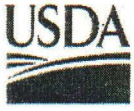


United States Department of Agriculture

Animal and Plant Health Inspection Service

Veterinary Services

Potential impact of West Nile virus in free-roaming horses in the western United States

August 2002
Center for Emerging Issues
Centers for Epidemiology and Animal Health
Animal and Plant Health Inspection Service, USDA

Potential impact of West Nile virus in free-roaming horses in the western United States

August 14, 2002

Executive Summary

Beginning with the first occurrence of West Nile virus (WNV) in the United States in 1999, the country has experienced outbreaks of WNV in horses in each subsequent year. In 1999, WNV-affected horses were found in only two counties in New York. In 2000, 7 northeastern states had confirmed equine cases and in 2001, the virus had spread to infect horses in 20 states. As of early August 2002, equine WNV cases have been reported in 9 states, including as far west as North Dakota, South Dakota, Kansas, and Texas. Many experts believe that WNV could spread throughout the US. This report evaluates the potential impact that WNV will have on free-roaming horses in the western US.

Approximately 45,500 wild horses and burros exist in the western US, primarily in Nevada. If WNV arrives in the western US, it will require local avian reservoir host populations to become endemic. Many bird species that have been found positive for WNV are common in western states. Although susceptible bird species appear to occur in sufficient numbers in western areas, it is not known which species are most likely to allow for transmission of the virus to mosquito vectors.

Potential mosquito vectors of WNV also exist throughout the western US. However, their numbers are likely to be low in the arid climates of many western wild horse habitats. Thus, although it appears likely that free-roaming horses will be exposed to WNV, the frequency of such exposure may be lower than in the eastern US. Horses are dead-end hosts for WNV and thus do not play a role in the transmission and spread of WNV.

Epidemiologic observations from the 1999, 2000, and 2001 outbreaks in the eastern US indicate that overall clinical attack rates are low and that clinical cases are geographically clustered. Clinical disease in free-roaming horses may be more common than in domestic horses due to deficiencies in the diet. One possible scenario based on current observations results in a mortality rate of 16 per 10,000, or about 73 free-roaming horses per year. Horses that die from WNV are generally older than horses that recover.

Although federal regulations specify that the Bureau of Land Management oversee free-roaming horses with minimum intervention necessary to keep herds at desired numbers, destruction of sick horses is allowed.

Prepared by Centers for Epidemiology and Animal Health
Animal and Plant Health Inspection Service, USDA

Table of Contents

Contributors:

Chris Kopral – primary contact
Jerry Freier
Al Kane
Josie Traub-Dargatz

Prepared by Centers for Epidemiology and Animal Health
Animal and Plant Health Inspection Service, USDA

Introduction

Beginning with the first occurrence of West Nile virus (WNV) in the United States in 1999, the eastern part of the country has experienced outbreaks of WNV in horses in each subsequent year. In 1999, WNV-affected horses were found in only two counties in New York. In 2000, 7 northeastern states had confirmed equine cases and in 2001, the virus had spread to infect horses in 20 states. As of early August 2002, equine WNV cases have been reported in 9 states, including as far west as North Dakota, South Dakota, Kansas, and Texas. Many experts believe that WNV could spread throughout the US. The purpose of this report is to evaluate the potential impact that WNV will have on free-roaming horses[1] in the western US.

Locations and numbers of free-roaming horses

Wild horses and burros are located primarily in the western US. Herd management areas, administered by the Bureau of Land Management (BLM), are located in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming (Figure 1). By far the largest number of wild horses is located in Nevada (Table 1).

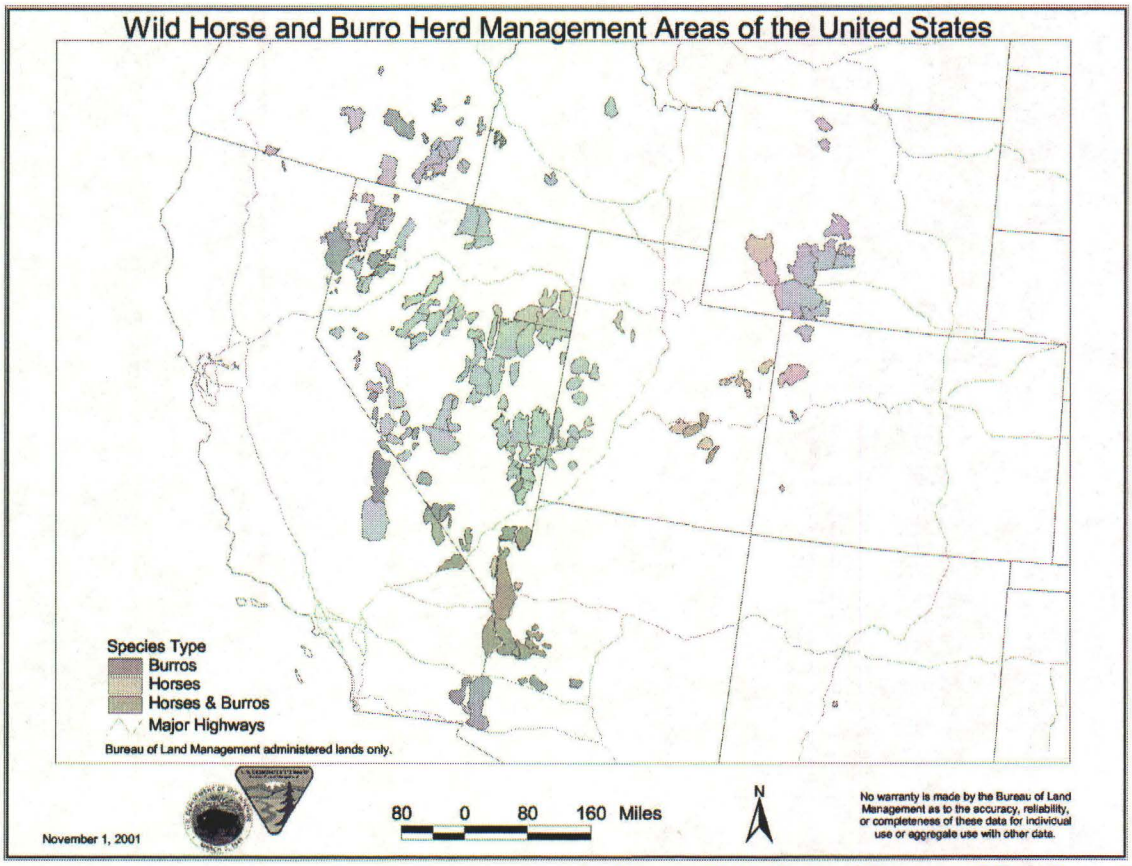


Figure 1 *Source: BLM, National Program Office, Reno, NV*

[1] Although this report generally refers only to horses, it is assumed that everything applies equally to burros.

Table 1: Number of herd management areas (HMAs), wild horses, and wild burros in the western US, March 2001

State	HMAs	Horses	Burros
AZ	11	220	3,146
CA	30	4,504	1,554
CO	4	775	0
ID	6	540	0
MT	1	189	0
NV	103	21,489	709
NM	1	70	0
OR	21	2,851	15
UT	24	2,712	230
WY	16	6,456	0
Total	217	39,806	5,654

Source: BLM, National Program Office, Reno, NV; State BLM offices

There are a few herds of wild horses in other states that are administered by the National Park Service (NPS), individual states, or private organizations. A herd of about 100 wild horses is located on North Carolina's Shackleford Banks, and two herds of 150 horses[2] each are in Virginia/Maryland's Assateague Island National Seashore (NPS). Wild horses are also found on Cumberland Island off the coast of Georgia. In North Dakota, the NPS oversees a herd of about 100 horses.

Free-roaming horses congregate in 'bands', which typically consist of one stallion and one to several mares and their offspring (BLM, NV). Young horses stay with the band for two to three years before being driven away or leaving to form their own bands or joining another. Bands have home ranges which may overlap, especially when resources are scarce. Home ranges vary in size from a few square kilometers up to 300 sq. km. (Miller, 1983). In one Wyoming study, the bands followed similar movement patterns each year, effectively resulting in a rotation grazing system whereby the same pasture was used during the same season each year (Miller, 1983).

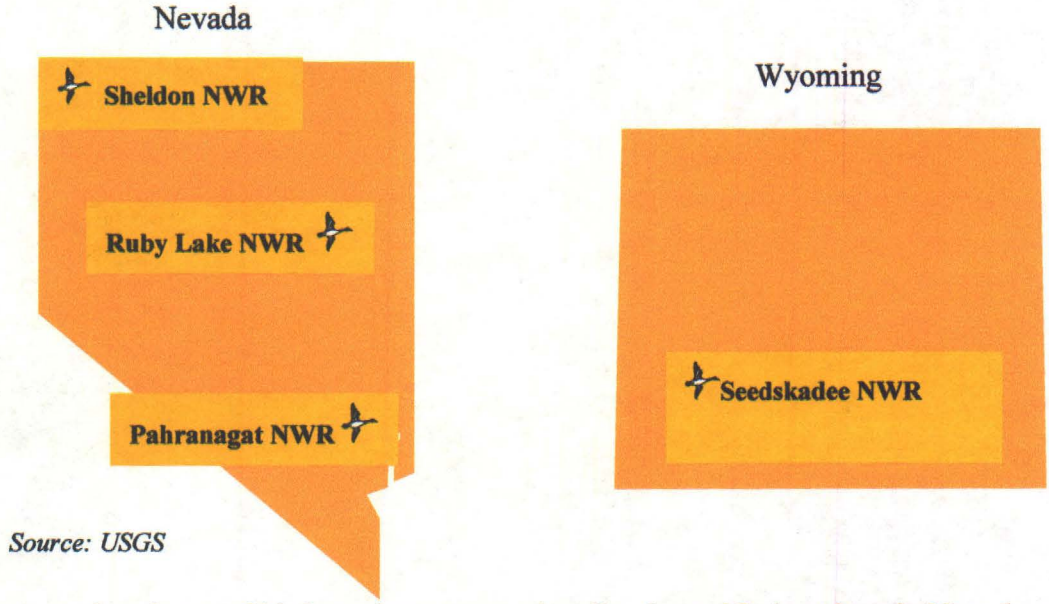
Abundance of bird reservoirs for WNV in the western US

The primary reservoir host for WNV is birds (Hayes, 1989). In the US, the virus has been found in more than 100 species of birds, including many common wild birds (CDC). The species that have been the most susceptible and thus have had the highest mortality due to WNV are American crows, fish crows, and blue jays, all members of the Family Corvidae (USGS, National Wildlife Health Center).

If WNV arrives in the western US, it will require local avian reservoir host populations to become endemic. The corvid species found to be most susceptible in the eastern US are rare (fish crow, blue jay) or less common (American crow) in the western US, although

[2] Although these animals are horses, they are often referred to as 'ponies' because of their small size.

the latter may be locally abundant, such as in suburban or agricultural habitats (i-bird). Other corvids including the western scrub jay, common raven, and black-billed magpie are common in western states. Of these, the common raven and the black-billed magpie have been found positive for WNV (USGS, National Wildlife Health Center).



Source: USGS

Because abundance of bird species can vary locally, 4 specific locations in Nevada and Wyoming (shown on maps above) near BLM herd management areas were selected to examine bird population data (Table 2). At the Ruby Lake, Nevada site, the common raven and black-billed magpie are recorded as common all year round, while at the Sheldon site, these two species plus the western scrub-jay are recorded as common from March through November (US FWS).[3] At the Pahranagat, Nevada site, corvids are uncommon. At the Seedskadee site in south-central Wyoming, only the black-billed magpie is common all year round.

Table 2: Abundance of selected corvids at 4 specific locations near BLM herd management areas

	Common raven				Black-billed magpie				Western scrubjay			
	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W
Nevada												
Pahranagat	u	u	u	u	u	u	u	u	u	u	u	u
Ruby Lake	c	c	c	c	c	c	c	c	-	u	u	u
Sheldon	c	c	c	u	c	c	c	u	c	c	c	u
Wyoming												
Seedskadee	u	-	u	u	c	c	c	c	r	r	r	r

Sp = Mar-May
S = Jun-Aug
F = Sep-Nov
W = Dec-Feb

c = common: usually seen in proper habitat
u = uncommon: present, but not certain to be seen
r = rare: rarely seen
- = unknown

Source: US FWS

[3] Although a bird species may be recorded as common at a specific site all year round, the same birds do not necessarily stay at the same site throughout the year.

Other bird species that have been found positive for WNV, including the Canada goose, red-tailed hawk, and northern flicker, are reported as common for the four sites above (US FWS; USGS).

The fact that many bird species have been found positive for WNV does not necessarily mean that they are capable of transmitting the virus (pers comm, N. Komar, CDC). And the observation that some species, such as corvids, are more susceptible to WNV does not necessarily mean that they are more likely to transmit the virus. Thus, although susceptible bird species appear to occur in sufficient numbers in western areas, it is not known which species are most likely to allow for transmission of the virus to mosquito vectors.

Unpublished studies on WNV reservoir competence of wild bird species indicate that species belonging to the orders Passeriformes and Charadriiformes were the most competent (pers. comm., N. Komar, CDC). Members of an additional six orders of birds were incompetent or weakly competent. Corvids are among the Passeriformes, along with numerous other families of birds, such as blackbirds, robins, and sparrows. An ecological evaluation of the 1999 WNV outbreak in New York City identified the House Sparrow (*Passer domesticus*) as the most important reservoir host (Komar, et al., 2001). House sparrows are abundant in certain habitats throughout the country, but their potential role in the WNV transmission outside of New York City is unknown.

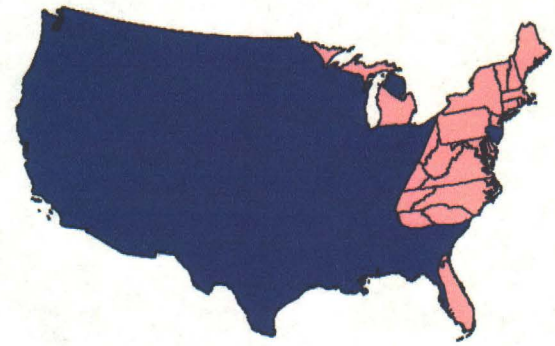
Abundance of mosquito vectors for WNV in the western US

While the primary reservoir host for WNV is birds, the principal vectors by which this virus is transmitted between birds and from birds to mammals are mosquitoes (Hayes, 1989). The virus has been isolated from 43 mosquito species in Europe, Africa, and the Middle East (Hubalek & Halouzka, 1999).

In the eastern US, WNV has been found in at least 27 species of mosquitoes (Nasci, 2002). *Culex* spp. are the most commonly reported; however, several species of the genera *Aedes* and *Ochlerotatus* are also frequently detected. Researchers postulate that, in the eastern US, *Cx. pipiens* and *Cx. restuans* are the primary mosquito vectors among birds, while *Cx. salinarius* and *Aedes/Ochlerotatus* spp. are the primary vectors of WNV for horses (Kulasekera, et al., 2001; Andreadis, et al., 2001). However, researchers believe that, as WNV extends its range westward, additional mosquito species will serve as vectors (Sardelis, et al., 2001).

Of the mosquito species most often found with WNV in the eastern US, some, including *Cx. restuans* and *Cx. salinarius*, do not occur in the western US (Darsie & Ward, 1981). *Cx. pipiens* is found mostly in central and northern regions of the western US. However, other potential vectors such as *Cx. tarsalis* exist throughout the western US. *Cx. tarsalis* is the primary mosquito vector for western equine encephalitis and St. Louis encephalitis viruses (Reisen, 1993). Females of this species feed on birds in spring and mammals in late summer, thereby serving as an important link in virus transmission to horses. *Ae. vexans* is another mosquito species that is abundant throughout the western US (Darsie &

Distribution of *Culex tarsalis*



C. tarsalis present

Source: Darsie & Ward

Ward, 1981). *Ae. vexans* is among the species found with WNV in the eastern US; however, it is considered an inefficient vector for WNV (Nasci, 2002).

Even though many mosquito species occur throughout the western US, their numbers are likely to be low in many western wild horse habitats. Many of the HMAs, especially in Nevada, have arid to semi-arid climates, and water sources are likely to be limited.

Potential exposure rate of free-roaming horses to WNV

Since both bird hosts and mosquito vectors for WNV occur in western states including Nevada, the necessary factors probably exist to sustain the virus' life cycle among birds and to allow for transmission of virus to wild horses. The question remains whether the western ecosystems will support birds and mosquitoes in sufficient concentrations and proportions to make transmission of WNV to free-roaming horses a likely event. It appears reasonable to expect that both birds and horses will seek out areas with a water supply, thereby increasing proximity. This is especially true in years of drought, when the horses stay close to water (BLM, NV). Generally, though, wild horses avoid lingering at water sources to avoid other stallions and potential predators (pers comm, T. Pogacnik, BLM). Thus, although it appears likely that free-roaming horses will be exposed to the WNV, the frequency of such exposure may be lower than in the eastern US.

There is only scant information about horses' exposure rates, with or without clinical disease, from the eastern US. In 1999, of 83 horses sampled from known affected premises in Suffolk Co., NY, including convalescing horses, 43% were seropositive (APHIS-VS).[4] However, of 594 horses sampled from known affected premises in 2000, only 9% were seropositive or confirmed clinical cases (APHIS-VS).

In 2000, a serosurvey was conducted of all horses located within a 10-km radius of 76 confirmed WNV cases in three provinces in southern France (Murgue, et al., 2001). Preliminary results from 5,133 total horses showed estimates of seroprevalence that range from 8% to 13%.[5]

Potential clinical disease rate of free-roaming horses due to WNV

In 1999, 25 cases of WNV in horses occurred in 2 New York counties, while 7 counties had at least one WNV-positive wild bird. The clinical attack rate of WNV in horses in

[4] A seropositive result means that the horse has been exposed to the WNV.
[5] 428 horses had IgG antibodies; 248 had IgM antibodies.

these 7 counties was 7.8 per 10,000 (APHIS-VS). In Suffolk County, NY, which had 22 of the 25 equine cases, the clinical attack rate was 42.3 per 10,000. On known affected premises in Suffolk Co., the clinical attack rate among seropositive horses was 36%. These observations suggest that, although the overall clinical attack rate in a geographic area is very small, pockets exist where clinical attack rates may be relatively high.

In 2000, 60 cases of clinical disease in horses occurred in 7 states (APHIS-VS). A spatial analysis of premises with WNV-affected horses in 2000 found a significant association between the number of affected premises per county and horse population estimates per county (APHIS-VS). However, it was found that affected premises were still spatially clustered. The study concluded that "exposure of equids to WNV is a geographically clustered event. Within regions of virus activity, exposure of individual equids appears to be a chance event" (APHIS-VS). Results from a concurrent case-control study suggested that affected premises were more likely than non-affected premises to be within ½ mile of blackbird roosts or waterfowl congregations, although this association was only marginally statistically significant (APHIS-VS).

In 2001, 738 clinical horse cases of WNV were reported in 20 states (APHIS-VS). Florida had by far the largest number of cases, at 492, and a clinical attack rate of 42 per 10,000.[6] Georgia, with 68, had the next highest number of cases. If Florida is excluded, there was an average of 13 positive horses per state. For all 20 states, the median number of equine cases per state was 6.5. Thus, although WNV activity was geographically widespread, clinical infection in horses, when viewed on a broad scale, was rare.

When viewed at the county level, there was an average of 6 positive horses per county. Although these numbers suggest a clustering of cases within counties, this may be a reflection of the horse population distribution.

The observed clinical attack rates of equine WNV in the US depend on the geographic area of consideration. On a large geographic scale, rates have varied from about 4 per 10,000 (all 20 states, 2001) to 42 per 10,000 (state of Florida, 2001). However, in a few Florida counties, clinical attack rates were as high as 7.6% (760 per 10,000), although these counties had relatively few WNV cases (Loerzel, 2002).

The clinical attack rate among approximately 500 free-roaming horses in the Camargue region of southern France was estimated at 10% in a 1962 outbreak of WNV (Bunning, et al., 2002). This region has several large marshes, numerous colonies of migratory and resident birds, and large mosquito populations (Murgue, et al., 2001). After a 35-year absence of disease in this area, clinical WNV reemerged in horses in 2000 (Murgue, et al., 2001).

In the US, two factors may contribute to increased clinical illness in free-roaming horses as opposed to domestic horses. One is that free-roaming horses may be exposed to greater numbers of mosquitoes, due to lack of mosquito-control measures, thereby increasing the amount of virus to which they are exposed. Free-roaming horses may also

[6] This rate is based on 2000 Florida EIA testing estimates for the equine population.

be more likely to become clinically ill due to dietary deficiencies (e.g., Vitamin E, selenium).

The epidemiologic observations from the US WNV outbreaks in 1999, 2000, and 2001 appear to be consistent. If these findings can be extrapolated to free-roaming horses in the western US, then it would be reasonable to expect that, overall, few of these horses will show clinical disease. Clinical cases are likely to be geographically clustered.

Potential mortality rate of free-roaming horses due to WNV

Equine case fatality[7] rates in the eastern US in 1999 and 2000 were 32% and 38%, respectively (APHIS-VS). In 2001, for the 470 horses for which an outcome was reported, the case fatality rate was 33%.

One possible scenario can be constructed by using the observed clinical attack rate in the US from the state of Florida in 2001 (42 per 10,000) and the maximum observed case fatality rate (38%). Under this scenario, 16 per 10,000, or about 73 free-roaming horses, would be expected to die annually as a result of WNV infection.

The case fatality rate of free-roaming horses may be higher than that of domestic horses because, although no specific treatment for WNV is available, domestic horses are likely to receive supportive treatment, such as provision of food and water, or frequent turning if recumbent. Observations from the 1999-2001 US cases have shown that domestic horses that die from WNV are generally older than those that recover (Crom, 2002).

Free-roaming horses' role in the maintenance and spread of WNV

Both experimental and epidemiologic evidence indicates that horses are dead-end hosts for WNV and thus do not play a role in the transmission and spread of the virus. In one experimental study in the US in which 4 horses were inoculated with WNV, viremias lasted at most 7 days post-inoculation, and the maximum viremia was $10^{2.5}$ PFU per ml (Berninger, et al., 2000). Viremias of $10^{5.5}$ to $10^{7.5}$ PFU per ml are considered low to moderate viremias in experimentally infected North American house sparrows and other birds (Sardelis, et al., 2001). Since, for other arboviruses, a dose-response relationship exists between the titer of the infective blood meal and the ability of vector mosquitoes to transmit, it appears unlikely that the low viremia observed in this study would lead to significant transmission rates (Bunning, et al., 2002).

In another US study, 12 horses were infected with WNV via the bites of infected mosquitoes (Bunning, et al., 2002). The highest viremia observed was 10^3 PFU per ml. Uninfected mosquitoes then were allowed to feed on 8 of the infected horses (the first 4 horses were used to determine peak periods of viremia). None of the 652 mosquitoes that fed on the viremic horses became infected with WNV. Only one of the 12 horses (8%) became clinically ill.

---

[7] Includes horses that died or were euthanized.

Other considerations

A conditionally-licensed commercial vaccine for prevention of WNV is available. Two injections, 3 to 6 weeks apart, are recommended for immunity. Vaccination must be repeated annually (Ft. Dodge).

Some wild horse herds administered by states or private organizations may be subject to interventions such as vaccination. For example, the Virginia herd in the Assateague Island National Seashore (the "Chincoteague ponies") is managed by the Chincoteague Fire Department and undergoes veterinary checks twice a year (NPS). The horses are vaccinated for eastern equine encephalitis, rabies, and tetanus, and are tested for equine infectious anemia. On the other hand, the Maryland herd on Assateague Island is managed by the NPS with a policy of minimum intervention (NPS).

In the western US, the mandate of the BLM specifies that 'management of wild horses and burros shall be undertaken with the objective of limiting the animals' distribution to herd areas. Management shall be at the minimum level necessary to attain the objectives identified in approved land use plans and herd management area plans' (43CFR 4710.4). Herds are gathered periodically to reduce the numbers of horses, and old, sick, or lame animals are destroyed (43CFR 4720.1). Destruction also is allowed as an act of mercy (43CFR 4730.1).

Conclusions

The western US probably has the necessary conditions to sustain the WN virus' life cycle among birds and to allow for transmission of virus to wild horses. The question remains whether the western ecosystems will support birds and mosquitoes in sufficient concentrations and proportions to make transmission of WNV to free-roaming horses a likely event. Although it appears likely that free-roaming horses will be exposed to WNV, the frequency of such exposure is currently unknown, but due to arid conditions in the west, is likely to be lower than in the eastern US. Horses are dead-end hosts for WNV and thus do not play a role in the transmission and spread of WNV. Free-roaming horses do not present a risk of transmitting WNV to domestic horses.

Epidemiologic observations from the 1999, 2000, and 2001 outbreaks in the eastern US indicate that overall clinical attack rates are low and that clinical cases are geographically clustered. Clinical disease in free-roaming horses may be more common than in domestic horses due to dietary deficiencies. One possible scenario based on current observations results in an annual mortality rate of 16 per 10,000, or about 73 free-roaming horses.

Federal regulations specify that the BLM manage free-roaming horses with minimum intervention necessary to keep herds at desired numbers; destruction of sick horses is allowed.

Sources

The date given in parentheses after a URL denotes the date the website was last reviewed/updated, where available.

Andreadis TG, Anderson JF, Vossbrinck CR. 2001. Mosquito surveillance for West Nile Virus in Connecticut, 2000: Isolation from Culex pipiens, Cx. restuans, Cx. salinarius, and Culiseta melanura. Emerging Infectious Diseases 7(4):670-674.

APHIS, VS. Summary of West Nile virus in the United States, 1999 @ www.aphis.usda.gov/vs/ep/WNV/summary.html, last accessed on May 22, 2002.

APHIS, VS. Update on the current status of West Nile virus. Equine cases of West Nile virus infection in 2001: 1 January through 31 December @ www.aphis.usda.gov/oa/wnv/wnvstats.html, last accessed on May 22, 2002.

APHIS, VS. West Nile virus in equids in the northeastern United States in 2000. @ www.aphis.usda.gov/vs/ceah (6/19/2002), last accessed on June 21, 2002.

Berninger ML, Ward G, Szkudlarek L, et al. 2000. West Nile virus infection in horses: a preliminary report. Proceedings of the West Nile Virus Action Workshop. January 2000; Tarrytown, NY.

Bunning ML, Bowen RA, Cropp CB, et al. 2002. Experimental infection of horses with West Nile virus. Emerging Infectious Diseases 8(4):380-386.

BLM, NV. Bureau of Land Management, Nevada @ www.nv.blm.gov/hma/ely/White%20River.pdf, last accessed on May 31, 2002, and www.nv.blm.gov/hma/ely/Butte%20HMA.pdf, last accessed on June 4, 2002.

CDC @ www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm (5/22/02), last accessed on June 21, 2002.

CDC @ www.cdc.gov/ncidod/dvbid/westnile (4/9/02), last accessed on May 22, 2002.

CDC. 2001. West Nile virus activity – Eastern United States, 2001. Morbidity and Mortality Weekly Report 50(29):617-619.

CDC. 2000. Update: West Nile virus activity – Eastern United States, 2000. Morbidity and Mortality Weekly Report, Nov 24, 2000.

Crom R. 2002. The evolving West Nile virus epizootic in horses. Third National Planning Meeting for Surveillance, Prevention, and Control of West Nile Virus in the United States. Atlanta, GA. March 22-23, 2002. @ www.cdc.gov/ncidod/dvbid/westnile/conf/march_2002.htm (5/7/02), last accessed on June 4, 2002.

Darsie RF, Ward, RA. 1981. Identification and geographical distribution of the mosquitoes of North America, north of Mexico. American Mosquito Control Association, Fresno, CA.

Fort Dodge. @ www.equinewestnile.com/vaccine.htm, last accessed on June 5, 2002.

Hayes CG. 1989. West Nile fever. In: The Arboviruses: Epidemiology and Ecology, Vol V (TP Monath, ed). CRC Press, Boca Raton, FL, pg 59-88.

Hubalek Z, Halouzka J. 1999. West Nile fever – a reemerging mosquito-borne viral disease in Europe. Emerging Infectious Diseases 5(5):643-650.

i-bird. International birding information resource data @ i-bird.com/commonname.htm (10/8/00), last accessed on June 4, 2002.

Komar N, Panella NA, Burns JE, et al. 2001. Serologic evidence for West Nile virus infection in birds in the New York City Vicinity during an outbreak in 1999. Emerging Infectious Diseases 7(4):621-625.

Kulasekera VL, Kramer L, Nasci RS, et al. 2001. West Nile virus infection in mosquitoes, birds, horses, and humans, Staten Island, New York, 2000. Emerging Infectious Diseases 7(4):722-725.

Loerzel S. 2002. Data cited in presentation by Crom R (see above).

Miller R. 1983. Seasonal movements and home ranges of feral horse bands in Wyoming's Red Desert. Journal of Range Management 36(2):199-201.

Murgue B, Murri S, Zientara S, et al. 2001. West Nile outbreak in horses in southern France, 2000: The return after 35 years. Emerging Infectious Diseases 7(4):692-696.

Nasci R. 2002. Mosquito species infected with West Nile virus in the US, 1999-2001, Implications for virus transmission. Presented at the Third National Planning Meeting for the Surveillance, Prevention, and Control of West Nile Virus in the US, Atlanta, GA, March 22-23, 2002 @ www.cdc.gov/ncidod/westnile/conf/March_2002.htm (5/7/02), last accessed on May 28, 2002.

National Park Service. @ www.nps.gov/asis/horses.htm (2/24/02); www.nps.gov/calo/hrs.htm (5/18/01); www.nps.gov/thro/tr_ponys.htm; all last accessed on June 4, 2002.

Reisen W. 1993. The western equine encephalitis mosquito, Culex tarsalis. Wing Beats, 4(2):16.

Sardelis MR, Turell MJ, Dohm DJ, et al. 2001. Vector competence of selected North American Culex and Coquillettidia mosquitoes for West Nile Virus. Emerging Infectious Diseases 7(6):1018-1022.

USDA-NASS. Equine. March 2, 1999 @ usda.mannlib.cornell.edu/reporst/nassr/livestock/quine/equi1999.txt, last accessed on May 31, 2002.

US Fish and Wildlife Service. 1993. Wildlife of Sheldon National Wildlife Refuge www.npwrc.usgs.gov/resource/othrdata/chekbird/r1/sheldon.htm (7/22/98), last accessed on June 4, 2002.

US Fish and Wildlife Service. 1992. Wildlife of Ruby Lake National Wildlife Refuge www.npwrc.usgs.gov/resource/othrdata/chekbird/r1/rubylake.htm (5/26/98), last accessed on June 4, 2002.

US Fish and Wildlife Service. 1988. Birds of Pahranagat National Wildlife Refuge www.npwrc.usgs.gov/resource/othrdata/chekbird/r1/pahran.htm (5/26/98), last accessed on June 4, 2002.

US Fish and Wildlife Service. 1979. Birds of Seedskadee National Wildlife Refuge www.npwrc.usgs.gov/resource/othrdata/chekbird/r6/seedskad.htm (5/22/98), last accessed on June 4, 2002.

USGS, National Wildlife Health Center. Wild birds implicated in rapid spread of West Nile virus. Wildlife Health Alert #01-02 @ www.nwhc.usgs.gov/whats_new/wha/wha0102.html (11/27/01), last accessed on May 31, 2002.

USGS, Northern Prairie Wildlife Research Center. Bird Checklists of the United States @ www.npwrc.usgs.gov/resource/othrdata/chekbird/r1/32.htm and www.npwrc.usgs.gov/resource/othrdata/chekbird/r6/56.htm, last accessed on June 27, 2002.