25.0	30.	0.015	30.	8.601	6.885
27	1	27	49.9	30.	25.1	30.	0.015	30.	8.548	6.810
28	1	28	50.1	30.	25.2	30.	0.015	30.	8.466	6.819
29	1	29	50.4	30.	25.4	30.	0.014	30.	8.385	6.775
30	1	30	50.6	30.	25.5	30.	0.014	30.	8.367	6.725
31	1	31	50.9	30.	25.8	30.	0.015	30.	8.349	6.676
32	2	1	51.1	30.	25.9	30.	0.015	30.	8.312	6.697
33	2	2	51.3	30.	26.0	30.	0.014	30.	8.294	6.646
34	2	3	51.5	30.	26.3	30.	0.014	30.	8.259	6.596
35	2	4	51.9	30.	26.4	30.	0.014	30.	8.214	6.593
36	2	5	52.2	30.	26.6	30.	0.014	30.	8.212	6.535
37	2	6	52.5	30.	26.8	30.	0.014	30.	8.268	6.581
38	2	7	52.7	30.	27.0	30.	0.015	30.	8.331	6.644
39	2	8	52.9	30.	27.2	30.	0.016	30.	8.444	6.707
40	2	9	53.1	30.	27.3	30.	0.016	30.	8.527	6.726
41	2	10	53.4	30.	27.4	30.	0.015	30.	8.539	6.734
42	2	11	53.6	30.	27.6	30.	0.015	30.	8.635	6.718

43	2	12	53.9	30.	27.8	30.	0.016	30.	8.738	6.701
44	2	13	54.1	30.	27.9	30.	0.016	30.	8.814	6.766
45	2	14	54.4	30.	28.1	30.	0.017	30.	8.858	6.786
46	2	15	54.8	30.	28.3	30.	0.015	30.	8.836	6.651
47	2	16	55.1	30.	28.5	30.	0.015	30.	8.783	6.621
48	2	17	55.4	30.	28.7	30.	0.015	30.	8.713	6.567
49	2	18	55.7	30.	28.9	30.	0.016	30.	8.718	6.562
50	2	19	56.0	30.	29.1	30.	0.016	30.	8.760	6.535
51	2	20	56.3	30.	29.3	30.	0.016	30.	8.810	6.597
52	2	21	56.6	30.	29.5	30.	0.015	30.	8.750	6.592
53	2	22	57.0	30.	29.7	30.	0.015	30.	8.699	6.610
54	2	23	57.3	30.	29.9	30.	0.015	30.	8.665	6.571
55	2	24	57.7	30.	30.1	30.	0.014	30.	8.584	6.490
56	2	25	58.0	30.	30.4	30.	0.015	30.	8.547	6.455
57	2	26	58.3	30.	30.7	30.	0.015	30.	8.588	6.434
58	2	27	58.5	30.	30.9	30.	0.017	30.	8.732	6.422
59	2	28	58.7	30.	31.0	30.	0.017	30.	8.816	6.430
60	2	29	58.9	8.	31.1	8.	0.016	8.	8.816	6.441
61	3	1	59.1	30.	31.2	30.	0.017	30.	8.821	6.337
62	3	2	59.4	30.	31.4	30.	0.017	30.	8.797	6.289
63	3	3	59.7	30.	31.5	30.	0.017	30.	8.808	6.291
64	3	4	59.9	30.	31.6	30.	0.018	30.	8.876	6.293
65	3	5	60.2	30.	31.7	30.	0.018	30.	8.833	6.327
66	3	6	60.4	30.	31.9	30.	0.018	30.	8.739	6.273
67	3	7	60.8	30.	32.0	30.	0.018	30.	8.683	6.247
68	3	8	61.2	30.	32.3	30.	0.017	30.	8.594	6.202
69	3	9	61.5	30.	32.5	30.	0.017	30.	8.582	6.161
70	3	10	61.8	30.	32.8	30.	0.018	30.	8.543	6.169
71	3	11	62.1	30.	33.0	30.	0.017	30.	8.548	6.150
72	3	12	62.3	30.	33.2	30.	0.018	30.	8.548	6.171
73	3	13	62.5	30.	33.4	30.	0.019	30.	8.597	6.166
74	3	14	62.5	30.	33.6	30.	0.018	30.	8.627	6.120
75	3	15	62.4	30.	33.7	30.	0.019	30.	8.691	6.203
76	3	16	62.5	30.	33.7	30.	0.020	30.	8.755	6.244
77	3	17	62.7	30.	33.8	30.	0.020	30.	8.755	6.251
78	3	18	62.9	30.	33.9	30.	0.020	30.	8.766	6.248
79	3	19	63.0	30.	34.0	30.	0.021	30.	8.783	6.255
80	3	20	63.2	30.	34.1	30.	0.021	30.	8.807	6.176
81	3	21	63.4	30.	34.3	30.	0.022	30.	8.870	6.164
82	3	22	63.5	30.	34.5	30.	0.022	30.	8.955	6.139
83	3	23	63.8	30.	34.7	30.	0.021	30.	9.003	6.143
84	3	24	64.1	30.	34.9	30.	0.021	30.	9.089	6.204
85	3	25	64.3	30.	35.1	30.	0.019	30.	9.112	6.309
86	3	26	64.6	30.	35.2	30.	0.019	30.	9.061	6.374
87	3	27	64.9	30.	35.4	30.	0.018	30.	9.063	6.383
88	3	28	65.2	30.	35.7	30.	0.017	30.	9.085	6.366
89	3	29	65.5	30.	35.9	30.	0.018	30.	9.165	6.400
90	3	30	65.7	30.	36.1	30.	0.017	30.	9.224	6.506
91	3	31	65.9	30.	36.3	30.	0.016	30.	9.207	6.574
92	4	1	66.2	30.	36.5	30.	0.016	30.	9.168	6.555
93	4	2	66.5	30.	36.8	30.	0.017	30.	9.135	6.560
94	4	3	66.8	30.	37.0	30.	0.016	30.	9.217	6.529
95	4	4	67.1	30.	37.3	30.	0.017	30.	9.242	6.599
96	4	5	67.2	30.	37.6	30.	0.017	30.	9.257	6.593
97	4	6	67.4	30.	37.7	30.	0.018	30.	9.331	6.605
98	4	7	67.6	30.	37.9	30.	0.017	30.	9.328	6.627
99	4	8	67.8	30.	38.2	30.	0.018	30.	9.390	6.622

100	4	9	68.0	30.	38.4	30.	0.018	30.	9.285	6.667
101	4	10	68.3	30.	38.7	30.	0.018	30.	9.299	6.674
102	4	11	68.7	30.	38.9	30.	0.018	30.	9.244	6.660
103	4	12	69.1	30.	39.2	30.	0.019	30.	9.237	6.666
104	4	13	69.6	30.	39.5	30.	0.017	30.	9.168	6.635
105	4	14	70.1	30.	39.9	30.	0.018	30.	9.065	6.643
106	4	15	70.4	30.	40.3	30.	0.017	30.	9.046	6.663
107	4	16	70.8	30.	40.6	30.	0.017	30.	8.958	6.657
108	4	17	71.2	30.	41.0	30.	0.016	30.	8.885	6.654
109	4	18	71.5	30.	41.3	30.	0.016	30.	8.904	6.680
110	4	19	71.9	30.	41.7	30.	0.016	30.	8.809	6.661
111	4	20	72.3	30.	42.0	30.	0.016	30.	8.682	6.601
112	4	21	72.5	30.	42.3	30.	0.017	30.	8.610	6.582
113	4	22	72.7	30.	42.6	30.	0.018	30.	8.632	6.598
114	4	23	72.9	30.	42.8	30.	0.018	30.	8.598	6.548
115	4	24	73.1	30.	43.1	30.	0.018	30.	8.636	6.491
116	4	25	73.4	30.	43.3	30.	0.018	30.	8.558	6.534
117	4	26	73.7	30.	43.6	30.	0.018	30.	8.474	6.514
118	4	27	74.0	30.	43.9	30.	0.018	30.	8.318	6.465
119	4	28	74.3	30.	44.2	30.	0.018	30.	8.220	6.402
120	4	29	74.7	30.	44.5	30.	0.018	30.	8.219	6.355
121	4	30	75.0	30.	44.9	30.	0.018	30.	8.189	6.370
122	5	1	75.3	30.	45.2	30.	0.017	30.	8.158	6.388
123	5	2	75.6	30.	45.6	30.	0.018	30.	7.992	6.396
124	5	3	75.8	30.	45.9	30.	0.018	30.	7.973	6.319
125	5	4	76.2	30.	46.1	30.	0.017	30.	7.874	6.295
126	5	5	76.5	30.	46.6	30.	0.017	30.	7.789	6.303
127	5	6	76.8	30.	46.9	30.	0.019	30.	7.768	6.227
128	5	7	77.1	30.	47.1	30.	0.020	30.	7.713	6.204
129	5	8	77.4	30.	47.4	30.	0.021	30.	7.741	6.183
130	5	9	77.7	30.	47.6	30.	0.020	30.	7.656	6.175
131	5	10	78.0	30.	47.9	30.	0.019	30.	7.576	6.154
132	5	11	78.3	30.	48.3	30.	0.020	30.	7.418	6.139
133	5	12	78.6	30.	48.6	30.	0.020	30.	7.383	6.095
134	5	13	78.9	30.	48.9	30.	0.019	30.	7.355	6.016
135	5	14	79.2	30.	49.2	30.	0.019	30.	7.315	5.971
136	5	15	79.5	30.	49.5	30.	0.020	30.	7.338	5.937
137	5	16	79.8	30.	49.7	30.	0.020	30.	7.390	5.945
138	5	17	80.1	30.	50.0	30.	0.019	30.	7.260	5.925
139	5	18	80.5	30.	50.3	30.	0.019	30.	7.254	5.898
140	5	19	80.7	30.	50.6	30.	0.019	30.	7.205	5.921
141	5	20	81.1	30.	50.8	30.	0.019	30.	7.093	5.943
142	5	21	81.5	30.	51.1	30.	0.018	30.	6.935	5.891
143	5	22	81.8	30.	51.5	30.	0.018	30.	6.896	5.852
144	5	23	82.2	30.	51.8	30.	0.018	30.	6.788	5.827
145	5	24	82.5	30.	52.2	30.	0.018	30.	6.735	5.776
146	5	25	82.7	30.	52.5	30.	0.019	30.	6.765	5.775
147	5	26	83.0	30.	52.8	30.	0.019	30.	6.765	5.762
148	5	27	83.3	30.	53.1	30.	0.019	30.	6.729	5.714
149	5	28	83.7	30.	53.4	30.	0.019	30.	6.662	5.686
150	5	29	83.9	30.	53.7	30.	0.019	30.	6.615	5.652
151	5	30	84.2	30.	53.9	30.	0.020	30.	6.559	5.549
152	5	31	84.5	30.	54.2	30.	0.019	30.	6.603	5.483
153	6	1	84.9	30.	54.5	30.	0.018	30.	6.529	5.447
154	6	2	85.2	30.	54.8	30.	0.018	30.	6.495	5.388
155	6	3	85.6	30.	55.1	30.	0.019	30.	6.407	5.320
156	6	4	86.1	30.	55.4	30.	0.017	30.	6.282	5.335

157	6	5	86.4	30.	55.8	30.	0.016	30.	6.213	5.297
158	6	6	86.8	30.	56.2	30.	0.015	30.	6.127	5.274
159	6	7	87.2	30.	56.5	30.	0.015	30.	6.035	5.240
160	6	8	87.6	30.	56.8	30.	0.015	30.	5.982	5.197
161	6	9	87.9	30.	57.1	30.	0.014	30.	5.957	5.161
162	6	10	88.3	30.	57.5	30.	0.016	30.	5.961	5.138
163	6	11	88.7	30.	57.8	30.	0.016	30.	6.004	5.158
164	6	12	89.0	30.	58.1	30.	0.017	30.	6.042	5.119
165	6	13	89.4	30.	58.4	30.	0.018	30.	6.051	5.124
166	6	14	89.8	30.	58.8	30.	0.019	30.	5.975	5.055
167	6	15	90.1	30.	59.2	30.	0.021	30.	6.004	5.000
168	6	16	90.4	30.	59.6	30.	0.022	30.	5.984	4.923
169	6	17	90.7	30.	59.9	30.	0.022	30.	5.996	4.851
170	6	18	91.0	30.	60.2	30.	0.022	30.	5.986	4.818
171	6	19	91.2	30.	60.5	30.	0.023	30.	5.964	4.808
172	6	20	91.4	30.	60.8	30.	0.025	30.	5.888	4.756
173	6	21	91.7	30.	61.1	30.	0.025	30.	5.879	4.711
174	6	22	91.9	30.	61.4	30.	0.026	30.	5.829	4.669
175	6	23	92.2	30.	61.6	30.	0.025	30.	5.688	4.602
176	6	24	92.4	30.	61.9	30.	0.027	30.	5.656	4.529
177	6	25	92.5	30.	62.2	30.	0.029	30.	5.624	4.493
178	6	26	92.7	30.	62.4	30.	0.029	30.	5.596	4.429
179	6	27	92.8	30.	62.7	30.	0.030	30.	5.573	4.382
180	6	28	92.9	30.	62.9	30.	0.029	30.	5.535	4.357
181	6	29	93.0	30.	63.1	30.	0.030	30.	5.508	4.362
182	6	30	93.1	30.	63.3	30.	0.032	30.	5.534	4.329
183	7	1	93.1	30.	63.5	30.	0.034	30.	5.548	4.310
184	7	2	93.1	30.	63.7	30.	0.034	30.	5.554	4.261
185	7	3	93.1	30.	63.9	30.	0.035	30.	5.592	4.201
186	7	4	93.1	30.	64.0	30.	0.035	30.	5.608	4.156
187	7	5	93.1	30.	64.1	30.	0.036	30.	5.602	4.104
188	7	6	93.0	30.	64.2	30.	0.037	30.	5.620	4.045
189	7	7	93.0	30.	64.3	30.	0.040	30.	5.597	3.983
190	7	8	92.9	30.	64.4	30.	0.040	30.	5.600	3.929
191	7	9	92.8	30.	64.5	30.	0.039	30.	5.517	3.878
192	7	10	92.8	30.	64.5	30.	0.041	30.	5.465	3.790
193	7	11	92.7	30.	64.6	30.	0.041	30.	5.445	3.738
194	7	12	92.6	30.	64.7	30.	0.040	30.	5.413	3.669
195	7	13	92.5	30.	64.7	30.	0.040	30.	5.374	3.633
196	7	14	92.4	30.	64.7	30.	0.039	30.	5.352	3.602
197	7	15	92.3	30.	64.7	30.	0.039	30.	5.339	3.620
198	7	16	92.2	30.	64.7	30.	0.039	30.	5.341	3.616
199	7	17	92.2	30.	64.7	30.	0.043	30.	5.381	3.567
200	7	18	92.1	30.	64.7	30.	0.043	30.	5.404	3.521
201	7	19	92.0	30.	64.7	30.	0.044	30.	5.457	3.486
202	7	20	91.9	30.	64.7	30.	0.046	30.	5.537	3.464
203	7	21	91.7	30.	64.7	30.	0.046	30.	5.580	3.460
204	7	22	91.6	30.	64.7	30.	0.047	30.	5.624	3.486
205	7	23	91.5	30.	64.7	30.	0.046	30.	5.656	3.507
206	7	24	91.5	30.	64.7	30.	0.045	30.	5.648	3.520
207	7	25	91.4	30.	64.6	30.	0.045	30.	5.651	3.537
208	7	26	91.3	30.	64.5	30.	0.049	30.	5.612	3.529
209	7	27	91.2	30.	64.5	30.	0.051	30.	5.601	3.530
210	7	28	91.1	30.	64.5	30.	0.051	30.	5.552	3.478
211	7	29	91.0	30.	64.4	30.	0.051	30.	5.515	3.445
212	7	30	90.9	30.	64.4	30.	0.050	30.	5.492	3.439
213	7	31	90.8	30.	64.3	30.	0.053	30.	5.464	3.426

214	8	1	90.7	30.	64.2	30.	0.054	30.	5.429	3.417
215	8	2	90.6	30.	64.2	30.	0.054	30.	5.362	3.411
216	8	3	90.5	30.	64.2	30.	0.055	30.	5.374	3.389
217	8	4	90.4	30.	64.1	30.	0.054	30.	5.370	3.388
218	8	5	90.3	30.	64.1	30.	0.054	30.	5.359	3.391
219	8	6	90.2	30.	64.0	30.	0.054	30.	5.340	3.382
220	8	7	90.1	30.	64.0	30.	0.054	30.	5.284	3.397
221	8	8	90.0	30.	64.0	30.	0.054	30.	5.198	3.388
222	8	9	89.9	30.	63.9	30.	0.055	30.	5.134	3.385
223	8	10	89.8	30.	63.8	30.	0.056	30.	5.105	3.402
224	8	11	89.6	30.	63.7	30.	0.059	30.	5.104	3.409
225	8	12	89.5	30.	63.6	30.	0.058	30.	5.080	3.391
226	8	13	89.3	30.	63.5	30.	0.060	30.	5.130	3.371
227	8	14	89.2	30.	63.4	30.	0.059	30.	5.144	3.414
228	8	15	89.1	30.	63.3	30.	0.058	30.	5.151	3.431
229	8	16	89.0	30.	63.2	30.	0.058	30.	5.124	3.426
230	8	17	88.9	30.	63.1	30.	0.055	30.	5.064	3.462
231	8	18	88.8	30.	63.1	30.	0.054	30.	4.990	3.466
232	8	19	88.7	30.	62.9	30.	0.053	30.	4.987	3.473
233	8	20	88.6	30.	62.8	30.	0.053	30.	4.995	3.463
234	8	21	88.5	30.	62.7	30.	0.053	30.	5.003	3.449
235	8	22	88.3	30.	62.6	30.	0.052	30.	5.026	3.492
236	8	23	88.2	30.	62.4	30.	0.052	30.	5.037	3.503
237	8	24	88.0	30.	62.3	30.	0.050	30.	5.041	3.486
238	8	25	87.9	30.	62.1	30.	0.048	30.	5.045	3.471
239	8	26	87.8	30.	62.0	30.	0.049	30.	5.128	3.504
240	8	27	87.6	30.	61.8	30.	0.048	30.	5.173	3.535
241	8	28	87.5	30.	61.7	30.	0.050	30.	5.202	3.557
242	8	29	87.3	30.	61.5	30.	0.046	30.	5.321	3.580
243	8	30	87.0	30.	61.3	30.	0.045	30.	5.388	3.664
244	8	31	86.7	30.	61.0	30.	0.047	30.	5.522	3.722
245	9	1	86.4	30.	60.8	30.	0.046	30.	5.568	3.815
246	9	2	86.2	30.	60.5	30.	0.045	30.	5.552	3.846
247	9	3	86.0	30.	60.2	30.	0.044	30.	5.617	3.896
248	9	4	85.7	30.	59.9	30.	0.044	30.	5.819	3.975
249	9	5	85.4	30.	59.6	30.	0.045	30.	5.962	4.039
250	9	6	85.1	30.	59.3	30.	0.045	30.	6.062	4.087
251	9	7	84.7	30.	58.9	30.	0.046	30.	6.165	4.139
252	9	8	84.4	30.	58.6	30.	0.045	30.	6.245	4.184
253	9	9	84.1	30.	58.3	30.	0.042	30.	6.339	4.234
254	9	10	83.8	30.	57.9	30.	0.042	30.	6.391	4.285
255	9	11	83.5	30.	57.6	30.	0.039	30.	6.335	4.348
256	9	12	83.2	30.	57.2	30.	0.040	30.	6.378	4.335
257	9	13	83.0	30.	56.9	30.	0.037	30.	6.393	4.352
258	9	14	82.6	30.	56.5	30.	0.037	30.	6.460	4.423
259	9	15	82.3	30.	56.1	30.	0.037	30.	6.532	4.490
260	9	16	82.0	30.	55.8	30.	0.036	30.	6.588	4.570
261	9	17	81.7	30.	55.4	30.	0.036	30.	6.604	4.578
262	9	18	81.4	30.	55.0	30.	0.037	30.	6.636	4.616
263	9	19	81.1	30.	54.6	30.	0.036	30.	6.659	4.659
264	9	20	80.8	30.	54.3	30.	0.037	30.	6.688	4.636
265	9	21	80.4	30.	53.9	30.	0.037	30.	6.767	4.654
266	9	22	80.0	30.	53.5	30.	0.037	30.	6.852	4.728
267	9	23	79.6	30.	53.1	30.	0.037	30.	6.964	4.793
268	9	24	79.2	30.	52.7	30.	0.035	30.	7.012	4.848
269	9	25	78.8	30.	52.2	30.	0.034	30.	7.064	4.917
270	9	26	78.5	30.	51.7	30.	0.034	30.	7.132	4.992

271	9	27	78.3	30.	51.3	30.	0.035	30.	7.146	5.047
272	9	28	78.0	30.	51.0	30.	0.034	30.	7.297	5.074
273	9	29	77.7	30.	50.6	30.	0.033	30.	7.295	5.130
274	9	30	77.4	30.	50.3	30.	0.032	30.	7.316	5.137
275	10	1	77.0	30.	49.8	30.	0.034	30.	7.407	5.164
276	10	2	76.6	30.	49.4	30.	0.034	30.	7.495	5.200
277	10	3	76.3	30.	49.0	30.	0.033	30.	7.474	5.230
278	10	4	75.9	30.	48.6	30.	0.032	30.	7.521	5.268
279	10	5	75.6	30.	48.2	30.	0.030	30.	7.591	5.345
280	10	6	75.2	30.	47.9	30.	0.029	30.	7.624	5.389
281	10	7	74.8	30.	47.5	30.	0.029	30.	7.671	5.428
282	10	8	74.5	30.	47.1	30.	0.029	30.	7.654	5.482
283	10	9	74.0	30.	46.7	30.	0.030	30.	7.682	5.509
284	10	10	73.6	30.	46.3	30.	0.031	30.	7.758	5.540
285	10	11	73.2	30.	45.9	30.	0.031	30.	7.791	5.603
286	10	12	72.7	30.	45.5	30.	0.032	30.	7.885	5.657
287	10	13	72.2	30.	45.1	30.	0.032	30.	7.982	5.642
288	10	14	71.8	30.	44.8	30.	0.033	30.	8.070	5.633
289	10	15	71.3	30.	44.3	30.	0.033	30.	8.098	5.675
290	10	16	70.7	30.	43.8	30.	0.033	30.	8.197	5.784
291	10	17	70.2	30.	43.3	30.	0.032	30.	8.299	5.865
292	10	18	69.6	30.	42.9	30.	0.031	30.	8.331	5.926
293	10	19	69.1	30.	42.4	30.	0.031	30.	8.343	6.007
294	10	20	68.6	30.	41.9	30.	0.031	30.	8.355	6.075
295	10	21	68.2	30.	41.5	30.	0.030	30.	8.407	6.096
296	10	22	67.8	30.	41.1	30.	0.029	30.	8.352	6.118
297	10	23	67.5	30.	40.7	30.	0.029	30.	8.324	6.088
298	10	24	67.0	30.	40.3	30.	0.029	30.	8.393	6.045
299	10	25	66.6	30.	39.9	30.	0.028	30.	8.417	6.000
300	10	26	66.1	30.	39.6	30.	0.028	30.	8.406	6.009
301	10	27	65.6	30.	39.1	30.	0.026	30.	8.254	5.982
302	10	28	65.2	30.	38.7	30.	0.028	30.	8.278	5.945
303	10	29	64.7	30.	38.3	30.	0.028	30.	8.368	5.965
304	10	30	64.3	30.	37.9	30.	0.027	30.	8.476	5.997
305	10	31	63.9	30.	37.6	30.	0.026	30.	8.451	6.031
306	11	1	63.5	30.	37.2	30.	0.028	30.	8.432	6.037
307	11	2	63.0	30.	36.8	30.	0.028	30.	8.422	6.017
308	11	3	62.6	30.	36.4	30.	0.029	30.	8.406	5.944
309	11	4	62.2	30.	36.1	30.	0.028	30.	8.379	5.952
310	11	5	61.8	30.	35.7	30.	0.026	30.	8.358	5.941
311	11	6	61.4	30.	35.3	30.	0.026	30.	8.386	5.945
312	11	7	61.0	30.	34.9	30.	0.025	30.	8.361	5.931
313	11	8	60.6	30.	34.5	30.	0.024	30.	8.364	5.974
314	11	9	60.1	30.	34.1	30.	0.024	30.	8.380	5.963
315	11	10	59.7	30.	33.8	30.	0.024	30.	8.371	5.932
316	11	11	59.3	30.	33.4	30.	0.023	30.	8.351	5.950
317	11	12	58.8	30.	33.0	30.	0.022	30.	8.405	6.008
318	11	13	58.3	30.	32.6	30.	0.022	30.	8.461	6.008
319	11	14	57.8	30.	32.2	30.	0.021	30.	8.463	6.067
320	11	15	57.3	30.	31.9	30.	0.021	30.	8.391	6.126
321	11	16	56.9	30.	31.5	30.	0.021	30.	8.392	6.137
322	11	17	56.5	30.	31.1	30.	0.020	30.	8.424	6.136
323	11	18	56.2	30.	30.8	30.	0.020	30.	8.409	6.124
324	11	19	55.9	30.	30.5	30.	0.019	30.	8.388	6.108
325	11	20	55.5	30.	30.2	30.	0.020	30.	8.432	6.096
326	11	21	55.1	30.	29.9	30.	0.020	30.	8.465	6.169
327	11	22	54.7	30.	29.6	30.	0.020	30.	8.418	6.244

328	11	23	54.3	30.	29.3	30.	0.019	30.	8.428	6.303
329	11	24	53.9	30.	29.0	30.	0.020	30.	8.522	6.346
330	11	25	53.5	30.	28.7	30.	0.020	30.	8.604	6.348
331	11	26	53.1	30.	28.4	30.	0.018	30.	8.649	6.355
332	11	27	52.8	30.	28.1	30.	0.018	30.	8.667	6.415
333	11	28	52.4	30.	27.8	30.	0.018	30.	8.590	6.453
334	11	29	52.0	30.	27.5	30.	0.018	30.	8.586	6.460
335	11	30	51.6	30.	27.2	30.	0.017	30.	8.556	6.452
336	12	1	51.3	30.	26.9	30.	0.016	30.	8.539	6.442
337	12	2	50.9	30.	26.7	30.	0.015	30.	8.525	6.512
338	12	3	50.6	30.	26.3	30.	0.015	30.	8.508	6.514
339	12	4	50.3	30.	26.1	30.	0.015	30.	8.513	6.538
340	12	5	50.1	30.	25.9	30.	0.015	30.	8.483	6.502
341	12	6	49.8	30.	25.7	30.	0.015	30.	8.493	6.536
342	12	7	49.5	30.	25.5	30.	0.016	30.	8.506	6.507
343	12	8	49.2	30.	25.3	30.	0.014	30.	8.495	6.543
344	12	9	49.0	30.	25.1	30.	0.014	30.	8.482	6.671
345	12	10	48.7	30.	24.8	30.	0.014	30.	8.462	6.741
346	12	11	48.5	30.	24.6	30.	0.013	30.	8.387	6.733
347	12	12	48.3	30.	24.5	30.	0.014	30.	8.369	6.722
348	12	13	48.3	30.	24.4	30.	0.015	30.	8.372	6.725
349	12	14	48.2	30.	24.3	30.	0.015	30.	8.414	6.693
350	12	15	48.1	30.	24.3	30.	0.016	30.	8.454	6.742
351	12	16	47.9	30.	24.2	30.	0.016	30.	8.448	6.753
352	12	17	47.7	30.	24.1	30.	0.016	30.	8.432	6.816
353	12	18	47.4	30.	24.0	30.	0.016	30.	8.494	6.901
354	12	19	47.1	30.	23.9	30.	0.016	30.	8.558	6.997
355	12	20	46.8	30.	23.6	30.	0.016	30.	8.586	7.037
356	12	21	46.5	30.	23.4	30.	0.016	30.	8.669	7.151
357	12	22	46.3	30.	23.3	30.	0.017	30.	8.749	7.289
358	12	23	46.2	30.	23.2	30.	0.016	30.	8.716	7.385
359	12	24	46.0	30.	23.1	30.	0.017	30.	8.743	7.536
360	12	25	45.9	30.	23.0	30.	0.017	30.	8.695	7.644
361	12	26	45.8	30.	22.9	30.	0.017	30.	8.635	7.634
362	12	27	45.8	30.	22.8	30.	0.016	30.	8.614	7.663
363	12	28	45.8	30.	22.8	30.	0.017	30.	8.602	7.671
364	12	29	45.8	30.	22.7	30.	0.017	30.	8.705	7.738
365	12	30	45.8	30.	22.8	30.	0.017	30.	8.748	7.759
366	12	31	45.9	30.	22.8	30.	0.017	30.	8.756	7.762

Appendix C – Mosquito Model Output by County

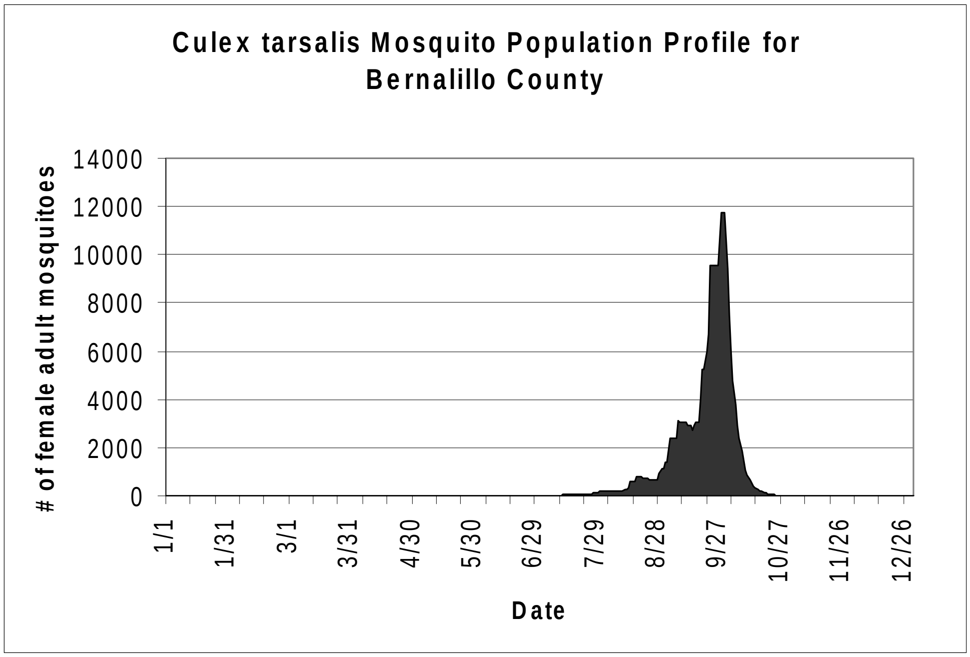
For each county in the New Mexico, one weather station was selected from the Western Regional Climate Center, from which the daily summary data for a 30-year period was obtained. The following pages summarize the output of the mosquito population model for each of these counties.

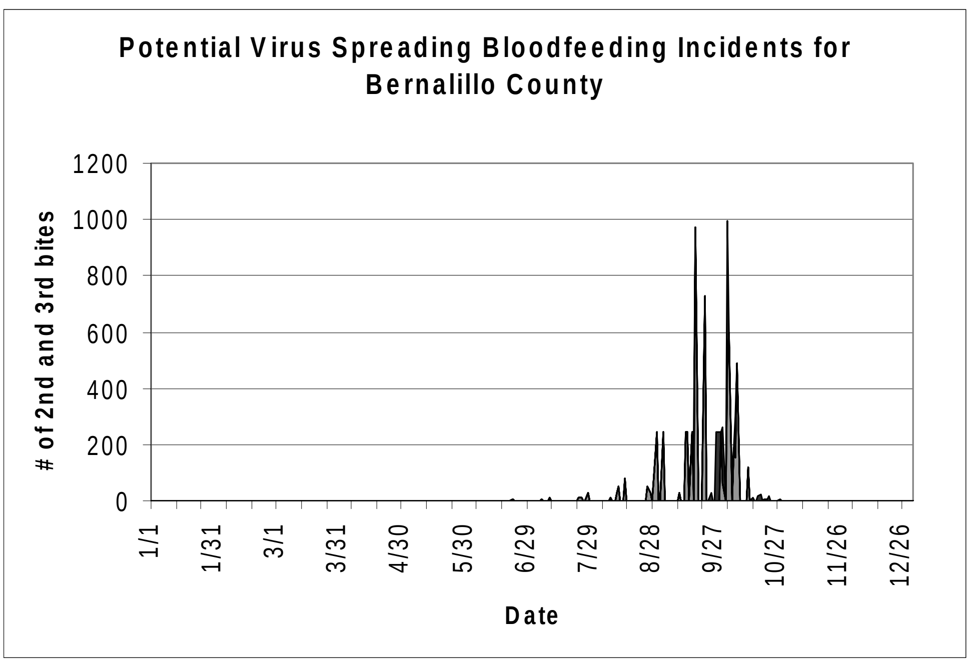
County	Weather Station	Years
Bernalillo	ALBUQUERQUE WSFO AIRPOR	1971 to 2000
Catron	HOOD RANGER STN	1971 to 2000
Chaves	ROSWELL WSO AIRPORT	1971 to 2000
Cibola	GRANTS AIRPORTs	1971 to 2000
Colfax	RATON KRTN RADIO	1971 to 2000
Curry	CLOVIS	1971 to 2000
De Baca	FORT SUMNER	1971 to 2000
Doña Ana	STATE UNIVERSITY	1971 to 2000
Eddy	CARLSBAD	1971 to 2000
Grant	SILVER CITY	1961 to 1990
Guadalupe	SANTA ROSA	1971 to 2000
Harding	MOSQUERO	1971 to 2000
Hidalgo	LORDSBURG 4 SE	1971 to 2000
Lea	LOVINGTON 2 WNW	1961 to 1990
Lincoln	CARRIZOZO	1971 to 2000
Los Alamos	LOS ALAMOS	1971 to 2000
Luna	DEMING	1971 to 2000
McKinley	GALLUP FAA AP	1971 to 2000
Mora	GASCON	1971 to 2000
Otero	ALAMOGORDO	1971 to 2000
Quay	TUCUMCARI FAA AIRPORT	1971 to 2000
Rio Arriba	EL VADO DAM	1971 to 2000
Roosevelt	PORTALES	1971 to 2000
San Juan	FARMINGTON 3 NE	1971 to 2000
San Miguel	LAS VEGAS 2 NW	1971 to 2000
Sandoval	BERNALILLO 1 NNE	1971 to 2000
Santa Fe	SANTA FE 2	1971 to 2000
Sierra	TRUTH OR CONSEQUENCES	1971 to 2000
Socorro	SOCORRO	1971 to 2000
Taos	TAOS	1971 to 2000
Torrance	ESTANCIA	1971 to 2000
Union	CLAYTON WSO AIRPORT	1971 to 2000
Valencia	LOS LUNAS 3 SSW	1971 to 2000

Bernalillo County

Mosquito Season: May 18 to November 3

VBI: 7378

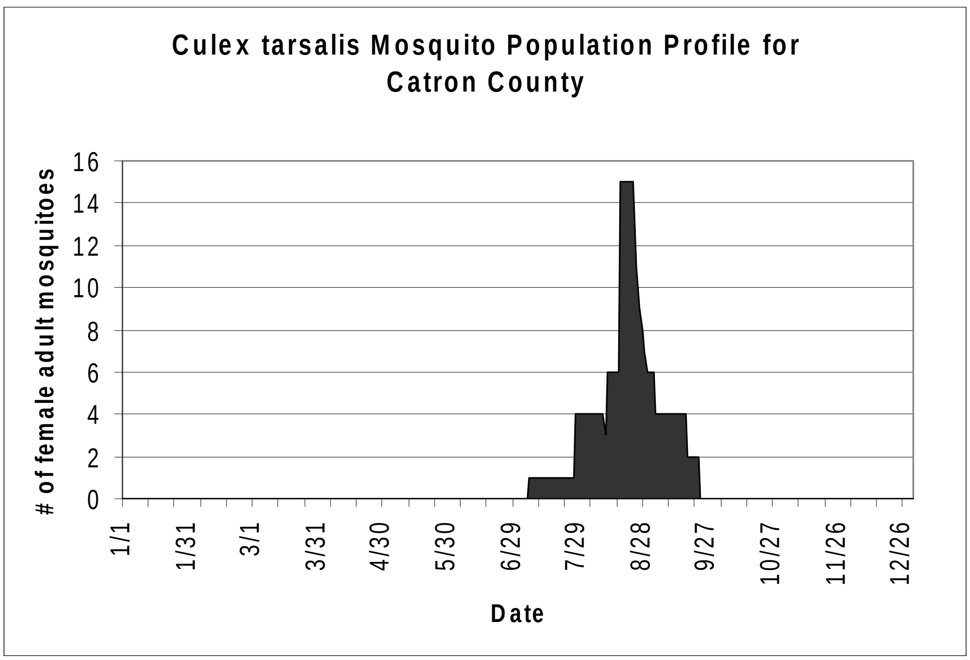


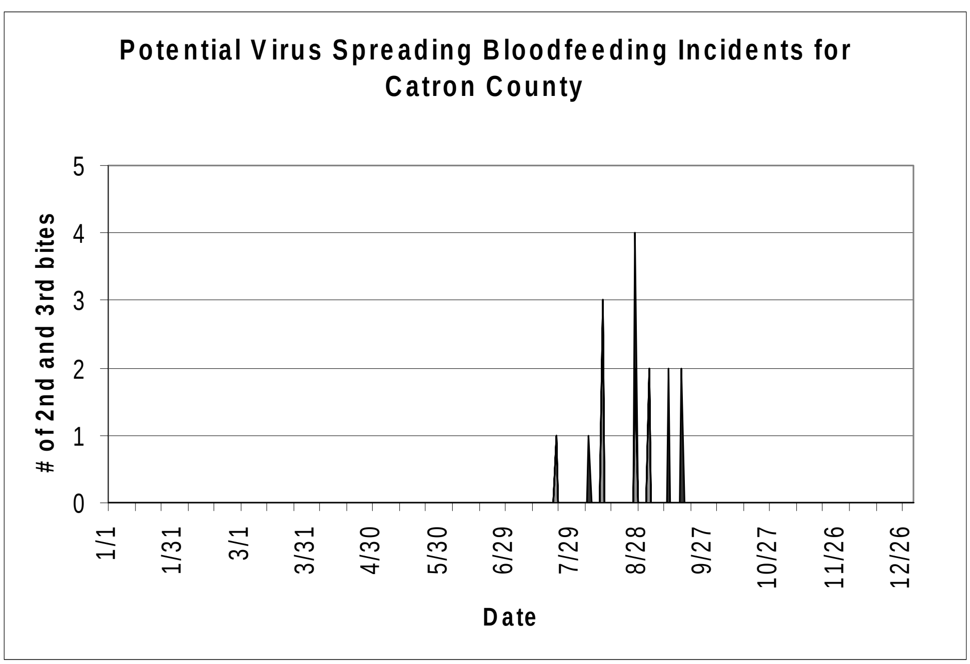


Catron County

Mosquito Season: July 7 to September 23

VBI: 15

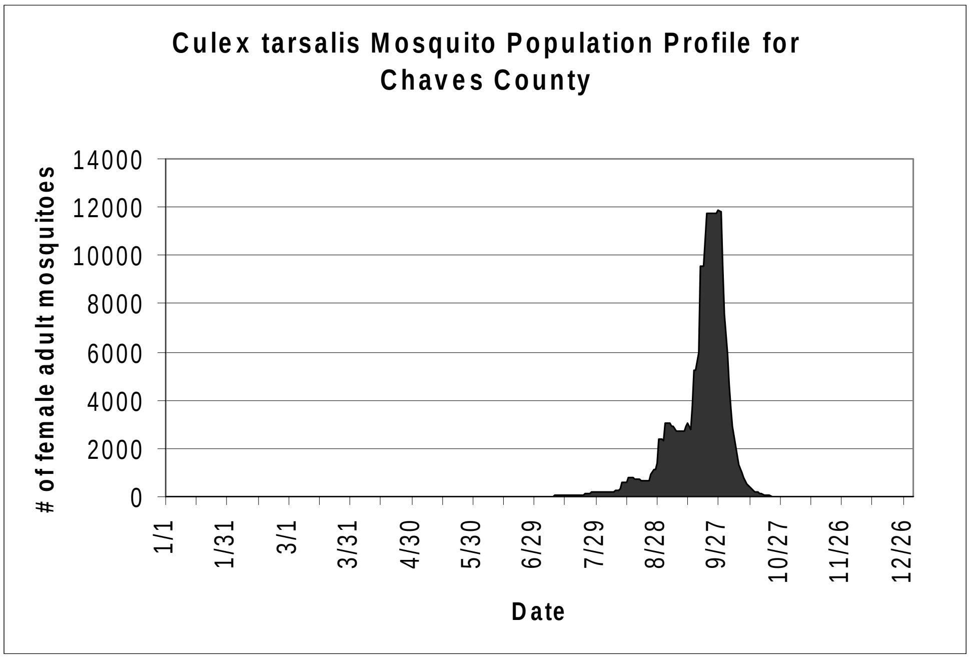


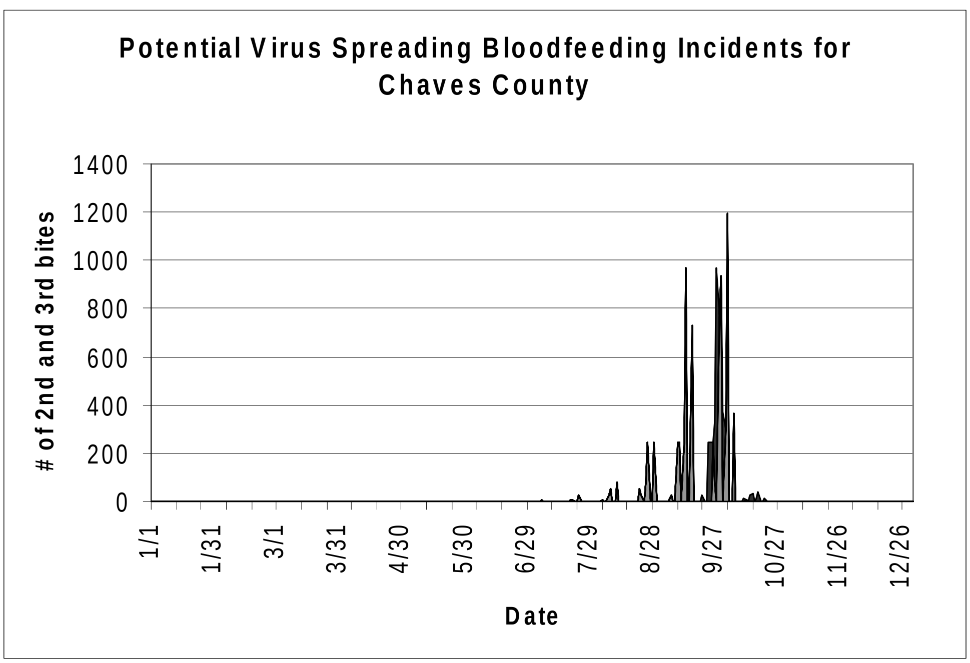


Chaves County

Mosquito Season: May 14 to November 2

VBI:9484

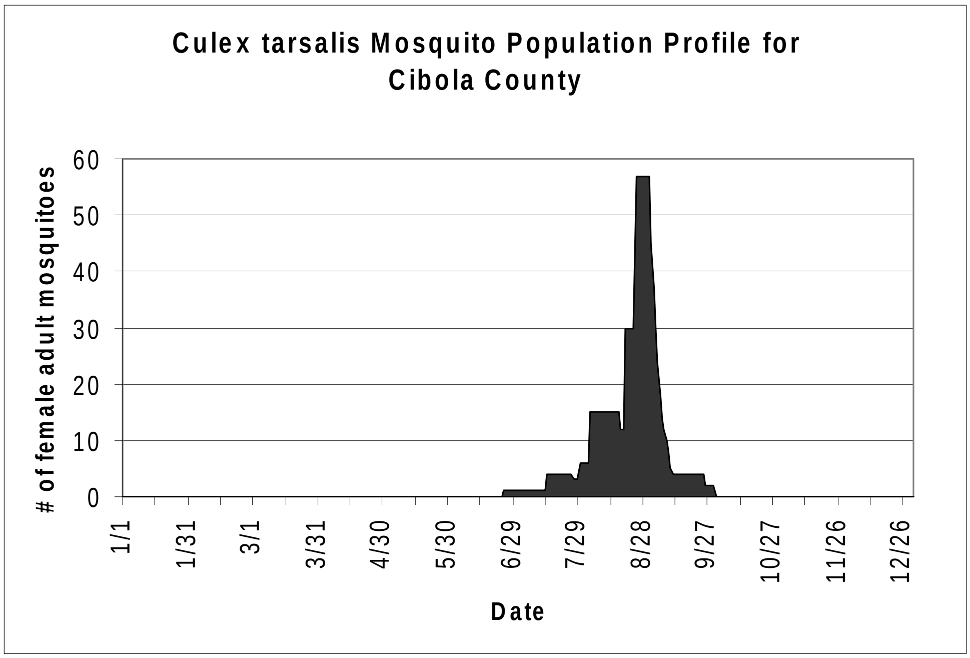


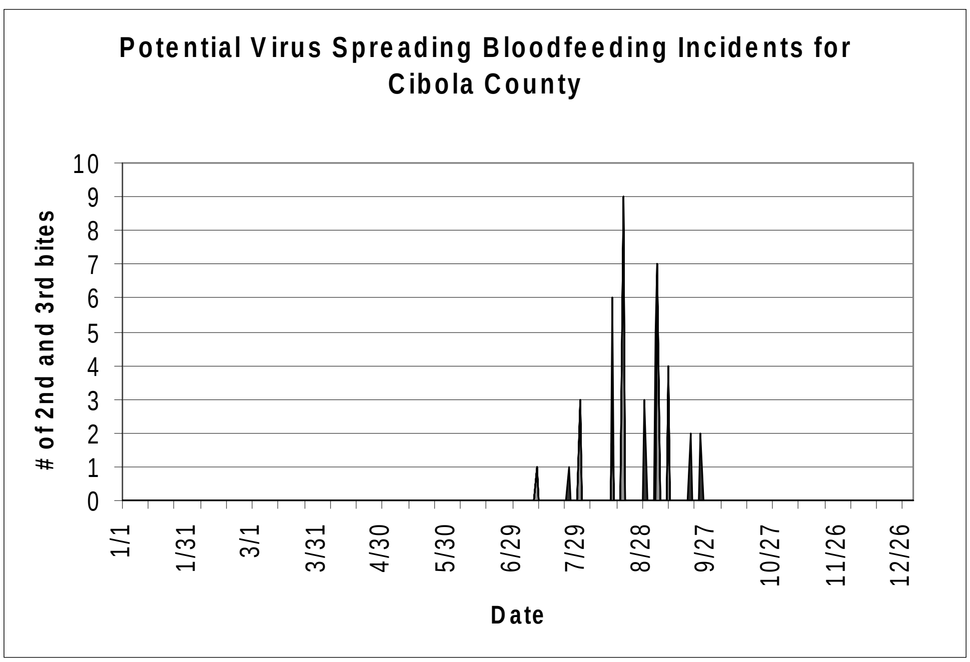


Cibola County

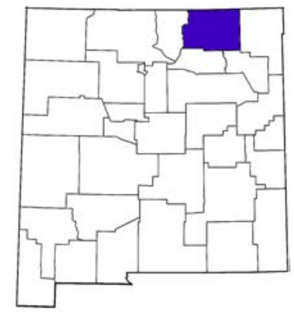
Mosquito Season: Jun 25 to September 30

VBI: 43



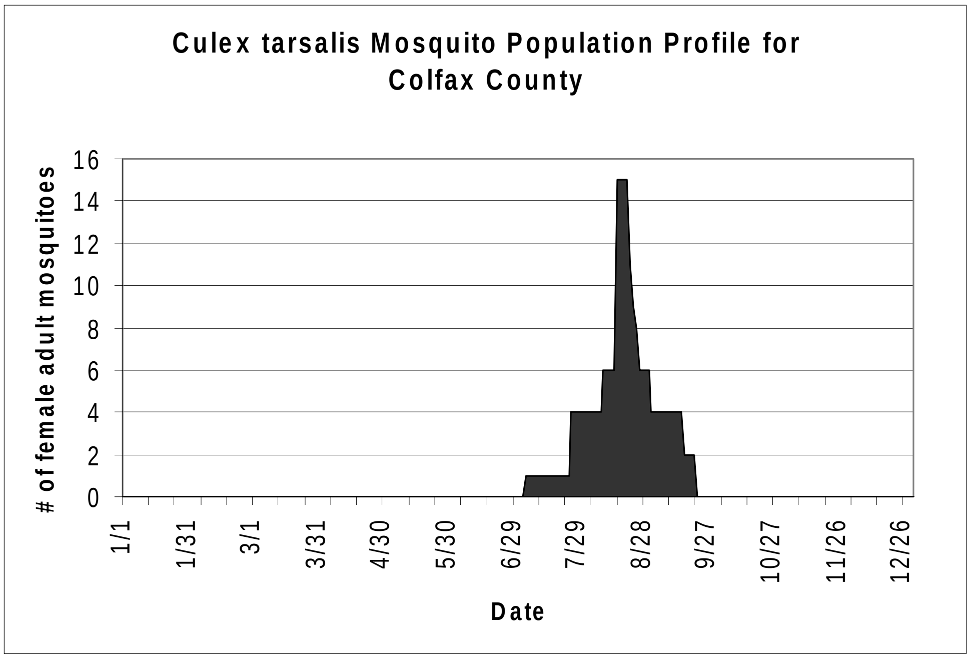


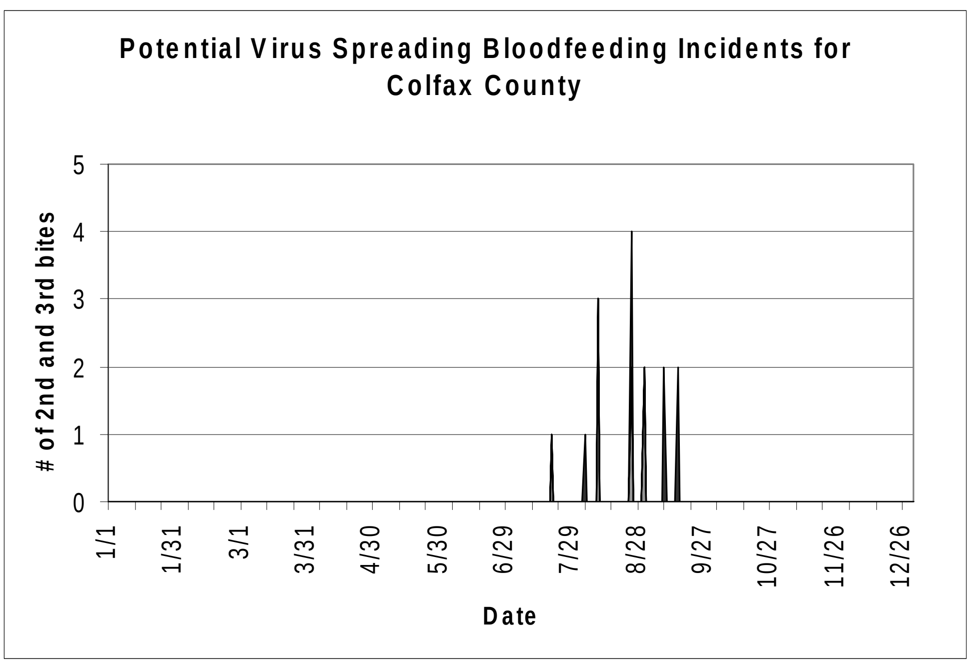
Colfax County



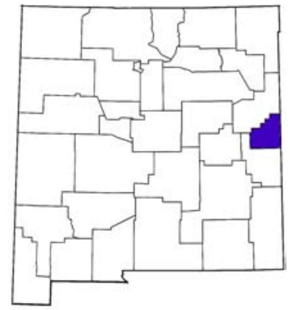
Mosquito Season: July 5 to September 21

VBI: 15



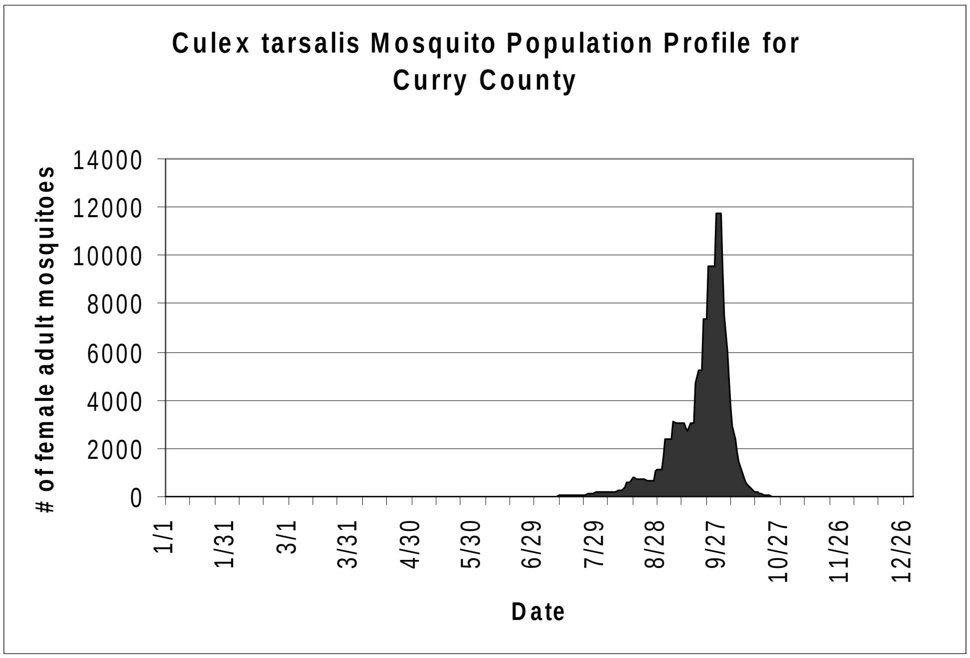


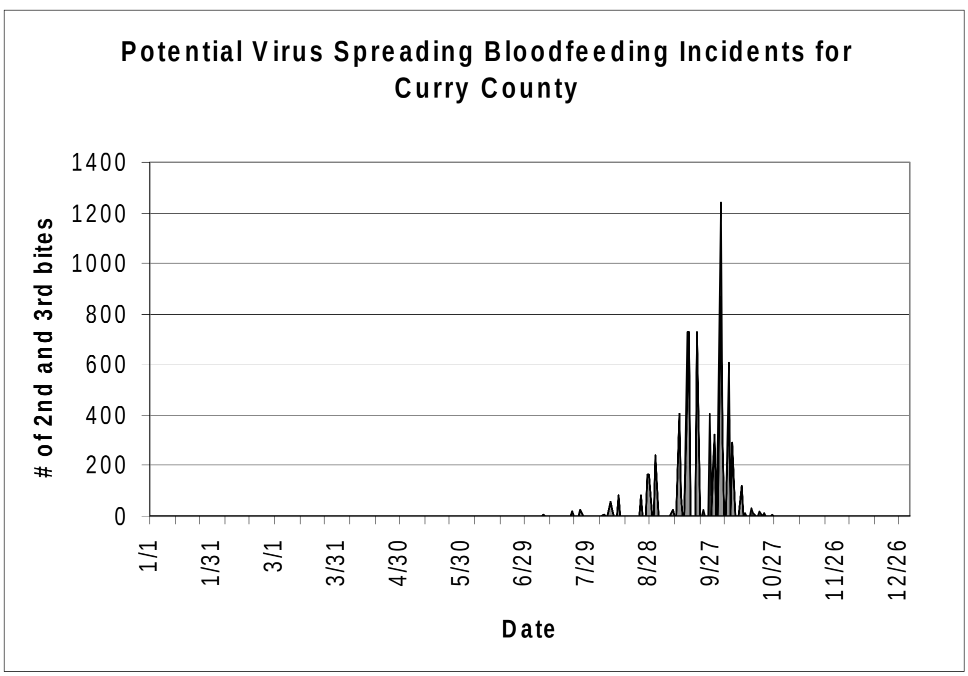
Curry County

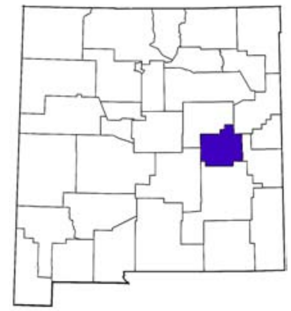


Mosquito Season: May15 to November 1

VBI: 7380



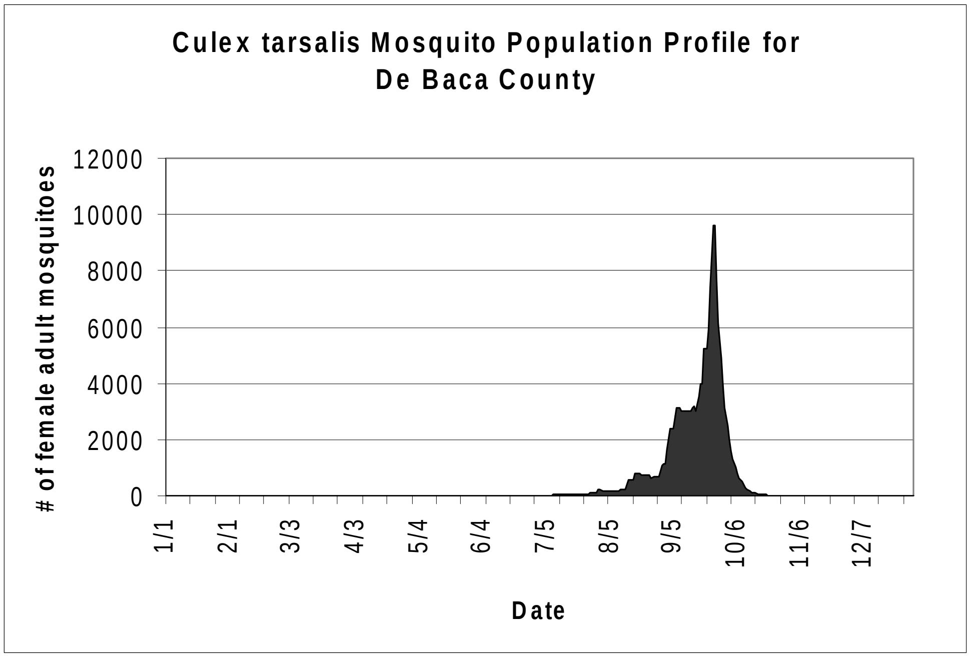


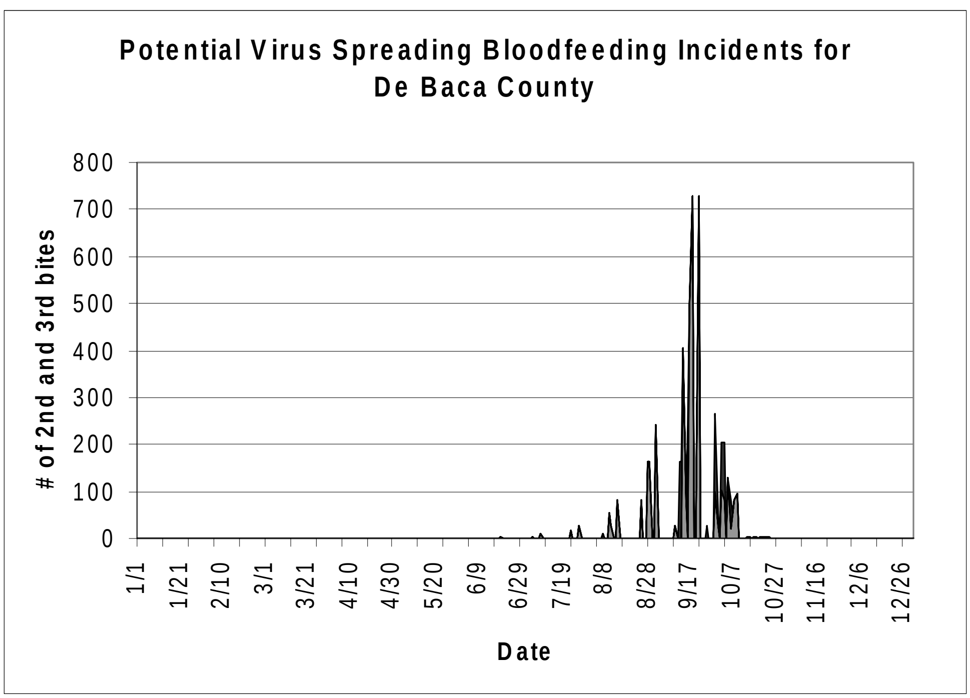


De Baca County

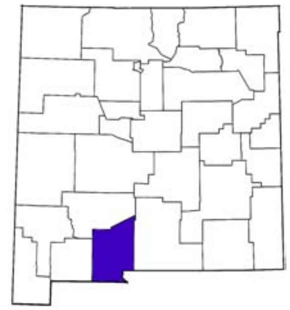
Mosquito Season: May 16 to October 30

VBI:5127



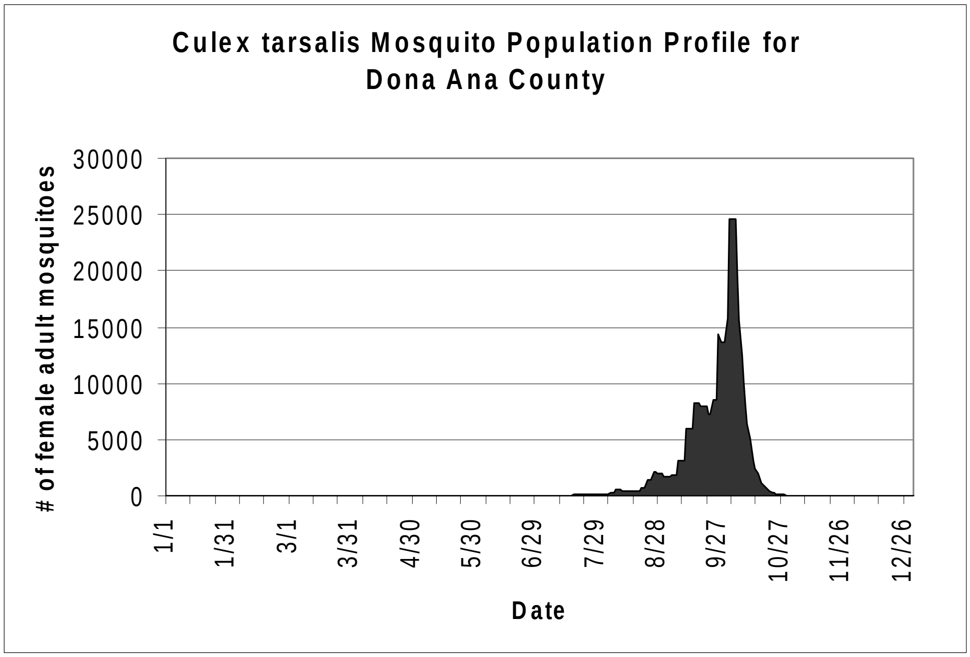


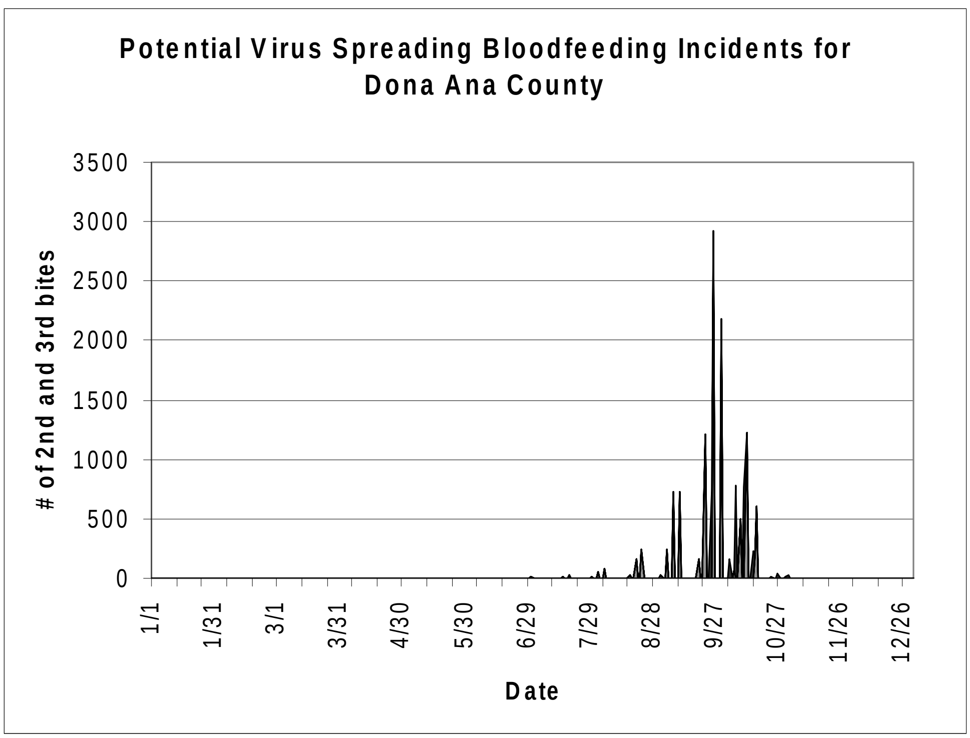
Dona Ana County

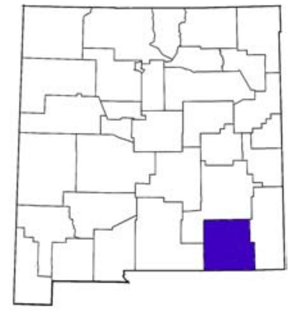


Mosquito Season: May 9 to November 7

VBI:14180



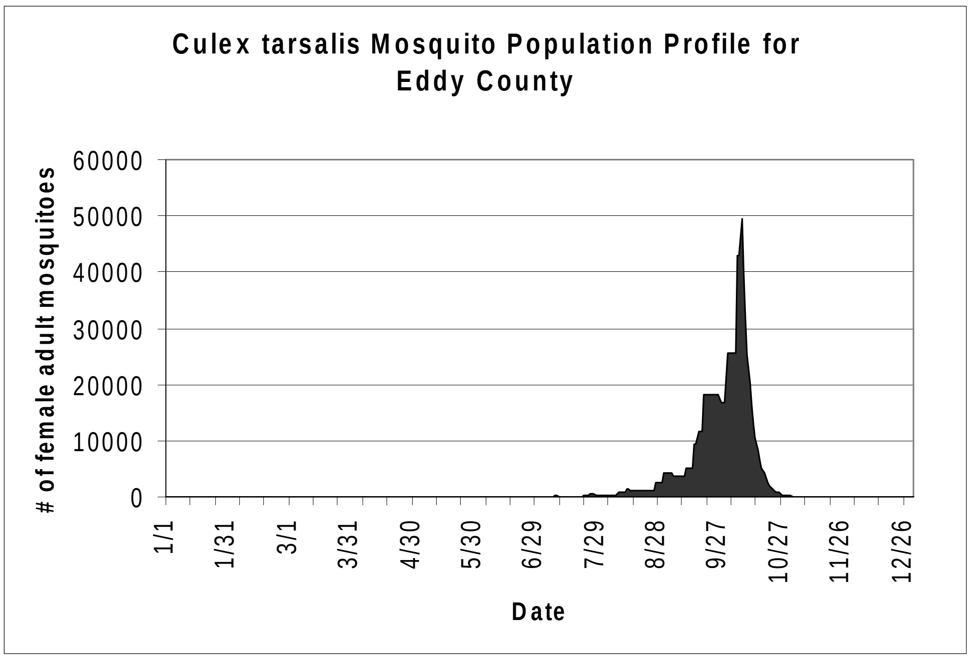


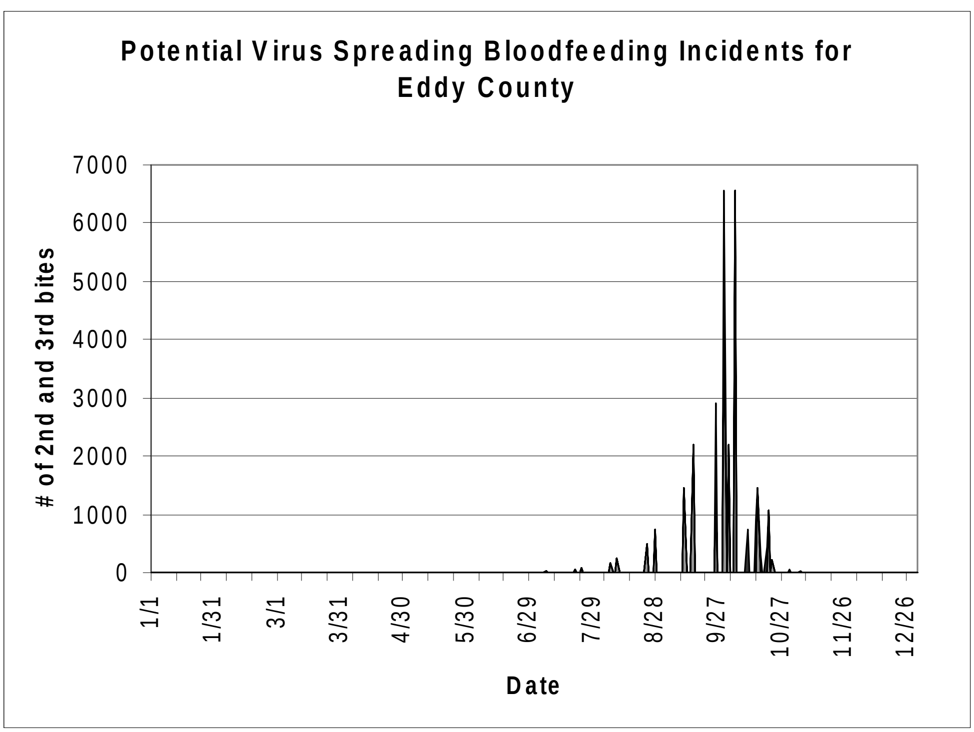


Eddy County

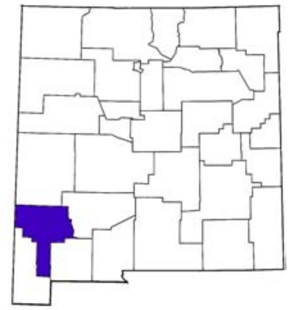
Mosquito Season: April 27 to November 13

VBI:28969



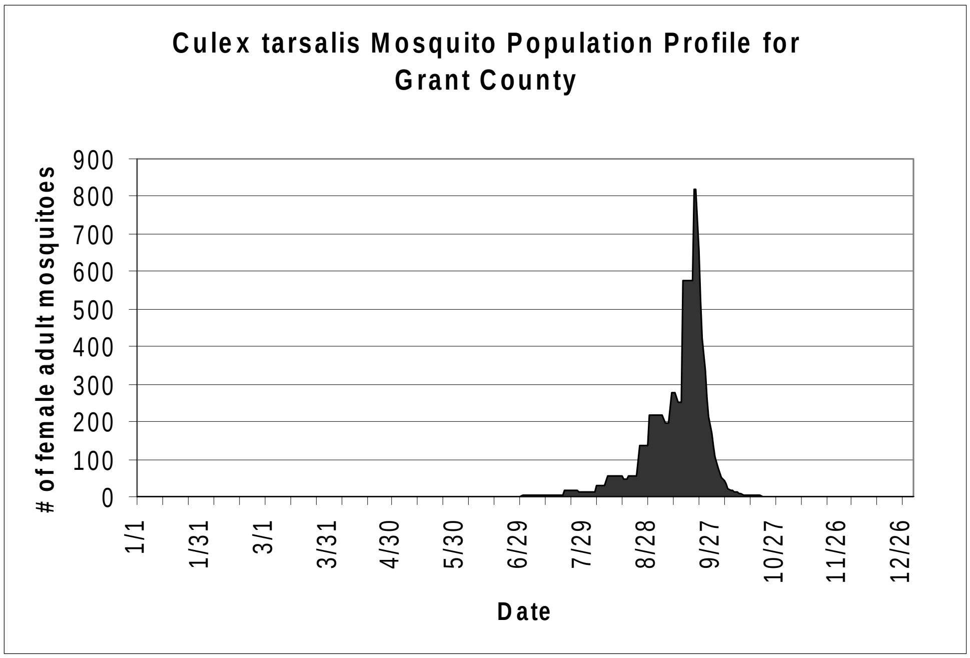


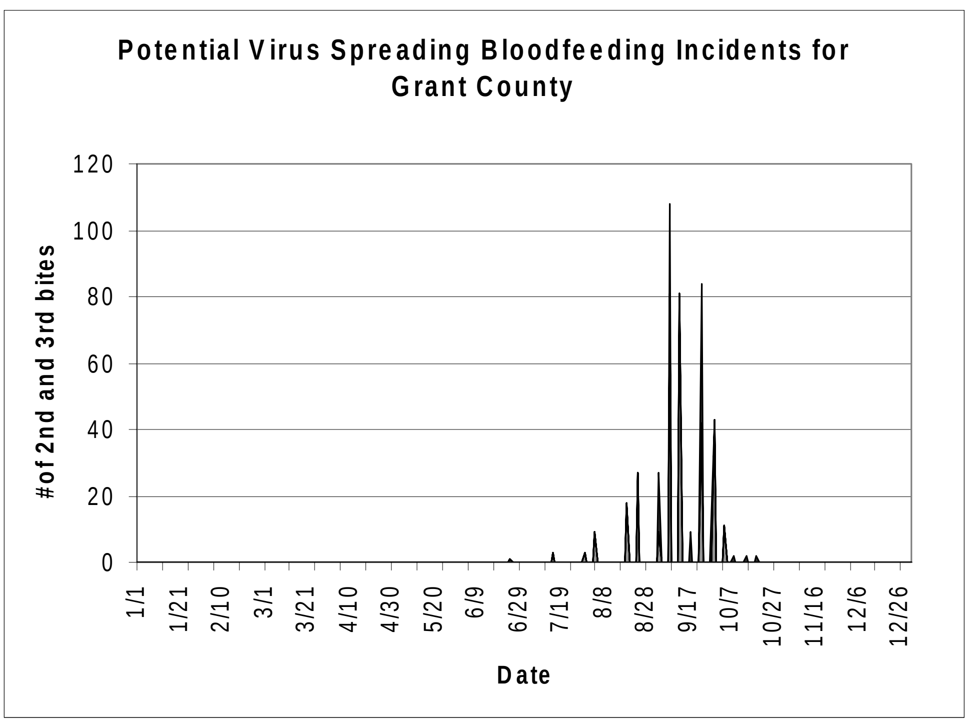
Grant County



Mosquito Season: June 10 to October 25

VBI: 444

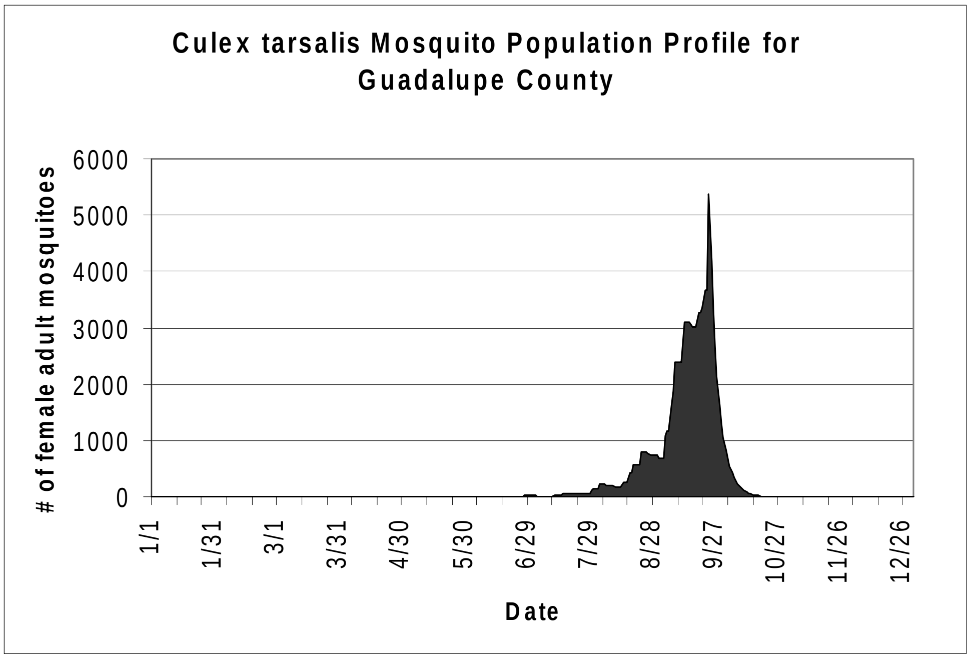


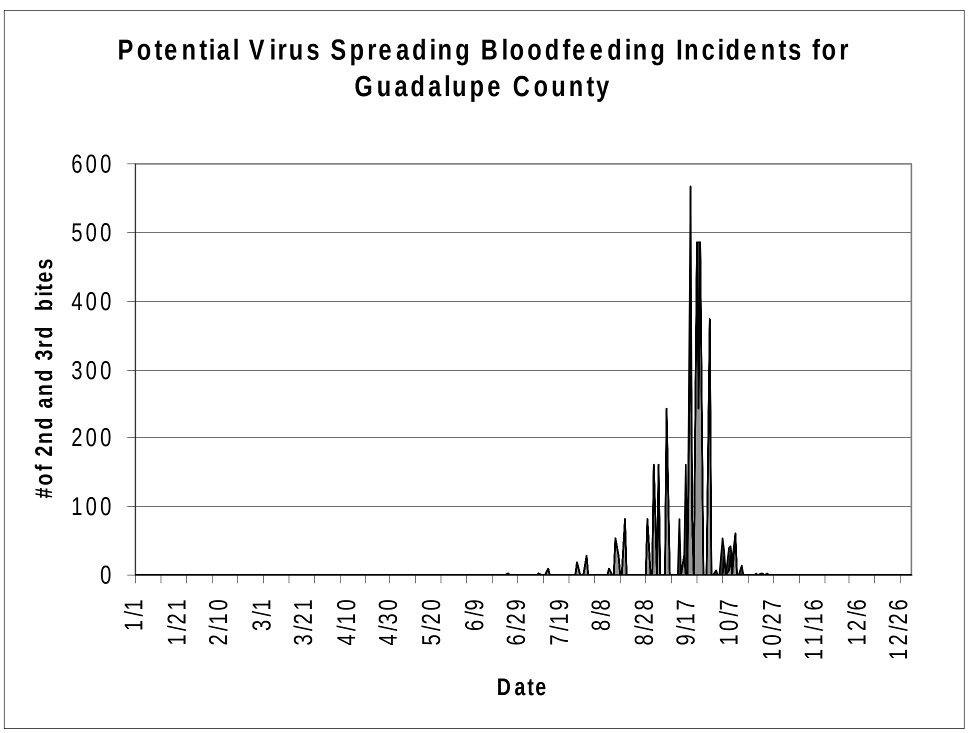


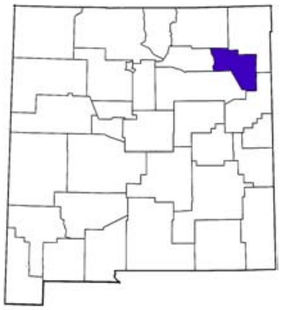
Guadalupe County

Mosquito Season: May 20 to October 30

VBI: 3910



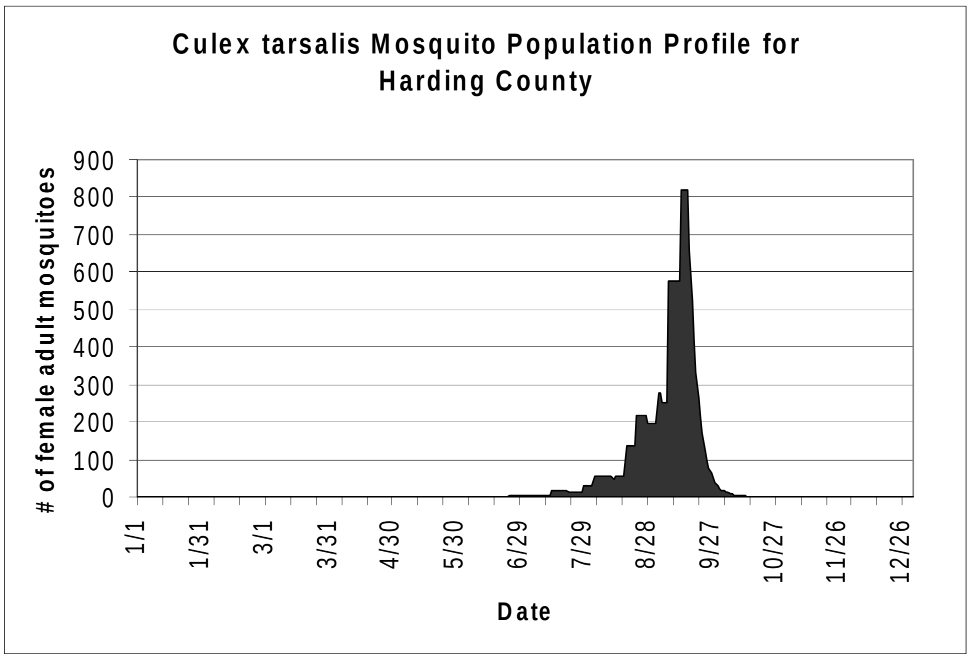


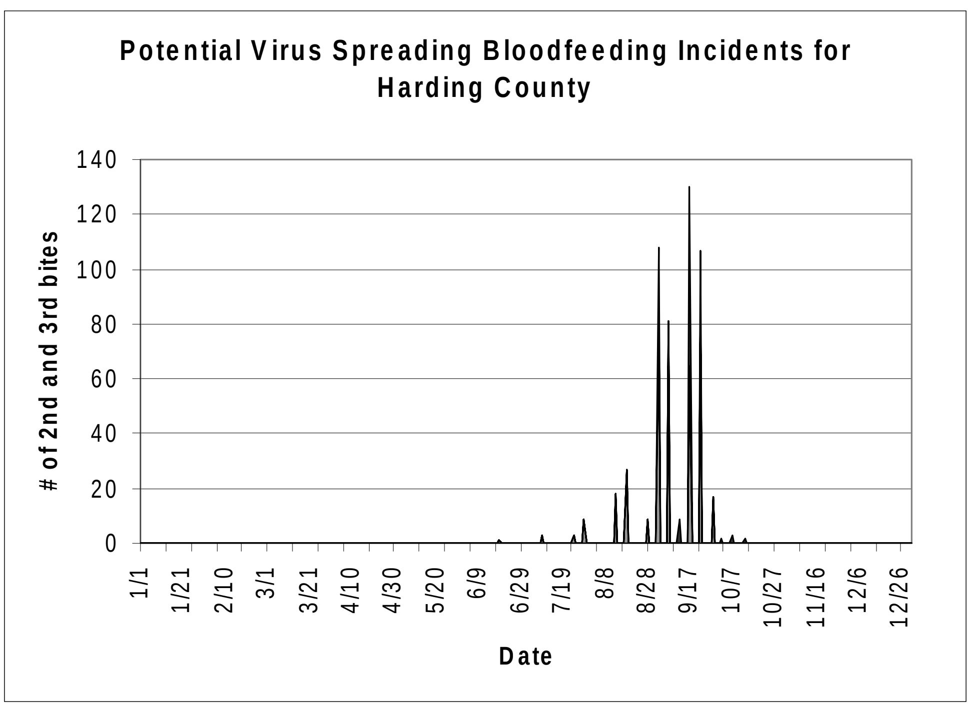


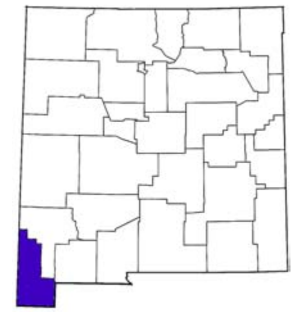
Harding County

Mosquito Season: June 4 to October 19

VBI: 529



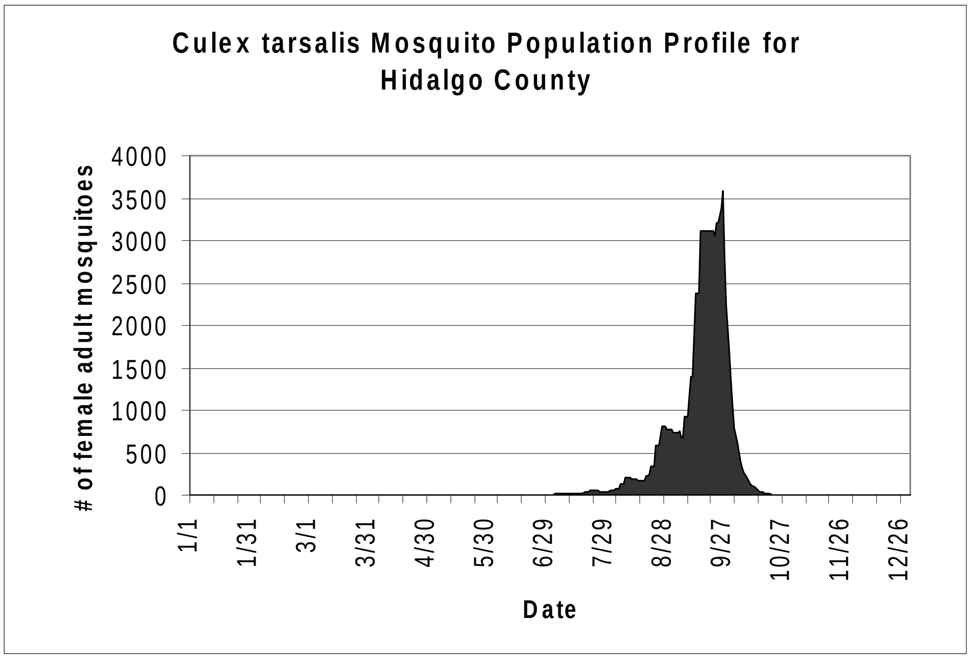


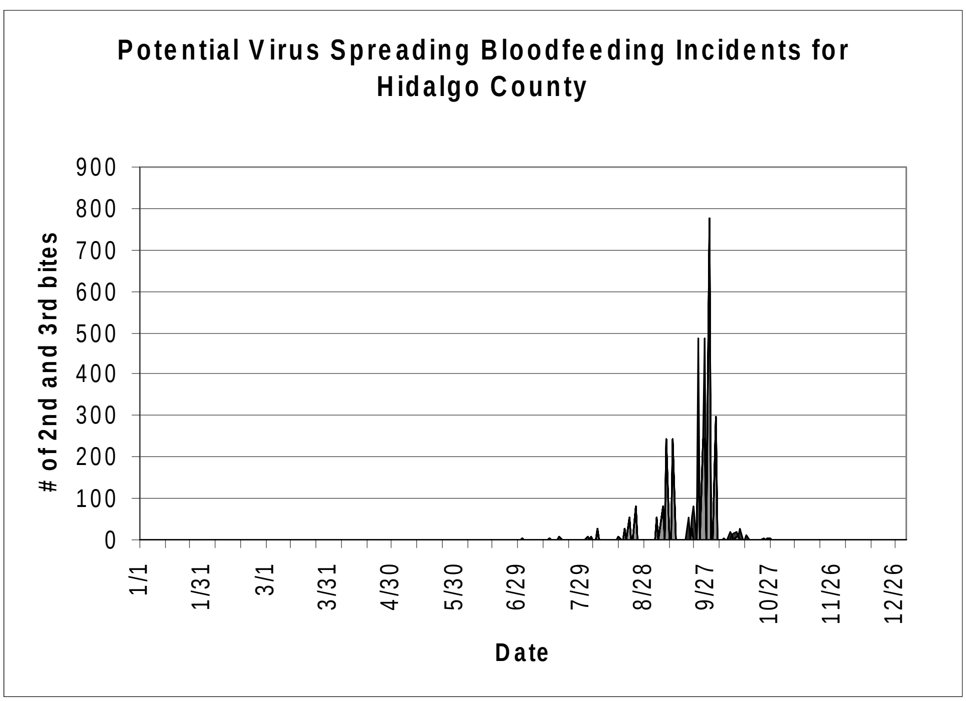


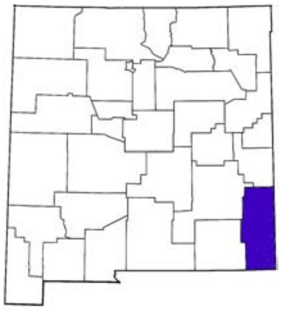
Hidalgo County

Mosquito Season: May 27 to November 2

VBI:3482



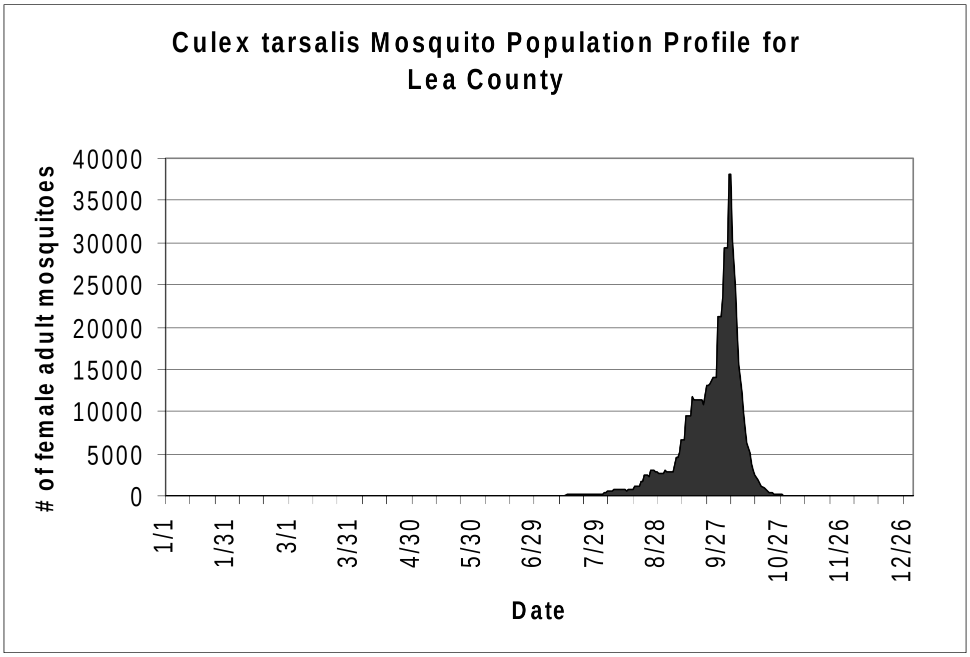


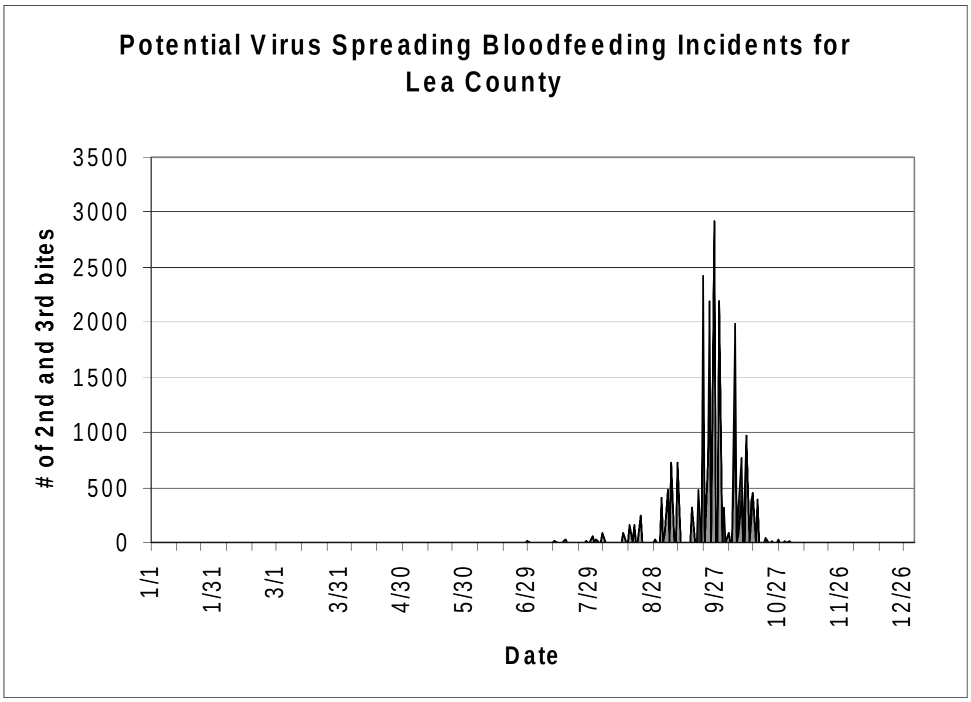


Lea County

Mosquito Season: May5 to November 7

VBI:20882

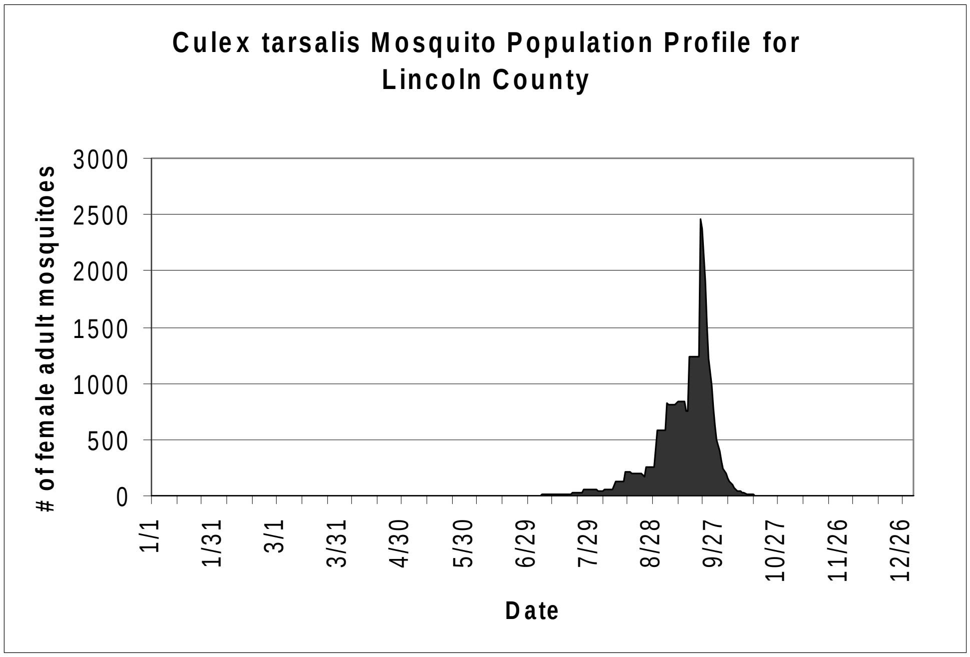


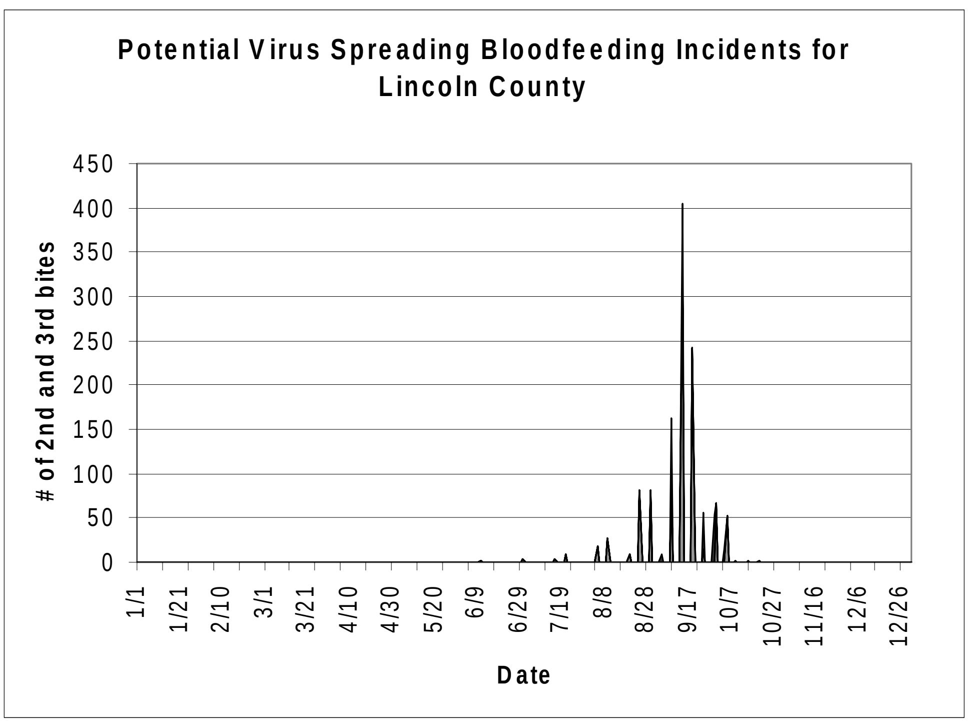


Lincoln County

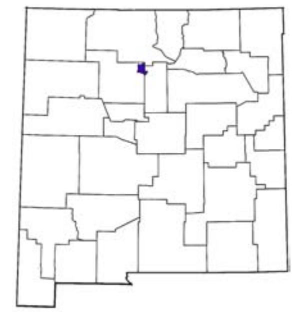
Mosquito Season: May 27 to October 26

VBI:1300



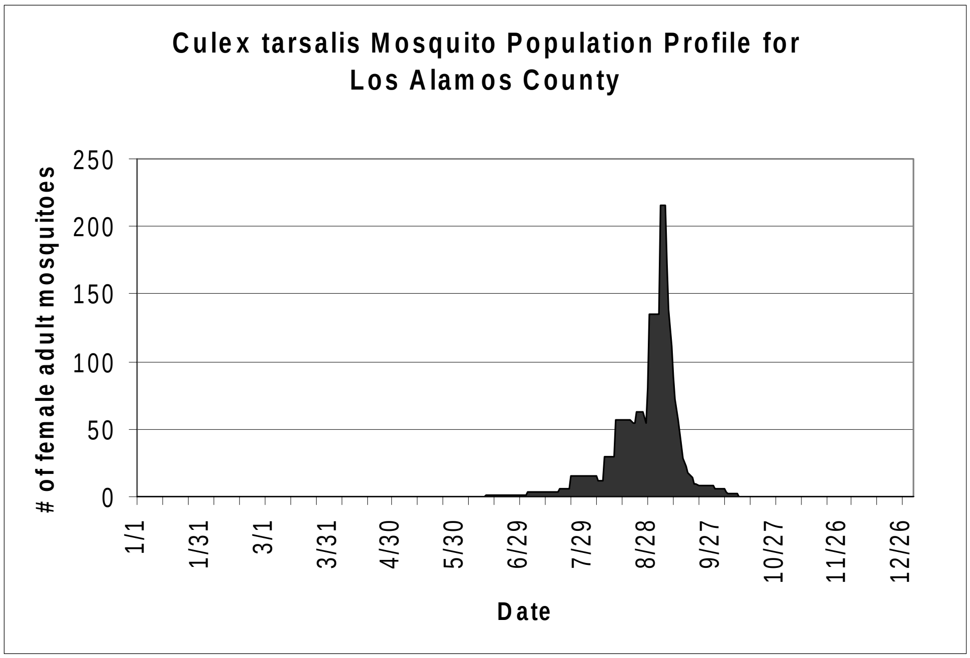


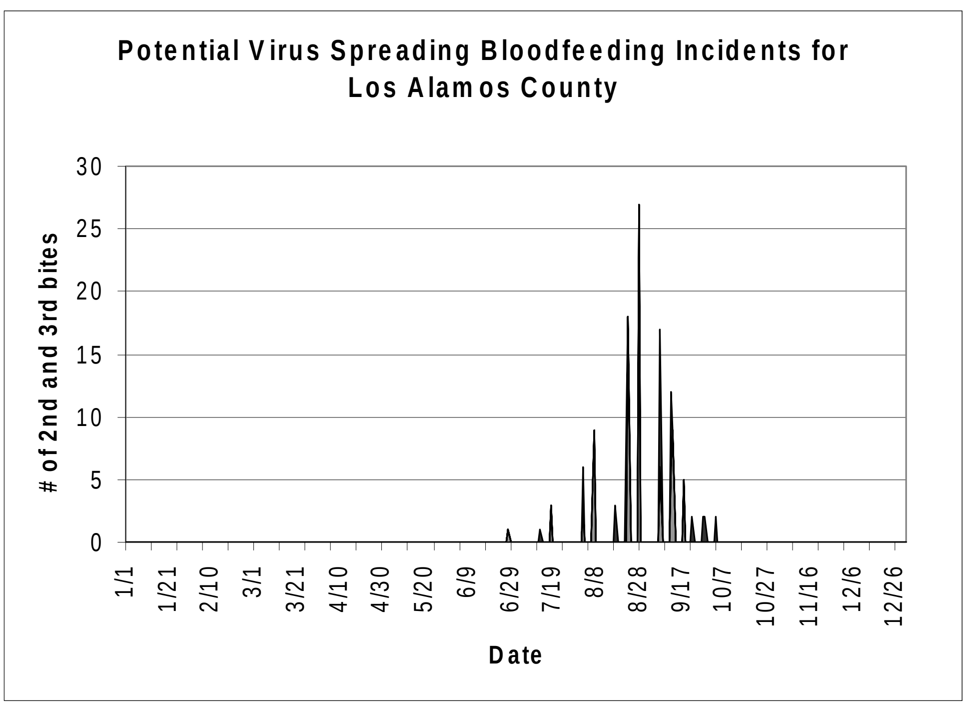
Los Alamos County



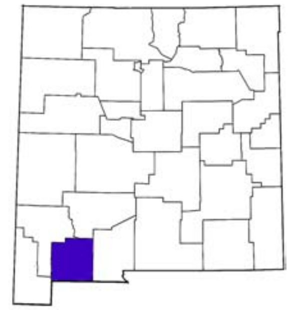
Mosquito Season: June 13 to October 9

VBI: 128



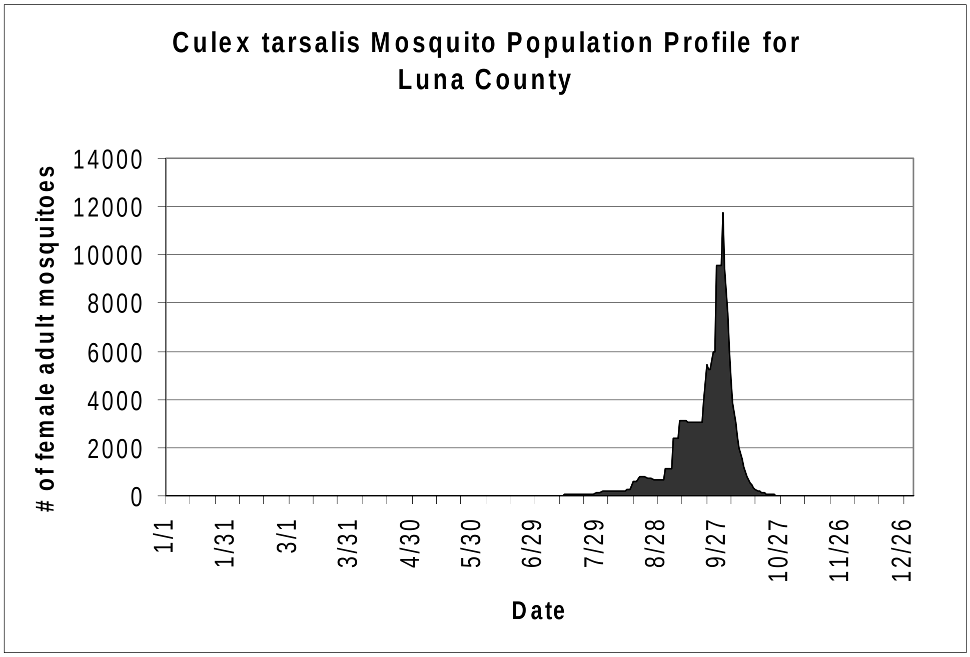


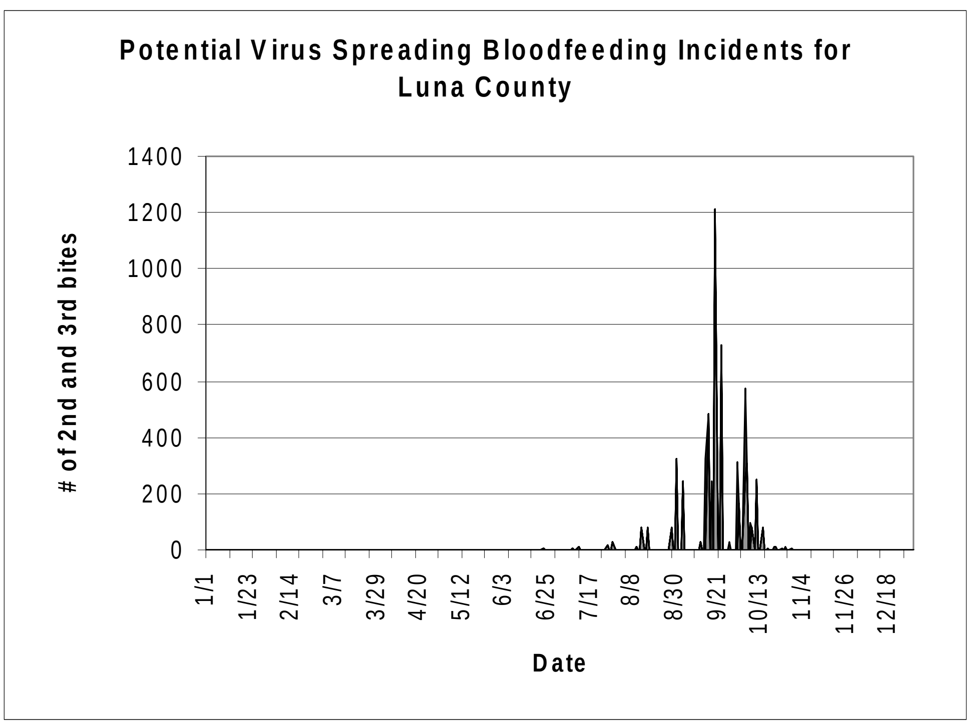
Luna County



Mosquito Season: May 19 to November 4

VBI:5830

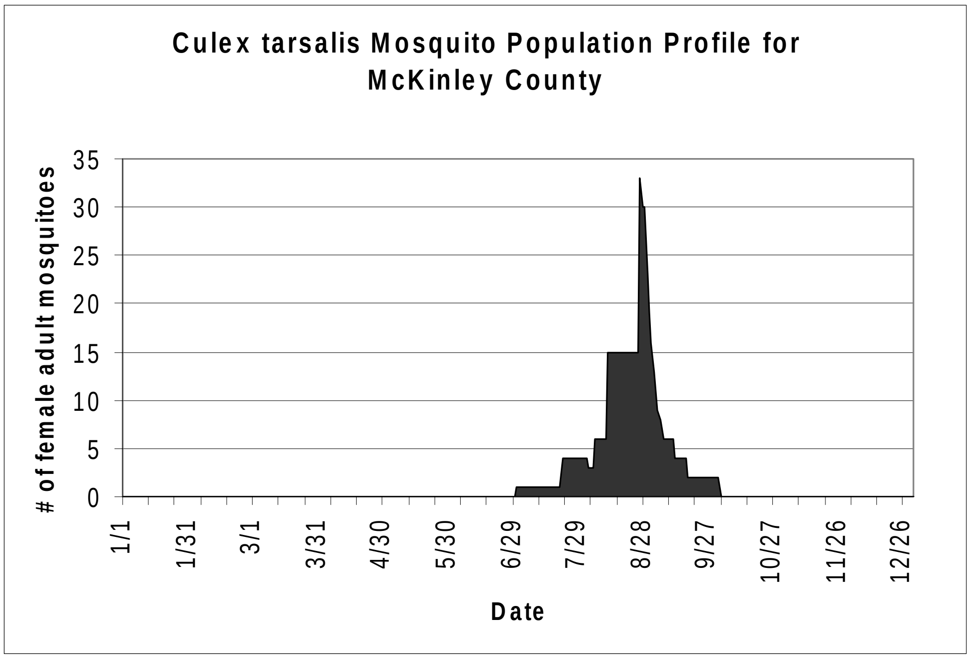


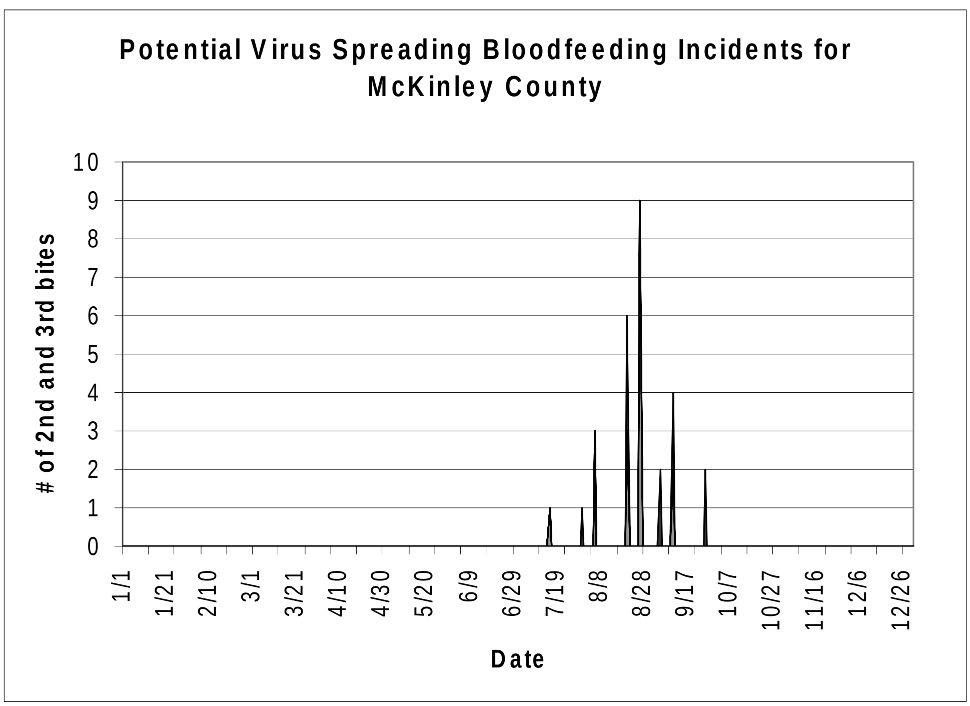


McKinley County

Mosquito Season: July 1 to October 2

VBI: 28

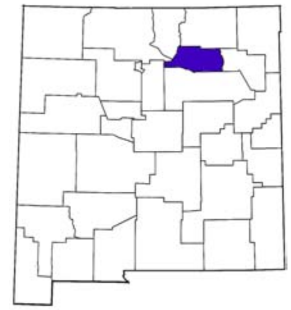


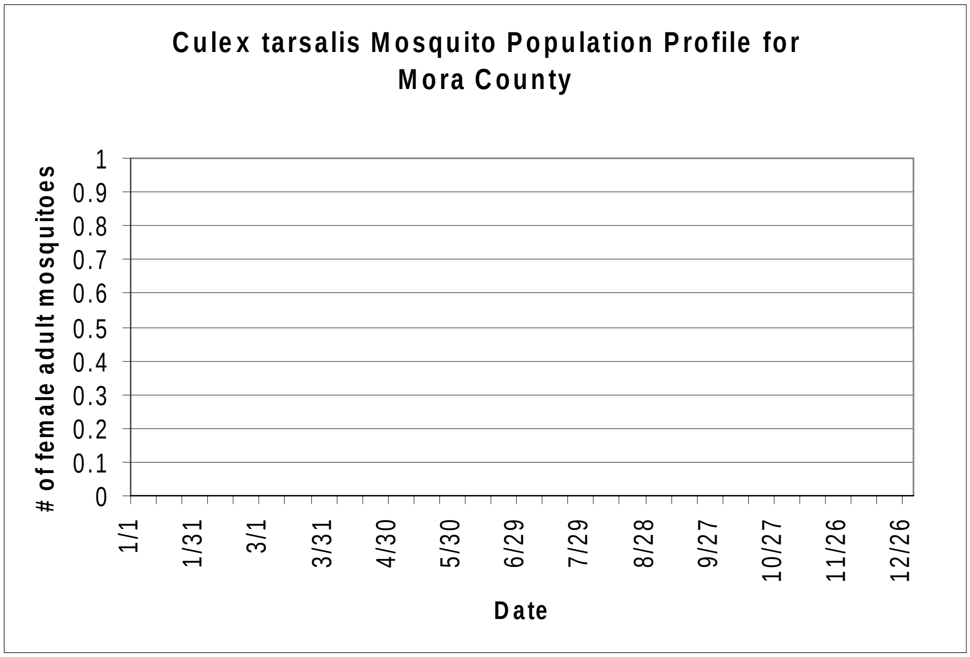


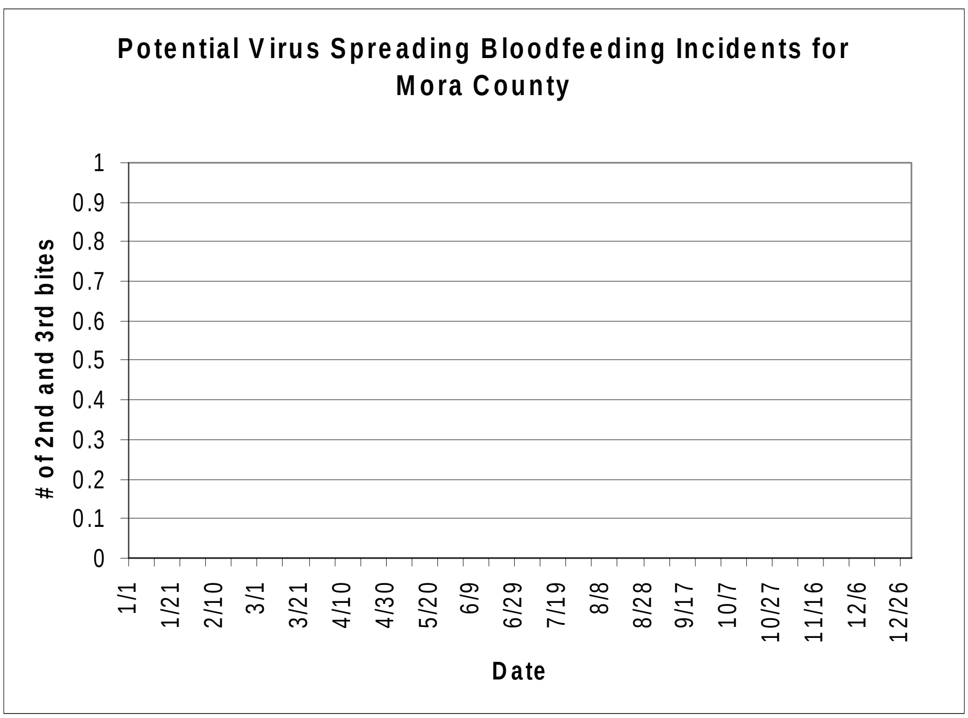
Mora County

Mosquito Season: None

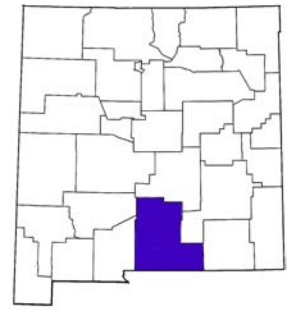
VBI:0





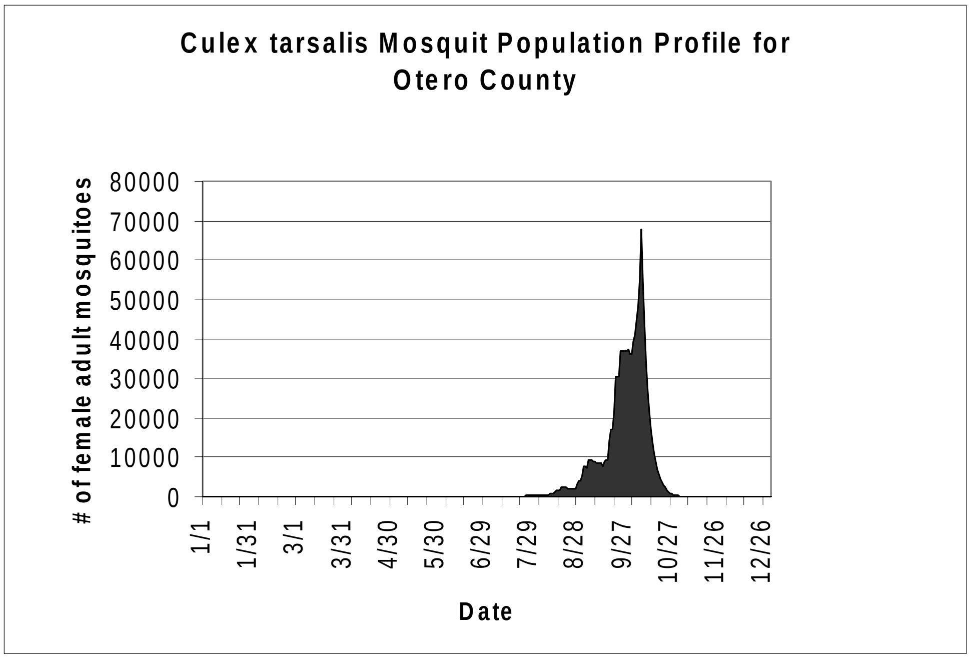


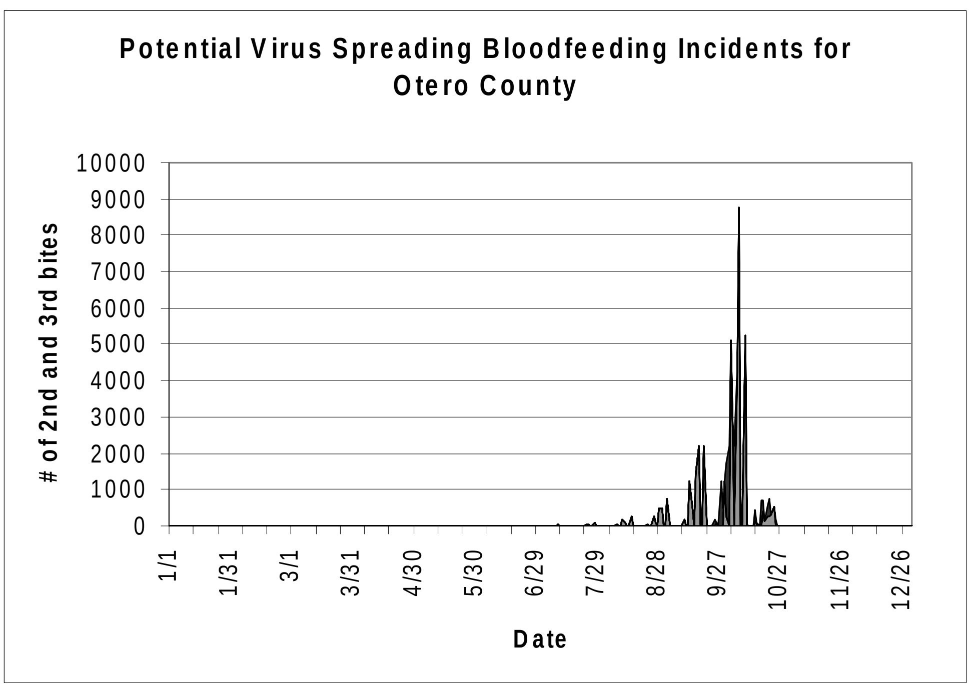
Otero County

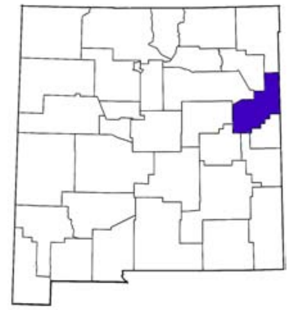


Mosquito Season: April 29 to November 14

VBI:50626



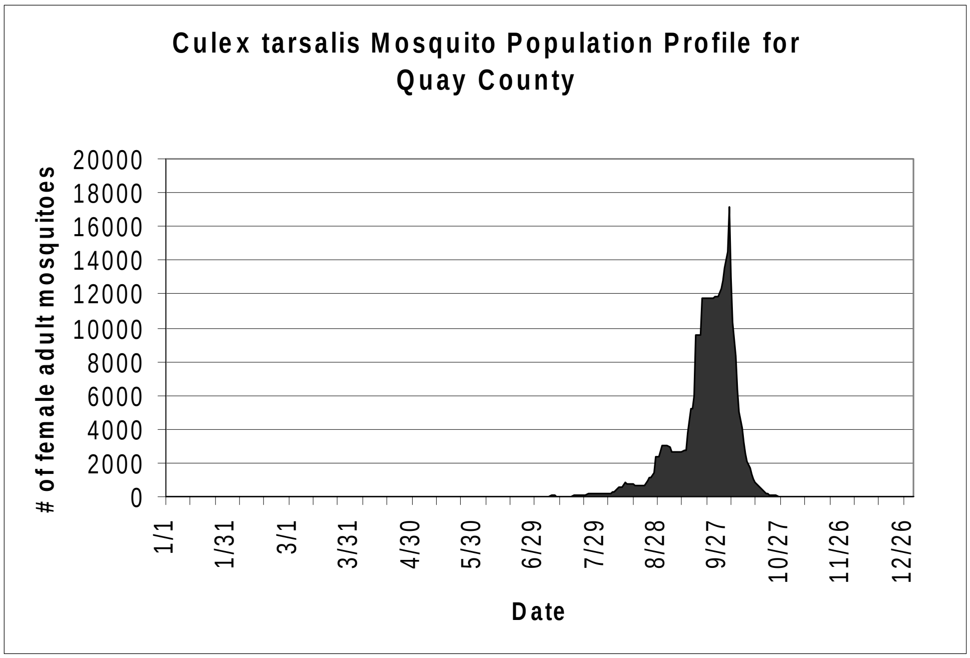


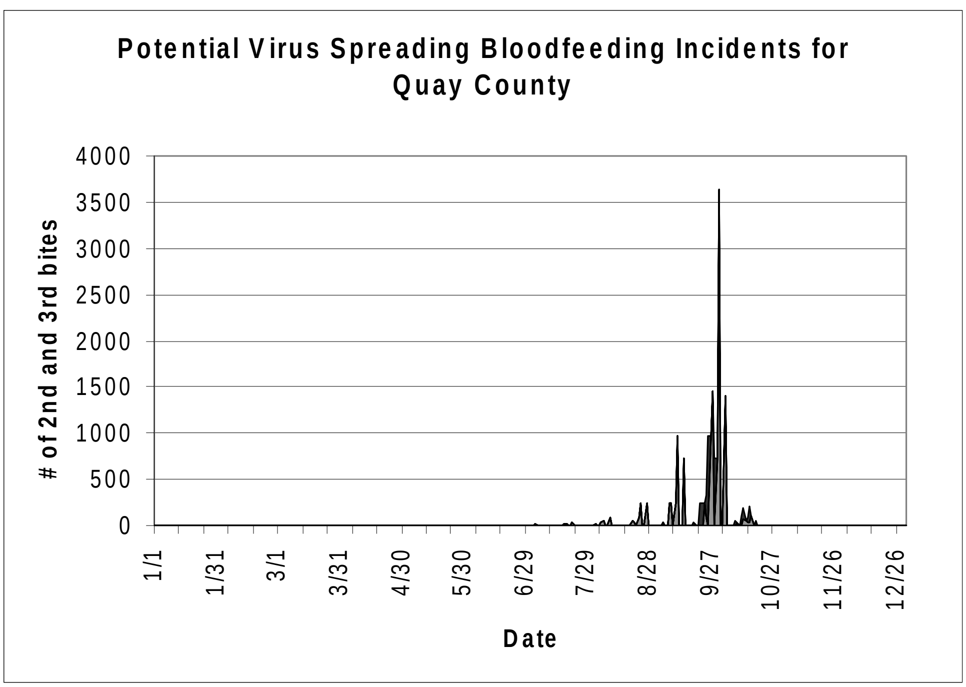


Quay County

Mosquito Season: May 12 to November 7

VBI:15190

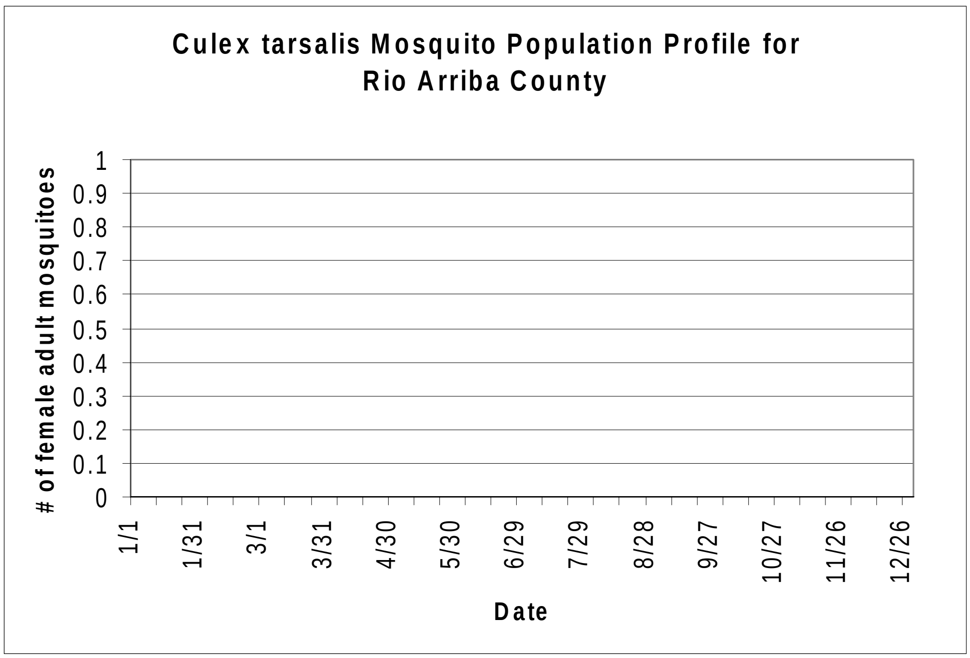


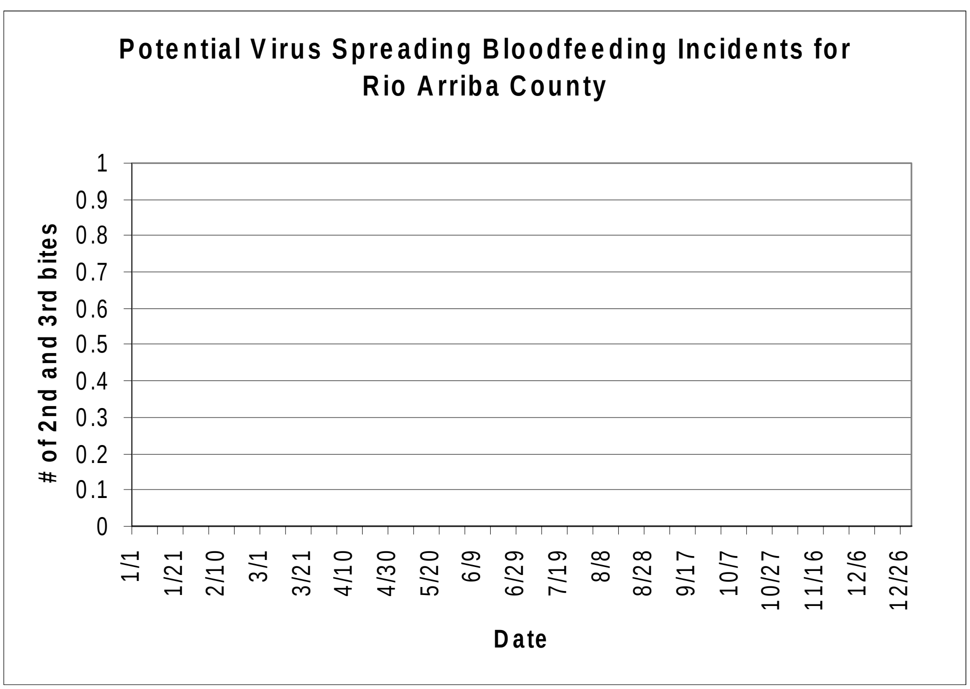


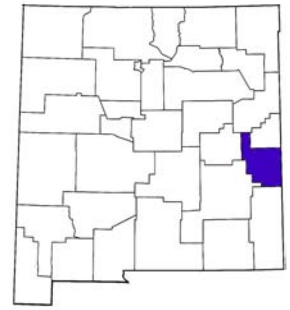
Rio Arriba County

Mosquito Season: None

VBI:0



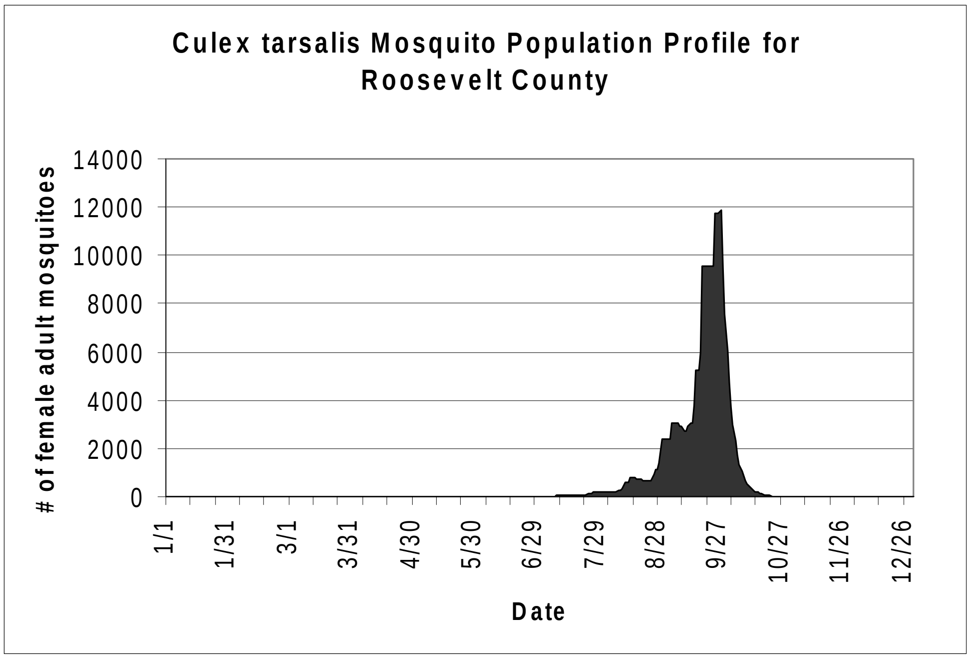


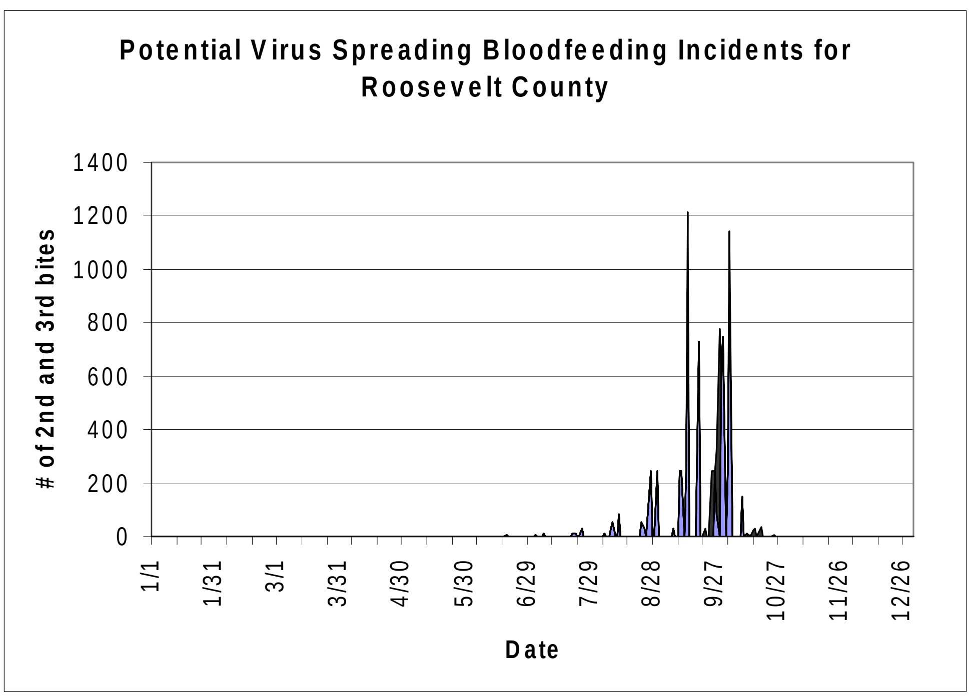


Roosevelt County

Mosquito Season: May 15 to November 3

VBI:8456

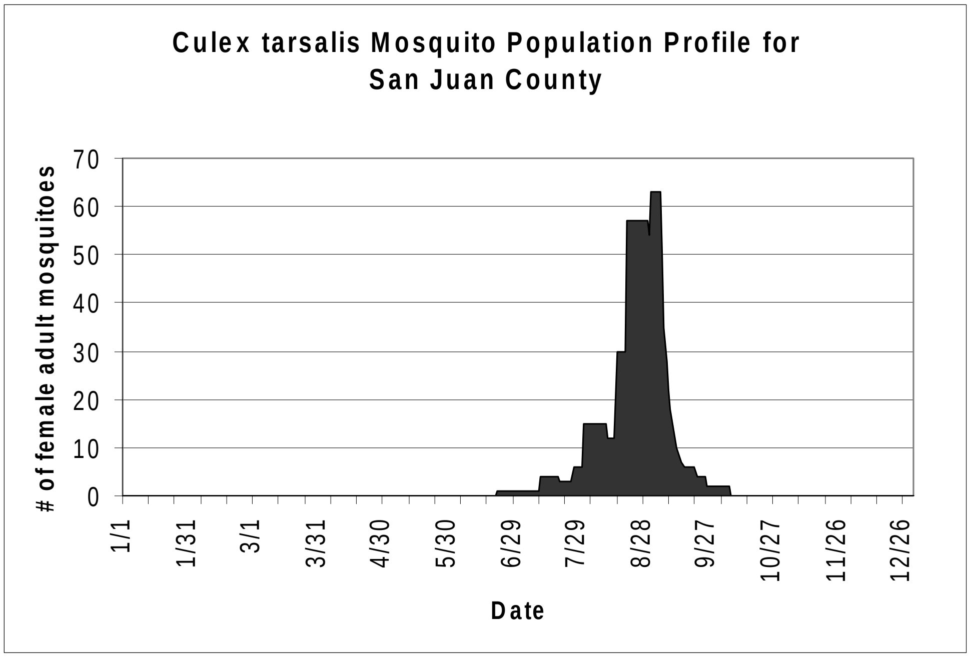


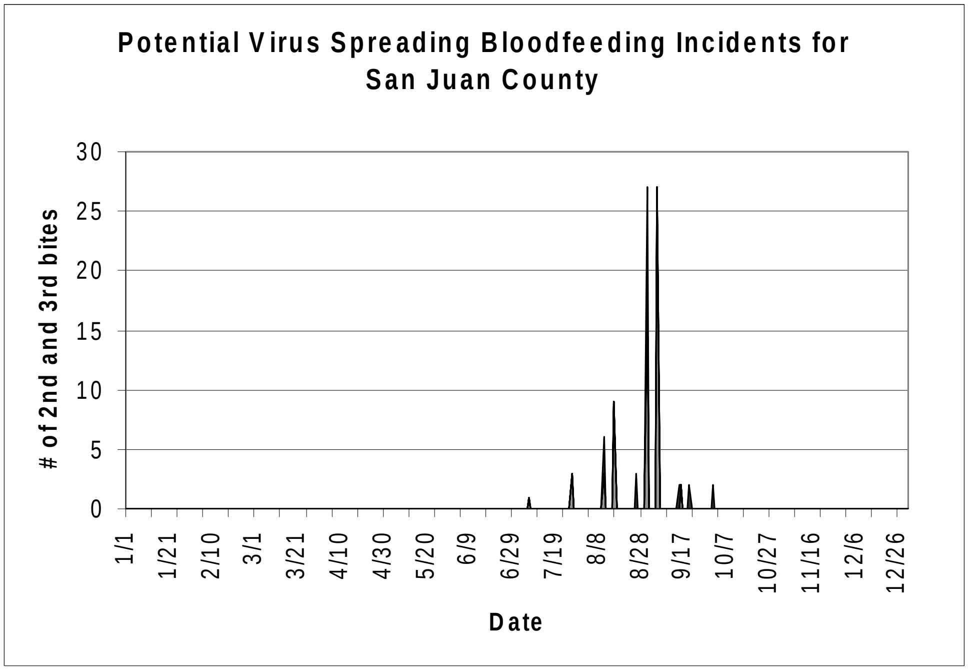


San Juan County

Mosquito Season: June 22 to October 7

VBI: 84

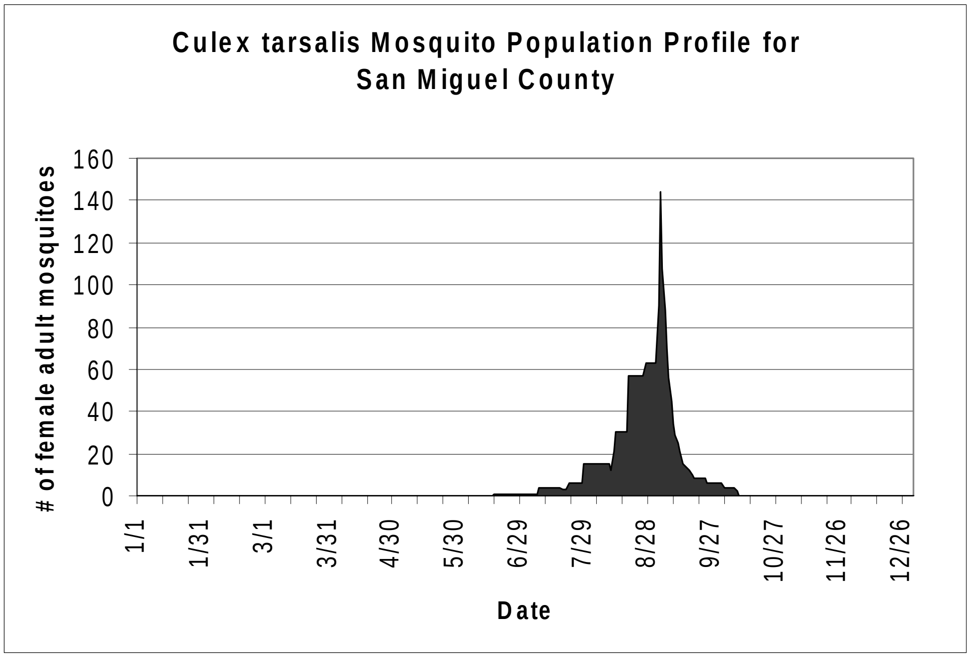


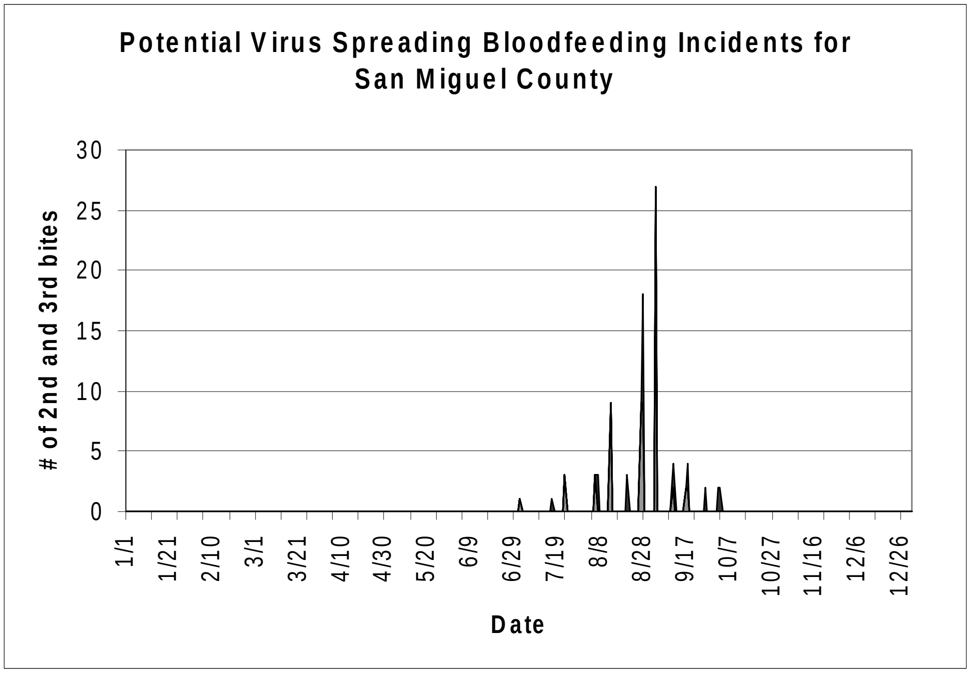


San Miguel County

Mosquito Season: June 17 to October 9

VBI:95

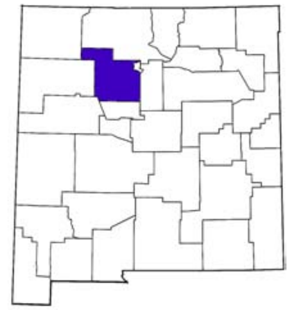


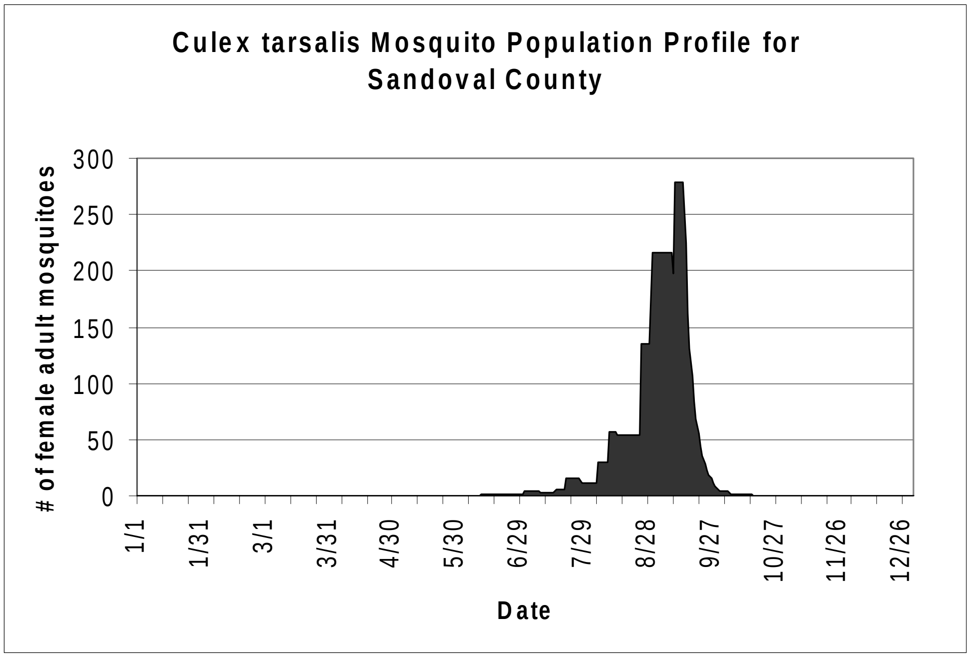


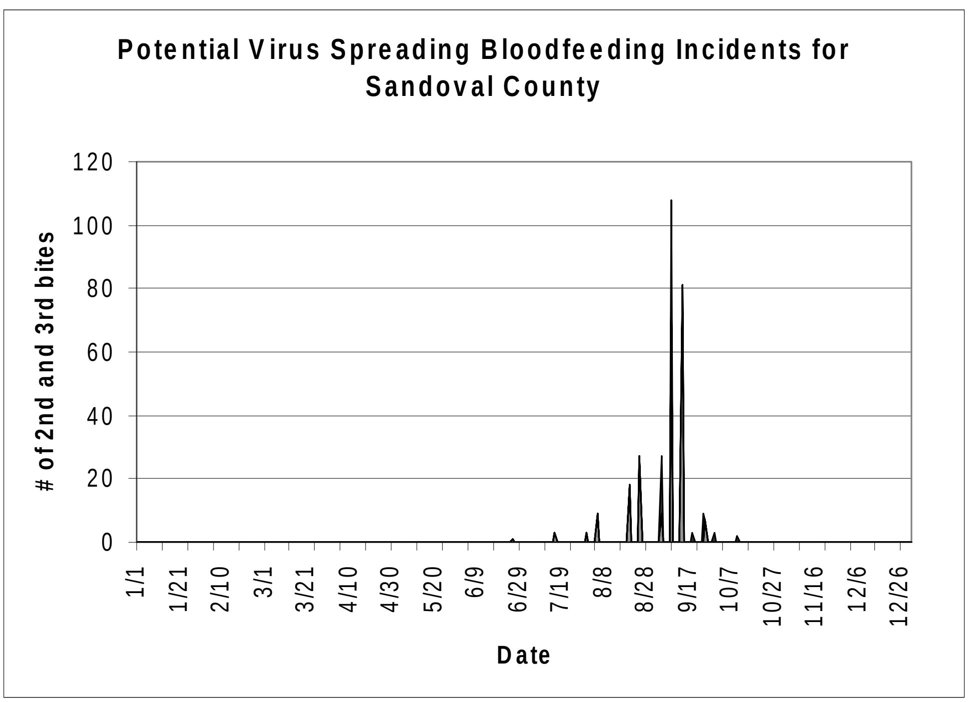
Sandoval County

Mosquito Season: June 11 to October 16

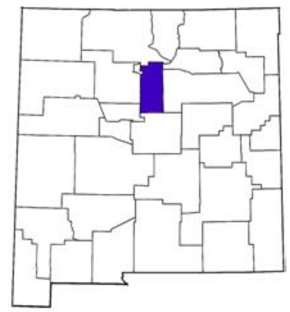
VBI: 301





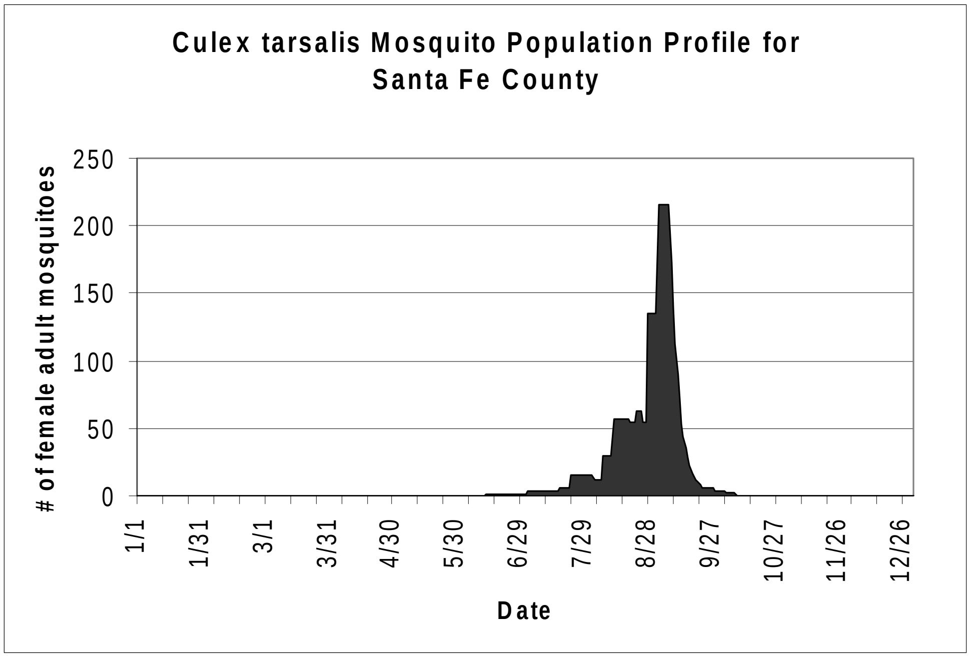


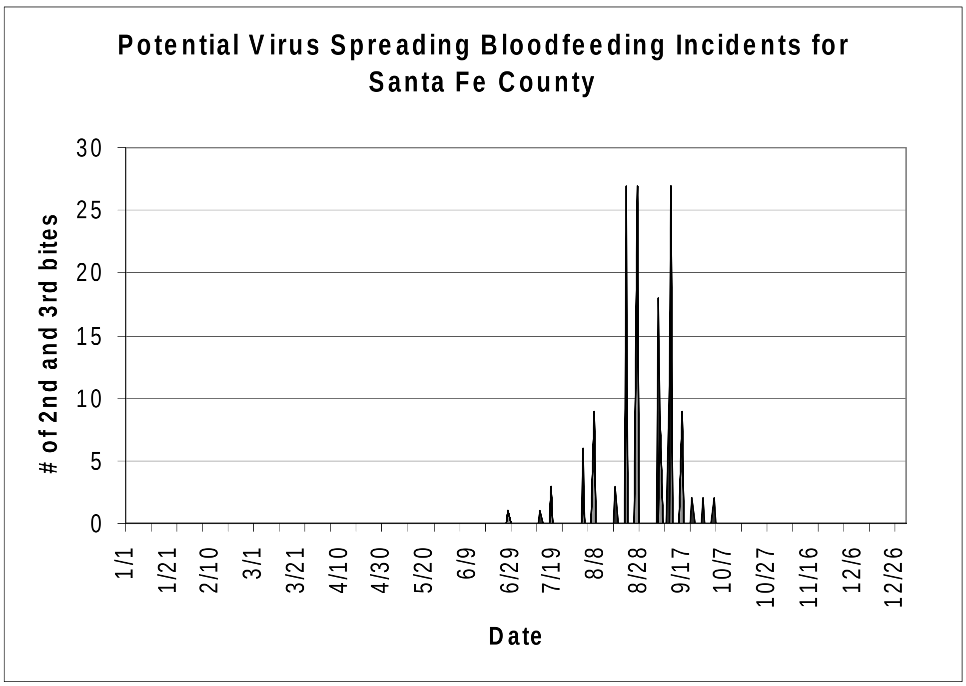
Santa Fe County



Mosquito Season: June 13 to October 8

VBI: 157

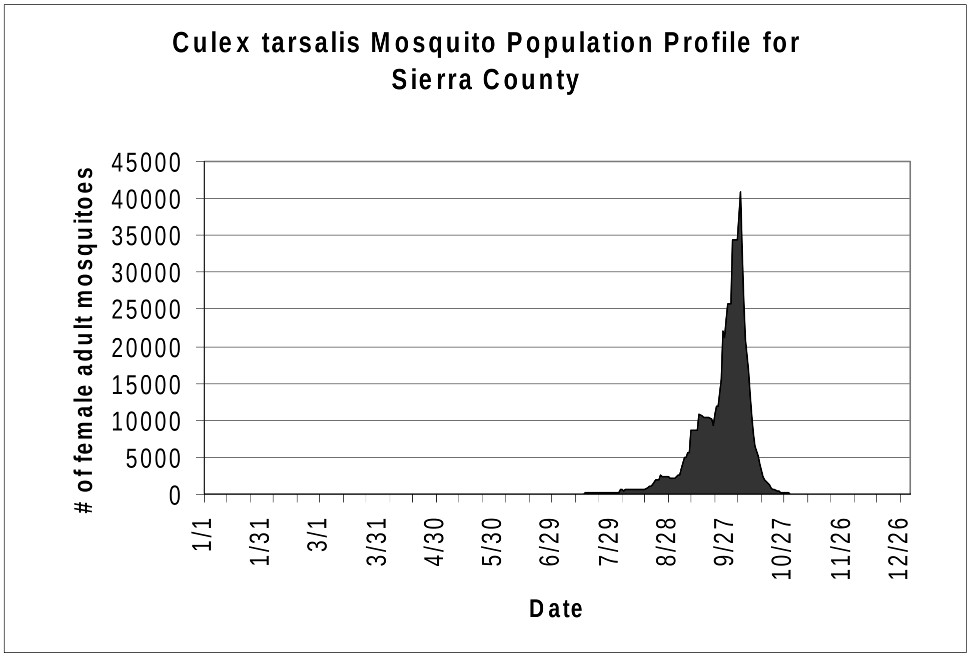


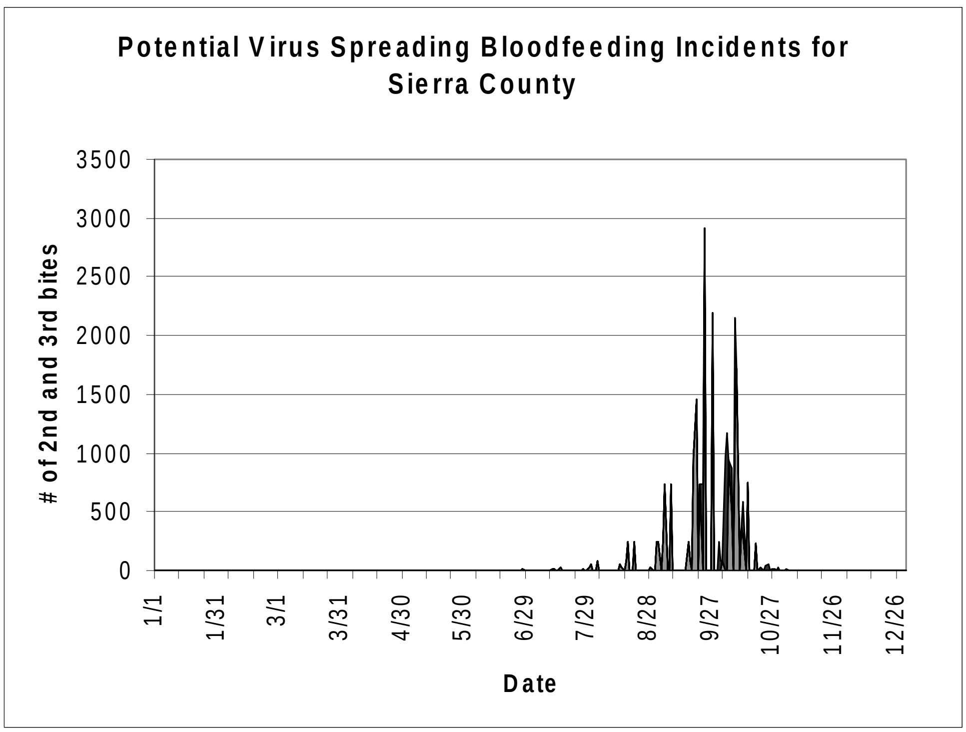


Sierra County

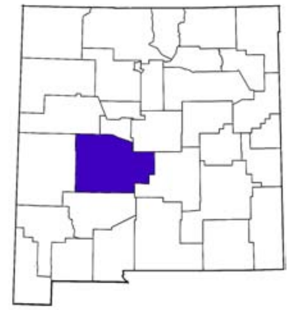
Mosquito Season: May 6 to November 9

VBI:22780



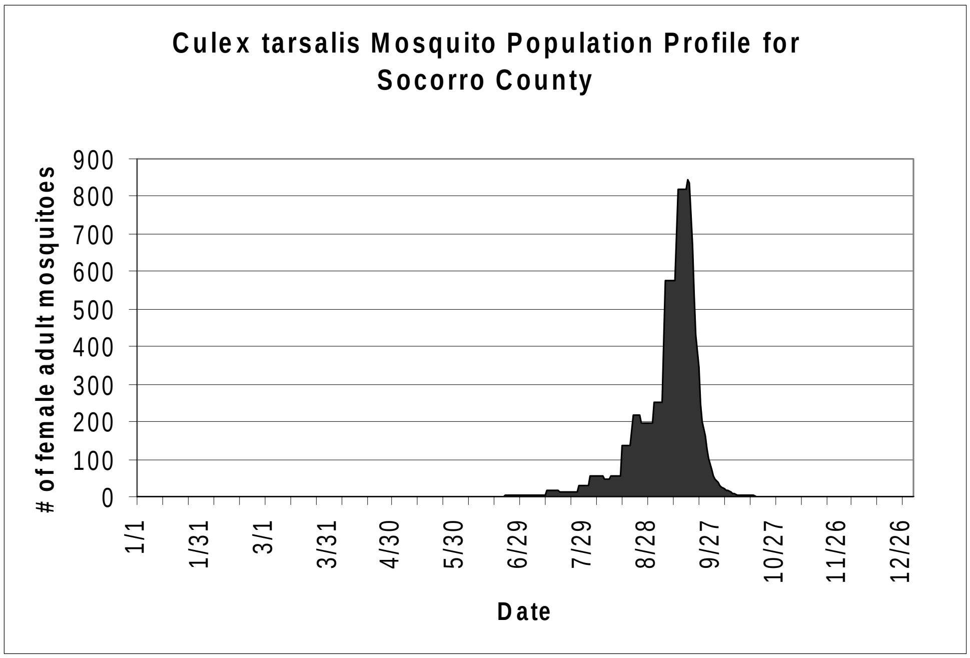


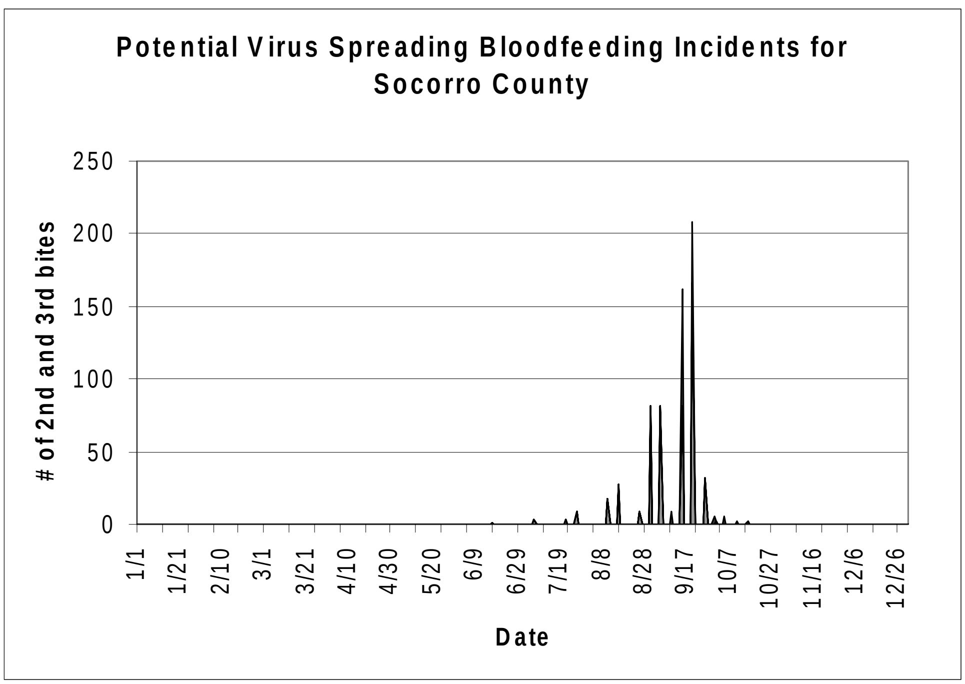
Socorro County



Mosquito Season: June 2 to October 22

VBI: 660

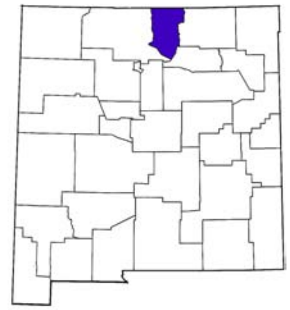


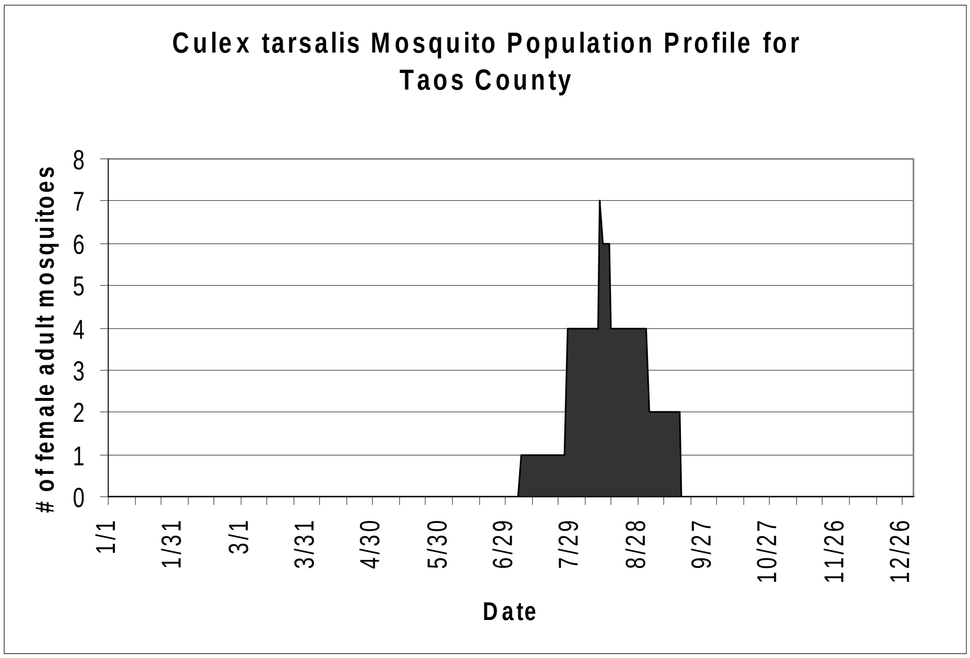


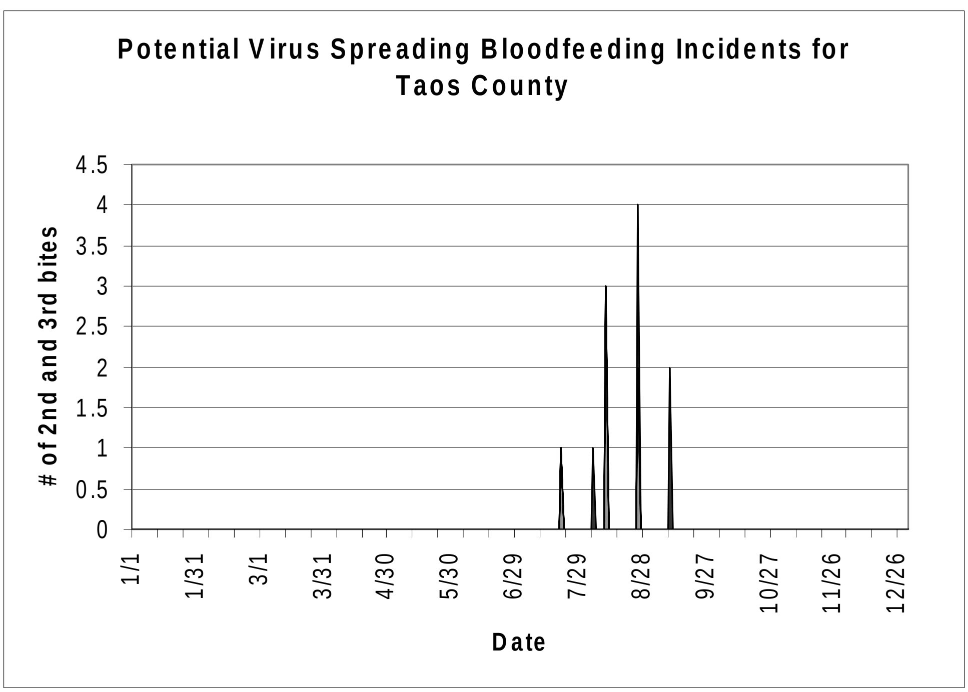
Taos County

Mosquito Season: July 6 to September 16

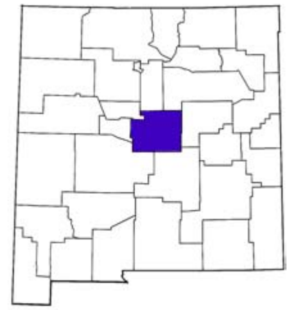
VBI: 11





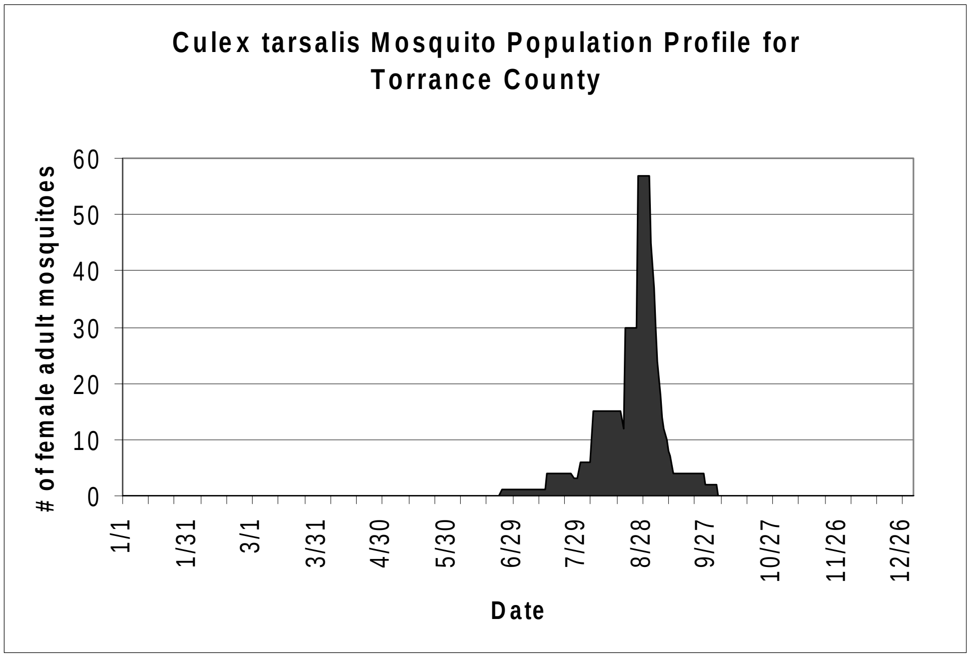


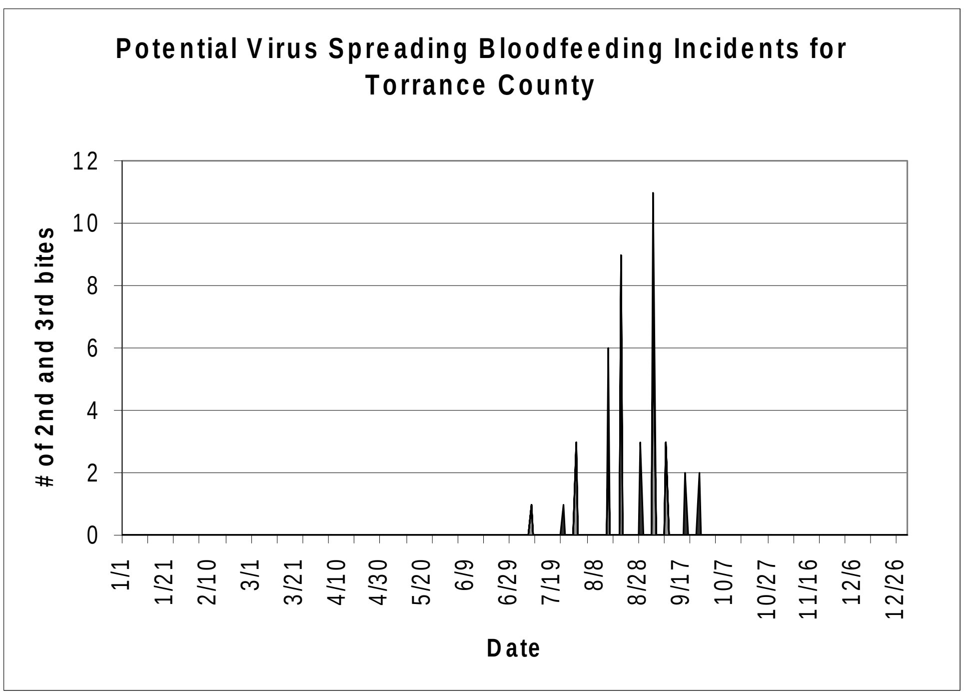
Torrance County

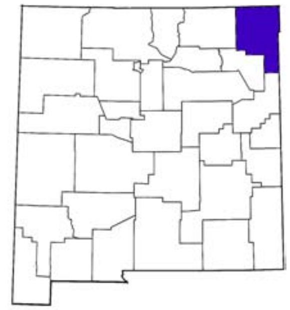


Mosquito Season: June 24 to October 1

VBI:41



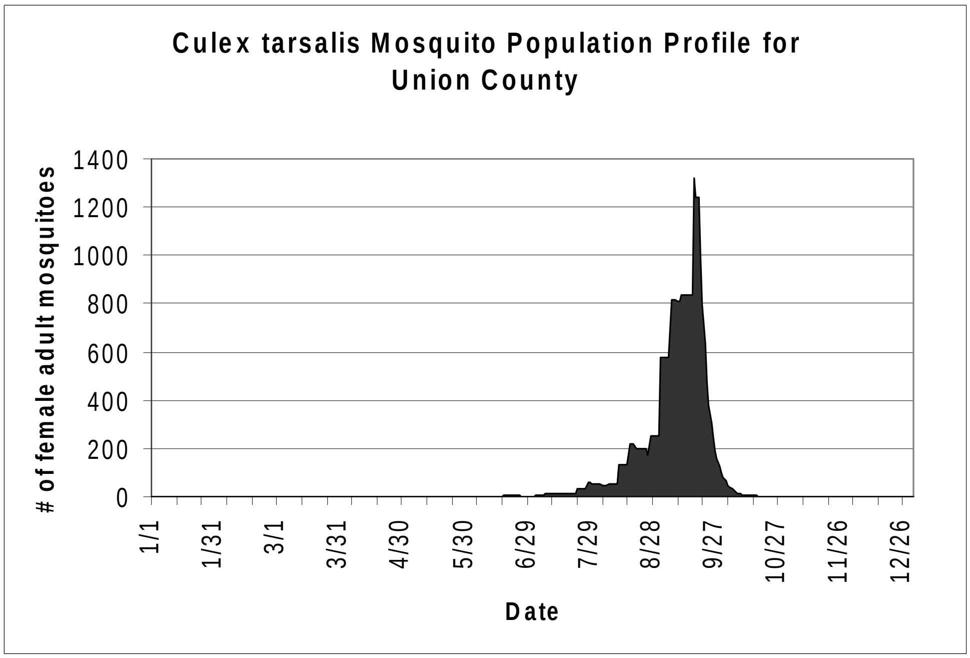


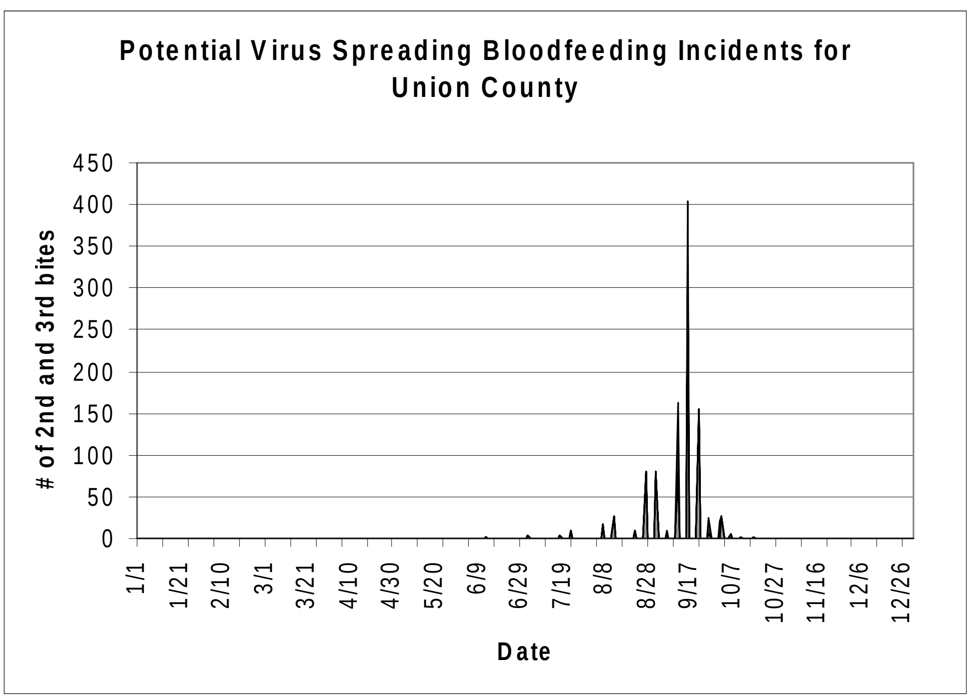


Union County

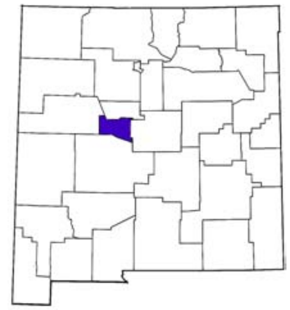
Mosquito Season: May 29 to October 23

VBI: 1046



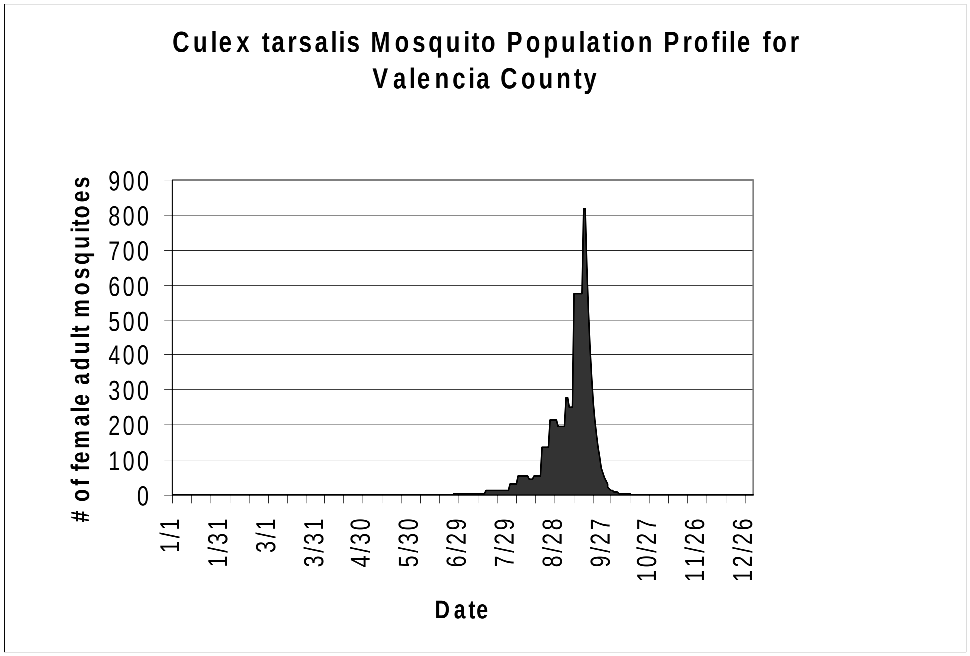


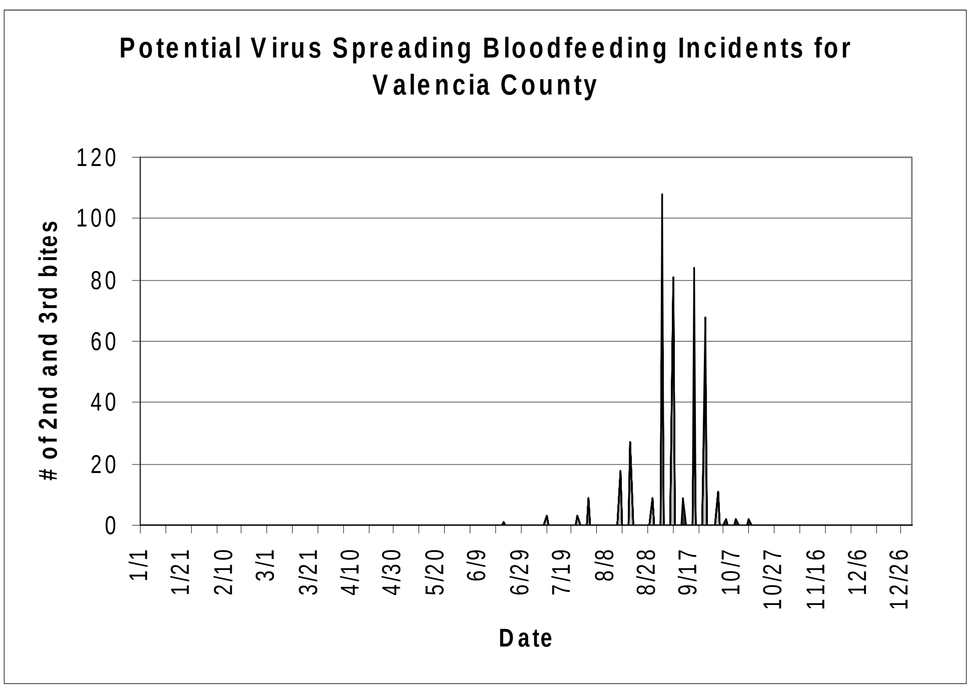
Valencia County



Mosquito Season: June 6 to October 21

VBI: 437





Appendix D – The Crow Model Code

```
/**********************************************************
This is a population model
Based on a single year
input     Average population
                    Varation about the average population
                                        varaition at start
                                        varation at conclusion
                    Month of the year (1-12)
Output Current population

  Kenny Sutherland
**********************************************************/
//* Define input libraries

#include <iostream.h>
#include <stdlib.h>
#include <math.h>
#include <stdio.h>
#include <fstream.h>
#include <string.h>

/**********************************************************/
//Main Program
int
main () {
                    ofstream outfile;
                    outfile.open("crowpopmodel");
          //Define variables
          char dummy;
          int i, month, minst, minsp, maxst, maxsp;
          double xav, dum, dum1, pop, xmax, xmini, xminf, vari, varf;
          double pi;
          pi=3.14159;
          // Start Program
          cout<<" The Main Program has Started."<<endl;
          //Input Average Population
          xav=1000;
          //Input Initial Variation
          vari=0.5;
          //Input Final Variation
          varf=0.5;
          //Input Minimum Starting Number
          minst=2*12;
```

```
//Input Minimum Stop Number
minsp=2*12;
//Input Maximum Starting number
maxst=120;
//Input Maximum Stopping Number
maxsp=120;
//Calculate the population parameters
xmax=xav*(1+vari);
xmini=xav*(1-vari);
xminf=xav*(1-varf);
        cout<<"The Int Max = "<< xmax <<endl;
        cout<<"The Int Min = "<< xmini <<endl;
        cout<<"The Fin Min = "<< xminf <<endl;
for (i=0; i <12*14; i++){
        month=i+1;
        cout<<"The Month Equals "<< month <<endl;
        //calculate the population
        if ((month<=minsp) && (month>=minst)){
                pop=xmini;
                if (pop<0.0) {
                        pop=0.0;
                }
        } else if ((month<=maxsp) && (month>=maxst)){
                pop=xmax;
                if (pop<0.0) {
                        pop=0.0;
                }
        } else if ((month>minsp) && (month<maxst)){
                dum=(month-minsp);
                dum1=(maxst-minsp);
                dum=dum/dum1;
                pop=xmini+(xmax-xmini)*sin((pi/2)*dum);
                //cout<<"Minimum Stop to Max Start "<< pop<<"  "<< dum <<endl;
                if (pop<0.0) {
                        pop=0.0;
                }
        } else if (month<minst){
                dum=month+12-maxsp;
                dum1=(minst+12-maxsp);
                dum=dum/dum1;
                pop=xmax-(xmax-xmini)*sin((pi/2)*dum);
                if (pop<0.0) {
                        pop=0.0;
                }
        } else {
                dum=month-maxsp;
```

```
                    dum1=(minst+12-maxsp);
                    dum=dum/dum1;
                    pop=xmax-(xmax-xminf)*sin((pi/2)*dum);
                    if (pop<0.0) {
                         pop=0.0;
                    }
               }
               cout<<"The Population = "<< pop <<endl;
               outfile<< pop <<endl;
          }

          cin>> dummy;

}
```

Appendix E – Crow Population Data

Region	60004	60005	60006	60009	60010	60013	60015
City	Ojo Sacro	Farley	Grenville	La Cienega	Pecos	Fence Lake	Valencia
County		Colfax	Union	Santa Fe	San Miguel	Cibola	Valencia
Year							
2000	42	3		5	31		
1999	33	2		2	23		
1998		1	1	5	29		
1997	27			6	13		
1996	11				14		1
1995	3			2			1
1994	18	2		1	14		2
1993	9	7			15		1
1992	9				28		2
1991	10		3		26		2
1990	3	5		9	65		
1989	8	10	2	4	30		
1988	10				11		6
1987	5	4			27		31
1986	9			1			
1985	7						1
1984	11						
1983	2						
1982							
1981	7			2			
1980	8			2	8	1	1
1979	9				22		
1978	10			2		6	1
1977	6				5		1
1976	11			1			1
1975	12						
1974				1			
1973	17				3		
1972	13			5			
1971	17						
1970	13			2			
1969	6						
1968	7						
1967							
1966							
1965							
1964							
1963							
1962							
1961							
1960							
1959							

Average	15	1.818182	0.363636	2.7272727	23.454545	0	0.818182
Center	21	5	1.5	4.5	32.5	3	15.5
Variation by 2	0.952381	0.9	0.666667	0.8888889	0.9538462	0.8333333	0.967742
Variation by 4	0.47619	0.45	0.333333	0.4444444	0.4769231	0.4166667	0.483871
Average Variation	0.714286	0.675	0.5	0.6666667	0.7153846	0.625	0.725806

Region	60025	60028	60053	60054	60056	60057	60058	60060
City	Caprock	Cloudcroft	Stinking lake	Angel Fire	Sedan	Mcgaffey	Mt. Taylor	Gallinas
County	Lea	Otero		Colfax	Union	Mc Kinley	Cibola	San Miguel
Year								
2000				19		5		11
1999			38			2		
1998			1	25		13	1	22
1997			5	23		6		5
1996			4	19		4		
1995				16		14		
1994			11	9	3	0		7
1993		2	2	17				
1992				19				8
1991								
1990	1							
1989								
1988								
1987								
1986								
1985								
1984								
1983								
1982								
1981								
1980								
1979								
1978								
1977								
1976								
1975								
1974								
1973								
1972								
1971								
1970								
1969								
1968								
1967								
1966								
1965								
1964								
1963								
1962								

1961								
1960								
1959								
	0.090909	0.181818	5.54545455	13.36364	0.272727	4	0.0909091	4.8181818
	0.5	1	19	12.5	1.5	7	0.5	11
	0	0	0.97368421	0.64	0	1	0	0.7727273
	0	0	0.48684211	0.32	0	0.5	0	0.3863636
	0	0	0.73026316	0.48	0	0.75	0	0.5795455

Region	60061	60062	60069	60071	60075	60078	60111	60112
City	Variadero	Rosebud	Reserve	Laborcita	Red Rock	Pinon	Sabinoso	Logan
County	Sam Miguel		Catron	Socorro	Grant	Otero		Quay
Year								
2000	6		2		0	2		1
1999	8	2	5	1		2		1
1998	6			1		2		2
1997		6	2			2	1	1
1996	7		10		1			1
1995	8	1				1		2
1994	3							1
1993			1					
1992								
1991								1
1990								1
1989								
1988								5
1987								2
1986								
1985								
1984								
1983								
1982								
1981								
1980								1
1979								2
1978								
1977								
1976								
1975								
1974								
1973								
1972								
1971								
1970								
1969								
1968								
1967								
1966								
1965								

1964								
1963								
1962								
1961								
1960								
1959								
	3.4545455	0.818182	1.818182	0.181818	0.090909	0.818182	0.090909	1
	4	3	5	0.5	0.5	1	0.5	2.5
	0.625	0.833333	0.9	0	1	0.5	0	0.8
	0.3125	0.416667	0.45	0	0.5	0.25	0	0.4
	0.46875	0.625	0.675	0	0.75	0.375	0	0.6