

# Preventing Vector-Borne Diseases in National Parks in California

*A pilot project between*

**National Park Service**

Office of Public Health

and

**California Department of Public Health**

Vector-Borne Disease Section



SUMMARY REPORT, 2007-2010



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## Table of Contents

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Summary Report, 2007 - 2010 . . . . .	1
Park Reports . . . . .	9
Death Valley National Park . . . . .	10
Devil’s Postpile National Monument . . . . .	11
Alcatraz Island, Golden Gate National Recreation Area . . . . .	12
Golden Gate National Recreation Area and Point Reyes National Seashore . . . . .	13
Lassen Volcanic National Park . . . . .	14
Lava Beds National Monument . . . . .	16
Manzanar National Historic Site . . . . .	19
Pinnacles National Monument . . . . .	20
Redwood National Park . . . . .	21
Sequoia and Kings Canyon National Parks . . . . .	22
Whiskeytown National Recreation Area . . . . .	23
Yosemite National Park . . . . .	24
Knowledge, Attitudes, and Practices of Vector-Borne Diseases: A Survey of NPS Employees . . . . .	28

## Summary Report, 2007-2010

In 2007, the National Park Service Office of Public Health and the California Department of Public Health's Vector-Borne Disease Section entered a Memorandum of Understanding to enhance vector-borne disease prevention services at NPS units in California. Funding was provided for a three-year pilot project, to extend from September 2007 to September 2010. This report summarizes field activities pursuant to that agreement that VBDS conducted at 13 of 24 NPS units statewide.

### Background

The 24 National Park Service (NPS) units in California attract over 32 million visitors annually and are staffed with approximately 3,000 NPS and 3,000 concessionaire employees. Collectively, these individuals represent significant potential exposures to vector-borne diseases (e.g. hantavirus, plague, Lyme disease, and West Nile infection) which are transmitted to humans by biting arthropods and wild rodents and are important causes of human morbidity and mortality.

At California NPS units, the presence and potential transmission of various vector-borne diseases are well-documented. From 1976 to 2007, plague was identified in more than 50 dead animals found within the boundaries of NPS lands. Rodent-borne hantavirus has been identified in several California NPS units, including up to 70% of deer mice on the Channel Islands and a case of hantavirus cardiopulmonary syndrome in a visitor to Yosemite National Park. In recent years, cases of tick-borne diseases such as Lyme disease and relapsing fever have been reported among NPS employees and visitors. Despite the public health risks associated with these diseases, the NPS has limited resources to support a robust, comprehensive vector-borne disease education and prevention program.

The NPS Office of Public Health (OPH) has a mission to promote a safe and healthy visitor experience while preserving the environment and wildlife. Health and safety issues of concern for park visitors and staff include vector-borne, foodborne, and waterborne illnesses. NPS OPH has public health consultants placed at the regional and park level to assist with food, water, waste water, and vector-borne disease issues. Two members of the Epidemiology branch, including a medical epidemiologist, provide support to parks in building a nationwide surveillance system, responding to outbreaks, and managing projects that promote public health awareness at parks.

The mission of the California Department of Public Health's (CDPH) Vector-Borne Disease Section (VBDS) is to protect the health and well-being of Californians from arthropod- and vertebrate-transmitted diseases and injurious pests. To this end, VBDS develops and implements statewide vector-borne disease surveillance, prevention, and control programs; designs and conducts scientific investigations; coordinates

preparedness activities for detection of and response to introduced vector-borne diseases; advises and provides training, information, and educational materials to local public health officials, allied agencies, and the public. VBDS consists of 27 staff, including biologists, epidemiologists, and administrative support personnel, in Sacramento headquarters and six regional offices. VBDS supplements OPH's broad disease prevention efforts by offering staff specifically trained and knowledgeable in vector-borne disease ecology and epidemiology; experience and expertise in conducting field evaluation and risk assessment; equipment and skills for collecting, identifying, and sampling mammalian and arthropod vectors; and, in collaboration with CDPH laboratories, support for testing of samples for infectious disease agents.

#### Funding and Memorandum of Understanding

In September 2007, the NPS OPH and CDPH VBDS entered a memorandum of understanding to enhance surveillance for and prevention of vector-borne infectious diseases among visitors, staff, and residents of the NPS units in California. The period of this three-year pilot project was from September 2007 to September 2010

The NPS provided \$70,000 of seed money for this MOU. Funding was coordinated through Public Health Foundation Enterprises, a non-profit agency. Monies were provided to cover costs associated with VBDS staff travel (lodging, per diem), mileage, material expenses (field supplies), and laboratory testing of specimens (per test cost) incurred in the course of performing work pursuant to the MOU. Monies were also used to support part-time seasonal staff in VBDS field offices whose principal activities were NPS work. MOU funds were not used to support full-time permanent staff, nor were any positions specifically created as a consequence of this MOU.

#### VBDS Services

Several vector-borne diseases occur in California, many of which may be of concern in habitats encompassed by NPS units. These include:

Rodent-borne diseases: hantavirus cardiopulmonary syndrome

Flea-borne diseases: plague, murine typhus

Mosquito-borne diseases: West Nile virus

Tick-borne diseases: Lyme disease, tick-borne relapsing fever, Rocky Mountain spotted fever

VBDS conducts surveillance, risk assessment, and control for these diseases through various means including visual evaluation, collection of vector and reservoir non-human animals, testing of tissues from non-humans for microbial pathogens, and monitoring of statewide disease surveillance data for cases of vector-borne disease that are reported to public health officials.

Specific techniques that VBDS employs to evaluate risk of vector-borne diseases include:

*Rodent-borne diseases (HCPS)*

- collection and identification of rodents species in a given area
- testing of blood from appropriate rodents for antibody to Sin Nombre virus
- evaluation of habitable structures for evidence of rodent activity and factors that would encourage or facilitate ingress and infestation

*Flea-borne diseases (plague)*

- collection and identification of rodents in an area of concern
- testing blood from appropriate rodents for antibodies to *Yersinia pestis*
- testing dead rodents for *Y. pestis*
- monitoring relative abundance of rodent species and density of vector fleas on rodents
- testing blood specimens from indicator large mammal species for *Y. pestis* antibody
- testing rodent fleas for *Y. pestis*
- when necessary, implementing flea control to reduce transmission risk

*Tick-borne diseases (Lyme disease)*

- collection and identification of ticks from vegetation
- testing of ticks for Lyme disease spirochetes, *Borrelia burgdorferi*
- evaluation of habitat for suitability to support ticks
- assessment of habitat composition to appraise likelihood for human contact with potential tick habitat

*Tick-borne diseases (relapsing fever)*

- visual evaluation of habitable structures for evidence of or potential for rodent ingress and activity
- testing of sera from appropriate rodents for antibodies to spirochete, *Borrelia hermsii*
- collection and testing of soft ticks for *B. hermsii*

*Mosquito-borne diseases*

- evaluation of habitat for standing water and other sources of mosquito breeding
- collection and identification of mosquito species

Vector borne disease activities performed at each NPS units were determined by: location (longitude, latitude, elevation), habitat, and diseases deemed to be of historical or potential concern; discussions initiated by VBDS Public Health Biologists with NPS staff; and specific requests from park staff and NPS management.

In addition to gathering empirical data on indicators for specific diseases, VBDS staff provided reports on surveillance activities, education and training on vector-borne disease prevention to interested persons, including Park Superintendents, through

oral presentations, informal discussions, printed preventive education materials, and consultation by phone or e-mail.

At the completion of each field effort that VBDS conducted, a comprehensive written report was prepared and delivered to Park Superintendants and other interested parties which detailed surveillance activities, data collected, and recommendations for disease prevention emergent therefrom.

#### Summary of VBDS – NPS activities, September 2007 – September 2010

During the three-year period of the MOU, VBDS contacted staff at 14 NPS units in California and made at least one visit to 13 of these (Table 1). Approximately 37 separate visits were made to these 13 parks. The most visits were made to Golden Gate National Recreation Area/Point Reyes National Seashore (10) and Yosemite National Park (6). Visits ranged from single-day dialogues with park staff to multi-day visual assessments, disease surveillance, and staff training.

VBDS conducted surveillance for hantavirus at eight parks, plague at five parks, relapsing fever at three parks, ticks at four parks, and mosquitoes at two parks (Tables 2 – 5). VBDS delivered seminars and conducted training workshops for NPS employees at seven parks.

Summaries of VBDS activities at each of the NPS units in California are provided in the following Park Reports. In addition to disease-specific field activities, VBDS collaborated with OPH to survey NPS staff on their knowledge and practices with regard to vector-borne diseases. A summary of the results of this survey is included.

#### Project Conclusions

This project successfully expanded the state of knowledge of vector-borne diseases at NPS properties in California. The microbial pathogens, invertebrate vectors, and mammalian reservoirs of several vector-borne diseases were identified at parks throughout the state. These surveillance data served to underscore the need for preventive education and action on the part of both NPS staff and public visitors. The presence of VBDS staff on-site at NPS units to conduct surveillance helped to emphasize to NPS employees the importance and proximity of these diseases. Contemporary data collected within the boundaries of the parks informed and motivated preventive measures that were appropriate for each individual park. Finally, in addition to the formal didactic education and training sessions that VBDS provided, NPS staff benefitted from joining VBDS staff during their field activities and gained a better understanding of the ecology and prevention of vector-borne diseases. These personal interactions formed the foundation for on-going communication between specific representatives of the respective agencies that should facilitate continued collaboration on vector-borne disease monitoring and prevention.

### Acknowledgements

VBDS extends its thanks to the numerous NPS staff who aided these endeavors by assisting VBDS staff with field work, providing information and insight on local ecology, making recommendations for sites of chief concern and study, arranging for accommodations, facilitating access to non-public areas. VBDS also acknowledges the invaluable contribution of the NPS Pacific West Regional Office and Office of Public Health without whose professional and financial support much of this work would not have been possible. Finally, VBDS acknowledges the contribution of the Microbial Diseases Laboratory and Viral and Rickettsial Disease Laboratory of CDPH, Rocky Mountain Laboratories of the National Institutes of Health, and the University of California--Davis for providing laboratory testing of vector-borne disease pathogens.

**Table 1. National Park Service units receiving services<sup>a</sup> by the California Department of Public Health, Vector-Borne Disease Section, 2007-2010**

NPS unit	Abbreviation	Year(s)
Channel Islands National Park <sup>b</sup>	CHIS	---
Death Valley National Park	DEVA	2009, 2010
Devil's Postpile National Monument	DEPO	2007
Golden Gate National Recreation Area	GOGA	2008
Alcatraz Island (GOGA)	ALCA	2008
Joshua Tree National Park	JOTR	2010
Lassen Volcanic National Park	LAVO	2008
Lava Beds National Monument	LABE	2008, 2009, 2010
Manzanar National Historic Site	MANZ	2008
Pinnacles National Monument	PINN	2009
Point Reyes National Seashore	PORE	2008
Redwood National Park	REDW	2009
Sequoia and Kings Canyon National Parks	SEKI	2009, 2010
Whiskeytown National Recreation Area	WHIS	2008
Yosemite National Park	YOSE	2007, 2008, 2009, 2010

<sup>a</sup>Services included meeting and discuss disease issues with NPS staff, visual evaluation of facilities, collection and sampling of mammals or arthropods, providing preventive education workshops or seminars.

<sup>b</sup>VBDS discussed vector-borne disease issues, including hantavirus and West Nile virus, with CHIS management but no on-site services were requested or rendered.

**Table 2. Serum antibodies to hantavirus (Sin Nombre virus) in rodents collected at National Park Service units in California, 2007-2010**

NPS unit	Mo. – Yr. collection	Deer mice ( <i>Peromyscus maniculatus</i> )		Other mice ( <i>Peromyscus spp.</i> )	
		No. positive (%)	No. tested	No. positive (%)	No. tested
DEVA	Mar – 2010	1 (100)	1	14 (31)	45
DEPO	Jun – 2007	5 (42)	12	1 (33)	3
	Aug – 2007	5 (17)	30	---	0
GOGA	Sep – 2008	0	13	---	0
JOTR	May – 2010	0	4	1 (8)	12
LAVO	Aug – 2008	1 (12.5)	8	---	0
LABE	Apr – 2008	1 (25)	4	1 (4)	27
	May – 2009	2 (20)	10	0	12
	May – 2010	0	12	0	13
MANZ	Sep – 2008	---	0	0	4
PINN	Apr – 2009	0	4	0	7
SEKI	Sep – 2010	0	4	---	0
YOSE	Sep – 2007	4 (13)	30	0	5
	Sep – 2008	5 (24)	21	---	0

**Table 3. Serum antibodies to tick-borne relapsing fever spirochete (*Borrelia hermsii*) in rodents collected at National Park Service units in California, 2007-2010**

NPS unit	Mo. – Yr. collected	Squirrels		Chipmunks		Other rodents	
		No. positive	No. tested	No. positive	No. tested	No. positive	No. tested
LAVO	Aug – 2008	1	10	0	5	---	0
LABE	May – 2009	3	3	---	0	---	0
	May - 2010 <sup>a</sup>		2		2		5
MANZ	Sep – 2008	0	2	---	0	0	12
SEKI <sup>b</sup>	Sep – 2010	0	12	5	22	0	4
YOSE	Sep – 2007	1	16	8	14	---	0
	Sep – 2008	1	4	2	7	0	23

<sup>a</sup>Test results not yet available

<sup>b</sup>Sera tested by PCR at University of Nevada, Reno

**Table 4. Serum antibodies to plague bacteria (*Yersinia pestis*) in rodents collected at National Park Service units in California, 2007-2010**

NPS unit	Mo. – Yr. collected	Squirrels		Chipmunks		Other rodents	
		No. positive	No. tested	No. positive	No. tested	No. positive	No. tested
DEPO	Jun – 2007	0	1	0	2	---	0
	Jul – 2007	0	1	0	14	---	0
LAVO	Aug – 2008	0	17	0	5	---	0
LABE	Apr – 2008	---	0	---	0	0	33
	May – 2009	0	3	---	0	---	0
SEKI	Sep – 2010	0	17	0	23	0	5
YOSE	Sep – 2007	0	17	0	13	---	0
	Sep – 2008	0	2	0	1	---	0

**Table 5. Western black-legged ticks (*Ixodes pacificus*) collected from National Park Service units in California and tested for *Borrelia spirochetes* by polymerase chain reaction, 2007-2010**

NPS unit	Year collected	No. ticks tested	No. positive <i>Borrelia</i> sp.	No. positive <i>B. burgdorferi</i>
GOGA	2008	118	1	1
PORE	2008	7	0	0
YOSE	2010	26	0	0

# Park Reports

## Death Valley National Park (DEVA)

### Activities

#### Hantavirus

In April 2009, VBDS staff conducted a preliminary visual assessment of buildings and facilities at DEVA for evidence of actual or potential rodent ingress and infestation. In March 2010, VBDS returned to collect and sample rodents for evidence of hantavirus infection. Rodent collection efforts were focused at:



- Scotty's Castle
  - Thirty-two cactus mice (*Peromyscus eremicus*) and one deer mouse (*Peromyscus maniculatus*) were collected
  - Evidence of hantavirus infection was identified in 13 *P. eremicus* (41%)
- Headquarters offices at Furnace Creek
  - 3 cactus mice
- Theatre at Furnace Creek
- Cow Creek housing
  - 8 cactus mice were collected
  - Evidence of hantavirus infection was identified in one cactus mouse (12.5%).
- Maintenance area
- Campgrounds
  - two canyon mice (*Peromyscus crinitus*) at Wildrose campground

### Conclusions

Mice and evidence of hantavirus were observed at several areas in DEVA where staff and visitors are likely to be present. All but one of the infected mice were cactus mice (*P. eremicus*). Only deer mice (*P. maniculatus*) are known to carry and shed a hantavirus (viz. Sin Nombre virus) that is infectious to humans; it is uncertain if the hantavirus detected in these cactus mice is SNV.

### Recommendations

- Efforts to control rodents through placement of snap-traps and exclusion of rodents from the interiors of heavily frequented buildings should continue.
- Increase exclusion efforts in Cow Creek Housing and Work Area through structural repairs/improvements and vegetation management.
- Although the risk of HCPS from cactus mice is unclear, all rodents should be considered a potential source of human disease and proper preventive precautions should be exercised at all times.

## Devil's Postpile National Monument (DEPO)

### Activities

#### Hantavirus and Plague

In June and August, 2007, VBDS conducted evaluation for hantavirus and plague in areas around the ranger station and the campground.



- A total of 300 trap-nights yielded 69 rodents.
- Antibodies to Sin Nombre virus (SNV), the cause of hantavirus cardiopulmonary syndrome, were detected in
  - 10 of 42 (24%) deer mice (*Peromyscus maniculatus*)
  - 1 of 3 (33%) piñon mice (*Peromyscus truei*).
- Antibody to *Yersinia pestis*, the cause of plague, was not detected from
  - 2 Belding's ground squirrels (*Uroditellus beldingi*)
  - 16 Lodgepole chipmunks (*Tamias speciosus*)
  - 6 voles (*Microtus* sp.)

### Conclusions

Although a greater proportion of deer mice from the campground (32%) demonstrated evidence of infection with hantavirus, the proximity of infected deer mice to buildings at the ranger station (tent cabins and utility sheds) may present a greater risk of hantavirus transmission for DEPO staff. The absence of evidence of plague activity in the few rodents evaluated at the time of the survey suggests that recent plague activity may be minimal, but does not negate the potential for plague to resurge in these rodent populations.

### Recommendations

- Use appropriate precautions to safely clean up areas contaminated with rodent excreta, to dispose of dead rodents, and to enter and clean indoor rodent-infested structures
- Place rodent warning posters in public buildings and provide informational brochures on prevention of vector-borne diseases in information hut
- Schedule structural improvements and corrections to buildings to eliminate rodent access points
- Continue to monitor rodents in the campground areas and report any ill or dead rodents to health authorities

## Alcatraz Island (ALCA), Golden Gate National Recreation Area (GOGA)

### Activities

#### Hantavirus

In September 2008, VBDS staff conducted rodent surveillance for Sin Nombre virus (SNV) on Alcatraz Island. Overnight live-trapping was conducted in both interior and exterior areas that visitors and/or NPS staff frequently visited, including cell blocks and maintenance areas. A total of 110 traps yielded 13 deer mice (*Peromyscus maniculatus*)—two from the cell blocks and 11 from outside. Serum antibodies to SNV were detected in none of the rodents.



### Conclusions

Deer mice are present on Alcatraz Island and may infest one or more buildings. The risk of hantavirus transmission appears minimal but cannot be completely discounted.



### Recommendations

- Educate NPS staff and volunteers about measures to minimize opportunity and incentive for rodents to enter buildings and public areas.
- Implement ongoing measures to minimize food and harborage for rodents
- Periodically monitor mouse populations, including specific surveillance for SNV at least every few years.

## Golden Gate National Recreation Area (GOGA) and Point Reyes National Seashore (PORE)

### Activities

#### Tick-borne disease

Between January and June, 2008, VBDS staff conducted tick surveillance in and around hiking and walking trails in GOGA and PORE. Flagging was conducted approximately monthly at each of six sites in:

- GOGA (Point Bonita, Fort Cronkite, and Fort Baker)
- PORE (Olema Valley, Five Brooks trailhead, Bear Valley Visitor Center).



A total of 271 ticks was collected from five of the six surveillance sites:

- 144 Pacific Coast ticks (*Dermacentor occidentalis*)
- 23 American dog ticks (*Dermacentor variabilis*).
- 104 western black-legged ticks (*Ixodes pacificus*)
  - *Borrelia* bacteria were detected by direct fluorescent antibody in 3 of 69 adult *I. pacificus* adults and 0 of 3 *I. pacificus* nymphs. The three positive ticks were collected from the Fort Baker area.

In February 2009, VBDS staff presented a seminar on the epidemiology, ecology, and prevention of Lyme disease and other tick-borne diseases to NPS staff. Approximately 24 NPS staff attended the seminar.



### Conclusions

Three tick species known to vector infectious diseases are present in GOGA and PORE. *Borrelia*-infected ticks indicate a possible risk of Lyme disease in the Fort Baker area.

### Recommendations

- Continue trailside vegetation maintenance
- Post tick “Warning” signs at trailheads to reduce risk of tick bite for visitors and staff.

## Lassen Volcanic National Park (LAVO)

### Activities

#### Hantavirus, plague, tick-borne relapsing fever

In August 2008, VBDS staff conducted surveillance of rodents for the agents of tick-borne relapsing fever (*Borrelia hermsii*), hantavirus cardiopulmonary syndrome (Sin Nombre virus), and plague (*Yersinia pestis*). Visual rodent surveillance at Manzanita Lake and Crags campgrounds estimated rodent densities of less than 1 rodent per 5 campsites. A total of 252 trap-nights of rodent collection were conducted in the campground, residential area, and maintenance yard near Manzanita Lake.



Serum antibody for:

- *Y. pestis* was detected in none of 17 golden-mantled ground squirrels (*Callospermophilus lateralis*) and 5 shadow chipmunks (*Neotamias senex*) captured.
- *B. hermsii* was detected in 1 of 10 *C. lateralis* and 0 of 5 *N. senex* tested.
- Sin Nombre virus was detected in one of eight deer mice (*Peromyscus maniculatus*) collected from the campground area.

VBDS staff inspected selected residences and maintenance buildings for signs of rodent infestation and conveyed observations and recommendations for rodent exclusion and control to LAVO staff.

In September 2010, VBDS conducted a visual survey of plague susceptible rodent species at Butte Lake Campground. Chipmunks, golden-mantled ground squirrels, and pine squirrels were abundant (approximately one rodent observed per three campsites) with no evidence of burrow abandonment. Observations were communicated to Park Resources staff.

VBDS provided to NPS staff safety information, educational brochures, and plague “Caution” posters for placement at recreation sites.

### Conclusions

Evidence of *B. hermsii* and Sin Nombre virus was detected among rodents in LAVO. No evidence of plague activity in rodents was observed. While these results suggest that the risk of these rodent-borne diseases may currently be low, historical data compiled by CDPH indicate that they likely have not disappeared and may resurface at any time.

### Recommendations

- Maintain an ongoing rodent control program using snap traps to monitor activity and to remove rodents from structures.

- Seal gaps larger than one-quarter inch along door sweeps, pipe conduits, vents, and dryer vents to prevent rodent ingress.
- Provide staff with rodent cleanup kits and instructions in their use.
- Educate staff to reduce food availability for rodents
- When buildings are opened seasonally or after extended periods of closure, open doors and windows for ventilation prior to working inside buildings and clean rodent-contaminated surfaces with a suitable disinfectant.
- Post plague “Caution” signs at all campgrounds prior to spring reopening to inform visitors of the potential for plague in the area and how to reduce their risk.

## Lava Beds National Monument (LBE)

### Activities

#### Hantavirus, plague, and tick-borne relapsing fever

VBDS conducted rodent surveillance for the agents of hantavirus cardiopulmonary syndrome (Sin Nombre virus [SNV]), plague (*Yersinia pestis*), and tick-borne relapsing fever (*Borrelia hermsii*) on three occasions:

- In April 2008, VBDS staff focused surveillance in caves that had high visitor use or in which evidence of plague had been previously observed. Trap success was low and three woodrats (*Neotoma* sp.) and 29 mice (*Peromyscus* sp.) tested for serum antibody to *Y. pestis* were negative.
- In September 2008, VBDS staff returned to conduct rodent surveillance on the surface--in and around the residential and maintenance compounds, campground loops, and trails--as well as in the caves.
  - Six bushy-tailed wood rats (*Neotoma cinerea*) and six canyon mice (*Peromyscus crinitus*) were captured from the caves; all were negative for antibodies to *Y. pestis* and SNV.



- A total of 23 rodents was captured on the surface; all were negative for antibodies to *Y. pestis*, but antibodies to SNV were detected in one of seven deer mice (*Peromyscus maniculatus*) and one of seven pinon mice (*Peromyscus truei*). Both seropositive mice were collected from the residential compound.
- VBDS staff instructed LBE staff in identifying potential exposure risks and implementing mitigation measures for rodent-borne diseases.

- In May 2009, VBDS conducted surveillance in five caves, the campground, residential area, and the maintenance compound.
  - A total of 25 rodents was collected and tested for serum antibodies to *Y. pestis*; all specimens were negative.
  - Of 22 mice tested for SNV, serum antibodies were detected in 2 of 10 deer mice (*P. maniculatus*). Both positive rodents were captured near the recycling bin area in the maintenance compound.
  - Serum antibodies to *B. hermsii* were detected in three California ground squirrels (*Otospermophilus beecheyi*) collected in the campground and one cave.
  - VBDS staff flagged vegetation for ticks at two sites, but no ticks were recovered.
  - VBDS staff presented information on vector-borne diseases to NPS staff at a Resources Department employee training session for LABE staff who worked with the visitor center and the many visitor programs.
- VBDS returned in May 2010 to collect and sample rodents from six caves
  - Twenty-five *Peromyscus* spp. rodents were collected and sampled. All were negative for serum antibodies to SNV.
  - All 25 *Peromyscus* mice and five woodrats (*Neotoma cinerea*) were negative for serum antibodies to *Y. pestis*.
  - Sera from the five woodrats, two chipmunks (*Tamias amoenus*), and two ground squirrels (*O. beecheyi*) were tested for antibodies to *B. hermsii*. (Results were pending at the time of this report.)
  - Three Rocky Mountain wood ticks (*Dermacentor andersoni*) were collected from the campground and tested for Colorado Tick Fever virus. (Results were pending at the time of this report.)
  - VBDS led a discussion of vector-borne disease prevention for Resources staff.



## Conclusions

Mice with evidence of infection with SNV were found in an area where NPS staff reside, underscoring the risk of hantavirus transmission and need for ongoing preventive practices in and around where NPS staff live. The significance of detecting serum antibodies to *B. hermsii* in California ground squirrels is unclear as this species of rodent is not known to be a reservoir for the relapsing fever bacteria.

### **Recommendations**

- Staff should avoid contact with ground squirrels and prevent them from establishing burrow systems (colonies) proximal to inhabited structures within the park.
- Rodent exclusion should be implemented in all continually and seasonally occupied buildings. Existing rodents should be removed using snap traps and contaminated areas cleaned using appropriate disinfectant and personal protective protocols.
- Plague “Caution” posters should be maintained at the campground and preventive information available to the public in the Visitor Center.

## Manzanar National Historic Site (MANZ)

### Activities

#### Hantavirus and Tick-borne Relapsing Fever

VBDS staff visited MANZ on two occasions:

- In July 2008, VBDS staff conducted a visual assessment of the main facility building. Little evidence of rodent infestation or opportunity for rodent ingress was observed.
- In September 2008, VBDS staff conduct rodent surveillance for the agents of hantavirus cardiopulmonary syndrome (Sin Nombre virus) and tick-borne relapsing fever (*Borrelia hermsii*). Forty-one live traps were set within and around the main facility and an outbuilding.
  - One deer mouse (*Peromyscus maniculatus*) was captured outside the main facility
  - One desert woodrat (*Neotoma lepida*) was captured near the outbuilding.
  - Thirty additional live traps set in the historic orchard area yielded seven woodrats, four cactus mice (*Peromyscus eremicus*), and two California ground squirrels (*Otospermophilus beecheyi*). Serum antibodies to Sin Nombre virus and *B. hermsii* were detected in none of the rodents tested.



### Conclusions

Rodents were infrequently collected around buildings and areas of human activity. There was no evidence of infection with hantavirus or relapsing fever spirochetes in the rodents tested. Risk of these diseases for visitors and staff is likely to be low.

### Recommendations

- Staff should maintain cleared buffer zones around buildings and promote cleanliness within buildings to reduce incentives for rodent ingress.

## Pinnacles National Monument (PINN)

### Activities

#### Hantavirus and Plague

In January 2009, VBDS staff conducted a visual assessment of buildings for evidence of rodent ingress and infestation. VBDS reported its observations of structural deficiencies and rodent incentives, as well as recommendations for their remediation, to PINN staff both at the time of the evaluation and during a staff safety meeting in February.

In April 2009, VBDS staff conducted surveillance for the agents of hantavirus cardiopulmonary syndrome (Sin Nombre virus) and plague (*Yersinia pestis*) at the office, storage, and maintenance buildings in Chalone and near the condor feeding station and release area. Four woodrats (*Neotoma* spp.) and 11 mice (*Peromyscus* spp.) were collected. All mice and both woodrats were negative for serum antibodies to Sin Nombre virus and *Y. pestis*, respectively.



### Conclusions

Deer mice, piñon mice, and two species of woodrats were collected both outside and within buildings frequented by employees. However, serologic testing failed to detect evidence of infection with disease agents. While a single night of trapping may be insufficient to estimate prevalence of both rodents and rodent-borne viruses, the available evidence suggests that risk to PINN staff of hantavirus transmission is low.

### Recommendations

- Rodent-proof the condor blind and catch/release area by closing holes in the façade and filling in open areas below buildings. Add windows/skylights to the buildings to facilitate ventilation and light penetration.
- To the extent possible clean rodent feces from the items in the maintenance area and seal obvious rodent runways (holes) to the outside. Active rodent trapping using snap traps should continue.
- Continue to educate staff and volunteers about measures to minimize opportunity and incentive for rodents to enter buildings and public areas.
- A comprehensive disease prevention program should include ongoing monitoring of mouse populations, including specific surveillance for hantavirus at least every few years.



## Redwood National Park

In January 2009, VBDS met with NPS staff and discussed potential vector-borne disease projects of mutual interest with a focus on tick-borne diseases and hantavirus. Vector-borne disease brochures were provided. No ticks were collected over two person-hours of flagging alongside Redwood Creek Trail.

## Sequoia and Kings Canyon National Parks (SEKI)

### Activities

#### Hantavirus, Plague, and Tick-borne Relapsing Fever

In August 2009, VBDS conducted a visual assessment of rodent populations at 11 campgrounds. Large numbers of rodents, mostly California ground squirrels, were observed in close proximity to visitors at Potwisha and Azalea campgrounds.

In September 2010, VBDS collected and sampled rodents at Azalea and Sunset campgrounds.

- Azalea Campground
  - Nine chipmunks (*Tamias quadrimaculatus*), seven California ground squirrels (*Otospermophilus beecheyi*), and one deer mouse (*Peromyscus maniculatus*) were collected
- Sunset Campground
  - Fourteen chipmunks, six California ground squirrels, four golden-mantled ground squirrels (*Callospermophilus lateralis*), three deer mice, and one vole (*Microtus* sp.) were collected



### Conclusions

Abundant rodents observed in visitor areas in 2009, considered in light of historical evidence of plague activity in SEKI, suggest an ongoing but unknown potential for plague transmission to visitors and staff.

### Recommendations

- Additional focused plague surveillance should be conducted to gain better information on the prevalence and distribution of *Y. pestis* in area rodent populations.

## Whiskeytown National Recreation Area (WHIS)

### Activities

In June 2008, VBDS staff attended an employee training day and led discussions on the ecology of vector-borne diseases, safety and employee awareness and responsibility issues, and past vector-borne disease problems at WHIS. WHIS staff were provided CDPH vector-borne disease prevention materials.

In February 2010, VBDS biologists met with the WHIS Resources Chief to discuss vector-borne disease including conducting hantavirus surveillance at several Park facilities. Vector-borne disease educational brochures were provided for staff and Visitor Center use. Contacts were also made with the Whiskeytown Environmental School, operated by the Shasta County Office of Education within WHIS. Tick-borne diseases, tick exposures, and hantavirus safety protocols were discussed with the school's Administrative Assistant.

### Tick-borne diseases

VBDS conducted tick surveillance at three high-use recreation sites: Clear Creek Trail, Crystal Creek Camp #2, and along Mill Creek Trail. Fifty-two adult western black-legged ticks (*Ixodes pacificus*) were collected along Clear Creek Trail, 25 at Crystal Creek Camp #2, and 54 along upper Mill Creek Trail over a total of approximately 12 person-hours of flagging. Vector-borne disease educational brochures and tick identification cards were provided to NPS staff at the park headquarters and Visitor Center.

### Conclusions

Ticks potentially capable of carrying and transmitting Lyme disease were identified alongside trails and recreation areas heavily used by park visitors.

### Recommendations

- WHIS staff should be aware of risks of tick bites and tick-borne diseases and instructed in taking the proper preventive precautions.
- Information on tick-borne diseases should be made available to visitors at key interaction points in the park.

## Yosemite National Park (YOSE)

### Activities

#### Tick-borne relapsing fever

In September 2007, VBDS conducted field surveillance in response to a case of relapsing fever reported in a visitor to YOSE in July 2006. VBDS performed visual inspection of facilities, assessment of habitat, and diurnal and nocturnal rodent collection at three sites the case-patient had visited:

- Tuolumne Meadows - Serum antibodies to relapsing fever-group *Borrelia* were detected in 7 of 13 chipmunks (*Tamias* spp.)
- Hodgdon Meadow - Serum antibodies to relapsing fever-group *Borrelia* were detected in one chipmunk (*Tamias* spp.)
- Wawona campgrounds - Serum antibodies to relapsing fever-group *Borrelia* were detected 1 of 4 ground squirrels (*Spermophilus* spp.)

In September 2008, VBDS returned to Tuolumne Meadows to conduct additional rodent surveillance for the agent of relapsing fever (*Borrelia hermsii*)

- Daytime and overnight live rodent trapping were conducted in and around staff buildings and residences. Serum antibodies to *B. hermsii* were detected in:
  - Two of seven (29%) lodgepole chipmunks (*Tamias speciosus*)
  - one of four (25%) golden-mantled ground squirrels (*Callospermophilus lateralis*)
- Carbon dioxide tick traps were placed in or near rodent nests found in buildings to attempt to collect “soft” ticks (*Ornithodoros* sp.). Rodent nesting materials that were removed from building interiors were examined for soft ticks. No soft ticks were collected from tick traps nor recovered from rodent nests.



In addition to activities at Tuolumne Meadows, VBDS visually inspected a residence in Foresta for the presence of rodents and *Ornithodoros* tick infestation following identification of a recent resident suspected of having relapsing fever. No ticks and minimal evidence of rodent activity were observed. VBDS staff advised the current residents of rodent control and relapsing fever preventive measures.

### Plague

Antibody to *Yersinia pestis* was not detected in 30 squirrels and chipmunks collected at the three sites in 2007. In 2008, three chipmunk and squirrel sera were tested for antibodies to *Y. pestis*; all were negative.

### Hantavirus

In 2007, antibodies to Sin Nombre virus were detected in 3 of 18 deer mice (*P. maniculatus*) at Tuolumne Meadows, 1 of 5 at Wawona, and none of 7 at Hodgdon. Deer mice were collected inside staff buildings at Tuolumne Meadows and signs of rodent activity (i.e., feces) were observed in one building inspected at Hodgdon Meadows.



Twenty-two deer mice were collected in 2008, 11 from inside buildings. Serum antibodies to SNV were detected in 5 of 21 deer mice tested. The exteriors of several buildings at the Ranger Station were visually assessed for rodent entry potential.

VBDS staff led seminars on the ecology, epidemiology, and prevention of vector-borne diseases for YOSE staff and concessionaires in 2008 and 2009.

In September 2010, VBDS responded to a case of hantavirus cardiopulmonary syndrome diagnosed in a patient who reported contact with rodents while visiting Tuolumne Meadows. VBDS staff met with NPS management, safety officers, concessionaires, and lodge managers to inspect tent cabins and surrounding buildings and environment at Tuolumne Meadows Lodge for evidence of rodent activity. Observations, conclusions, and recommendations were shared with the Superintendent and other YOSE staff.

### Lyme disease

VBDS conducted field collection of ticks on four occasions in 2010: April (2), May, and November. VBDS staff conducted 21 surveillance events at 15 sites (total of 50 person-hours), mostly in areas at which past surveillance yielded large numbers of ticks or ticks positive for *Borrelia burgdorferi*. A total of 41 adult and 2 nymphal *Ixodes pacificus* ticks were collected. *B. burgdorferi* was detected in none of 38 ticks tested.



## Conclusions

While estimates of rodent numbers were relatively low, a substantial number of rodents were collected from within and around buildings occupied by NPS staff. Many buildings had evidence of rodent infestation, or had structural conditions that would facilitate rodent ingress.



The greatest number of rodents with evidence of *B. hermsii* infection was observed at Tuolumne Meadows where serum antibodies were detected in 54% of chipmunks sampled in 2007 and 29% in 2008. While evidence of plague was minimal during both years of evaluation, historical records and the cyclical nature of plague caution that transmission of disease is still possible and may re-emerge at any time. The large number of rodents attracted to campgrounds, picnic areas, and other recreational areas underscore the need for continued vigilance in protecting the public.

Deer mice infected with SNV were identified at several locations in the park (overall 18% infected), including areas frequented by both staff and visitors. The potential for rodent ingress into buildings further heightens the risk for aerosol transmission of the virus to persons living and working inside. The identification of the second case of HCPS with likely exposure in Tuolumne Meadows underscores the ongoing risk and need for dutiful adherence to a rodent exclusion and control program.

Tick surveillance in 2010 showed that *Ixodes* ticks do occur in YOSE, but in small numbers. While all 2010 tested ticks were negative for *B. burgdorferi*, infected ticks were collected by VBDS in Wawona Campground in 1992 and 1995. The presence of ticks and past surveillance results emphasize that park staff and visitors should remain aware of ticks and tick-borne diseases.

## Recommendations

- Inspections for rodent infestations and appropriate exclusion efforts, particularly for buildings where people sleep, should be enhanced. When found, nesting materials and harborage should be removed from within and around buildings.
- Vector-borne disease prevention information should be available at staff lodging and visitor centers.
- Campgrounds and other areas that host large numbers of visitors should be posted with information about potential plague risk and prevention measures. Rodent activity within campsites should be discouraged.

- In addition to enhancing rodent exclusion efforts in buildings, an active trapping program (using snap traps and appropriate disinfection and disposal measures) should be standard practice for buildings with a history or high risk of infestation.
- Staff should be adequately trained in the appropriate procedures for removing and handling rodents and preventing HPS. Staff may wish to consult with VBDS for appropriate procedures when opening seasonal buildings each spring as overwintering mouse populations can create significant infestations in these buildings.

## **Knowledge, Attitudes, and Practices of Vector-Borne Diseases: A Survey of NPS Employees**

In 2008, VBDS and NPS collaborated to design, implement, and evaluate a survey of NPS employees at 24 NPS units in California and the Pacific West Regional Office. The survey asked NPS employees to provide information on the following topics: 1) personal characteristics and job title, 2) work activities and exposures, 3) self-perceived risk and knowledge of tick-borne, rodent-borne, and mosquito-borne diseases, 4) occupational safety and health, and 5) education and training. The survey instrument was made available on the NPS web site for four months (June to September) and participation was promoted through Park emails and newsletters.

257 NPS staff from 18 NPS units and the Pacific West Regional Office completed the survey. Key results included:

- Most NPS employees believed that reducing the risk of vector-borne diseases in the workplace is important or extremely important.
- The self-perceived risk of acquiring a vector-borne disease at work was higher for mosquito-borne diseases than for tick-borne diseases.
- Contact with potential disease vectors and opportunities for exposure to vector-borne diseases were highest for Resource Protection and Resource Management employees.
- Self-perceived risk of acquiring a vector-borne disease was highest for Resource Protection employees.

A complete report on the survey results and emergent recommendations was delivered in December 2008 to the Pacific West Regional Office for dissemination to NPS staff throughout California.



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