

CALIFORNIA COMPENDIUM OF PLAGUE CONTROL
Vector-Borne Disease Section – Infectious Diseases Branch

Updated September 2021

Objective

The purpose of this compendium is to provide information on plague to California's public health and environmental health officials, medical professionals, veterinarians, vector control professionals, land use agencies, and other parties interested in plague activity within the state. The recommendations below are reviewed and updated on a periodic basis to reflect the status of plague and disease prevention activities in California. Updates are based on a review of the scientific literature and consultation with the U.S. Centers for Disease Control and Prevention, the World Health Organization, the Council of State and Territorial Epidemiologists, and academia. Recommendations by state and federal experts and existing standards of practice outlined in this document are intended to provide guidance to individuals and agencies involved with plague detection, prevention, and control in California. Except for statutes and regulations specifically cited, the information contained in this document are recommendations provided for informational purposes only and are not intended to be regulatory in effect or practice.

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PART I - PLAGUE ECOLOGY IN CALIFORNIA

A. Causative Agent

The plague bacillus, *Yersinia pestis*.

B. History of Plague in California

The first autochthonous human cases of plague in the United States were recorded in San Francisco in 1900 and plague appeared in Los Angeles in 1908. The disease was introduced into these and other West Coast seaports via infected domestic rats and humans arriving aboard ships from Asia. Outbreaks in rats and humans followed the introduction of plague in both San Francisco and Los Angeles. These outbreaks involved local domestic rats, rat fleas, and humans.

Plague was transferred to wild (sylvatic) rodents by fleas and was first isolated from native ground squirrels and woodrats in California in 1908. In Oakland, a pneumonic plague outbreak in humans occurred in 1919 and was traced to an index patient who hunted and skinned ground squirrels. Thirteen of the 14 human cases associated with this outbreak were fatal. A second pneumonic plague outbreak of 32 cases, 31 of which were fatal, occurred in Los Angeles in 1924. The Los Angeles outbreak was associated with an epizootic among domestic rats and ground squirrels near present-day Union Station. The 1924 outbreak is the last known occurrence of human-to-human plague transmission in the United States. From 1900 to 1925, 426 human plague cases occurred in California, 234 (55%) of which were fatal. During subsequent decades, plague expanded throughout most of the state via sylvatic rodent populations. Today, plague is found in many foothill and mountainous regions of the state but is absent from the Central Valley and southeastern desert regions (Figure 1). Since 1970, plague-positive rodents have been found in 34 of California's 58 counties.

From 1927 through 2019, 63 human plague cases with exposure in California were reported, almost all of which were directly or indirectly associated with sylvatic rodent plague activity and most commonly involved California ground squirrels (*Otospermophilus beecheyi*). Human cases have occurred in a variety of habitats, ranging from close to sea level, to approximately 9000 feet elevation in the Sierra Nevada Mountains.

C. Plague in Humans

1. Transmission and Incubation

Plague is a zoonotic flea-borne rodent disease that is transmitted from infected to susceptible hosts through direct contact with infected animals, tissues, or infected fleas. The most frequent means of plague transmission to humans in California is through the bite of infected fleas (especially *Oropsylla montana*, a ground squirrel flea) from sylvatic rodents. Other means of transmission are via contact with infected animal tissues (from

rodents, rabbits, or carnivores) and airborne droplets from infected humans or animals (especially cats) with plague pneumonia or pharyngitis. Humans are incidental hosts for *Y. pestis* and play no role in the natural maintenance of plague. However, humans with plague pneumonia can be a direct source of human-to-human transmission. The typical incubation time following exposure through direct contact or the bite of an infected flea is two to six days. For primary respiratory exposure, the incubation time is usually shorter (two to four days).

2. Clinical Symptoms

There are three principle manifestations of plague infection in humans:

Bubonic plague is the most common form and is characterized by an acute onset of fever and one or more swollen, painful lymph nodes (buboes).

Septicemic plague is characterized by bacteria in the blood with no apparent bubo, with presence of fever, and bleeding into skin and organs.

Pneumonic plague can develop secondary to septicemic plague or can be primary, following respiratory exposure to plague bacilli, and includes symptoms of fever, cough, and pneumonia.

Atypical plague presentations rarely occur and may include pharyngitis, meningitis, endophthalmitis, osteomyelitis and cutaneous manifestations. If antibiotic treatment is delayed or inadequate, patients with bubonic plague may develop septicemia or secondary plague pneumonia.

3. Diagnosis, Treatment, and Prevention

Plague is most often diagnosed through microscopic examination and culture of tissues (particularly lymph node aspirate, blood, sputum, or spinal fluid) and serology. Observation of bipolar stained (Gram, Wayson) coccobacilli is suggestive but not definitive for a diagnosis of plague. Confirmation of *Y. pestis* is made by direct florescent antibody test (DFA) using the F-1 antigen, culture, polymerase chain reaction (PCR), or bacteriophage lysis. A plague case is considered confirmed if *Y. pestis* is isolated from a clinical specimen or a four-fold rise in serum antibody titer is observed.

Early treatment of human plague is critical to the survival of the patient. The fatality for untreated bubonic plague cases is approximately 50%. The fatality approaches 100% for untreated septicemic and pneumonic cases. Fluoroquinolones are the recommended first-line antibiotic treatment. Tetracyclines and chloramphenicol are acceptable alternatives in the treatment of uncomplicated bubonic or septicemic plague. While multi-drug resistant strains of *Y. pestis* have been infrequently reported from Africa, there is no evidence of reduced antibiotic susceptibility of *Y. pestis* in North America.

The California Code of Regulations (CCR) (17CCR§2596) requires isolation of human cases of plague. Respiratory precautions should be implemented immediately in the case of suspected or confirmed plague pneumonia. Persons with close contact to a known case should be advised to monitor themselves for onset of symptoms, particularly fever. Persons who had intimate contact with a suspect plague patient, or known exposure to potentially plague infectious animals, their fleas, and/or tissues, should be monitored and considered for chemoprophylaxis.

The U.S. Centers for Disease Control and Prevention (CDC) and the World Health Organization conduct worldwide surveillance for human cases of plague. Plague, along with cholera, smallpox, and yellow fever, is an internationally quarantinable disease. Due to the potential for aerosol transmission through respiratory secretions, plague is considered a Category A (highest priority) potential biological weapon by the Working Group on Civilian Biodefense. Plague is a reportable disease in California. When laboratory or other evidence suggestive of plague in a human or an animal is found, it must be reported immediately by telephone to the local health officer (17CCR§2500 and 17CCR§2505).

No commercial plague vaccine is currently available.

D. Plague in Animals

1. Sylvatic (Rural) Plague

In California, plague is maintained in a cycle of infection among moderately resistant and susceptible rodents and their fleas within specific geographic foci. Within each focus a cyclical disease pattern exists, alternating between periods of increased activity (epizootic plague), often evidenced by die-offs of susceptible rodents, and quiescent periods when the disease circulates at low levels among more resistant rodents (enzootic plague).

Historic and recent evidence from testing of fleas, rodents, and carnivores throughout California has identified plague foci representing a variety of ecological habitats in the plague endemic regions of the state (Figure 1). Most of these foci have not been adequately studied or described.

Sylvatic rodent species in California that appear to be moderately to highly susceptible to plague include ground squirrels (*Callospermophilus lateralis* and *Otospermophilus beecheyi*), certain chipmunks (*Tamias* spp.), marmot (*Marmota flaviventris*), Douglas squirrel/pine squirrel (*Tamiasciurus douglasii*), and some species of woodrats (*Neotoma* spp.). Plague epizootics among these more susceptible species are characterized by a decrease in the number of rodents, by sometimes sudden and extensive mortality, and a concomitant increase in the number of infective fleas. Because plague transmission in these susceptible rodent species can magnify an epizootic event, these rodent species are often referred to as amplifying reservoirs. Some individuals of these species survive infection and may serve as a source of continuing infection for additional animals. Surviving

animals may also perpetuate the disease over several generations and/or seasons within a regional plague focus.

Other rodent species appear more resistant to plague infection and may play a role in maintaining *Y. pestis* during enzootic periods. Certain species of chipmunks (*Tamias* spp.) and woodrats (*Neotoma* spp.), deer mice (*Peromyscus* spp.), and meadow voles (*Microtus* spp.) are, in general, more resistant to plague, though they may become sufficiently bacteremic to infect fleas, which are then capable of transferring the infection to more susceptible rodent species. The importance these species play in maintaining plague may vary regionally. Among these moderately resistant populations, individual animals may succumb to the disease also allowing their potentially infective fleas to seek new hosts. These rodents and their fleas interact within a complex of poorly understood biological, ecological, and abiotic factors that perpetuate transmission of *Y. pestis* in plague endemic regions. Adding to this complexity is that the degree of resistance (or susceptibility) exhibited by some of these species appears to vary regionally in California, thus potentially altering the roles they play in local plague transmission.

Humans have a greater risk of exposure to *Y. pestis* from rodent fleas during epizootic plague activity. Epizootic plague may kill a large proportion of the susceptible rodent population and this mortality results in an increased number of infected fleas that are displaced from their rodent hosts. California ground squirrels often have much greater flea densities than other host species. Because the fleas most commonly found on California ground squirrels (i.e., *Oropsylla montana*) are host-feeding generalists and competent vectors of *Y. pestis*, the risk of transmission to humans increases when an epizootic involves this rodent species.

Epizootic activity in rodents may also spill over into lagomorph (hare, rabbit, and pika) populations, which are susceptible to plague. Several rabbit-associated human plague cases have been documented in the western U.S. (including one case in California), most of which involved direct handling of infected animals.

2. Plague in Domestic Animals

Domestic animals, especially cats, are susceptible to plague infection, but are not part of the natural sylvatic transmission cycle. However, dogs and cats may play a limited role in the dissemination of fleas or rodent carcasses, potentially increasing the risk of exposure for humans.

Plague in dogs is rarely documented and most infections are probably subclinical. However, like wild canids, infected domestic dogs develop antibody titers in response to infection and can be valuable sentinel animals for surveillance. A high proportion of pets in a given area with elevated serologic titers may signal recent plague activity among rodents. Such a finding in dogs can be valuable during human case investigations when rodent

populations have suffered extensive mortality and cannot be adequately tested. Historically, dogs were used to monitor plague activity on Indian reservations and military bases in California.

In contrast to dogs, domestic cats are highly susceptible to *Y. pestis* infection. Cats most often acquire plague via oral contact with infected rodents and their natural hunting behavior of small rodents is implicated as their primary means of exposure. Plague in cats is characterized by a short incubation period of approximately two days, followed by a sudden onset of fever, lethargy, lymphadenopathy (commonly submandibular) with abscess formation (buboes), and less frequently, pneumonia. Cats with pneumonic plague show respiratory distress including sneezing, coughing, wheezing, nasal discharge (sometimes bloody), oral lesions, and/or lower respiratory involvement. Untreated plague in cats is often fatal.

Feline plague is diagnosed by culture (bubo aspirate, blood, sputum, or carcass), DFA testing, PCR, or serology.

Because results of diagnostic testing may not be available immediately, treatment should not be delayed but started promptly based on clinical impression and supportive information (e.g., bipolar, ovoid, Gram-negative organisms on microscopy from bubo aspirate or sputum).

Plague-infected cats present a serious public health concern as exudates from buboes or respiratory secretions and sputum can transmit *Y. pestis* to humans. In California, exposure to infected cats has been linked to at least four cases of human plague, three of which were fatal. Cats with suspected plague infection should be treated with antibiotics by a veterinarian and placed in isolation in a veterinary hospital. The antibiotic of choice is streptomycin but its availability in the U.S. is limited; gentamicin, tetracyclines, and trimethoprim-sulfa have also demonstrated clinical effectiveness. The following precautions must be taken while handling a cat suspected of having plague:

- a. Hospitalize the cat and place it in isolation until signs are completely resolved. Limit contact of veterinary staff with the cat.
- b. Protect veterinary clinic personnel from secretions and other body fluids by using disposable masks (preferably N-95), gowns, gloves, and eye protection while handling the animal. Thoroughly disinfect and dispose of all contaminated materials as medical waste.
- c. Treat the cat for fleas at admission with an effective insecticide. Alert hospital staff to the potential hazard posed by fleas from the animal. Instruct the owner on how to treat the cat's environment and other household pets. Recommend professional pest control to the owner.

- d. Contact the local public health agency immediately. In consultation with the local health officer, owners of cats with suspected plague, the treating veterinarian and staff, and others who had significant contact with the cat may be advised to receive prophylactic treatment. All persons who had contact with the cat should be instructed to monitor their health and to contact their physician immediately if symptoms, such as fever or lymphadenopathy, develop.

To help prevent plague in cats, pet owners should be advised to keep them confined and away from rodents. The American Veterinary Medical Association, American Association of Feline Practitioners, American Animal Hospital Association, and others strongly encourage owners to keep all cats indoors as much as possible. If allowed outdoors, cats should be kept within a confined area, on a leash, or closely supervised to prevent hunting. Veterinarians should provide information on safe and effective flea control to their clients. Veterinarians should instruct their staff on the safe use of insecticides for flea control in the veterinary clinic. Suspect cases of plague in cats or dogs should be reported to the local public health agency immediately.

PART II - LABORATORY TESTING

A. Human Plague Testing

The California Laboratory Response Network provides diagnostic testing for specimens from suspected human plague cases. Appropriate specimens include blood (best if collected prior to antibiotic administration), lymph node or bubo aspirate, sputum, throat swab, and cerebrospinal fluid. Diagnostic testing includes Gram staining, Wayson staining, DFA testing, culture, bacteriophage testing, and PCR.

Submission of human plague diagnostic specimens should be coordinated through the public health department who has jurisdiction for the area in which the patient is examined or hospitalized.

B. Animal Plague Testing

1. Suspected feline plague

[Information and specimen submission instructions for suspected feline plague](https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Plague.aspx) are available on the [CDPH-VBDS plague website](https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Plague.aspx) under “Information for Health Professionals” (<https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Plague.aspx>).

2. Wild animal testing for surveillance

The California Department of Public Health (CDPH), Vector-Borne Disease Section (VBDS) laboratory, accepts sera or dried blood samples (i.e., Nobuto filter paper strips) for plague

antibody testing for environmental surveillance. Carcasses, tissues, aspirates and throat-swabs from selected animal species are tested for the presence of plague bacteria by the CDPH Microbial Diseases Laboratory (MDL).

CDPH annually distributes updated guidelines for sample collection and submission to local agencies that collaborate in plague surveillance. Specimens accepted include carcasses of wild rodents and lagomorphs (rabbits), fleas, and Nobutos from select wild carnivores and small mammals (Appendix A).

To facilitate efficient use of limited laboratory resources, the following submission criteria for animal carcasses should be adhered to:

- a. Testing is limited to those mammals most likely to be infected. See Appendix A for listings of rodents, carnivores and other mammals that are suitable for testing. Contact VBDS (530-552-9730) for questions on testing criteria and carcass submission protocols.
- b. The animal should be from an area where plague is enzootic (Figure 1).
- c. The animal should be an adult. Both young and adult animals may die from plague, but experience has shown that an adult animal is much more likely to test positive for plague than a young animal.
- d. The animal should be in reasonably good condition for testing. Carcasses compromised by open wounds, desiccation, autolysis, or fly larvae are more difficult to test due to contamination from other bacteria.
- e. Other causes of death such as physical trauma (including road kill) or rodent control (poisoning) should be ruled out prior to submission of specimens.

Animal carcasses and tissue specimens should be sent to the VBDS Laboratory (address below). The plague testing submission form (see Appendix C) requests pertinent collection information and must be completed and included with the shipment. Specimens should be sealed in double clear plastic bags and shipped on frozen "blue ice" in an insulated container via an overnight commercial carrier. Label the outside of the package with the words "Biological Substance, Category B" and apply a corresponding "UN3373" label (see Appendix D). The VBDS Laboratory must be contacted by telephone prior to specimen shipment.

Address shipment to:

California Department of Public Health, Specimen Receiving
Vector-Borne Disease Laboratory
850 Marina Bay Parkway Richmond, CA 94804
(Telephone: 510-412-6251)

Upon receipt, specimens are evaluated for plague testing suitability based on carcass condition, species susceptibility to plague, and location of collection. Suitable carcasses are processed immediately, as they can provide direct evidence of a plague epizootic in progress.

Nobuto filter paper strips from rodents, lagomorphs, and domestic and wild carnivores are tested for plague-specific antibodies by VBDS, with results typically available within one week.

Fleas collected from live-trapped rodents and from rodent burrows are tested by the VBDS Laboratory, but approval prior to submission is required. Plague bacteria are detected in fleas by PCR.

For more information on the submission of diagnostic specimens from wildlife, domestic animals, or fleas, contact VBDS at 530-552-9730.

PART III - SURVEILLANCE AND CONTROL

A. Plague Surveillance

Health officials have performed routine plague surveillance and control in California since the early 1900s. Public health concerns continue to be: (1) the potential secondary transmission of plague through respiratory secretions from an initial human or feline case of pneumonic plague, (2) the export of an incubating human case from California's plague-endemic recreational areas to a location where the disease may not be recognized, (3) the continuing potential for exposure among persons living in or traveling to plague endemic areas in California, (4) the potential transfer of the infection from a sylvatic source to commensal rat populations in heavily urbanized regions, and (5) the intentional and malicious use of plague bacilli as a biological weapon. Consequently, the surveillance, prevention, and control of plague remain an important public health endeavor in California.

The California Plague Surveillance and Control Program is a collaborative effort involving state, federal, and local agencies under the direction of CDPH. The program is instrumental in the prevention of human cases by incorporating education, epidemiological investigation, disease surveillance of host and vector populations, serological testing of domestic and wild carnivores, vector suppression, and disease outbreak management. The primary goal of this program is to detect increases in sylvatic plague transmission to reduce the risk of human disease transmission. This goal is consistent with the letter and intent of international, federal, and state health regulations.

B. Plague as a Biological Weapon

A modern risk from plague involves the threat of an intentional release of the plague bacteria into an urban area. A bioterrorism release of *Y. pestis* into a highly populated area could infect humans and commensal rodents alike, a phenomenon not seen naturally in California since

the 1920s. An airborne release of plague bacteria may result in initial human pneumonic plague cases and may precipitate plague epizootics among rats and a secondary wave of human cases acquired from plague-infected commensal rodent fleas. Thus, health authorities must develop response plans that include not only detection and treatment of immediately affected human victims but also outline vector and rodent control measures to be taken following the release of plague bacteria during a bioterrorism event. Medical and public health response and management of plague in the event of its use as a biological weapon are summarized in a Consensus Statement of the Working Group on Civilian Biodefense (JAMA 2000; 283:2281-90) with treatment updates provided by the Centers for Disease Control and Prevention ([Antimicrobial Treatment and Prophylaxis of Plague: Recommendations for Naturally Acquired Infections and Bioterrorism Response | MMWR](#)).

C. Sylvatic Plague Epizootic Response

Plague in wild rodents in California is characterized by periodic epizootics, often evidenced by die-offs of susceptible rodent populations within geographical disease foci. Periods between local epizootics are characterized by low levels of infection among more resistant populations of rodents. The risk of a plague epizootic increases when susceptible rodent populations and associated flea densities reach a threshold above which contact between rodents and their fleas allows *Y. pestis* infections to rapidly spread.

As indicated above, evidence suggestive of human or animal plague is immediately reportable to the local health authority (17CCR§2500 and 17CCR§2505) and the risk of disease transmission is promptly assessed by trained vector control biologists and technicians (California Health and Safety Code (HSC) §116110). The geographic scope and ecologic complexity of sylvatic rodent plague in California creates a diverse set of surveillance and control challenges. Plague control can best be accomplished through an integrated approach involving surveillance, education, habitat management to reduce rodent attraction, control of vector fleas, and rodent population management. Due to periodic epizootic plague activity in rodent populations, appropriate monitoring and surveillance by trained vector-borne disease specialists is indispensable in plague endemic regions, particularly in areas with a history of plague activity or human cases.

Plague activity may peak during some years in which epizootics occur regionally, over hundreds of square miles and encompass multiple geographical foci, typically under conditions of increased host and vector densities. Rodents may die in areas only sparsely inhabited or rarely visited by humans. However, large-scale control activities in these areas, even if logistically and economically feasible, are not justified because of limited risk for human exposure. For this reason, control strategies are focused primarily on limiting contact between humans and sylvatic rodents and their fleas, and through specific actions to reduce rodent and flea populations in areas of human residence and activity, particularly campgrounds or other recreational areas. The presence of plague in a dense population of susceptible rodents

closely associated with human activity sometimes necessitates the use of insecticides to suppress the number of infective fleas to lower the transmission risk to humans. In some instances, temporary closure of recreational facilities, in lieu of or prior to plague control, is necessary when the risk of disease exposure is imminent.

D. Epizootic Investigation and Risk Evaluation

Reports of animal die-offs should be investigated by local and state health authorities to determine if a plague epizootic is in progress and if the public is at risk of exposure. Unnatural causes of mortality such as poisoning or shooting should be ruled out. Evaluating local rodent abundance by visual counts can help document a possible die-off and assess the potential for contact between humans, rodents and their fleas. (Note: Evaluating rodent population changes in recreation or other potential high-risk areas is made easier by routine, prior monitoring to acquire baseline knowledge of rodent species present and their relative abundance) When investigating a potential epizootic, fleas should be collected from burrow systems using a burrow swab (a small white flannel cloth attached to the end of a flexible rod) and any fresh rodent carcasses should be retained for laboratory testing. Appropriate personal protective equipment (PPE) should be used to prevent direct contact with rodent carcasses or fleas. If rodent carcasses are being collected for plague testing, they should be placed in a clear plastic bag using a shovel, disposable gloves, or by grasping the animal through a clear plastic bag, and inverting the bag over the animal without directly touching it and sealing the bag. Place the bag inside another clear plastic bag and label the outside with date/time and location of collection and the collector's name and agency. Multiple carcasses should be placed in individual clear plastic bags and then into one large clear plastic bag.

Detection of *Y. pestis* from a rodent carcass or their fleas indicates that transmission of plague has recently occurred in the local rodent population. This information should trigger a more intensive evaluation involving direct rodent surveillance and possible control recommendations, or area closure to protect the public health. "Plague Warning" signs should be posted immediately in areas where plague activity is confirmed. The public should also be notified.

A comprehensive plague risk evaluation of the area is warranted and should include:

- a. Live-trapping all available rodent species in the area to estimate the relative abundance of known reservoirs and amplifying species, determine flea species and abundance, and to collect blood samples for the assessment of recent plague transmission. Positive serum antibody titers from rodent species can provide retrospective evidence of plague transmission in the local rodent populations. Because serum antibody titers may remain elevated in rodents for weeks to months following exposure, they may or may not be due to current active plague, and therefore have limited value when evaluating a possible active epizootic. The quantitative value of rodent serum antibody titers (e.g., 1:256) is

chiefly determined by the robustness of the individual rodent's immunologic response or time since exposure and should not alone be considered an indicator of the magnitude, virulence, or temporal proximity of *Y. pestis* activity in the area. One or a few positive serum antibody titers in the absence of other supportive evidence should not be solely interpreted as evidence of active plague.

- b. Assessing the extent and phase of the epizootic. The proportion of rodents with positive serological titers can provide a rough indication of the recent level of plague activity in the rodent population, but must be interpreted within the entire context of the assessment. Other factors such as a decline in susceptible rodents (e.g., ground squirrels or chipmunks), evidence of rodent burrow abandonment, fleas inhabiting burrow entrances, and the presence of carrion eating flies are consistent with a recent epizootic event. These assessments are best done by personnel experienced in the interpretation of current plague activity.
- c. Evaluating the abundance of fleas on rodents (flea index: number of fleas per rodent host) and in or around burrow entrances, and testing fleas for *Y. pestis* to estimate the infection prevalence of known vector species.
- d. Assessing the potential for humans to be exposed to vector fleas.
- e. Reviewing the area's history of plague activity and/or human plague cases.

Confirmation of plague among rodents and/or their fleas, in combination with other risk factors such as high densities of these rodents and their fleas, evidence of a recent rodent die-off, local history of plague activity and/or human cases, and the imminent possibility for human exposure may require intervention in the disease cycle through suppression of vector fleas and the control of rodent populations. Plague control is a collaborative effort between state and local health and county agricultural authorities and property owners. In recreational situations, property ownership or management may include federal, state, and local land use agencies, and private interests (e.g. concessionaires). Decision flowcharts used for plague surveillance and response are included as Figures 2-4. See Appendix B for a risk evaluation template that can be used to summarize the investigation and communicate findings to other local authorities.

1. Protocols and Procedures Involved in Plague Surveillance

Trapping and sampling methods for rodents that minimize disease exposure help ensure the safety of personnel conducting vector-borne disease surveillance (See: Methods for trapping and sampling small mammals for virologic testing, Sept. 1995, U.S. Dept. Health & Human Services, CDC).

When working with a pathogen or other hazardous substance known to adversely affect human health, special precautionary methods should be implemented, including the use of

personal protective equipment (PPE) as covered in the Code of Federal Regulations (CFR) and the California Code of Regulations (CCR). Personnel engaged in rodent disease surveillance or otherwise handling live rodents are required to follow their organization's protocols and all applicable regulations regarding the use of PPE (Title 8 California Administrative Code §5199.1). Workers conducting surveillance should be aware of the symptoms of rodent-borne diseases and should immediately seek medical attention if a febrile illness develops after a potential exposure.

2. Control of Rodent Fleas

The bite of plague-infected fleas remains the most frequent route of plague transmission to humans in California. Therefore, insecticidal suppression of sylvatic rodent fleas is the most effective means of minimizing human contact with the plague vector. Control of fleas on dogs and cats in plague endemic regions is necessary because pets may serve as transporters of rodent fleas to humans. Numerous insecticides and insect growth regulators are commercially available for control of fleas on dogs and cats. These products can be administered by the pet owner or veterinarian.

When restricted-use insecticides (insecticides not available to the general public) are used in suppressing vector fleas on public lands, a use permit is required from the local Agricultural Commissioner (3CCR§6412, 3CCR§6420) and a pesticide use report must be submitted after the pesticide application (Food and Agricultural Code (FAC) §12979).

Suppression of vector fleas found on sylvatic rodents should be considered when the following occur:

- a. Plague activity is confirmed among rodents and/or fleas in areas of human activity.
- b. Vector fleas are abundant in areas of human activity.
- c. There is a significant potential for humans to be exposed to vector fleas.

Suppression measures are limited to areas of potential human exposure at the time of treatment. Under this regimen, routine or repetitive pesticide treatments, which might lead to development of insecticide resistance, are avoided. Reduction of flea density to less than one flea per rodent host is considered sufficient to interrupt transmission to humans.

How insecticides are delivered to the target species is as important as the materials used. Two target delivery systems are currently approved and employed:

- (1) Application of insecticidal dusts into rodent burrow systems.
- (2) Application of insecticides via rodent bait stations. This method targets fleas on animals that do not use burrows for nesting, or rodents that have burrows inaccessible to direct application or are difficult to find.

Both methods of insecticide application may be necessary where mixed rodent populations (e.g., ground squirrels and chipmunks) are present.

Burrow dusting for flea suppression is accomplished by applying insecticide dust directly into rodent burrow systems with hand or pressurized applicators. Burrow dusting is most effective against ground squirrel fleas where rodent burrows are easily located.

Bait stations attract and treat rodents by the placement of bait inside a PVC tube that also contains an insecticidal dust or is lined with carpet that has been sprayed with a liquid insecticide (e.g., deltamethrin). When rodents enter the tube, insecticide is transferred via contact with the dust or treated carpet. Bait stations should be inspected at least every other day, and bait and insecticide reapplied as necessary. Current formulations of liquid deltamethrin leave a residual that can last for weeks to months, so reapplication of insecticide may not be necessary. Bait stations are most effective against fleas on ground squirrels, chipmunks, and woodrats. The number of bait stations used should be appropriate for the area being treated and the estimated rodent density. Bait stations should be placed no greater than 100 ft. (30m) apart. Occasionally, dominant individuals may deter entry of other rodents into bait stations, thus leaving subordinate individuals untreated. Increase the density of bait stations in areas with high densities of rodents or in areas where dominance is observed or suspected. Current pesticides available for rodent flea control require approximately seven days of use in bait stations to be effective.

3. Pesticide Application and Safety in Flea Suppression Methods

Minimizing the exposure of people to pesticides is a primary concern during flea suppression activities. Following pesticide label directions, worker safety regulations, and common-sense practices reduce the chances of pesticide exposure to humans and non-target wildlife. All government agency pesticide applicators engaged in flea suppression are required by law to be properly certified for public health applications of pesticides, or work under the direct supervision of a certified applicator (HSC§106925). Prior to handling pesticides, all government agency or commercial applicators must receive pesticide application and safety training for the specific pesticide product(s) (3CCR§6724). Additionally, applicators are required to wear PPE that is required by the pesticide label (40CFR§156.212). This may include disposable protective coveralls, rubber gloves, head and foot protection, and protective eyewear (3CCR§6738). Available washing facilities are required for all control operations (3CCR§6734).

Exposure of the public to insecticides should be minimized during all plague control operations by restricting access to the treatment site and following applicable laws and regulations. The public should be notified in advance of any pesticide applications. Bait stations with insecticidal dust present a potential source of poisoning for children and pets. All insecticide-containing bait stations should be constructed, placed, and labeled in such a manner as to prevent pesticide non-target exposure.

A post-treatment evaluation should follow all flea suppression operations to determine the success or failure of flea reduction and evaluate any environmental impacts to non-target wildlife. Pre- and post-treatment evaluations and a summary of the suppression effectiveness should be documented. Summary Pesticide Use Reports must be submitted to the county agricultural commissioner (3CCR§6627).

PART IV - PLAGUE PREVENTIVE MEASURES

Land use agencies responsible for areas with a history of plague activity should not rely on chemical control of flea populations as a primary or exclusive prevention strategy. An integrated disease management program that focuses on host population and disease monitoring, public education, and habitat management to limit rodent abundance will be more effective. Using an integrated approach can minimize potential disease risk to humans, as well as reduce the need for chemical intervention and temporary closure of public use areas.

A. Sylvatic Rodent Management

Sylvatic rodents are a vital component of California's natural ecosystems and can contribute to the aesthetic quality of recreational activities for many people. However, human-influenced habitat changes and increased food availability through supplemental feeding often lead to artificially inflated rodent abundance. Ideally, rodent abundance within campgrounds or other developed recreational sites should not be significantly higher than in the surrounding natural habitats. In recreational areas (e.g., campgrounds or day use areas), ground squirrel populations may be considered excessive if 20% or more of the structures, barriers, or campsites have evidence of rodent activity (e.g., burrows, chewing, nesting).

Repeated evidence of plague activity and/or periodic plague epizootics and high densities of rodents involved in plague transmission in close proximity to humans may lead to management strategies that incorporate suppression and/or reduction of excessive rodent numbers. Various management and control methods can be used to reduce the numbers of rodents or increase the practical distance between rodents and humans.

If rodent removal (i.e., lethal control) methods are utilized, it is essential to ensure that fleas are controlled prior to rodent control to avoid exacerbating the risk of human exposure to plague-infected fleas.

1. Sanitation

Rodents are opportunistic foragers and will readily take advantage of supplemental food such as garbage, spilled food, pet food, or handouts. People in recreational areas should be encouraged to store all food in sealed containers that are inaccessible to rodents. Similarly, people should be instructed to dispose of all garbage and food waste in tightly sealed dumpsters and garbage cans and avoid feeding wild rodents.

2. Habitat Modifications

Human-made structures (e.g., buildings, barrier logs, rock walls, concrete pads, wood piles) provide refuge for wild rodents that contribute to unnaturally high rodent abundance, particularly when coupled with supplemental food. These structures can increase the potential for contact between humans, rodents, and fleas. Thick brush or other vegetation around these landscape features may further attract rodents to these sites.

Habitat modification of recreational and home environments should include the following:

- a. Thin or remove brush at least 15 feet (5 meters) away from homes and structures, or from campsites in recreational areas.
- b. Remove fallen logs.
- c. Place logs used as barriers on supports at least six inches off the ground.
- d. Cut and remove tree stumps.
- e. Bury large rocks used as barriers or for decorative purposes 1/3 to 1/2 below grade.
- f. In campgrounds, campsites should be located away from large rocks or boulders where rodents normally construct burrow systems.
- g. After road construction, rocks should be removed and banks well-compacted. Metal barriers, rather than logs, should be used as roadway barriers.
- h. L-shaped concrete footing lips or stiff wire mesh (10 inches wide and buried 8 inches below ground adjacent to pads) should be used instead of shallow concrete pads or low wooden risers in building foundation construction to deter burrowing rodents.
- i. Seal gaps between walls and roofs, and access areas of lower walls in structures.
- j. Eliminate sources of supplemental food and water (e.g., leaking faucets).

3. Rodent Proofing

Preventing rodents from accessing buildings, food storage boxes, and refuse containers requires implementation and consistent maintenance of effective exclusion methods. Properly screening vents, providing tight-fitting doors and windows, and plugging gaps where pipes or other conduit enter buildings are essential exclusion measures. The proper design and construction of buildings and camping facilities that emphasize rodent exclusion will significantly reduce rodent access and habitation.

4. Trapping

Although labor-intensive, trapping may be an effective supplemental method for reducing rodent numbers. Animals that are live-trapped for removal should be humanely euthanized and properly disposed. It is illegal to relocate any furbearing or non-game mammal in California (14CCR §465.5), therefore all animals should be released where trapped, if they are not euthanized. Follow all applicable regulations for trapping, euthanizing, and disposing rodents. In regions with a history of plague activity, rodent control should be preceded by flea control, as outlined in Part III above.

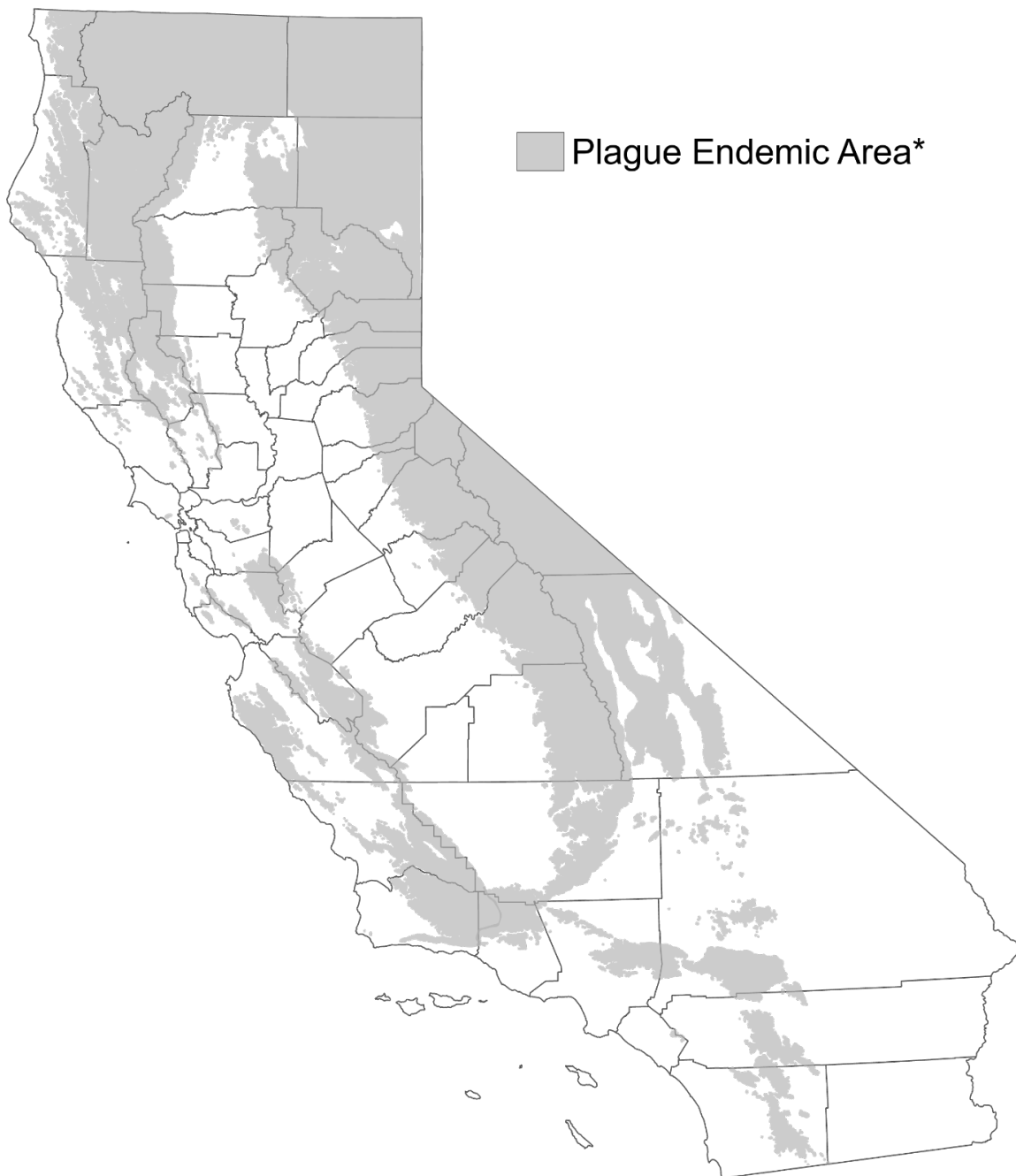
5. Toxic Baits

The use of rodenticides, particularly in recreational areas, should be a control method of last resort. Rodenticides labeled for control of sylvatic rodent species are increasingly limited and the office of the local County Agricultural Commissioner should be consulted for available rodenticides and appropriate treatment methods. As with removal trapping, flea control should precede the use of rodenticides.

B. Health Education

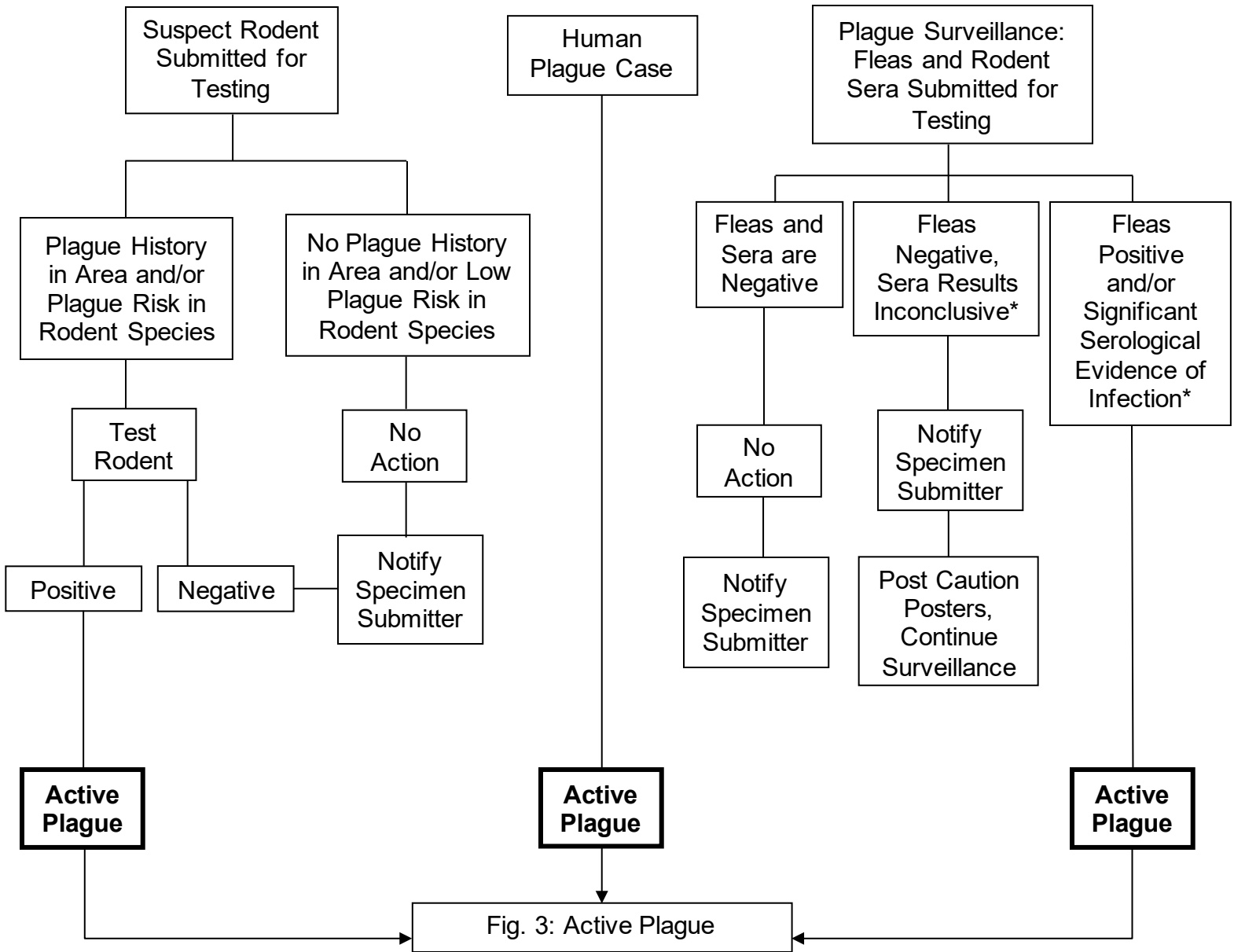
The appropriate use of print and digital media educational resources, as well as in-person training and presentations, are key elements of plague control. Many rodent-associated plague cases can be prevented if people are aware of the risk of exposure in plague endemic areas and are educated to avoid rodents and their fleas. The public should be educated about the necessity to treat pets for fleas and control rodents on their properties by removing rodent harborage and rodent-proofing structures. Campers and visitors to recreation areas should be alerted with print materials and posted signs that explain the risk of plague, how to avoid it, and where to report evidence of rodent mortality. The medical and veterinary communities should be kept informed of recent plague activity in endemic regions and be provided current information on case occurrence, diagnosis, precautions, treatment, and therapy.

Fig. 1: Plague Endemic Areas of California



*Plague endemic areas in California are estimated based on the location of surveillance indicators (plague positive rodent or carnivore samples) collected from 1983-present, with appropriate regional elevation limits (e.g., > 3,000 feet for interior areas) and distance buffers.

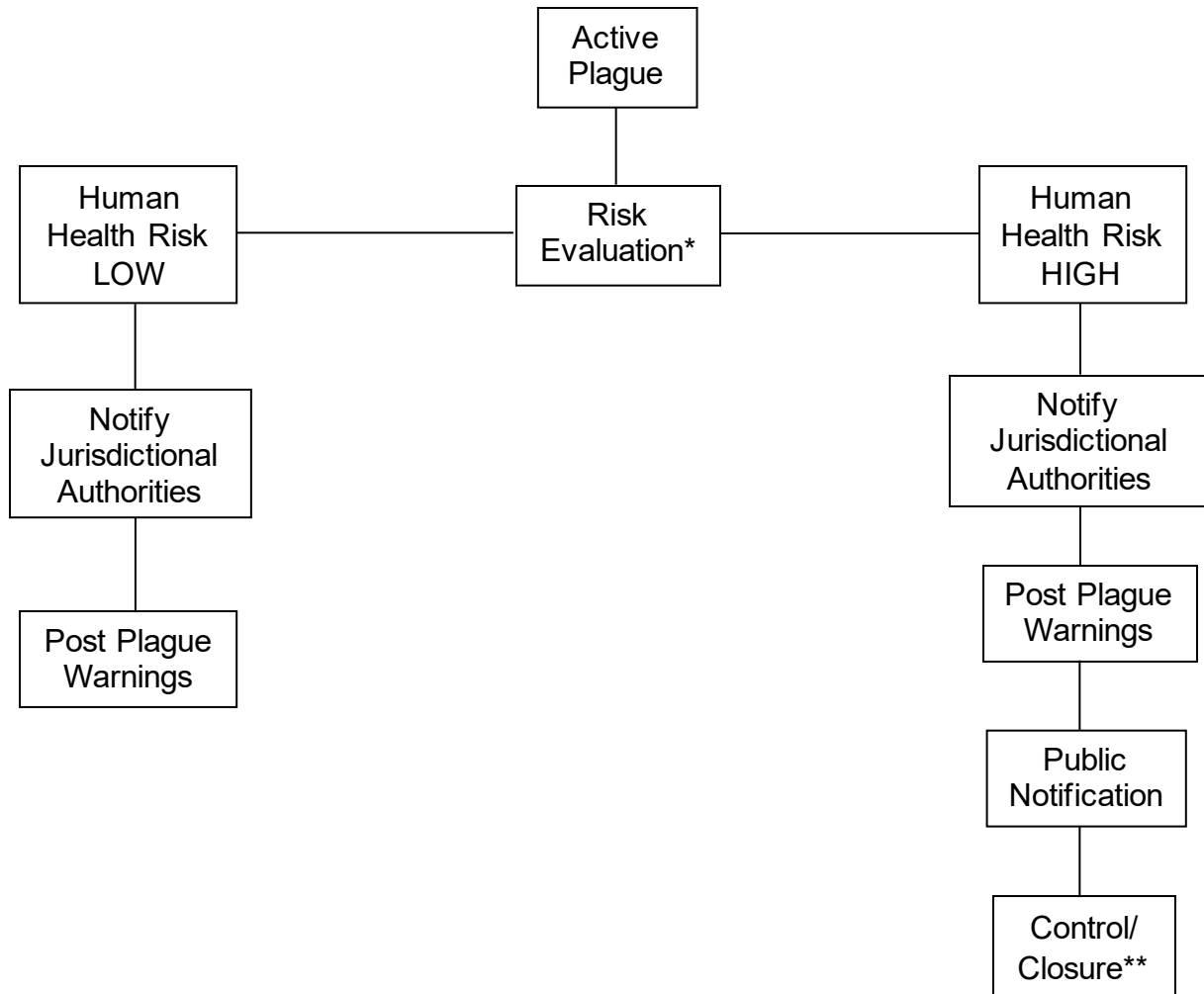
Fig. 2: Plague Detection



*High antibody levels and a high proportion of serologically positive animals may indicate more recent and increased plague activity. A large percentage (>25%) of sera with relatively high titers (>1:256) should prompt additional investigation.

**Inconclusive results can occur from small sample sizes with negative antibody results and/or low titers (<1:256).

Fig. 3: Active Plague



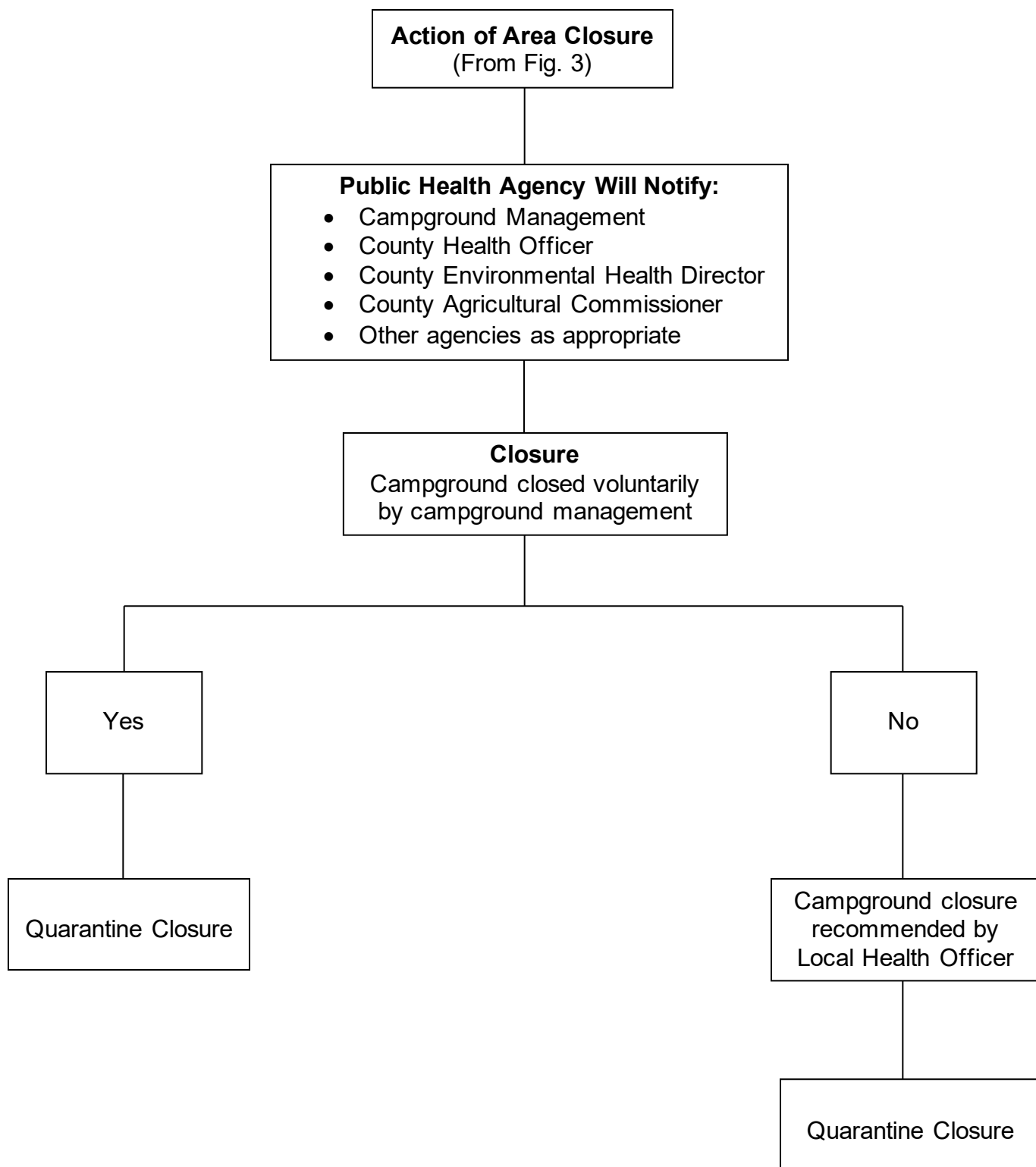
***Risk Evaluation:**

- 1) Past history of disease and evidence of current epizootic activity
- 2) Presence and densities of susceptible and resistant rodent species
- 3) Presence of vector fleas and bite exposure potential
- 4) Human usage and exposure potential

****Control/Closure Recommended if:**

- 1) History of past disease and current epizootic documented
- 2) High density of disease susceptible host rodent species present
- 3) Vector fleas present, species readily bite humans – exposure potential for human transmission is high
- 4) High human usage and close co-mingling of humans, rodents, and vectors
- 5) Potential for pesticide exposure to humans

Fig. 4: Procedures for Closure of Recreational Areas for Plague Prevention



Appendix A: Submission Criteria for the Detection of *Yersinia pestis* (Plague) in Rodents and Lagomorphs (Carcasses and Serum) from California

Based on information provided by years of plague surveillance conducted in California by the California Department of Public Health, Vector-Borne Disease Section (CDPH, VBDS) the following small mammals are species suitable for plague testing.

Rodentia

Common Name(s)	Species
California ground squirrel	<i>Otospermophilus beecheyi</i>
Belding's ground squirrel	<i>Urocitellus beldingi</i>
Golden-mantled ground squirrel	<i>Callospermophilus lateralis</i>
Douglas Squirrel, Pine squirrel, chickaree	<i>Tamiasciurus douglasii</i>
Chipmunks (all species)	<i>Tamias</i> spp.
Northern flying squirrel	<i>Glaucomys sabrinus</i>
Yellow-bellied marmot	<i>Marmota flaviventris</i>
Woodrats (all species)	<i>Neotoma</i> spp.
Deer mouse, brush mouse, pinon mouse, California mouse, others	All <i>Peromyscus</i> spp. mice
Voles (all species)	<i>Microtus</i> spp., <i>Clethrionomys</i> spp., <i>Myodes</i> spp., <i>Arborimus</i> spp.

Lagomorpha

Common Name	Species
Brush rabbits	<i>Sylvilagus</i> spp.
Jack rabbits	<i>Lepus</i> spp.
Pika	<i>Ochotona princeps</i>

Rodent carcasses submitted for bacteriological testing should be from the plague endemic regions of California. Other causes of death (e.g., trauma, shooting, poisoning) should be ruled out. The carcass should be fresh and in good condition as it is difficult to conduct tests on a desiccated or maggot-ridden carcass due to contamination from other bacteria. Place the specimen in an appropriately-sized **clear plastic bag**, and then place this bag in a second plastic bag. The bagged specimen should be identified with locality (latitude and longitude if possible), date found, the contact person or agency, and a phone number for notification. The specimen should be packaged with frozen blue-ice, labeled as "Biological Substance, Category B" (see Appendix C), and shipped in accordance with applicable laws and regulations.

Submission Criteria for Plague Testing of Wild Carnivore Sera in California

CDPH, VBDS plague surveillance of large wild mammals since 1974 has helped determine that the following animals are most appropriate for submission and testing for antibodies to *Y. pestis*. This is not an exhaustive list and additional carnivores may be tested depending on a variety of factors. Contact VBDS for any questions concerning the submission of Nobuto samples from carnivores.

Carnivora

Common Name(s)	Species
Canids (coyote, fox)	<i>Canis</i> spp., <i>Urocyon cinereoargenteus</i> , <i>Vulpes</i> spp.
Black bear	<i>Ursus americanus</i>
Raccoon	<i>Procyon lotor</i>
Striped skunk	<i>Mephitis mephitis</i>
Spotted skunk	<i>Spilogale gracilis</i>
Mustelids (Weasels, badger, marten, fisher)	<i>Mustela</i> spp., <i>Taxidea taxus</i> , <i>Martes caurina</i> , <i>Pekania penanti</i>
Mountain lion	<i>Puma concolor</i>
Bobcat	<i>Lynx rufus</i>

Artiodactyla

Common Name	Species
Feral pig	<i>Sus scrofa</i>

The following animals have limited value in plague surveillance and will be tested only after special arrangements have been made with CDPH, VBDS.

Rodentia

Common Name	Species
Gophers	<i>Thomomys</i> spp.
Kangaroo rats	<i>Dipodomys</i> spp.
Pocket mice	<i>Perognathus</i> spp., <i>Chaetodipus</i> spp.
Western gray squirrel	<i>Sciurus griseus</i>

Eulipotyphla

Common Name	Species
Moles	<i>Scapanus</i> spp., <i>Neurotrichus gibbsii</i>
Shrews	<i>Sorex</i> spp.

The following animals have limited value in plague surveillance and samples should not be submitted for plague testing.

Didelphimorphia

Common Name	Species
Opossum	<i>Didelphis virginiana</i>

Rodentia

Common Name	Species
Beaver	<i>Castor canadensis</i>
Porcupine	<i>Erethizon dorsatum</i>

Appendix B: CDPH Vector-Borne Disease Section Plague Surveillance Risk Evaluation Form

Jurisdiction (Forest Service, State Park, etc.) _____	County _____
Ranger District _____	Ecological Zone _____
Survey Location _____	Contact Person _____
Concessionaire _____	Phone number _____
Campground Host _____	Email address _____
Date _____	Weather _____
	Elevation _____

Risk Assessment Factors (RAF): Rank each from 0-5 points.
 0 = no risk; 1-2 = Low Risk; 3-4 = Moderate Risk; 5 = High Risk

Note: These scores are primarily subjective; ratings should be based on past experience and local knowledge of plague ecology. This form should be used as a general guideline to evaluate a situation and communicate findings. Please consult the Compendium for additional details and contact CDPH for assistance.

1. **Plague History Assessment**
 (Previous plague activity, including human cases, documented in local area)
 _____ RAF _____
2. **Plague Susceptible Species**
 (Presence and abundance of known plague susceptible rodents - infection in these species can rapidly amplify disease activity)
 _____ RAF _____
3. **Moderately Resistant Species** (presence and abundance of known rodent reservoirs - these rodents typically exhibit less mortality than susceptible species but previous plague exposure often demonstrated by serological antibodies)
 _____ RAF _____
4. **Human Exposure Assessment** (Abundance and proximity of rodents and burrow systems to campsites, trails, occupied buildings, or other areas with significant human use)
 _____ RAF _____
5. **Release Assessment** (Potential for infected rodents and fleas to spread plague. For example, infected fleas, vector fleas abundant on susceptible rodents, signs of a rodent die-off such as carcasses, burrow abandonment, fleas on the surface or in burrow entrances, presence of carrion flies in or near burrows)
 _____ RAF _____

Plague Surveillance Risk Evaluation Form

Recommendations/additional observations:

Total Score (add RAFs together, 25 possible points)

Risk Assessment (total score divided by 5)

2.0 or below = Low Risk
2.1 - 4.4 = Moderate Risk
4.5 - 5.0 = High Risk

Evaluator (s) _____

Appendix C: Animal Carcass Testing Submission Form Vector-Borne Disease Laboratory

Collector(s):

Collecting agency:

Jurisdiction (e.g. Forest Service, State Park, Private):

Date Collected:

Location (general):

Specific location (e.g. campsite number, by dumpster):

County:

Elevation:

Latitude:

Longitude:

Comments about condition/behavior:

Address shipment to:
California Department of Public Health Specimen Receiving
Vector-Borne Disease Section Laboratory
850 Marina Bay Parkway
Richmond, CA 94804
(Telephone: 510-412-6251)

Appendix D: Biological Substance Label



**BIOLOGICAL SUBSTANCE
CATEGORY B**



**BIOLOGICAL SUBSTANCE
CATEGORY B**



**BIOLOGICAL SUBSTANCE
CATEGORY B**



**BIOLOGICAL SUBSTANCE
CATEGORY B**



**BIOLOGICAL SUBSTANCE
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