

**TECHNICAL HEALTH ASSESSMENT RESOURCE FOR SPECIES AT RISK
IN BRITISH COLUMBIA**

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Health assessment and management of species at risk populations

The material presented in this document was taken entirely from the more detailed report: "HEALTH ASSESSMENT AND MANAGEMENT RESOURCE FOR SPECIES AT RISK IN BRITISH COLUMBIA" by Fraser and Parmley (2006). This document is intended to provide a quick technical reference to tools and techniques used to assess the health of species at risk that were covered in more detail in the original document. For further information and examples of how the health assessment model outlined here can be applied to species at risk recovery plans please see the original document. All references are also provided in the original document.

1. An approach to health assessment

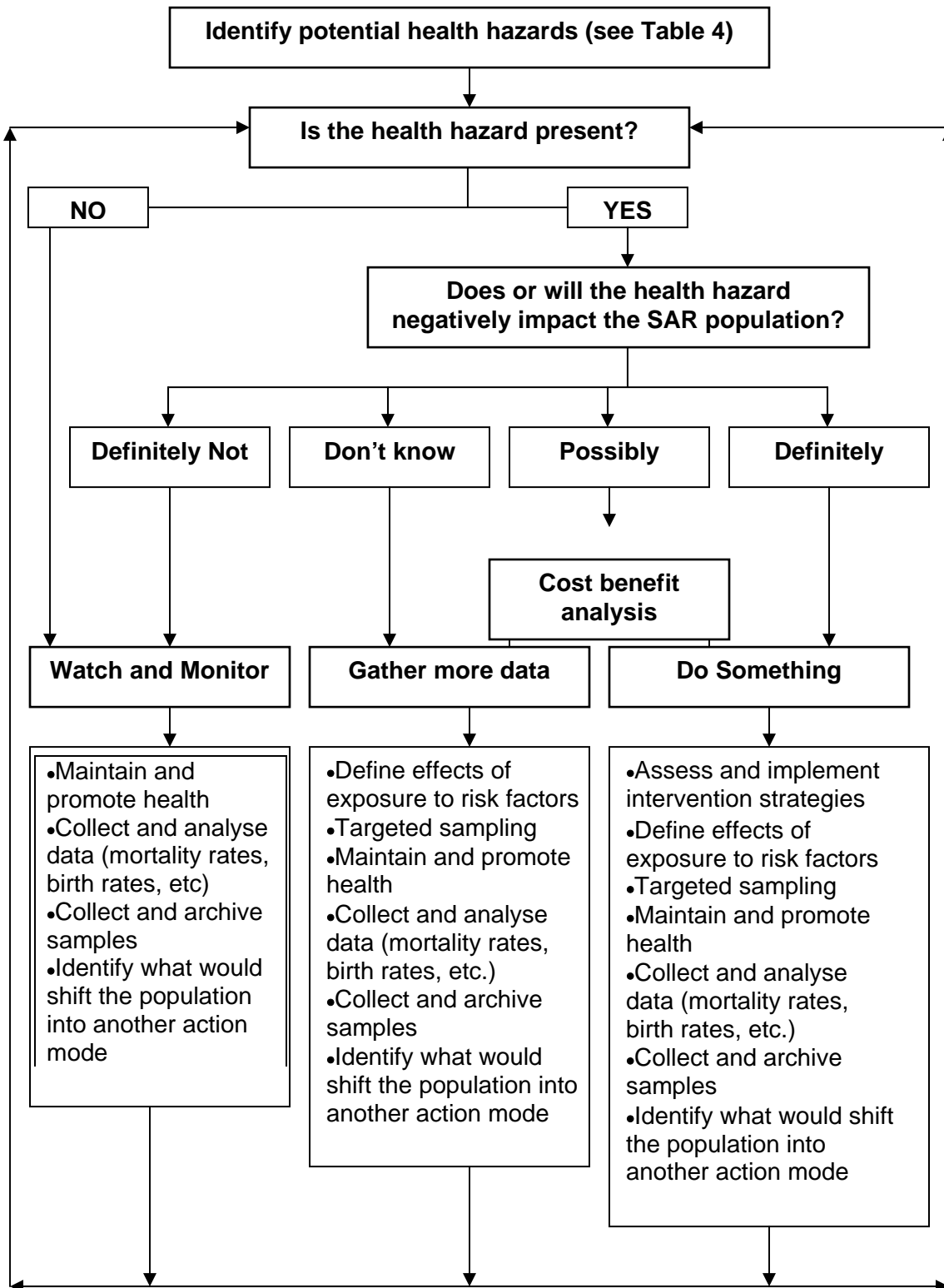
There are number of risk assessment models available to evaluate and manage disease risks in wildlife and domestic livestock. These models often focus on specific disease agents and animal movement events and usually require very detailed information about the prevalence and distribution of these agents in the species of concern. Here we present a more generalized assessment model for evaluating population health that allows for health monitoring and mitigation actions to be tailored to a population's overall level of risk (Figure 1).

The first step in assessing the health of species at risk is to identify real or potential health risk factors for the population of concern (Table 1). In order to do this, one must consider the population of interest and the current management strategies in place. In addition, one must consider what is known about the potential hazards (where they are, what species are at risk, is the hazard infectious/how is it transmitted, how does it affect the health of the host and the population, etc.). Before potential health hazards can be identified and their potential for impact on species at risk populations assessed, the specific population of interest needs to be defined. For several species at risk, both wild and captive populations exist and the population of interest may be one or the other or both. Although the four basic biological processes influencing population dynamics (birth, death, immigration and emigration) are the same for all populations, the particular areas of concern differ. In wild populations we are concerned about reduced reproduction and fecundity, increased mortality and changes in animal movement. In captive populations we have the same concerns as for wild population but we also need to consider reduction in survival both in captivity and in those animals that are reintroduced to the wild as well as factors that may inhibit our ability to reintroduce a population into the wild.

Once potential hazards have been identified, their impacts on the species at risk population dynamics can be evaluated. However, identification of important health risks and information about their potential impact on wildlife populations can be challenging to find. Wildlife biologists, managers and planners should consider several sources from which to gather information. These include:

1. *Review of the literature*
 - a. disease reports for species at risk or similar species (local, from other jurisdictions or other countries)
 - b. clinical trials performed in captive or sympatric populations
 - c. case studies and trials performed on other wildlife species, domestic animals or even humans to generate hypotheses about the importance of and threats associated with certain health risk factors.

Figure 1: Health assessment for species at risk populations



2. *Personal communications*
 - a. between and within provincial ministries
 - b. among provinces
 - c. across international borders
 - d. between industry, governments and other interested parties
3. *Past experience*
4. *Analysis of surveillance data*
 - a. calculate mortality rates (either cause specific or overall)
 - b. track trends over time and in different geographic locations
5. *Review of archived samples for potential testing*

Table 1: Some potential health hazards and their impacts on species at risk populations

Health Risk Factors:	Potential impact
Translocation or captive breeding	Increased susceptibility to disease or injury from stress, nutritional deficiency, genetic intermixing etc. Increased potential for disease transmission and propagation due to increased density or exposure to novel pathogens
Inbreeding or genetic bottleneck	Increased disease susceptibility
Association with domestic livestock	Potential for disease transmission (either to or from wildlife)
History of disease issues in species or family	Known susceptibility to an infectious agent or environmental contaminant
Some habitat issues that put population health at risk: <ol style="list-style-type: none"> a. Insufficient quantity or quality of food b. Increased density due to diminished habitat availability c. Distribution (e.g. out of historic range, new species sharing range) d. Exposure to pollutants, habitat disturbance or human development (i.e. roads, industry, etc). 	<p>Poor nutrition leads to increased disease susceptibility</p> <p>Greater likelihood of disease transmission, increased predation, etc.</p> <p>Potential for exposure to novel pathogens for which the species of concern has no immunity</p> <p>Direct impact: overt disease from toxicity Indirect impact: increased susceptibility to disease or predation, altered behaviour, reproduction, stress, etc.</p>

With as much information as possible gathered on the potential impacts of identified hazards, wildlife experts then need to determine whether or not they are present in the population of interest and the degree of threat they pose. The level of threat from health hazards to a population influences the amount and type of health mitigation strategies that are required. If there are no obvious health risks to a species at risk population then no action is required. The population will however require ongoing monitoring (Figure 3: Watch and Monitor). Populations where health risk factors are present and are clearly a threat to the population (based on good quality evidence) without a doubt require that action be taken quickly if that population is to recover (Figure 3: Do Something).

The situation is less certain when we don't have the knowledge to determine whether a health hazard is present, is an important threat to the population, or when it seems reasonable to assume that the hazard will have an impact but the level of impact is as yet unclear. If there is a paucity of scientific research about the species at risk (habitat, natural behaviour, range, etc.) or

about potential health hazards (pathogens, environmental contaminants, habitat destruction, etc.) then more information must be gathered before any action can be taken. If, however, there is some evidence of risk to health but the impact or effect is uncertain then a cost-benefit analysis should be performed (Aubert, 1999). Things to consider include:

- 1 - population status (where on the SAR continuum is the population of interest?)
- 2 - nature of the potential hazard (does it act quickly, will the impact be severe and irreversible?)
- 3 - the cost of the required intervention

The responses to these considerations will determine whether action will be taken or whether there is time to gather more information before the decision to act is made.

2. Health assessment methods

a. Basic epidemiology

To describe a disease in a species at risk population we need to consider all possible means of effect. These include what species and which individuals within the population may be most affected, how the population will be affected and in what regions and/or habitat types and season the impact will be greatest. In basic terms one needs to identify the “W5” of the disease: who, what, where, when and why (Table 2).

Table 2: The “W5” of wildlife health management

Who	What	Where	When	Why
<ul style="list-style-type: none"> •species •age •sex •sub-population 	<ul style="list-style-type: none"> •organ systems •habitat 	<ul style="list-style-type: none"> •habitat •distribution 	<ul style="list-style-type: none"> •season •temporal trends 	This is where we need to generate hypotheses

To further characterise the impact of disease on the population, rates of disease need to be calculated. There are two measures of disease rates: incidence and prevalence (Box 1). For many species at risk however, we don't know either the population at risk or their distribution. Consequently it is very difficult to accurately calculate a rate of disease.

Box 1: Rates of disease:

Incidence (I) - new cases of a disease in a given population over a specified period of time

$$I = \frac{\text{number of new cases over a given time period}}{\text{population at risk over a given time period}}$$

Prevalence (P) – total number of cases of a disease in a given population at a single point in time

$$P = \frac{\text{number of total cases at a given time}}{\text{population at risk at a given time}}$$

b. How do we know if an agent or risk factor is CAUSING a health impact?

Our understanding of disease and ability to detect it is continually evolving. When a declining population is noted, our first step usually is to go looking for a cause – a pathogen, a toxin or some other agent. If we identify an agent from the diseased or dead animals then our instinct is to label it as the cause of the population decline. However, establishing a causal relationship is

not so straightforward. How do we know that the identified agent has not always been there and is simply a commensal parasite/agent of that species? If it has always been there – has it changed or has something else affected the species at risk to make them more susceptible to that agent? To establish whether a specific agent is causing a health impact there are several criteria that need to be met (Box 2).

Box 2: Evan's Postulates of Causation (Adapted from Last, 2001)

- Rates (prevalence and incidence) of disease are higher in populations exposed to the health hazard than those that are not
- Exposure to the health hazard is more frequent in the population with the disease than those without disease
- Disease should follow exposure in time
- High exposure results in more severe disease, low exposure should result in less severe disease
- Experimentally exposed animals are more likely to develop the disease than unexposed controls
- Reducing exposure should decrease rate of disease
- Improving host response to exposure should decrease or eliminate disease
- All relationships and findings should make biological and common sense

3. Health assessment tools

There are a variety of tools available to assess the health of domestic animals and, in general, the same tools can also be used to assess the health of wildlife populations. Although the same tools are available, in many circumstances the tests have not been validated in many wildlife species. Consequently, there are important limitations to be aware of when interpreting test results. This section outlines a range of health assessment tools that can be applied to both live (Table 3) and dead (Table 4) animals.

4. Who to contact for further assistance or information?

International contacts

World Conservation Union (IUCN-CBG) -- wildlife risk assessment model
United States Geological Survey (USGS) – wildlife biologists, veterinarians etc.

National contacts

Canadian Committee on Animal Care (CCAC) – animal care and handling guidelines
Canadian Cooperative Wildlife Health Centre (CCWHC) -- pathology
Canadian Wildlife Service
Centre for Animal Parasitology, Canadian Food Inspection Agency -- parasitology
Centre for Coastal Health (CCH) –risk assessment, disease outbreak investigations

BC laboratories and agencies

BC Centre for Disease Control (BCCDC) – zoonotic diseases, public health
BC Ministry of Environment, Ecosystem Branch – Dr. Helen Schwantje, wildlife veterinarian
BC Ministry of Agriculture and Lands, Animal Health Centre – pathology, disease testing

Table 3: Measurable health parameters in live animals¹

Parameter	What can it tell you?	What are its limitations?	Skill level ²	Equipment ³
Physical observation or examination ⁴	<ul style="list-style-type: none"> • <i>At a distance</i>: abnormalities in behaviour, physical condition, gait, posture, attitude, symmetry, coat/feathers. • <i>Up close</i>: clinical signs of gross abnormalities in some major systems (gastrointestinal, respiratory, cardiovascular, genitourinary, musculoskeletal, skin, nervous and lymph systems) 	<ul style="list-style-type: none"> • Limited to opportunities when animals can be observed closely or handled (tagging, radio collaring, translocation, captive breeding etc.). • Quantification of findings are difficult as rating systems are subjective 	Novice to expert depending on level of detail	<ul style="list-style-type: none"> • Basic observation or exam: camera • Detailed exam: thermometer, stethoscope, pen light
Fecal examination: <i>Parasitology / microbiology:</i>	<ul style="list-style-type: none"> • Parasite/pathogen burden and identification of species 	<ul style="list-style-type: none"> • Not all parasites and pathogens are shed at all times 	Novice	Sealable bag
Fecal examination: <i>DNA analysis</i>	<ul style="list-style-type: none"> • Can isolate mitochondrial DNA (mtDNA), microsatellite DNA, and single-copy nuclear DNA (scnDNA) from scat. • MtDNA can confirm species, geographic origins of populations and assess rates of evolution. • scnDNA can establish gender • microsatellite DNA can establish individual identity, geographic distribution and genetic relatedness 	<ul style="list-style-type: none"> • Usefulness of test depends on: a) the length of DNA extracted from feces b) confirmation that DNA in feces is identical to that obtained from blood or hair of same animal, c) elimination of sample contamination (hair, blood), d) prevention of sample degradation, and e) removal of dietary inhibitors. 	Novice	Sterile tongue depressor, small vial
Fecal examination: <i>Fecal hormones</i>	<ul style="list-style-type: none"> • Non-invasive measure of physiological stress (adrenal hormones) or endocrine disruption (gonadal hormones). 	<ul style="list-style-type: none"> • Hormones are also excreted in urine; some animals may urinate on feces which elevates level of hormone. • Fecal hormone levels are affected by diet (freeze-drying samples helps address this). • Not validated for all species and baseline levels unknown for many species 	Novice	Sealable bag, freezer (-20°C)
Blood examination: <i>Haematology</i>	<ul style="list-style-type: none"> • Accurate, practical assessment of red blood cells and hydration status • Indication of presence and duration of infection 	<ul style="list-style-type: none"> • Normal ranges unknown for many species • Animal restraint is needed (physical or chemical restraint) 	<ul style="list-style-type: none"> • Novice for blood sample from toenail or ear • Intermediate for direct venous sample 	Blood collection tubes, needles, syringes, cooler and cold packs for sample storage, clipper for collection from toenail or ear
Blood examination: <i>Serum Biochemistry</i>	<ul style="list-style-type: none"> • Provides a means of evaluating organ function and stress • Can confirm haematological findings (infection, hydration) 	<ul style="list-style-type: none"> • Normal ranges unknown for many species • Animal restraint is needed (physical or chemical restraint) • Depending on the number of tests to be run, a larger volume of blood than can be collected by ear or toenail clip may be needed 	<ul style="list-style-type: none"> • Novice for blood sample from toenail or ear • Intermediate for direct venous sample 	Blood collection tubes, needles, syringes, cooler and cold packs for sample storage, clip/blade for collection from toenail or ear
Blood examination: <i>Serology</i>	<ul style="list-style-type: none"> • Level of antibodies can confirm the presence of infection • Evaluate whether the host was previously exposed to an infectious agent through natural infection or vaccination and has developed immunity to the agent 	<ul style="list-style-type: none"> • Test may cross-react with a shared antibody from another infection • Antibodies may be as a result of transfer from mother to young (not from infection) • Poor test specificity resulting in false positive results (see test section) 	Intermediate	Blood collection tubes, needles, syringes, cooler and cold packs for sample storage

¹ Refer to the CCAC guidelines, 2003

² Skill level: novice: no experience required, intermediate: some training required, expert: expertise required

³ The equipment required and sampling techniques are constantly changing, consequently it is best to contact lab that will be doing the analysis for these details.

⁴ Refer to Appendix A for an example of information to collect in a physical exam

Parameter	What can it tell you?	What are its limitations?	Skill level ²	Equipment ³
Other tissues: <i>Hair/feather</i>	<ul style="list-style-type: none"> •DNA/genetic analysis to identify species and individual characteristics (age, sex...) •Presence or absence of heavy metals or other toxins •Diet history via stable isotopes 	<ul style="list-style-type: none"> •Normal ranges unknown for many species •Test characteristics (sensitivity and specificity) for the most part unknown 	Novice	Bag for collection and holding of samples, sterile gloves and forceps for collection
Other tissues: <i>Biopsy (skin, muscle...)</i>	<ul style="list-style-type: none"> •DNA/genetic analysis to identify species and individual characteristics (age, sex...) •Presence or absence of heavy metals or other toxins •Diet history via stable isotopes •Presence or absence of parasites 	<ul style="list-style-type: none"> •Normal ranges unknown for many species •Test characteristics (sensitivity and specificity) for the most part unknown 	Advanced	Requires capture of individual animal, sedation or full anaesthesia, administration of pain control medications and surgical skills

Table 4: Measurable health parameters in dead animals⁵

Parameter	What can it tell you?	What are its limitations?	Skill level	Equipment
Fecal examination: <i>Parasitology / microbiology:</i>	<ul style="list-style-type: none"> Parasite/pathogen burden and identification of species 	<ul style="list-style-type: none"> Not all parasites and pathogens are shed at all times 	Novice	Sealable bag
Fecal examination: <i>DNA analysis</i>	<ul style="list-style-type: none"> Can isolate mitochondrial DNA (mtDNA), microsatellite DNA, and single-copy nuclear DNA (scnDNA) from scat. MtDNA can confirm species, geographic origins of populations and assess rates of evolution. scnDNA can establish gender microsatellite DNA can establish individual identity, geographic distribution and genetic relatedness 	<ul style="list-style-type: none"> Usefulness of test depends on: a) the length of DNA extracted from feces b) confirmation that DNA in feces is identical to that obtained from blood or hair of same animal, c) elimination of sample contamination (hair, blood), d) prevention of sample degradation, and e) removal of dietary inhibitors. 	Novice	Sterile tongue depressor, small vial
Fecal examination: <i>Fecal hormones</i>	<ul style="list-style-type: none"> Non-invasive measure of physiological stress (adrenal hormones) or endocrine disruption (gonadal hormones). 	<ul style="list-style-type: none"> Hormones are also excreted in urine; some animals may urinate on feces, which elevates level of hormone. Fecal hormone levels are affected by diet (freeze-drying samples helps address this). Not validated for all species and baseline levels unknown for many species 	Novice	Sealable bag, freezer (-20°C)
Blood examination ⁶ : <i>Serum Biochemistry</i>	<ul style="list-style-type: none"> Provides a means of evaluating organ function and stress Can confirm haematological findings (infection, hydration) 	<ul style="list-style-type: none"> Normal ranges unknown for many species Good serum sample may or may not be available depending on the quality of the carcass 	Intermediate	Blood collection tubes, needles, syringes, cooler and cold packs for sample storage, filter paper
Blood examination: <i>Serology</i>	<ul style="list-style-type: none"> Confirm the presence of infection Evaluate whether the host was previously exposed to an infectious agent through natural infection or vaccination and has developed immunity to the agent 	<ul style="list-style-type: none"> Normal ranges unknown for many species Good serum sample may or may not be available depending on the quality of the carcass Test may cross-react with a shared antibody from another infection Antibodies may be present as a result of transfer from mother to young (not from infection) Poor test specificity resulting in false positive results (see test section) 	Intermediate	Blood collection tubes, needles, syringes, cooler and cold packs for sample storage, filter paper
Other tissues: <i>Hair/feather</i>	<ul style="list-style-type: none"> DNA/genetic analysis to identify species and individual characteristics (age, sex...) Presence or absence of heavy metals or other toxins 	<ul style="list-style-type: none"> Normal ranges unknown for many species Test characteristics (sensitivity and specificity) for the most part unknown 	Novice	Bag for collection and holding of samples, sterile gloves and forceps for collection
Post mortem examination: <i>Gross exam</i>	<ul style="list-style-type: none"> Body condition, age and sex Presence or absence of injury or disease (acute or chronic) 	<ul style="list-style-type: none"> Quality of findings dependent on the quality of the carcass 	Intermediate to advanced	Gloves, scalpel or knife, saw, axe, scissors, scale
Post mortem examination: <i>Microscopic exam</i>	<ul style="list-style-type: none"> Level of organ function Presence or absence of disease presence or absence of heavy metals and other toxins 	<ul style="list-style-type: none"> Quality of findings dependent on the quality of the carcass and conditions in the field 	Intermediate to advanced	Gloves, scalpel or knife, sample containers and formalin, cooler and cold packs

⁵ See footnotes in Table 3

⁶ Adequate, quality samples are unlikely if the animal has been dead for any significant period of time. However, PCR testing on filter paper sample may be done for some diseases. Unless bleeding is done at or just after death, this sampling technique is not practical for serum.

Appendix A: Sample physical examination form

Date	_____		
Species	_____		
Species ID	_____		
Examiner	_____		
Temperature			
Pulse			
Respiration			
	Normal	Abnormal	Not examined
General appearance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Skin/coat/feathers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Musculoskeletal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Circulatory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Respiratory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Digestive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Genitourinary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Eyes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ears	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mouth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Neural system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lymph nodes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Samples collected	Yes	No	
Feces	<input type="checkbox"/>	<input type="checkbox"/>	
Blood	<input type="checkbox"/>	<input type="checkbox"/>	
Hair/feathers	<input type="checkbox"/>	<input type="checkbox"/>	
Other			

What to look for

Normal temperature range varies among species but generally range from 36°C to 39°C in mammals and 37.7°C to 43.5°C in birds. Increased temperature is indicative of an active infection or stress.

Count the number of pulses in 15 seconds and multiply by 4 to get the number of beats per minute. Normal range varies greatly among species (e.g. 30 beats per minute in an elephant and 750 beats per minute in a mouse). Pulse generally increases with stress.

Count the number of breaths in 15 seconds and multiply by 4 to get breaths per minute. Normal ranges vary (e.g. 16-40 breaths per minute in cats and 10-14 breaths per minute in horses)

Gross asymmetries, abnormal movement or behaviour, emaciation, excess salivation

Evidence of injury (wounds, scars), quality of coat/feathers (discolouration, bald patches), presence of growths or ectoparasites
Skeletal deformity, muscle wasting/emaciation

Nasal discharge, breathing pattern (rapid or slow, shallow or deep) and sounds (wheezing). Stethoscope can provide more detail.

Look for signs of emaciation, distended abdomen, diarrhea (feces, staining, redness, swelling or discharge around anus)

Cloudiness, redness or swelling in or around the eyes, ocular discharge

Carriage of ears should be symmetric and should move to respond to stimuli
Colour (should be a rosy pink), lumps, ulcers, dryness and symmetry of gums, condition of teeth