Health risk assessment for the introduction of Eastern wild turkeys (*Meleagris gallopavo silvestris*) into Nova Scotia

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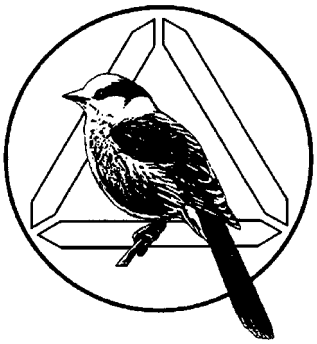

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SUMMARY

This health risk assessment evaluates potential health risks associated with a proposed introduction of wild turkeys to the Annapolis Valley of Nova Scotia. The preferred source for the turkeys would be the Province of Ontario, but alternative sources include the northeastern United States from Minnesota eastward and Tennessee northward. This report assesses qualitatively the probability that health hazards would be created in Nova Scotia in association with the introduction of wild turkeys and the magnitude of harm that would result, and the probability that the introduced wild turkeys would encounter health hazards in Nova Scotia and the magnitude of the harm that would result. The assessment is based primarily on peer-reviewed scientific literature. Additional sources of information include unpublished reports, opinions of poultry health experts, compiled laboratory findings and anecdotal information solicited from wildlife health personnel in the states and provinces from which the turkeys might originate, and from Nova Scotia. The methods of the assessment used are those recommended by the World Organization for Animal Health (formerly the OIE), Working Group on Wildlife Diseases. One hundred and twenty two potentially hazardous infectious agents were considered; eleven were assessed in full detail: avian pox viruses, three species of *Mycoplasma*, two species of *Salmonella, Bordatella avium*, three groups of protozoan blood parasites and the tick *Amblyomma americanum*.

Summary Conclusions of the Health Risk Assessment

- The overall health risk of introducing wild turkeys into Nova Scotia, where assessable, is LOW, and can be reduced further by application of testing protocols identified in the document.

- Health risks associated with the possible introduction of four potential disease-causing agents CAN NOT BE ASSESSED due to lack of essential qualitative information.

  - Three parasitic protozoa: *Leucocytozoon smithi, Haemoproteus meleagridis and Plasmodium* sp.
  - The bacterium *Bordatella avium*.

- Health risk associated with introduction of wild turkeys obtained from Ontario is as low or lower than is the case for birds obtained from the United States.

- These conclusions are drawn in association with a range of uncertainties that are presented in the report and must be understood as inherent properties of the conclusions.

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INTRODUCTION

The following health risk assessment was carried out following the Office International des Epizooties (OIE, now the World Organization for Animal Health) and Canadian Cooperative Wildlife Health Centre (CCWHC) guidelines for the 'Analysis of health and related risks in translocations of wild animals' (http://wildlife1.usask.ca/ccwhc2003/wildlife_health_topics/risk_analysis/RSKGUIDINDEX.htm). This risk assessment is intended to be read with close reference to these guidelines.

SECTION 1: THE TRANSLOCATION PLAN.

Details of the proposed introduction of wild turkeys into Nova Scotia are presented in the document entitled 'Translocation plan for eastern wild turkeys (*Meleagris gallopavo silvestris*) into Nova Scotia' prepared by the National Wild Turkey Federation (NWTF). Approximately 50 wild turkeys would be introduced into Nova Scotia each year over four years, comprising a total of 200 introduced birds. The primary source of wild turkeys would be southern Ontario, although other potential source ecosystems include New Hampshire, Massachusetts, Maine, New York, Vermont, Connecticut, Tennessee, Wisconsin, Minnesota and Michigan. Capture and translocation would be conducted during the winter, particularly from mid-January to mid-March. Introductions would begin in the northeast end of the Annapolis Valley in Nova Scotia. The following risk assessment is based on the above information.

SECTION 2: IDENTIFICATION OF HEALTH HAZARDS.

Disease-causing agents potentially carried by translocated wild turkeys.

The primary source ecosystem is to be southern Ontario. Pending turkey availability and other constraints, animals may also come from New Hampshire, Massachusetts, Maine, New York, Vermont, Connecticut, Tennessee, Wisconsin, Minnesota and/or Michigan. A comprehensive list of disease-causing agents that wild turkeys are susceptible to, and locations where infection or exposure has been documented within the United States, is presented in Appendix 1. Only a single disease-causing agent (*Histomonas meleagridis*) has been reported in wild turkeys in Ontario. Appendix 1 includes some disease-causing agents documented in turkeys outside of the proposed source populations because few studies have been published on disease presence and prevalence in the proposed source ecosystems. Additionally, the amount of information on wild turkey disease-causing agents for a given location often reflects research interest and surveillance capabilities rather than true prevalence. Pathogens of domestic turkeys have also been included, even if not documented in wild turkeys.

Phylogenetically-related species in the destination ecosystem

Although a wide range of species exists in the destination ecosystem, this risk assessment focuses primarily on other galliform birds, as they are the most susceptible to potential disease-causing agents of wild turkeys. Other gallinaceous birds currently

in the destination ecosystem include ruffed grouse (*Bonasa umbellus*), spruce grouse (*Falcipennis canadensis*) introduced ring-necked pheasants (*Phasianus colchicus*) and Gray (Hungarian) partridges (*Perdix perdix*) (National Geographic Society, 1999). A small, localized population of Bobwhite quail (*Colinus virginianus*), consisting of birds that have escaped or have been released from captivity, also is at least temporarily established (M. O'Brien, pers. comm.). There have also been anecdotal reports of Chukar partridge (*Alectoris chukar*) and feral guinea fowl (*Numida meleagris*) (M. O'Brien, pers. comm.). Farm stock wild-type turkeys that have escaped or have been released are regularly reported in a number of locations, including the Annapolis Valley (M. O'Brien, pers. comm.).

Of the above galliform birds, the spruce grouse is the only protected species. However, it is not rare at the proposed introduction site and is considered a Green species (not believed to be sensitive or at risk) under the Status of Nova Scotia Wildlife ranking system (http://www.gov.ns.ca/natr/wildlife/genstatus/ranks.asp).

There is a commercial poultry industry in the Annapolis Valley. For turkeys, this consists only of commercial meat birds (both indoor and range). Chicken production includes broiler breeder, broiler and commercial egg layer farms and two chick hatcheries for broiler chicks. Both indoor and range farms exist. Although there are range farms and backyard flocks throughout the valley, they are primarily located in the western end, around Middleton (G. Finley, pers. comm.).

Disease-causing agents present in the destination ecosystem

Wild birds

Diseases of wild birds in Nova Scotia are not well-documented. Confirmed reports of disease-causing agents include *Pasteurella multocida*, Avian pox, *Salmonella typhimurium* and a number of internal parasites (CCWHC, UPEI, pers. comm.). Carbofuran toxicity has been documented in a bald eagle, starlings and a crow, and mercury and lead toxicity are reported in loons (CCWHC, UPEI, pers. comm.). Newcastle disease has been found in wild birds in New Brunswick and PEI (CCWHC, UPEI, pers. comm.). A list of known disease-causing agents that gallinaceous birds in the destination ecosystem are susceptible to and that are potential disease-causing agents for wild turkeys is presented in Appendix 2. Although these galliform birds are likely susceptible to more diseases than listed here, only diseases with published documentation in each species (e.g. not just 'partridge', but gray or chukar) are listed.

The poultry industry

The more important diseases and disease-causing agents in the Nova Scotia poultry industry already diagnosed at the introduction site include: *Histomonas meleagridis*, *Mycoplasma gallisepticum* (in chickens), hemorrhagic enteritis, *Pasteurella multocida*, infectious bronchitis, coccidiosis, infectious bursal disease, *Erysipelothrix rhusiopathiae*, *Salmonella arizonae* and infectious laryngotracheitis (G. Finley, pers. comm.).

Other information

At present, information is not complete for disease-causing agents already present in the destination ecosystem. This risk assessment thus assumes that disease-

causing agents (with the exception of those listed above in wild birds and poultry) carried in by introduced wild turkeys are not currently present in the destination ecosystem.

Disease-causing agents associated with important health risks

A. Disease-causing agents from Appendix 1 that pose no significant health risks

The following disease-causing agents were eliminated from further consideration because of one or more of the following criteria (see Appendix 3 for detailed criteria for each disease):

1. Never documented in wild turkeys.
2. Not documented in source or destination ecosystems i.e. occurs well out of source and destination ranges.
3. Not a significant pathogen* for the poultry industry or for native galliform birds already in the source ecosystem.

A number of parasites were eliminated at this stage because they were considered weakly pathogenic and/or because they were not associated with clinical disease. Uncertainties associated with these assumptions are presented in detail in Section 3.

Aegyptianella pullorum
Amoebotaenia cuneata
Amphimerus elongatus
Argas persicus
Avian encephalomyelitis
Avian paramyxovirus-2
Avian paramyxovirus-3
Borrelia anserina
Ceratophyllus niger
Cheilopistes meleagridis
Cheilospirura hamulosa
Choanotaenia infundibulum
Collyriclum faba
Cryptosporidium spp.
Cyrnea colini
Cytodites nudus
Dermanyssus gallinae
Drepanidotaenia watsoni
Echidnophaga gallinacea
Freyana chanayi
Gongylonema ingluvicola
Imparmargo baileyi
Knemidocoptes mutans
Laminosioptes cysticola
Menacanthus stramineus
Neoschongastia americana
Ornithonyssus sylvarium
Ornithorhinobacterium rhinotracheale
Oxyspiura mansoni
Pasteurella anatipestifer
Postharmostomum gallinum
Rotavirus
Strongyloides avium
Subulura brumpti
Syringophilus bipectinatus
Trypanosoma spp.
Turkey viral enteritis
Turkey viral hepatitis
Yersinia pseudotuberculosis

*Pathogens were defined as disease-causing agents that cause clinical disease in the species in question.

All other disease-causing agents in Appendix 1 were given further review. After this review, two categories were established: i) those that posed no substantial risk and

ii) those identified as potentially important health hazards. Disease-causing agents in the former category are considered in Part B below and those in the latter category in Part C and Sections 3, 4, 5 and 6. Risk categories and risk rating criteria are presented in detail in the CCWHC/OIE guidelines and in Section 3 of this report.

B. Review of disease-causing agents posing no substantial risk

A second group of disease-causing agents listed in Appendix 1 warranted further consideration. Although there are potential health risks associated with each, these agents were excluded from detailed risk assessment for reasons outlined below. The majority of internal and external parasites have been eliminated, primarily because they have been found in wild turkeys during health surveys and are considered weakly pathogenic or non-pathogenic. There are uncertainties attached to these assumptions and a risk statement summarizing all of these parasites is presented in Section 3 (below).

Ascaridia dissimilis: High mortality in domestic turkeys has been associated with *A. dissimilis* (Norton et al., 1992). There are many reports of wild turkeys harbouring this parasite (Appendix 1), but no reports of clinical disease. *Ascaridia spp.* are already present in poultry in the maritimes (G. Conboy, pers. comm.). This parasite is transmitted directly (Ruff and Norton, 1997) and therefore tends only to be a problem under intensive rearing conditions where feces become concentrated. Biosecurity precautions should prevent entry of this parasite into intensive commercial production units, but range turkeys may be at risk. This parasite poses some introduction risk, but it may be both undesirable and unrealistic to introduce parasite-free turkeys. See Section 3 for an overview of parasite risk.

Ascaridia galli: This is a potential poultry pathogen and has been reported in wild turkeys. It poses a potential risk for the same reasons as *A. dissimilis* (see above). See Section 3 for an overview of parasite risk.

Avian Influenza: There are numerous strains of Influenza A viruses in wild birds, especially in waterfowl, and only the highly pathogenic strains for poultry or humans are of concern. Because this is a reportable disease and would be devastating to the poultry industry, it must be considered. However, with one exception, it has never been reported in wild turkeys (Cook et al., 2003). In a serological study of 383 wild turkeys in California, only a single bird was positive and it had a low antibody titre to Influenza A on agar gel immunodiffusion (Charlton, 2000). No confirmation of this positive serologic reaction was made, and the author postulated that the low-specificity of the test (i.e. a false positive) may explain the result (Charlton, 2000). Low-pathogenicity strains of AI are carried worldwide by waterfowl and wild birds. Experimental infections of AI from wild birds into poultry did not cause mortality, and strains highly pathogenic to poultry did not cause mortality in wild waterfowl (Friend and Franson, 1999). Although wild waterfowl have been implicated as a source of AI strains for domestic birds, there is no evidence to implicate wild turkeys. The risk of highly pathogenic AI introduction in wild turkeys is therefore negligible and AI will not be assessed further. However, in light of

recent AI outbreaks world-wide, serological tests for AI are available if testing is required by CFIA or the Nova Scotia government (Cook et al., 2003).

Avian paramyxovirus-1 (APMV-1), including Newcastle Disease: There are numerous strains of APMV-1 with varying degrees of virulence for poultry and other birds (Alexander, 1997). With the exception of the highly pathogenic strains called Newcastle disease virus (ND), most are mildly to non-pathogenic. Given the presence of low-pathogenicity strains in wild birds and various vaccination protocols against ND used in domestic poultry, serological evidence of APMV-1 exposure does not imply exposure to or infection with highly pathogenic ND (Alexander, 1997). Even in clinically ill poultry, isolation of ND alone does not confirm disease and pathogenicity tests must be carried out in live chickens to characterize the virulence of the virus (Alexander, 1997).

ND is a reportable disease and wild birds are a potential source for poultry (Alexander, 1997). Although antibody titres (strain not specified) have been found in wild turkeys from Arkansas (Hopkins et al., 1990) and California (Charlton, 2000), clinical disease or virus isolation has never been reported in these birds (Cook et al., 2003). Highly pathogenic strains of ND have been reported in cormorants from western Canada (Wobeser, 1997), Quebec, Ontario, Minnesota (Heckert et al., 1996) and Michigan (Banerjee et al., 1994). Cormorants therefore present a far greater risk of introduction of ND into Nova Scotia than do wild turkeys. The risk of ND introduction by wild turkeys is negligible and will not be assessed further. However, serological tests exist if required by CFIA or the Nova Scotia government (Cook et al., 2003).

Low-pathogenicity strains of APMV-1 are found in low prevalence in wild birds worldwide (Wobeser, 1997). Wild waterfowl carry such strains (slight or no virulence to chickens) (Wobeser, 1997) and migratory waterfowl in North America periodically are infected. Strains of APMV-1 have been reported in wild birds from New Brunswick and PEI (CCWHC, UPEI, pers. comm.) and therefore likely also are present in wild birds in Nova Scotia. Given the non-pathogenicity to poultry and the likely presence in Nova Scotia, these strains will not be considered further.

Brachylaema virginiana: This trematode is reported in both wild turkeys (Appendix 1) and ruffed grouse. It is considered non-pathogenic to both species (Davidson and Wentworth, 1992) (Wentworth and Davidson, 1989). This trematode is therefore of little significance and will not be assessed further.

Capillaria spp.: Various species of this nematode genus have been documented in wild turkeys and other wild galliform birds from potential source populations (Appendices 1 and 2). In high numbers, *C. contorta* can cause severe disease in turkeys and gray partridge (Ruff and Norton, 1997). However, because *C. contorta* is a directly transmitted parasite, severe disease is usually associated with dense host populations in unsanitary conditions. *Capillaria spp.* are widespread, exist in PEI (G. Conboy, pers. comm.) and are possibly present in Nova Scotia already. Although there is some risk of introduction, it may be undesirable and unrealistic to introduce turkeys without parasites. See Section 3 for an overall statement on parasite risk.

Cheilospirura spinosa: This nematode was originally a grouse parasite, which has spread to other gamebirds (Ruff and Norton, 1997). Pathogenicity is related to worm burden and light infections are relatively non-pathogenic (Ruff and Norton, 1997). It has been documented in ruffed grouse from New England, Michigan and Minnesota (Wentworth and Davidson, 1989) and is therefore likely present in wild turkeys from these areas. It may already be present in Nova Scotia. This parasite poses some introduction risk and an overall risk statement for parasites is presented in Section 3.

Chlamydia psittaci: In two different studies in Texas, antibodies were not detected to this bacterium in wild turkeys (Hensley and Cain, 1979), (Peterson et al., 2002). No evidence of this infection was found in wild turkeys, even in those living adjacent to domestic poultry that were experiencing this disease (Hensley et al., 1979). Wild turkeys are most likely susceptible, but are rarely infected and are not significant carriers of infection (Davidson and Wentworth, 1992). Because *Chlamydia* has been found in many free-ranging US birds such as pigeons, waterfowl and shorebirds (Friend and Franson, 1999), turkeys have likely been exposed in source populations. Turkeys therefore pose negligible risk regarding introduction and are at minimum risk from *Chlamydia* already present in Nova Scotia.

Clostridium colinum: This is a bacterial infection of quail, although pheasants, partridge and turkeys are also susceptible to this pathogen (Appendices 1 and 2). However, outbreaks of this infection in free-ranging wild birds are rare (Friend and Franson, 1999) and it has only been mentioned in wild turkeys once (Hewitt, 1967). This is a disease of confined game birds (Friend and Franson, 1999). Wild turkeys therefore present negligible probability of introduction and are at negligible risk if the organism is present in the destination ecosystem.

Cotylurus flabelliformis: This trematode has been found in wild turkeys during surveys (Maxfield et al., 1963). It is not associated with clinical disease and is considered non-pathogenic (Davidson and Wentworth, 1992). Although reported in Tennessee, it poses negligible risk to turkeys and other galliform birds and will not be assessed further.

Davainea meleagridis: This cestode has no known pathogenicity to wild turkeys (Davidson and Wentworth, 1992) and many reports of infection have come from surveys of healthy, hunter-collected birds (Maxfield et al., 1963). It is not reported in other wild galliform birds, nor in chickens (Reid and McDougald, 1997). Like other parasites, there is potential for spread to backyard domestic turkey flocks. However, it may be undesirable and unrealistic to introduce parasite-free wild turkeys. See Section 3 on an overall risk statement regarding parasites.

Dispharynx nasuta: This nematode parasite can cause disease in grouse and has already been documented in ruffed grouse from Nova Scotia (Wentworth and Davidson, 1989). It has only been documented in wild turkeys outside of the range of the possible source populations (Appendix 1). Because it is already in grouse in Nova Scotia and because habitat partitioning of grouse and turkeys probably would limit further grouse exposure if an introduced wild turkey were infected, risk is negligible.

Eastern Equine Encephalitis: There is no published documentation of this mosquito-transmitted virus in wild turkeys. Winter translocation would preclude active infection and transmission to mosquito vectors at the destination ecosystem. This is therefore not an important risk and will not be considered further.

Echinoparyphium recurvatum: Many reports of this trematode in wild turkeys are from surveys in hunter-collected animals (Maxfield et al., 1963) and trematodes have not been associated with clinical disease in wild turkeys (Davidson and Wentworth, 1992). This trematode causes localized lesions and subclinical disease in ruffed grouse (Wentworth and Davidson, 1989) and has been reported (without associated disease) in both ruffed grouse and wild turkeys in Michigan (Wentworth and Davidson, 1989) (Davidson and Wentworth, 1992). Although it may be introduced with wild turkeys, it poses negligible risk to turkeys and grouse.

Echinostoma recurvatum: Although this trematode has been recorded in wild turkeys in Michigan, there are no reports of clinical disease (Davidson and Wentworth, 1992). Even if introduced, it poses negligible risk.

Eimeria spp.: Both the pathogenic coccidial intestinal protozoans *E. adenoides* and *E. meleagrimitis* and relatively non-pathogenic *E. dispersa* and *E. meleagridis* have been found in wild turkeys (Appendix 1). *E. dispersa* also has low pathogenicity in ruffed grouse (Wentworth and Davidson, 1989). Coccidia generally require high densities of birds (e.g. confinement, aggregation) to build up enough oocysts to be pathogenic, and clinical coccidiosis has not been documented in free-ranging wild turkeys (Davidson and Wentworth, 1992). Various *Eimeria* spp. already exist in the Nova Scotia poultry industry (G. Finley, pers. comm.) Introduction risk to other wild galliform and farmed birds, and risk of clinical disease from Nova Scotia *Eimeria* to introduced wild turkeys, are therefore negligible.

Erysipelothrix rhusiopathiae: This bacterium is ubiquitous in temperate environments and soil is likely a common source (Bricker and Saif, 1997). It has been reported in a wide variety of wild bird species (Friend and Franson, 1999) and has been seen sporadically in Nova Scotia poultry (G. Finley, pers. comm.). It is not documented in wild turkeys, so introduction risk is negligible. Because it is ubiquitous, turkeys of source ecosystems have likely been exposed. The lack of reported mortality events in wild turkeys suggests that although Erysipelas is present in Nova Scotia, it poses little risk to introduced wild turkeys.

Heterakis gallinarum: This nematode carries the pathogenic protozoan *Histomonas meleagridis*, which can cause serious disease of wild turkeys. The decline of gray partridge in Britain has been attributed to *Heterakis gallinarum* due to amplification of the parasite in introduced ring-necked pheasants (Tompkins et al., 2001). However, the nematode is considered relatively non-pathogenic to turkeys and grouse (Davidson and Wentworth, 1992) (Wentworth and Davidson, 1989). Both *H. gallinarum* and *H.*

meleagridis are already present in Nova Scotia (G. Finley, pers. comm.). See *H. meleagridis* for further risk assessment discussion (below).

Hexamita meleagridis: This is a protozoan infection of turkey poults in confinement (McDougald, 1997). There are no published reports of this protozoan in wild turkeys. Wild turkeys therefore pose negligible introduction risk. Introduced turkeys may be at risk if this protozoan is present in Nova Scotia, but low wild turkey density would result in only isolated illness. This protozoan therefore is not a significant risk.

Histomonas meleagridis: This protozoan causes a very important disease in wild turkeys (Cook et al., 2003). Ruffed grouse and chukar partridges are also quite susceptible (Davidson and Wentworth, 1992) and *H. meleagridis* is relatively non-pathogenic to chickens and pheasants, which can therefore act as amplifying hosts (Davidson and Wentworth, 1992). Although *H. meleagridis* has been reported in wild turkeys from Tennessee, Michigan, New York, Wisconsin and Ontario, it is already present in Nova Scotia (G. Finley, pers. comm.). Wild turkeys therefore pose no additional risk of disease in Nova Scotia. Ring-necked pheasants and chickens already present in Nova Scotia present the greatest health risk to other galliform birds there. There is, however, a risk to introduced wild turkeys, and some mortality of introduced turkeys should be expected from this disease. *H. meleagridis* and its nematode host *H. gallinarum* will not be considered further.

Hymenolepis cantaniana: Although documented in wild turkeys (Appendix 1), this tapeworm is considered mild or harmless (Reid and McDougald, 1997) and therefore poses negligible risk.

Hymenolepis carioca: This cestode is documented in various locations from wild turkeys and can infect chickens, bobwhite quail and ruffed grouse. However, experimental infections of hundreds of cestodes per chicken had no effect on weight gains (Reid and McDougald, 1997) and this tapeworm is mildly or non-pathogenic in ruffed grouse (Wentworth and Davidson, 1989). This parasite therefore poses negligible risk even if introduced and will not be considered further.

Infectious laryngotracheitis (ILT): There is no published documentation of infection with this virus in wild turkeys, and of 44 wild turkeys tested in Arkansas, none were seropositive (Hopkins et al., 1990). This is primarily a chicken disease (Bagust and Guy, 1997). It has been found sporadically in backyard flocks in Nova Scotia, which were then depopulated (G. Finley, pers. comm.). For all of the above reasons, wild turkeys pose negligible risk of introducing this pathogen. There is a slight risk that wild turkeys may contract ILT in Nova Scotia, but it has not been reported in wild turkeys from other ILT areas. ILT is not an important risk.

Ixodes scapularis: This tick is the vector for Lyme disease, which is present in parts of Ontario and throughout New England. However, there are no published reports of this tick parasitizing wild turkeys. In an experimental trial, wild turkeys were not competent hosts (Ostfeld and Lewis, 1999). Wild turkeys pose negligible risk for introducing this

tick, which is already present, along with the Lyme disease bacterium, in other parts of Nova Scotia (R. Lindsay, pers. comm.).

Marek's Disease: There is no published documentation of Marek's disease virus infection in wild turkeys. However, a similar herpesvirus has caused disease in wild turkeys in Florida (Cook et al., 2003). Reports are confined to Florida, which is outside of the source population range. This disease is not an important risk providing wild turkeys are not translocated from Florida.

Megninia cubitalis: This feather mite is primarily a chicken parasite, but has been reported in wild turkeys in Maryland (Schorger, 1966). It has little economic significance and *Megninia spp.* are non-pathogenic in ruffed grouse (Wentworth and Davidson, 1989). It poses negligible risk.

Metroliasthes lucida: Although this cestode has been found in wild turkeys in various States (Appendix 1), no reports of illness or death from this parasite are published. Sasseville et al. (1988) reported no change in body weight or macroscopic and microscopic lesions in infected wild turkeys. There are no reports of pathogenicity in wild turkeys (Davidson and Wentworth, 1992). This parasite rarely affects chickens (Reid and McDougald, 1997). It is therefore of minor importance.

Mycobacterium avium: Although infection with this bacterium is an OIE List B disease, it is not frequently reported in wild turkeys and much more frequently affects captive wild birds or domesticated fowl (Thoen, 1997). Two reports come from wild turkeys held in captivity and only two cases have been documented from free-ranging wild turkeys (Schorger, 1966; K. Beheler, pers. comm.). Wild birds generally pick up the infection from contact with feces of domestic fowl. Highest prevalences in wild birds are found in house sparrows, starlings, scavengers and raptors (Wobeser, 1997), so these pose a far greater risk to poultry than do turkeys. Because this disease has been so infrequently reported in wild turkeys, turkeys would add negligibly to the risk from wild birds already in Nova Scotia.

Mycoplasma gallopavonis: Although this bacterium is considered non-pathogenic (Luttrell et al., 1992), antibodies to this organism can cross-react with other *Mycoplasma* spp. (Cook et al., 2003). This bacterium will not be included further in the risk assessment, but those involved with the introduction should be aware of false positives to other *Mycoplasma* spp. (especially *M. meleagridis*) caused by *M. gallopavonis*.

Oncicola canis: This is an acanthocephalan parasite of dogs and coyotes, and young turkeys are potential aberrant hosts. It has also been reported in bobwhite quail (Rosene, 1969). Because it has never been reported in wild turkeys and turkeys are a dead-end host, this parasite is not important to this risk assessment.

Oxylipeurus spp.: Lice (such as *Oxylipeurus*) need close contact for transmission and they are not considered highly pathogenic, except perhaps to poults (Arends, 1997).

Pathogenicity in wild turkeys is none to mild (Davidson and Wentworth, 1992). These lice do not pose a significant health risk.

Pasteurella multocida: This bacterium is thought to be widespread in avian and other vertebrate hosts, and all bird species are likely susceptible (Rimler and Glisson, 1997a). Although positive antibody titres have been found in wild turkeys, turkeys are not considered a significant reservoir of the bacterium (Cook et al., 2003). Avian cholera, the disease associated with the infection, has been documented in Nova Scotia poultry (G. Finley, pers. comm.), suggesting the bacterium is already present there in domestic and wild birds. A gull and an eider duck from Nova Scotia were diagnosed with *P. multocida* in the 1990s (CCWHC, UPEI, pers. comm.). Wild turkeys do not pose any additional introduction risk, although they may become infected once in Nova Scotia. However, these birds are also at risk in their source ecosystems due to the widespread nature of the bacterium. Because it has been associated with only a single wild turkey mortality event (K. Beheler, pers. comm.), it is likely not important. Avian cholera is typically only a problem when high numbers of birds are aggregated (confinement, at feeding sites). Given all of these reasons, this disease will not be considered further.

Raillietina spp.: A variety of species of this genus of cestode are found in wild turkeys (Appendix 1). There has been no reported pathogenicity in wild turkeys associated with these cestodes with the exception of *R. cesticillus* (mild or none) (Davidson and Wentworth, 1992). *R. georgensis* can cause enteritis in farmed turkeys if in great enough numbers and this parasite was apparently introduced to a domestic farm from wild turkeys (Reid and McDougald, 1997). Although it has been found in Tennessee, Kentucky is its northernmost published range in wild turkeys (Appendix 1). A brown ant (*Pheidole vinelandica*) is the intermediate host (Reid and McDougald, 1997) and likely limits the range of this parasite. For example, this ant is not listed as one of the 113 ant species found in Michigan (Wheeler et al., 1994). Even if wild turkeys came from Tennessee and some were carrying this parasite, the intermediate host may not be found in Nova Scotia. Risk is negligible. If this parasite is a concern (the risk is too low to be considered further in this assessment), wild turkeys from Tennessee can be avoided or tested and treated. See Section 3 for an overall risk statement on parasites.

Reticuloendotheliosis virus: This virus is not considered economically important to the poultry industry (Witter, 1997) and contact infection rarely results in clinical disease in chickens (Witter, 1997). It has the potential to affect various galliform birds and is spread via blood-feeding vectors, including mosquitoes, or by contact with feces (Trampel et al., 2002). To date, only isolated reports of neoplastic disease caused by the virus have been found in individual wild turkeys in Texas, Georgia and North Carolina (Appendix 1). The virus may exist in other US wild turkey populations and introduced wild turkeys from source populations (particularly from southern states like Tennessee) are at negligible to low risk for being infected. Even if introduced, it appears to only cause isolated or sporadic disease. Given the fact that economic and ecological significance appears to be minimal, this virus will not be assessed further.

Salmonella arizonae: Although an infection of domestic turkeys, this bacterium has not been documented in wild turkeys. *S. arizonae* was reported in Nova Scotia poultry years ago (G. Finley, pers. comm.). Because wild turkeys are not reported to harbour it and disease has already been found in Nova Scotia, risk from introduced turkeys is negligible.

Salmonella typhimurium: Positive antibody titres to this bacterium have been found in wild turkeys from various States (Appendix 1) and this bacterium was cultured from a dead wild turkey in Wisconsin (Appendix 4). *S. typhimurium* has also been diagnosed in wild birds from Nova Scotia (CCWHC, UPEI, pers. comm.) and winter outbreaks in infected songbirds occur throughout North America and Europe (Friend and Franson, 1999). Reservoirs therefore already exist in Nova Scotia and introduced wild turkeys pose negligible additional risk.

Sarcocystis sp.: Because the many species of this genus of protozoa are not economically important to the poultry industry (Wentworth and Davidson, 1989), are widespread (particularly in waterfowl) and have only been documented in wild turkeys sporadically, they will not be considered further.

Strigea elegans meleagris: This trematode has been reported from wild turkeys in Michigan (Davidson and Wentworth, 1992). However, these trematodes are not considered highly pathogenic and are not associated with clinical disease in turkeys (Davidson and Wentworth, 1992). Two intermediate hosts are required, the first is a snail and the second is unknown. Even if an infected bird were imported from Michigan, this would be insignificant to the intensively managed commercial poultry industry. Bringing in parasite-free turkeys may be unrealistic and unfeasible (see Section 3 for a discussion on risk regarding parasites). Given the negligible economic impact and negligible to low chance of importing an infected turkey, this fluke will not be considered further.

Syngamus trachea: This tracheal nematode is found worldwide and is reported in wild turkeys, other gamebirds and passerines in the United States (Friend and Franson, 1999). It can be a serious infection in ruffed grouse (Wentworth and Davidson, 1989) and in domestic turkey poults (Sasseville et al., 1988). It has been found in wild turkeys from Connecticut and Michigan (Appendix 1), and given its widespread nature, it likely infects wild turkeys in other areas as well. It most likely already exists in Nova Scotia, as it is found in crows and grackles in PEI (G. Conboy, pers. comm.). Therefore, if this parasite were brought in with wild turkeys, it would not contribute significant additional risk. See Section 3 for a discussion of overall parasite risk.

Toxoplasma gondii: This ubiquitous protozoan is found in mammals, birds and reptiles and is of little significance to the poultry industry (Springer, 1997). Although a zoonosis, only felids produce infective oocysts. An infected turkey would make zero to a negligible contribution to toxoplasmosis in Nova Scotia.

Trichomonas spp.: Wild turkeys in Pennsylvania and Connecticut have been found infected with this protozoan during parasite surveys (Appendix 1). Infection occurs via contaminated feed or water. Both avirulent and virulent strains of the parasite are widespread in nature and up to 80-90% of adult pigeons (*Columba liva*) are infected without clinical disease (Friend and Franson, 1999). Due to the high prevalence of *Trichomonas* in pigeons, introduced wild turkeys will add negligible risk to the presence of *Trichomonas* in Nova Scotia.

Trichostrongylus tenuis: This nematode has been isolated from US wild turkeys as far north as Michigan (Appendix 1) and can cause disease in pheasants and bobwhite quail. It was not included in a comprehensive review of ruffed grouse parasites (Wentworth and Davidson, 1989). This parasite has been found to regulate population cycles and cause devastating crashes in red grouse (*Lagopus lagopus scoticus*) in England and Scotland (Dobson and Hudson, 1994). Ruffed grouse, however, belong to a different genus (*Bonasa*). Because bobwhite quail, ruffed grouse and wild turkeys have co-existed in states like Michigan where *T. tenuis* has been found, risk from introduced turkeys appears negligible. *T. tenuis* is found in Canada geese from PEI and New Brunswick (G. Conboy, pers. comm.) and therefore likely already exists in Nova Scotia. See Section 3 for an overall statement of parasite risk.

Turkey corona virus: This virus can be excreted for months in recovered domestic turkeys and can persist in the environment (Nagaraja and Pomeroy, 1997). However, it has never been reported in wild turkeys (Appendix 1). As such, wild turkeys are not considered a source of infection for domestic poultry.

Turkey hemorrhagic enteritis: Although tested for, this virus has not been found in wild turkeys (Hopkins et al., 1990). This disease is already present in commercial poultry in Nova Scotia (G. Finley, pers. comm.), therefore introduced turkeys provide no additional risk.

West Nile Virus: Although experimental infection has caused death in a turkey poult, turkeys experimentally infected did not produce a viremia high enough to infect mosquitoes and they are not thought to be an amplifying host (Perkins and Swayne, 2001; Swayne et al., 2000). Therefore, wild turkeys will add little to the amplification and persistence of West Nile virus already present in Nova Scotia and will not be considered further.

Western Equine Encephalitis: Positive antibody titres to this virus have been found in wild turkeys from Texas where the disease is endemic (Davidson and Wentworth, 1992). It is not reported in turkeys from source populations and winter translocation would limit mosquito vectors at both source and destination ecosystems. This virus does not pose an important risk.

Zygocotyle lunata: This trematode has been documented in wild turkeys from Michigan (Appendix 1). In general, trematodes of wild turkeys are not considered highly

pathogenic have not been associated with clinical disease (Davidson and Wentworth, 1992). This trematode therefore will not be assessed further.

C. Disease-causing agents requiring detailed risk assessment

The following disease-causing agents pose a potential risk to the poultry industry and/or to native galliform birds in the source ecosystem and are thoroughly assessed below:

OIE List A and B/CFIA Reportable disease-causing agents
Avian Pox virus
Mycoplasma gallisepticum
Salmonella gallinarum
Salmonella pullorum

Other disease-causing agents
Bacterial
Bordatella avium
Mycoplasma meleagridis
Mycoplasma synoviae

Protozoal
Haemoproteus meleagridis
Leucocytozoon smithi
Plasmodium spp.

Ectoparasites
Amblyomma americanum

SECTION 3: ASSESSMENT OF HEALTH RISKS.

Risk for each disease-causing agent was determined following the risk categories in the OIE/CCWHC 'Analysis of health and related risks in translocations of wild animals' (http://wildlife1.usask.ca/ccwhc2003/wildlife_health_topics/risk_analysis/RSKGUIDINDEX.htm). Risk was assessed primarily with regard to introduction to Nova Scotia of disease-causing agents along with wild turkeys, although risk to the introduced wild turkeys posed by pathogens already present in Nova Scotia was also considered.

Risk was determined based on the probability of arrival of disease-causing agents into Nova Scotia and subsequent exposure of susceptible species, as well as the potential magnitude of negative consequences of pathogen introduction on health of susceptible species, the ecosystem and the human economy. For each component, risk was assessed as follows:

Risk rating	Probability of introduction into Nova Scotia and exposure of susceptible species	Magnitude of negative consequences to susceptible species' health, the destination ecosystem and the human economy
Negligible	Extremely low to negligible	Negligible impact
Low	Low, but possible	Limited host range/minor impact
Medium	Likely	Moderate host range/moderate impact
High	Very likely or certain	Extensive host range/severe impact

An overall risk rating was then determined for each disease-causing pathogen by combining the rating for each of the above components.

Approximately 50 birds will be introduced initially, with a total of up to 200 birds coming from external sources over the course of the introduction project (J. Pedersen, pers. comm.). Michigan, Tennessee, New York and Minnesota all have on-going disease testing for trap and transfer of wild turkeys (Appendix 4). All turkeys transferred to Ontario from the US were tested and found not to be infected with *Salmonella pullorum*, *S. gallinarum*, *Mycoplasma gallisepticum* and *Pasteurella multocida* (Appendix 4). All of the above states and provinces opportunistically send sick or dead turkeys to diagnostic laboratories for testing. Connecticut, Wisconsin and Massachusetts also use diagnostic facilities for dead wild turkeys submitted by the public. Some degree of pre-transfer testing has been done in the past in both Vermont and Wisconsin. No surveillance or testing is known for New Hampshire and no data are available from Maine (Appendix 4). However, all potential source areas have a high level of veterinary infrastructure in place.

Avian Pox

Of all of the disease-causing agents that have caused clinical disease in wild turkeys, avian pox is one of the most common (Appendices 1 and 4). For example, 25% of wild turkeys found sick or dead in eight southeastern States had avian pox (Davidson et al., 1985). There are numerous strains of this virus, and turkeys are susceptible to a number of them. Two general presentations of disease are recognized: the diphtheritic/wet form (more serious) and the cutaneous/dry form (Tripathy and Reed, 1997). Pox lesions of the mouth, respiratory tract and eyes are most debilitating. Lesions generally resolve on their own in 6-12 weeks if the bird survives (Davidson and Wentworth, 1992). The period between infection and appearance of clinical disease (incubation period) ranges from 4-10 days and there are some reports of recrudescence of latent infections in some chicken flocks (Tripathy and Reed, 1997). Transmission occurs through both direct contact and via mechanical arthropod vectors. Blood-feeding arthropods are thought to be most important in the transmission among wild turkeys and the highest prevalence of disease occurs when mosquito numbers are highest (Davidson and Wentworth, 1992).

Avian pox has been documented in wild turkeys from Michigan, New York, Wisconsin and Tennessee (Appendix 1, Appendix 4). Both Michigan and New York have avoided areas of pox outbreaks for wild turkey translocations in the past (Appendix 4). Avian pox has not been documented in poultry in Nova Scotia (G. Finley, pers.

comm.), although it has been found in crows there (CCWHC, UPEI, pers. comm.). Given the widespread presence of pox in source ecosystems, the probability that wild turkeys in the source ecosystem have pox is medium to low, depending on source location. However, capture during winter when vectors are absent (with the possible exception of Tennessee) will bring this probability down to low to negligible. Likelihood of capture during the virus incubation period (i.e. before lesions develop) is low to negligible, given the season of capture. However, there is a low probability that a turkey may be a latent carrier. Likelihood of transmission during transport is negligible because of individual turkey boxes used and winter conditions. Even if a pox-positive turkey arrived in Nova Scotia, transmission probability at the release site is low to negligible, given the lack of vectors in the winter and the free-ranging, low density existence of released turkeys. Therefore, the overall probability of avian pox arriving in Nova Scotia is low to negligible, with turkeys from Ontario or northern States presenting lower probability than turkeys from Tennessee with milder winters.

At the destination ecosystem, because of winter conditions, arthropod vectors will not be present to spread pox. Presumably, habitat partitioning of grouse (woodlands) and turkeys (open agricultural areas) will reduce transmission probability to grouse, should grouse be susceptible to the strain of pox virus introduced. Range overlap with bobwhite quail is more likely, but the greatest transmission potential via direct transmission occurs with free-ranging pheasants and backyard or range poultry flocks. Given that lesions resolve in 6-12 weeks, infected wild turkeys largely should be free from pox by the time mosquitoes re-emerge in spring. If latent infections exist, recrudescence is typically associated with stress. Although not always the case, winter is often the most likely period for increased stress. The overall probability of infecting animals at the destination site is therefore low to negligible.

If avian pox were introduced to Nova Scotia, native galliform birds, other wild birds and range poultry are all potentially at risk. Pox epornitics have been reported in bobwhite quail in the southeastern US with morbidity rates of 2% and mortality rates of 0.6-1.2% (Davidson et al., 1980). The nature of the disease depends on the pox virus strain, but diphtheritic forms can cause serious debilitation, inability to forage and increased risk of predation. The magnitude of negative consequences of pox in Nova Scotia species is therefore medium to low.

Negative consequences to the destination ecosystem as a whole may be most significant if native galliform birds are affected, but the probability of this is low to negligible (see above). The overall magnitude of negative consequences to the destination ecosystem as a whole is low.

The magnitude of negative consequences to the human economy in the destination ecosystem is considered low. Infected range poultry flocks would suffer some morbidity or even mortality and may need vaccination, but hunting of pheasants and bobwhite quail should not be significantly affected (e.g. only up to 1.2% mortality rate was reported in a pox outbreak in wild bobwhite quail). Mitigation efforts to capture and cull affected wild birds may contribute some economic cost. If a large enough proportion of introduced wild turkeys were infected with more severe virus strains and died, costs and efforts of the introduction program may be wasted.

Overall risk of avian pox in Nova Scotia from introduced wild turkeys = **Low**

Mycoplasma gallisepticum*, *M. meleagridis* and *M. synoviae

M. gallisepticum (MG) is an OIE List B disease because of its potentially devastating impact on the commercial poultry industry. It is one of the most costly diseases in the industry (Ley and Yoder, 1997). Although less economically important, *M. meleagridis* (MM) and *M. synoviae* (MS) are also of economic concern to the industry and will be considered along with MG.

Although these bacteria survive poorly in the environment, they can be carried and shed by asymptomatic carrier birds (Ley and Yoder, 1997). Horizontal transmission is most important for MG and MS, whereas vertical and venereal transmission of MM is the most significant (Ley and Yoder, 1997; Yamamoto and Ghazikhanian, 1997; Kleven, 1997). Many positive antibody titres have been found for *Mycoplasma* spp. in wild turkeys (Appendix 1), indicating past exposure and potential carrier ability. However, with the exception of non-pathogenic *M. gallopavonis*, mycoplasmas are rarely isolated from wild turkeys.

Mycoplasma gallisepticum There is a latent phase of 12-21d. before antibodies to MG are detected in infected chickens (Ley and Yoder, 1997). Generally, the greater the bird density, the greater the lateral spread of MG (Ley and Yoder, 1997). Positive titres to MG have been found in wild turkeys in a number of States, including Wisconsin (Appendix 1). However, the bacterium has been isolated only from confined wild turkeys on a Georgian island (Davidson and Wentworth, 1992), a single wild turkey from New York (Appendix 1), a single turkey in Rio Grande, Texas (Fritz et al., 1992) and from two 'wild-type' turkeys on a farm with domestic turkeys in California (Jessup et al., 1983). There is also a report of MG infection in confined wild turkeys in Manitoba (G. Finley, pers. comm.). Follow-up of wild turkeys on the Georgian island eight years later indicated that MG did not persist in free-ranging turkeys, despite close proximity to carrier chickens (Luttrell et al., 1991). It appears that although wild turkeys are exposed and susceptible to MG, they do not maintain infection in their free-ranging populations.

As mentioned above, wild turkeys from Wisconsin were seropositive for MG. All birds imported into Ontario from the US have tested negative for MG (Appendix 4) and test results for MG in Connecticut, Michigan, Vermont and Minnesota also have all been negative. MG has been diagnosed in a chicken flock in Nova Scotia in the past (G. Finley, pers. comm.) It is worth noting that an on-going MG epidemic in house finches, first seen in the 1990s, has been documented in all source States and Ontario (Feederwatch program, Cornell Laboratory of Ornithology at www.birds.cornell.edu). Although also documented in house finches on the New Brunswick side of the Bay of Fundy, no reports have come from Nova Scotia. Given all of the above information, the probability that wild turkeys have been exposed to MG is medium, but the probability that MG will be introduced by wild turkeys is low. (A greater risk is posed by house finches).

If MG were introduced into Nova Scotia, considering preferred turkey habitat, pheasants and range poultry would be most at risk of contracting the infection. There must be relatively close contact for transmission, given the poor survival of MG in the environment. Theoretically, presence of wild turkeys at bird feeders would also put house finches at risk of contracting MG or vice versa. If MG is brought into Nova Scotia by wild turkeys, probability of spread to susceptible species is low.

The magnitude of negative consequences on health of hosts in Nova Scotia is low to medium, primarily because of the potential to affect commercial poultry. Affected flocks suffer feed and egg production losses and also have high condemnation rates at slaughter (Ley and Yoder, 1997).

Magnitude of negative consequences to the ecosystem as a whole is low. Although MG can affect a variety of wild birds, free-ranging conditions limit contact and therefore morbidity and mortality. The exception to this would be winter congregation of house finches at bird feeders.

The most significant negative consequences of MG introduction would be on the human economy because of effects on the poultry industry. As mentioned before, MG is one of the most costly diseases in the industry. Costs would be incurred by the industry through production losses, control and prevention measures, as well as by the province through mitigation measures to eliminate disease from infected wild turkeys. The magnitude of potential negative consequences on economy is classified as medium to high.

If MG were introduced to Nova Scotia by house finches, although wild turkeys may be exposed, they would not be significant carriers of the disease (see above).

Overall risk of MG in Nova Scotia from introduced wild turkeys = **Low**

Mycoplasma meleagridis This is a bacterium specific to turkeys (Yamamoto and Ghazikhanian, 1997). Although positive antibody titres have been found in wild turkeys outside of potential source populations (Appendix 1), no positive isolations have ever been made in wild turkeys. False positives on serology are much more common for MM than other mycoplasmas, possibly because of cross reaction with the common *M. gallopavonis* (Cook et al., 2003). In light of this information, risk of introduction of MM into Nova Scotia is negligible and it will not be assessed further.

Overall risk of MM in Nova Scotia from introduced wild turkeys = **Negligible**

Mycoplasma synoviae This bacterium affects turkeys, chickens and guinea fowl (Appendix 2). Positive antibody titres have been found in wild turkeys of many States, including Tennessee (Appendix 1). MS was isolated from five wild turkeys from Arizona (Fritz et al., 1992) and a single pen-raised wild turkey in North Carolina (Luttrell et al., 1992). Wild turkeys tested in Michigan and Vermont were negative for MS (Appendix 4). These findings indicate that although rare, wild turkeys can be subclinical carriers of MS. Given the low prevalence in wild turkeys and the need for close contact for transmission, risk of exposure of source turkeys is medium to low, but risk of infection and introduction of MS to Nova Scotia is low.

Because of reasons outlined for MG, only pheasants and range poultry would be at risk for transmission from infected introduced turkeys. Although not natural hosts, pheasants can be experimentally infected with MS (Kleven, 1997). The probability of spread to susceptible species in the destination ecosystem is low.

The magnitude of negative consequences on health of hosts in Nova Scotia is low to medium. In domestic poultry, synovitis, air sacculitis, decrease in egg production and condemnation at slaughter are all possible outcomes (Kleven, 1997). Morbidity in

chicken flocks ranges from 2-75% (typically 5-15%) and is 1-20% in turkey flocks (Kleven, 1997).

Magnitude of negative consequences to the destination ecosystem as a whole is low to negligible, given that pheasants have only been experimentally infected.

As with MG, the greatest potential negative consequences would be to the human economy. Costs for production losses, condemnations, control, prevention and mitigation would not be as high as for MG, but would still rank medium.

Overall risk of MS in Nova Scotia from introduced wild turkeys = **Low**

Salmonella pullorum* and *Salmonella gallinarum

Both bacterial infections are reportable to CFIA and are OIE list B diseases. *S. pullorum* (SP) and *S. gallinarum* (SG) are very similar in terms of epizootiology and the same serological test is used for both organisms (Cook et al., 2003). Distinguishing between the two requires culture and identification of the bacteria. For these reasons, SP and SG will be considered together.

SP tends to affect younger birds and SG is more commonly diagnosed in adults. Both are highly host-adapted and rarely cause clinical signs in species other than chickens and turkeys (Shivaprasad, 1997). However, reports of exposure in other galliform birds are described (Appendix 2). Both diseases can be transmitted horizontally and transovarially. Carriers and clinically infected birds are the most important source of infection (Shivaprasad, 1997).

There has been no published evidence of SG in wild turkeys (Appendix 1). However, serological tests do not distinguish between SG and SP and reports of exposure to SP in wild turkeys were not confirmed by culture. In any case, a very low prevalence of seroreactors to SP has been found in wild turkey populations and only outside of source population range (Appendix 1). False positive serological test results are common (Charlton, 2000) and as stated, no attempts to confirm seroreactors by culture were made in published reports. Davidson and Wentworth (1992) believe there is no evidence of SP or SG in wild turkeys in the US. Given all of the above information, the probability of SP or SG introduction into Nova Scotia is low to negligible.

If SP or SG were introduced into Nova Scotia, susceptible species include range poultry, pheasants, ruffed (and likely spruce) grouse, bobwhite quail and guinea fowl. Environmental persistence of SG has been 11 days in feces in a range house and up to 43 days in freezing-thawing conditions (Shivaprasad, 1997). Therefore, food and water sources contaminated by infected wild turkeys can infect local galliform birds. Winter conditions may even facilitate spread through aggregation of birds at feed sources. Pheasants and range poultry are more likely to come in contact with contaminated areas from infected wild turkeys than are grouse due to habitat partitioning. The probability of susceptible hosts being infected with SP or SG would be low to medium.

The magnitude of negative consequences on health of susceptible hosts in Nova Scotia is medium, primarily because of effects on domestic poultry in confined conditions. Although pathogenicity varies with strain, mortality due to SP and SG in commercial poultry ranges from 0-100% and 10-93%, respectively (Shivaprasad, 1997). Morbidity is often much greater than mortality.

The magnitude of negative consequences to the destination ecosystem is low. The low densities of wild galliform birds will prevent widespread transmission.

The most significant potential impacts of SP or SG introduction would be on human economy. The poultry industry would be most affected. Control, prevention and mitigation costs would be high and trade would be affected. As such, the magnitude of negative consequences on economy must be classified as high.

In summary, wild turkeys pose low to negligible risk regarding SP and SG introduction. The risk from wild turkeys imported from the US becomes negligible once CFIA testing requirements are met (see Section 6). No wild turkeys with serological evidence of SP or SG exposure were imported into Ontario.

Overall risk of SP and SG in Nova Scotia from introduced wild turkeys = **Low**

Bordatella avium

Although infection with this bacterium cannot be thoroughly assessed because of incomplete information on its epidemiology, it is included here for a more complete discussion of potential risk.

This highly contagious bacterial disease causes upper respiratory tract infection in young poults (Raffel et al., 2002). Although this bacterium has been reported to cause clinical disease on its own, it often causes disease in the presence of other respiratory pathogens or environmental stressors (Rimler and Glisson, 1997a). Clinical disease is most often apparent in commercial production settings. This organism can persist in dust and feces for up to 33 days at 10°C and has survived at least 10 months in damp, undisturbed litter (Rimler and Glisson, 1997a). A carrier state is likely (Rimler and Glisson, 1997a). Although Rimler and Glisson (1997a) state that disease caused by *B. avium* likely results in several million dollars in losses per year in the US turkey industry, this pathogen is no longer of major economic significance to commercial turkey industry in the southeastern US (J. Barnes, pers. comm.). Although *B. avium* is still present in the southeastern US, it no longer causes appreciable disease in commercial turkeys (J. Barnes, pers. comm.).

Antibodies to *B. avium* were found in 95% of Arkansas wild turkeys tested via ELISA (Hopkins et al., 1990). Culture was not done to confirm presence of infection versus just previous exposure. A single wild turkey housed in a rehabilitation facility (Raptor Trust, NJ) carried a strain of *B. avium* indistinguishable from those of domestic turkeys (Raffel et al., 2002). However, mallards at the facility also carried strains indistinguishable from those of domestic turkeys (Raffel et al., 2002). In this same study, 41 different species of wild birds were found to be seropositive for *B. avium*, many of which species also live in Nova Scotia. The authors suggest that one or more species of wild birds is the reservoir for the domestic turkey disease. Without confirmatory isolation from free-ranging wild turkeys and without knowledge of isolate pathogenicity in strains carried by other wild birds, risk assessment of this disease is difficult. Based on the only published study that examined serological presence of *B. avium* in wild turkeys (Hopkins et al., 1990), prevalence of exposure in wild turkeys may be high. Because intensive rearing conditions tend to favour development of clinical

disease, infections of wild birds are likely subclinical or of minor significance and therefore go unnoticed.

Overall risk of *B. avium* in Nova Scotia from introduced wild turkeys = **Unknown and not assessable at this time**

***Leucocytozoon smithi*, *Haemoproteus meleagridis* and *Plasmodium* spp.**

These cosmopolitan blood parasites of birds are widespread throughout wild and domestic turkeys in the US (Appendix 1; J. Barnes, pers. comm.). They have not been documented in poultry in Nova Scotia (L. Ferns, pers. comm.). Given their similar modes of transmission and epidemiology, they will be considered together. All are transmitted by blood-feeding arthropod vectors. Infection is therefore seasonal, typically peaking in spring with the emergence of vectors (Friend and Franson, 1999).

L. smithi is transmitted by blackflies (*Simulium spp.*), particularly *S. occidentale*, *S. aureum*, *S. meridionale*, *S. nigroparvum*, *S. slossanae*, *S. congareenarum*, *S. jenningsi* and *Prosimulium hirtipes* (Springer, 1997)(Davidson and Wentworth, 1992). This turkey-specific protozoan parasite has very high prevalence in some wild turkey populations (100% in studies from both South Carolina and Virginia (Fedynich and Rhodes, Jr., 1995; Springer, 1997). Young domestic turkeys are most severely affected and disease can be fatal in the acute phase (Springer, 1997). In domestic turkey hens, decreased egg production and even mortality has been reported (Springer, 1997). However, often disease is more subtle and may predispose domestic turkeys to morbidity and mortality from other agents (Davidson and Wentworth, 1992). Although historically a problem in commercial turkey production, *L. smithi* is no longer a significant pathogen for commercial turkeys (J. Barnes, pers. comm.). The black fly vectors do not enter barns, precluding transmission to commercial turkeys raised indoors (J. Barnes, pers. comm.). Even though range flocks are still at risk, clinical disease caused by *L. smithi* is rare (J. Barnes, pers. comm.). Wild turkeys rarely show clinical signs of infection (Springer, 1997) and there are no confirmed instances of death in wild turkeys by this parasite (Davidson and Wentworth, 1992). Although only documented in New York, Michigan, Minnesota and Wisconsin (Appendix 1), birds from other source states are also likely infected. Recovered turkeys can carry the parasite for more than one year (Springer, 1997).

H. meleagridis is transmitted by midges (*Culicoides* spp.), particularly by *C. edeni, C. hinmani*, *C. arboricoli, C, knowltoni* and *C. haemoproteus* (Springer, 1997). Prevalences as high as 54% have been reported in wild turkeys in South Carolina (Fedynich and Rhodes, Jr., 1995). In contrast to *L. smithi*, *H. meleagridis* is not considered to be particularly pathogenic. Exceptions include experimental infection in domestic turkeys which caused clinical signs of lameness, diarrhoea and depression and occasional reports of anemia and hepatomegaly attributed to *H. meleagridis* infection (Springer, 1997). Reports of clinical disease in wild turkeys are rare, consisting of a single report of myositis in an emaciated adult (Davidson and Wentworth, 1992).

Although a number of *Plasmodium spp.* infect domestic turkeys, only *P. hermani*, *P. kempi* and *P. lophurae* have been reported in wild turkeys and only the latter two have been found in potential source populations of Wisconsin and Minnesota (Appendix

1). However, Davidson and Wentworth (1992) warn that prevalence data are minimal because these infectious agents require inoculation of poults for detection and many studies rely only on blood films. Vectors of *Plasmodium* are mosquitoes and include *Culex nigripalpus (P.h.), C. salinarius (P.h.)*, *C.restuans (P.h., P.k.)*, *C. tarsalis (P.k.)* and *C. pipiens (P.k.)*. Known pathogenic species of *Plasmodium* for domestic turkeys (Springer, 1997) have not been found in wild turkeys. The pathogenicity of *Plasmodium* species found in wild turkeys is unknown, with the exception of synergistic effects of *P. hermani* and avian pox infections (Davidson and Wentworth, 1992).

The paucity of detailed information on carrier states, vectors in Nova Scotia and pathogenic potential of these organisms precludes a thorough risk assessment. The probability that one or more of these blood parasites will arrive in Nova Scotia with introduced wild turkeys is medium, especially with high prevalences of *L. smithi* documented in wild turkey populations. Because birds infected with *L. smithi* can carry infection for more than one year, potential black fly vectors present in the spring and summer could propagate infection. Some 150 blackfly species are found in Canada (Integrated Pest Management, Nova Scotia Department of Natural Resources (http://www.gov.ns.ca/enla/envin/pest/mosquito.htm) but data on competent vector species present in Nova Scotia are unavailable. Likewise, although various *Culicoides* species are found in Nova Scotia, data on the presence of competent vectors for *H. meleagridis* is not available. Both *Culex restuans* and *C. pipens*, vectors of *P. hermani* and *P. kempi*, are found in Nova Scotia (J. Ogden, pers. comm.). Reduction of risk through pre-transfer testing is also problematic. Both *L. smithi* and *H. meleagridis* can be detected readily on blood films, but *Plasmodium spp.* require poult inoculation, making pre-transfer testing difficult. Given the high prevalence of these parasites, locating parasite-free birds may also be difficult.

If any of these parasites were to arrive in Nova Scotia, they would only pose a threat to commercial range turkeys, as intensive operations practise arthropod control. Although *P. hermani* can infect bobwhite quail, this infectious agent has only been found in wild turkeys from Florida (Appendix 1). Given the unknowns previously described, the probability of exposure for commercial range turkeys in Nova Scotia cannot be estimated. Likewise, magnitude of negative impact to susceptible host health, the destination ecosystem and human economy cannot be evaluated. There is already evidence that *P. kempi* may have been introduced into northern States with translocated wild turkeys (Castle and Christensen, 1990), therefore there is some probability of introduction. It is the impact of introduction that remains unknown.

Overall risk of *L. smithi*, *H. meleagridis* and *Plasmodium spp.* in Nova Scotia from introduced wild turkeys = **Unknown and not assessable at this time**

Amblyomma americanum

This tick is frequently found on wild turkeys in the US, and wild turkeys may be an important host, particularly for immature stages (Mock et al., 2001). These ticks are established as far north as New York (Means and White, 1997), Massachusetts (King Wan Wu, pers. comm.) and Maine (Keirans and Lacombe, 1998). Adult ticks have been

recovered from various locations in southern Ontario, but these are thought to have arrived on migratory birds or have been documented in people and animals with a history of travel to tick-infested areas (King Wan Wu, pers. comm.). Although *A. americanum* appears to be extending its range northward, there currently is no established population of *A. americanum* in eastern Canada, as climate appears to be a limiting factor (King Wan Wu, pers. comm.). *A. americanum* is a competent vector for Human monocytic ehrlichiosis (HME) (*Ehrlichia chaffeensis*) and perhaps also for *Borrelia burgdorferi* (the cause of Lyme disease) and *Borrelia lonestari*, a bacterium which causes a disease similar to Lyme disease (Means and White, 1997). Both white-tailed deer and dogs are natural mammalian hosts for *E. chaffeensis*. *E. chaffeensis* is maintained in nature with white-tailed deer as the reservoir host and *A. americanum* as a principle vector (Davidson et al., 2001). *E. chaffeensis* has been detected in deer from Florida, Georgia, Missouri and South Carolina and most human cases of HME are found within the range of *A. americanum* (Davidson et al., 2001). White-tailed deer, dogs and coyotes are present in Nova Scotia. *A. americanum* has also parasitized bobwhite quail and chickens (Mock et al., 2001). Infection with larval ticks in young chickens in Missouri reportedly have been severe enough to be fatal (Mock et al., 2001).

The probability of introduced turkeys arriving with *A. americanum* is low to negligible because of winter capture and likelihood that ticks are overwintering in the environment in diapause (Arends, 1997). In temperate climates, all stages of *A. americanum* fall off the host and enter winter diapause as days get shorter, and the ticks emerge from diapause the following spring (Sonenshine et al., 2002). Probability of these ticks being present on the introduced wild turkeys is negligible if coming from northern states or Ontario, and low if coming from Tennessee. Suitable conditions for tick survival at the destination site are unknown, but establishment has occurred in Maine (Keirans and Lacombe, 1998) and recent establishment of other Ixodid tick species has been documented in the Lunenburg area of Nova Scotia (R. Lindsay, pers. comm.).

If introduced to Nova Scotia, range poultry and bobwhite quail would be susceptible to infection. Direct contact is not required. Only spatial overlap between wild turkeys and other suitable hosts is needed for transmission. Humans present in these areas in the spring, summer and fall would also be at risk of exposure. If established in Nova Scotia, probability of exposure of susceptible hosts would be low to medium.

The magnitude of negative consequences on health of susceptible hosts is low to negligible for other bird species. However, if arriving ticks are infected with *E. chaffeensis*, *B. burgdorferri* or *B. lonestari*, negative consequences to human health would be medium to high. Overall magnitude of negative consequences to susceptible hosts is medium.

The magnitude of negative consequences to the destination ecosystem is low to negligible, as parasitized wild birds and mammals would not be significantly affected.

The magnitude of negative consequences to human economy must be classified as medium if human diseases were brought in with ticks or become established in ticks. Health care costs and social costs of these diseases could be significant, as could be mitigation efforts.

In summary, although likelihood of tick arrival in Nova Scotia appears to be low to negligible; given the potential human health risks, overall risk from this tick is classified as low.

Overall risk of *A. americanum* in Nova Scotia from introduced wild turkeys = **Low**

Internal parasites- General considerations

Endoparasites of wild turkeys often are found during surveys and are rarely associated with clinical disease. Although many parasites are listed as mildly pathogenic or non-pathogenic, their effects upon populations are difficult to assess. The host clearly loses some amount of energy or resources when supporting a parasite, even if losses are negligible. Very few studies have attempted to document population effects of parasites, but there is evidence that parasites can sometimes affect wild populations. For example, *Trichostrongylus tenuis* has a very high impact on red grouse in Scotland (Dobson and Hudson, 1994). Other studies have shown that parasite-mediated competition can occur between host animal species. *Heterakis gallinarum*, pathogenic to native gray partridge in England, was non-pathogenic to introduced pheasants. Pheasants served as amplifying hosts of this parasite for gray partridge and this parasite-mediated competition was considered to be a factor in the decline of gray partridge (Tompkins et al., 2001).

All wild animals support some type of parasite community. These parasites are generally well-adapted to the host species and cause little negative consequences except in heavily infected individuals. For these reasons, it may not be desirable to introduce parasite-free wild animals to wild ecosystems. Because of intermittent fecal shedding of many parasite species, lack of validation of tests for parasites in wild turkeys and absence or impracticality of anti-mortem tests for some parasites, pre-transfer testing would not identify all parasites in all hosts. Different treatments exist for different parasites but none is 100% effective. Therefore, introduction of parasite-free turkeys is not likely to be feasible.

Commercial poultry operations are unlikely to come in contact with these parasites given typical biosecurity precautions and closed rearing conditions. Treatments do exist if range poultry contract these parasites. Unfortunately, without information on parasite impact on host populations (see above), one cannot thoroughly assess the risk of introducing these parasites to existing wild galliform birds in Nova Scotia. Anecdotal evidence from other introduction projects where wild turkeys overlap with ruffed grouse or bobwhite quail and have potential contact with range poultry indicate that, thus far, there have been no reports of introduced wild turkeys producing a negative impact on native wild birds or range poultry with respect to endoparasitic disease.

Summary of risk

The probability of Nova Scotia experiencing a serious negative impact from disease-causing agents introduced with wild turkeys is as follows:

Avian Pox = **Low**
Mycoplasma gallisepticum = **Low**
Mycoplasma meleagridis = **Negligible**
Mycoplasma synoviae = **Low**
Salmonella pullorum = **Low**
Salmonella gallinarum = **Low**
Bordatella avium = **Unknown and not assessable at this time**
Leucocytozoon smithi, *Haemoproteus meleagridis* and *Plasmodium* spp. = **Unknown and not assessable at this time**
Amblyomma americanum = **Low**

Although risk from endoparasite introduction is negligible for commercial poultry, risk of serious negative impact on galliform birds native to Nova Scotia is unknown.

SECTION 4: OVERALL ASSESSMENT OF HEALTH RISK.

Overall health risk of introduction of wild turkeys into Nova Scotia where assessable is LOW

Sources of uncertainty in the risk assessment

The following are the most important sources of uncertainty in this risk assessment:

1. Validity, sensitivity and specificity of serological screening tests that were developed for domestic poultry used to assess exposure of wild turkeys to disease-causing agents (Appendix 1).
2. Lack of comprehensive knowledge of potential disease-causing agents of wild galliform birds already present in the destination ecosystem. (For example, no published reports of disease in spruce grouse appear to exist).
3. Lack of comprehensive information on prevalence and disease-causing agents in both source and destination ecosystems.
4. Lack of knowledge on the epidemiology, presence of competent vectors in Nova Scotia, duration of infectious/carrier state and pathogenicity of blood protozoans.
5. Lack of knowledge on the significance of wild turkeys as reservoirs for *Bordatella avium*.
6. Suitability of environmental conditions for the survival of *Amblyomma americanum* in Nova Scotia.

SECTION 5: ADDITIONAL SOURCES OF HAZARDS AND RISKS.

Environmental contaminants

In Ontario and Vermont, reported causes of wild turkey mortality include zinc phosphide toxicity (Appendix 4). Similarly, wild turkeys in New York have been killed following ingestion of insecticide-treated insects (Appendix 4). Two wild turkeys in Wisconsin have died from diazonin toxicity in the past 12 years (Appendix 4). Although not frequent, wild turkey mortality from pesticide exposure does occur.

The Annapolis Valley is a modern agricultural area with pesticide use. Although use is likely similar to Ontario, Vermont, New York and Wisconsin, available data do not permit actual comparisons. Introduced turkeys will likely be exposed to agricultural pesticides and some degree of sporadic mortality can be expected.

Eagle feeding stations

Dead livestock and poultry are fed to wild bald eagles in the Annapolis Valley. Carcasses are placed outdoors at feeding sites and eagle watching at these sites has become a popular tourist attraction. This practice is widespread enough to have prompted creation of guidelines to minimize risk of disease spread, among other things (M. O'Brien, pers. comm.). For example, only non-diseased carcasses are to be placed at feeding sites. However, there is the potential for pathogens normally contained within poultry units to gain access to the surrounding ecosystem. As such, there is potential exposure of introduced wild turkeys to these pathogens through this practice. Although wild turkeys may not develop clinical disease, they may become potential reservoirs for infections important to the poultry industry.

SECTION 6: REDUCTION OF RISK.

Post-release monitoring of wild turkeys

If turkeys are released in Nova Scotia, a subset will be radio-collared for post-release monitoring (M. O'Brien, pers. comm.). Heightened public awareness following release will help with reporting of any sick or dead turkeys. Both of these factors will aid in identification of disease-causing agents introduced with wild turkeys for subsequent mitigation of the problem. All turkeys found sick or dead should be examined by qualified veterinary pathologists.

Risk reduction for specific disease-causing agents

Risk for diseases assessed in detail could be reduced by implementation of the following measures:

Avian Pox: Pre-transfer examination for pox lesions (including oral lesions), avoidance of source birds from areas with pox outbreaks (as done in Michigan and New York) and transfer of turkeys from northern States or Ontario (rather than from Tennessee where weather is milder and transmission by vectors may be possible at the time of capture) would reduce risk from low to negligible.

Mycoplasma gallisepticum: Pre-transfer serological testing of wild turkeys with Rapid Plate Agglutination and rejection of positive birds will drop introduction risk from low to negligible.

Mycoplasma meleagridis: If authorities wish to perform pre-transfer testing for MM, serology (RPA or HI) can be done, but reactors should be cultured to confirm infection. Alternatively, if acceptable to all parties, swabs from the trachea, palatine cleft and vagina/phallus can be cultured from live turkeys before transfer (Cook et al., 2003; Yamamoto and Ghazikhanian, 1997). Cultures require a minimum of 10 days for negative confirmation.

Mycoplasma synoviae: If pre-transfer testing is done (Rapid Plate Agglutination) and only seronegative birds are moved, risk of introduction drops from low to negligible.

Salmonella pullorum and *S. gallinarum*: Pre-transfer serological testing (or proof of disease-free status) is required by CFIA for importation of turkeys into Canada. RPA is the most commonly used serological test for wild turkeys (Appendix 4), although false positives do occur because of lack of specificity (Cook et al., 2003). The microagglutination test is considered most specific by the National Poultry Improvement Plan, but like all tests discussed here, this has only been validated in domestic poultry. Pre-transfer testing with the RPA test for SP/SG would decrease introduction risk from low to negligible.

Bordatella avium: In the absence of further knowledge on the epidemiology of *B. avium* and because this bacterium has not been reported in Nova Scotia (G. Finley, pers. comm.), pre-transfer screening of source flocks could be done as encouraged by Cook et al. (2003). However, positive serology does not necessarily indicate presence of the organism. Isolation of the organism from seropositive turkeys would have to be attempted and then typed to determine if the strain is pathogenic to domestic turkeys. If wild turkeys from source flocks were found to carry *B. avium* strains pathogenic to domestic turkeys, they would then not be translocated (see p. 22).

Amblyomma americanum: As previously mentioned, risk is negligible if turkeys are transferred from Ontario where no established populations of *A. americanum* exist. Likewise, given winter translocation, risk is negligible for wild turkeys from all northern States. Avoidance of Tennessee as a potential source population will drop overall introduction risk of *A. americanum* from low to negligible.

Importation requirements

CFIA will require certification before importation, which will include health certificates from veterinarians, further reducing risk of disease introduction (certainly of clinically apparent disease). This is not required by CFIA if turkeys are translocated from Ontario.

Potential source populations

In general, wild turkey introduction from northern source populations (i.e. not Tennessee) would help minimize introduction risk of disease-causing agents. Wild turkeys from Tennessee, because of the warmer climate, may be more likely to have arthropod-transmitted disease at the time of translocation (e.g. Avian Pox). Ranges for diseases like *Raillietina georgiensis* and reticuloendotheliosis virus are confined to the southeastern US, including Tennessee. Ranges of *Amblyomma americanum* and associated *Ehrlichia chaffeensis* and *Borrelia lonestari* are limited by climate, with New England as the northernmost range. Turkeys from Ontario would be associated with lowest introduction risk for this tick.

Additional considerations

Finally, with respect to the natural ecosystem, wild turkeys would not be the first non-native galliform bird to be introduced to Nova Scotia. Although turkeys and pheasants are not susceptible to all of the same diseases, one might expect possible detrimental effects on native galliform populations to have become evident after introduction of ring-necked pheasants or gray (Hungarian) partridge. In other parts of the wild turkey's natural range, turkeys have co-existed with ruffed grouse and/or bobwhite quail for centuries.

Summary of risk reduction

If all of the above measures were implemented, overall risk would be reduced as follows:

Avian Pox, *Mycoplasma gallisepticum, M. synoviae, Salmonella pullorum, S. gallinarum* and *Amblyomma americanum*:
Reduced from low to negligible
Mycoplasma meleagridis: **Unchanged (negligible)**
Bordatella avium and blood protozoa: **Unchanged (unknown and not assessable at this time)**

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APPENDIX 1. POTENTIAL DISEASE-CAUSING AGENTS OF WILD TURKEYS, THEIR REGULATORY STATUS AND AMERICAN STATES WHERE DISEASE, INFECTION OR EXPOSURE HAS BEEN DOCUMENTED.

US States in bold denote potential source populations of wild turkeys for introduction into Nova Scotia.

Disease-causing agent	**OIE List A or B**	**CFIA reportable**	**States where positive titres or disease has been documented in wild turkeys**
Bacterial:			
Bordatella avium (Turkey coryza)	-	N	Arkansas (Hopkins et al., 1990), New Jersey (Raffel et al., 2002)
Borrelia anserina	-	N	No published reports in wild turkeys.
Clostridium colinum (Quail disease, ulcerative enteritis)	-	N	Location not specified (Hewitt, 1967)
Erysipelas rhusiopathiae	-	N	No published reports in wild turkeys.
Mycobacterium avium (Avian tuberculosis)	B	N	Location not specified (Hewitt, 1967), Colorado (Schorger, 1966), **Wisconsin** (K. Beheler, pers. comm.).
Mycoplasma gallisepticum (Avian mycoplasmosis)	B	N	Texas (Peterson et al., 2002), (Hensley et al., 1979), Colorado (Charlton, 2000) (Hoffman et al., 1997), South Dakota, Pennsylvania (Charlton, 2000), California (Jessup et al., 1983), Kansas (Veatch et al, 1998) (Crupper et al., 2002), Georgia (Luttrell et al., 1991), Arizona, New Mexico, North Dakota, Oklahoma (Fritz et al., 1992), Missouri, **Wisconsin** (Davidson et al., 1992)
Mycoplasma gallopavonis	-	N	South Carolina, Georgia (Luttrell et al., 1992), Colorado (Hoffman et al., 1997), North Carolina (Cobb et al., 1992)
Mycoplasma iowae	-	N	No published reports in wild turkeys.
Mycoplasma meleagridis	-	N	South Dakota (Charlton, 2000), Colorado (Hoffman et al., 1997), Georgia, North

			Carolina (Davidson et al., 1988), Kansas (Crupper et al., 2002)
Mycoplasma synoviae	-	N	Texas (Peterson et al., 2002), South Dakota, California (Charlton, 2000), Colorado (Hoffman et al., 1997), **Tennessee** (Davidson et al., 1988), Kansas (Crupper et al., 2002), Arizona, New Mexico, North Dakota, Oklahoma (Fritz et al., 1992)
Ornithobacterium rhinotracheale	-	N	No published reports in wild turkeys.
Pasteurella multocida (Fowl cholera)	B	N	Arkansas (Hopkins et al.), Colorado (Hewitt, 1967), **Wisconsin** (K. Beheler, pers. comm.)
Pasteurella anatipestifer	-	N	No published reports in wild turkeys.
Salmonella arizonae (Avian arizonosis)	-	N	No published reports in wild turkeys.
Salmonella gallinarum (Fowl typhoid)	B	Y	No published reports specific for *S. gallinarum* in wild turkeys.
Salmonella pullorum (Pullorum disease)	B	Y	Texas (Hensley et al., 1979), South Dakota, California (Charlton, 2000), Kansas (Crupper et al., 2002), **Vermont** (D. Blodgett, pers. comm.)
Salmonella typhimurium (Paratyphoid)	-	N	Texas (Hensley et al., 1979), South Dakota, Colorado, California (Charlton, 2000), Alabama, Georgia, Virginia, Florida (Davidson et al., 1992), **Wisconsin** (K. Beheler, pers. comm.).
Yersinia pseudotuberculosis (Pseudotuberculosis)	-	N	No published reports in wild turkeys.
Chlamydia and Rickettsia:			
Aegyptianella pullorum	-	N	Texas (Castle et al., 1985)
Chlamydophila psittaci	B	N	No published reports in wild turkeys.
Viral:			
Avian encephalomyelitis	-	N	No published reports in wild

			turkeys.
Avian Influenza	A	Y	California (Charlton, 2000)
Avian paramyxovirus 1/ Newcastle Disease	A	Y	Arkansas (Hopkins et al.), California (Charlton, 2000)
Avian paramyxovirus 2	-	N	No published reports in wild turkeys.
Avian paramyxovirus 3	-	N	No published reports in wild turkeys.
Avian pox (Fowl pox)	B	N	Texas (Davidson et al., 1992), Alabama, Arkansas, Georgia, South Carolina, **Tennessee,** Virginia, West Virginia (Davidson et al., 1985), Florida (Davidson et al., 1985) (Akey et al., 1981), Oregon (Lutz et al., 1987), New Jersey (Schorger, 1966), **New York** (W. Stone, pers. comm.), **Michigan** (T. Cooley, pers. comm.), **Wisconsin** (K. Beheler, J. Pedersen, pers. comm.)
Eastern Equine Encephalitis	B	Y	No published reports in wild turkeys.
Infectious bursal disease virus	B	N	No published reports in wild turkeys.
Infectious laryngotracheitis (Fowl herpes I)	B	N	No published reports in wild turkeys.
Marek's Disease	B	N	No published reports in wild turkeys.
Reticuloendotheliosis virus	-	N	Texas (Peterson et al., 2002), North Carolina (Ley et al, 1989), Georgia (Hayes et al., 1992)
Rotavirus	-	N	No published reports in wild turkeys.
Turkey corona virus (Transmissible enteritis, Infectious enteritis)	-	N	No published reports in wild turkeys.
Turkey hemorrhagic enteritis (adenovirus 2-indistinguishable from agent causing marble spleen disease in pheasants)	-	N	No published reports in wild turkeys.
Turkey viral enteritis (astrovirus)	-	N	No published reports in wild turkeys.
Turkey viral hepatitis	-	N	No published reports in wild

			turkeys.
West Nile virus	-	N	No published reports of natural occurrence in wild turkeys.
Western Equine Encephalitis	B	Y	Texas (Davidson et al., 1992)
Protozoa:			
Cryptosporidium baileyi	-	N	No published reports in wild turkeys.
Cryptospordium meleagridis	-	N	No published reports in wild turkeys.
Eimeria spp.	-	N	Connecticut (Sasseville et al., 1988)
Eimeria adenoeides	-	N	Alabama, Arkansas, Mississippi, West Virginia (Davidson et al., 1992)
Eimeria dispersa	-	N	Arkansas (Hopkins et al.), Alabama, Mississippi, West Virginia (Davidson et al., 1992)
Eimeria gallopavonis	-	N	Alabama, Mississippi, West Virginia (Davidson et al., 1992)
Eimeria innocua	-	N	No published reports in wild turkeys.
Eimeria meleagridis	-	N	Pennsylvania, Colorado (Hewitt, 1967), Arkansas, Mississippi, West Virginia (Davidson et al., 1992)
Eimeria meleagrimitis	-	N	Alabama, Arkansas, Mississippi, West Virginia (Davidson et al., 1992)
Eimeria subrotunda	-	N	Mississippi, West Virginia (Davidson et al., 1992)
Haemoproteus meleagridis	-	N	Arkansas (Hopkins et al.), Missouri, **Minnesota**, **Wisconsin** (Castle et al., 1990), Mississippi (Stacey et al., 1990), South Carolina (Fedynich et al., 1995), Florida (Atkinson et al., 1987), Kentucky, **Tennessee** (Castle et al., 1984), West Virginia (Eve et al., 1972), Alabama, Georgia, Iowa, North Dakota, **New York**, Pennsylvania, Texas, **Michigan** (Davidson

			et al., 1992).
Hexamita meleagridis	-	N	No published reports in wild turkeys.
*Histomonas meleagridis**	-	N	Georgia, **Tennessee**, Virginia (Davidson et al., 1985), North Carolina (Ley et al., 1989), Mississippi (Hurst, 1980), Pennsylvania (Schorger, 1966), Alabama, Arkansas, Florida, Iowa, Kentucky, **Michigan**, **New York**, South Carolina, Texas, Virginia, West Virginia (Davidson et al., 1992), **Wisconsin** (K. Beheler, pers. comm.)
Leucocytozoon smithi	-	N	**Wisconsin**, Missouri, **Minnesota** (Castle et al., 1990), Arkansas (Hopkins et al.), Mississippi (Stacey et al., 1990), South Carolina (Fedynich et al., 1995), Virginia (Springer, 1997), West Virginia (Eve et al., 1972), Georgia, Florida (Hewitt, 1967), Alabama, **Michigan**, **New York**, Pennsylvania, South Dakota (Davidson et al., 1992).
Plasmodium durae	-	N	No published reports in wild turkeys.
Plasmodium griffithsi	-	N	No published reports in wild turkeys.
Plasmodium hermani	-	N	Florida (Forrester et al., 1974)
Plasmodium juxtanucleare	-	N	No published reports in wild turkeys.
Plasmodium kempi	-	N	**Wisconsin**, Missouri, North Dakota, **Minnesota** (Castle et al., 1990), Iowa (Davidson et al., 1992).
Plasmodium lophurae	-	N	**Wisconsin** (Castle et al., 1990)
Sarcocystis sp.	-	N	Georgia (Dubey et al., 2000), West Virginia (Teglas et al., 1998)
Toxoplasma gondii	-	N	Alabama (Lindsay et al., 1994), West Virginia, Georgia,

			Louisianna, North Carolina (Quist et al., 1995)
Trichomonas gallinarum	-	N	Connecticut (Sasseville et al., 1988), Pennsylvania (Davidson et al., 1992).
Trichomonas gallinae	-	N	No published reports in wild turkeys.
Trypanosoma spp.	-	N	West Virginia (Eve et al., 1972)
Internal parasites:			
Amoebotaenia cuneata	-	N	Mississippi, West Virginia (Davidson et al., 1992)
Amphimerus elongatus	-	N	No published reports in wild Turkeys.
Ascaridia dissimilis	-	N	Arkansas (Hopkins et al. 468-72), Connecticut (Sasseville et al., 1988), Kentucky, **Tennessee**, Florida, Georgia, Alabama, Virginia, Mississippi, Maryland, Illinois, Louisianna (Castle et al., 1984), Pennsylvania (Schorger, 1966), **Michigan**, North Carolina, South Carolina, West Virginia (Davidson et al., 1992).
Ascaridia galli	-	N	Florida, Maryland (Maxfield et al., 1963), Illinois, North Carolina (Davidson et al., 1992).
Brachylaema virginiana	-	N	Alabama, Arkansas, Florida, Louisianna, Maryland, **Tennessee**, Virginia (Maxfield et al., 1963), **Michigan**, Mississippi, North Carolina, South Carolina (Davidson et al., 1992).
Capillaria spp.	-	N	Connecticut (Sasseville et al., 1988)
Capillaria annulata	-	N	Maryland (Maxfield et al., 1963), **Michigan**, Mississippi (Davidson et al., 1992).
Capillaria bursata	-	N	Maryland, **Tennessee** (Maxfield et al., 1963)
Capillaria caudinflata	-	N	**Tennessee** (Castle et al., 1984), Arkansas, Kentucky,

			Maryland, **Michigan**, Mississippi, North Carolina (Davidson et al., 1992).
Capillaria contorta	-	N	Pennsylvania (Schorger, 1966), Arkansas, **Michigan**, Mississippi, Virginia (Davidson et al., 1992).
Capillaria obsignata	-	N	Alabama, Arkansas, Florida, Georgia, **Tennessee**, Virginia (Maxfield et al., 1963), **Michigan**, Mississippi (Davidson et al., 1992).
Cheilospirura hamulosa	-	N	No published reports in wild turkeys.
Cheilospirura spinosa	-	N	Florida (Davidson et al., 1992)
Choanotaenia infundibulum	-	N	No published reports in wild turkeys.
Collyriclum faba	-	N	No published reports in wild turkeys.
Cotylurus flabelliformis	-	N	Alabama, Arkansas, Florida, **Tennessee**, Virginia (Maxfield et al., 1963), Mississippi, North Carolina (Davidson et al., 1992)
Cyrnea colini	-	N	Alabama, Arkansas, Florida (Maxfield et al., 1963), Georgia, Mississippi, Virginia (Davidson et al., 1992).
Davainea meleagridis	-	N	Alabama, Arkansas, Florida, Maryland, **Tennessee**, Virginia (Maxfield et al., 1963), **Michigan**, Mississippi, West Virginia (Davidson et al., 1992).
Dispharynx nasuta	-	N	South Carolina (Maxfield et al., 1963), Alabama, Florida, Mississippi, West Virginia (Davidson et al., 1992).
Drepanidotaenia watsoni	-	N	Location not specified (Reid et al., 1997)
Echinoparyphium recurvatum	-	N	Alabama, Arkansas, Florida, Louisianna, **Tennessee** (Maxfield et al., 1963), **Michigan**, Mississippi, North Carolina, Oklahoma, South Carolina, West Virginia

			(Davidson et al., 1992)
Echinostoma revolutum	-	N	Florida, **Michigan**, **Minnesota**, South Dakota (Davidson et al., 1992)
Gongylonema ingluvicola	-	N	Alabama (Maxfield et al., 1963), West Virginia (Davidson et al., 1992).
Heterakis gallinarum	-	N	Arkansas (Hopkins et al.), (Castle et al., 1984), Connecticut (Sasseville et al., 1988), Kentucky, **Tennessee**, Georgia, Alabama, Virginia, Mississippi, Maryland, Illinois, Louisiana (Castle et al., 1984), Florida (Maxfield et al., 1963), California, Colorado, Georgia, **Michigan**, North Carolina, Pennsylvania, South Carolina, South Dakota, Texas, **Wisconsin**, West Virginia (Davidson et al., 1992).
Hymenolepis cantaniana	-	N	Georgia, **Tennessee**, Virginia (Maxfield et al., 1963)
Hymenolepis carioca	-	N	Kentucky, **Tennessee**, Florida, Georgia, Alabama, Virginia, Arkansas, Mississippi (Castle et al., 1984), **Michigan** (Davidson et al., 1992).
Imparmargo baileyi	-	N	West Virginia, California (Davidson et al., 1992).
Metroliasthes lucida	-	N	Connecticut (Sasseville et al., 1988), Rhode Island (Amr et al., 1988), Kentucky, **Tennessee**, Florida, Georgia, Alabama, Virginia, Arkansas, Mississippi, Illinois, Louisiana (Castle et al., 1984), North Carolina, South Carolina, Oklahoma, Texas, West Virginia (Davidson et al., 1992).
Oncicola canis	-	N	No published reports in wild turkeys.
Oxyspiura mansoni	-	N	No published reports in wild

			turkeys.
Postharmostomum gallinum	-	N	New Mexico (Pence, 1994)
Raillietina spp.	-	N	Arkansas (Hopkins et al.)
Raillietina cesticillus	-	N	Maryland (Schorger, 1966), Florida, North Carolina (Davidson et al., 1992).
Raillietina georgiensis	-	N	Kentucky, **Tennessee** (Castle et al., 1984), Alabama, Florida (Maxfield et al., 1963), Georgia, Mississippi (Davidson et al., 1992).
Raillietina magninumida	-	N	No published reports in wild turkeys.
Raillietina ransomi	-	N	Florida, Georgia, **Tennessee**, Alabama, Virginia, Arkansas, Mississippi, Maryland (Castle et al., 1984), Louisianna, North Carolina, Pennsylvania, West Virginia (Davidson et al., 1992),
Raillietina williamsi	-	N	Kentucky, **Tennessee**, Florida, Georgia, Alabama, Virginia, Arkansas, Mississippi, Maryland, Illinois (Castle et al., 1984), Pennsylvania (Schorger, 1966), North Carolina, Texas, West Virginia (Davidson et al., 1992).
Strigea elegans meleagris	-	N	Florida, **Michigan**, Texas (Davidson et al., 1992)
Strongyloides avium	-	N	Florida (Maxfield et al., 1963)
Subulura brumpti	-	N	No published reports in wild turkeys.
Syngamus trachea	-	N	Connecticut (Sasseville et al., 1988), Alabama, Arkansas, **Michigan**, Mississippi, Pennsylvania, West Virginia (Davidson et al., 1992).
Trichostrongylus tenuis	-	N	Maryland (Schorger, 1966); Alabama, Florida, Georgia (Maxfield et al., 1963), Arkansas, Louisianna, **Michigan**, Mississippi, North Carolina, South Carolina (Davidson et al., 1992).

Zygocotyle lunata	-	N	Florida (Maxfield et al., 1963), Arkansas, **Michigan**, Oklahoma (Davidson et al., 1992)
External parasites:			
Amblyomma americanum (Lone star tick)	-	N	Kansas (Mock et al., 2001), Missouri (Kollars, Jr et al., 2000), Alabama, Mississippi (Davidson et al., 1992).
Argas persicus (Fowl tick)	-	N	No published reports in wild turkeys.
Ceratophyllus niger (Western chicken flea)	-	N	No published reports in wild turkeys.
Chelopistes meleagridis (Large turkey louse)	-	N	Alabama, Arkansas, Arizona, Mississippi, Oklahoma, Pennsylvania, South Dakota, Texas, Virginia, West Virginia (Davidson et al., 1992).
Cytodites nudus (Air sac mite)	-	N	No published reports in wild turkeys.
Dermanyssus gallinae (Chicken mite)	-	N	No published reports in wild turkeys.
Echidnophaga gallinacea (Sticktight flea)	-	N	No published reports in wild turkeys.
Freyana chanayi (Feather mite)	-	N	No published reports in wild turkeys.
Ixodes scapularis (Black-legged tick)	-	N	No published reports in wild turkeys.
Knemidocoptes mutans (Scaly-leg mite)	-	N	Texas (Davidson et al., 1992).
Laminosioptes cysticola (Fowl cyst mite)	-	N	No published reports in wild turkeys.
Megninia cubitalis	-	N	Maryland (Schorger, 1966)
Menacanthus stramineus (Chicken body louse)	-	N	Alabama, Arkansas, Mississippi, Oklahoma, South Dakota, Virginia, West Virginia (Davidson et al., 1992).
Neoschongastia americana (Chigger)	-	N	Alabama, Mississippi (Davidson et al., 1992).
Ornithonyssus sylvarium (Northern fowl mite)	-	N	No published reports in wild turkeys.
Oxylipeurus corpelentus	-	N	Alabama, Arkansas, Mississippi, Texas, West Virginia (Davidson et al., 1992).

Oxylipeurus polytrapezius (Slender turkey louse)	-	N	Alabama, Arkansas, Arizona, Florida, Missouri, Mississippi, North Carolina, Oklahoma, South Dakota, Texas (Davidson et al., 1992).
Syringophilus bipectinatus (Quill mite)	-	N	No published reports in wild turkeys.

**Histomonas meleagridis* has also been reported in wild turkeys in Ontario (D. Campbell, pers. comm.)

APPENDIX 2. INFECTIOUS AGENTS KNOWN TO CAUSE DISEASE IN GALLIFORM BIRDS PRESENT AT THE RELEASE SITE

(RG=Ruffed Grouse, SG=Spruce Grouse, RNP=Ring-Necked Pheasant, BQ=Bobwhite Quail, GP=Gray Partridge, CP=Chukar Partridge, GF= Guinea Fowl).

Disease-causing agents	**RG**	**SG**	**RNP**	**BQ**	**GP**	**CP**	**GF**
Amblyomma americanum				Y			
Avian encephalomyelitis			Y				
Avian Influenza			Y	Y			Y
Avian Pox	Y		Y	Y			
Brachylaema virginiana	Y						
Capillaria annulata	Y			Y			Y
Capillaria caudinflata	Y						
Capillaria contorta	Y		Y	Y	Y		Y
Cheilospirura hamulosa			Y				Y
Cheilospirura spinosa	Y		Y	Y			
Chlamydia psittaci			Y	Y	Y	Y	
Choanotaenia infundibulum	Y						
Clostridium colinum	Y		Y	Y	Y	Y	
Cryptosporidiosis				Y			
Cytodites nudus	Y						
Cyrnea colini				Y			
Dispharynx nasuta	Y		Y	Y	Y		Y
Eastern equine encephalitis			Y	Y		Y	
Echinoparyphium recurvatum	Y						
Echinostoma revolutum	Y						
Eimeria dispersa	Y		Y	Y	Y		
Erysipelothrix rhusiopathiae				Y		Y	Y
Gongylonema ingluvicola				Y			
Hemorrhagic enteritis/marble spleen disease (adenovirus II)			Y			Y	
Heterakis gallinarum	Y		Y	Y	Y	Y	Y
Hexamita sp.			Y	Y			
Histomonas meleagridis	Y		Y	Y		Y	Y
Hymenolepis cantaniana				Y			
Hymenolepis carioca	Y			Y			
Infectious bursal disease virus							Y
Infectious laryngotracheitis			Y				
Ixodes scapularis				Y			
Knemidocoptes mutans	Y						
Megninia cubitalis				Y			
Menacanthus stramineus							Y
Metroliasthes lucida							Y
Mycobacterium avium	Y			Y			
Mycoplasma gallisepticum			Y	Y		Y	
Mycoplasma synoviae							Y

Newcastle Disease			Y	Y	Y	Y	Y
Onicola canis				Y			
Oxyspiura mansoni	Y						Y
Pasteurella multocida	Y		Y	Y	Y		
Plasmodium hermani				Y			
Plasmodium kempi				Y		Y	Y
Raillietina cesticillus				Y			Y
Raillietina magninumida							Y
Reticuloendotheliosis			Y		Y	Y	Y
Rotavirus			Y				Y
Salmonella gallinarum	Y			Y	Y		Y
Salmonella pullorum			Y	Y			Y
Salmonella typhimurium			Y	Y			
Sarcocystis sp.			Y				
Strongyloides avium				Y			
Subulura brumpti				Y	Y		
Syngamus trachea	Y		Y	Y			
Toxoplasma gondii			Y	Y			
Trichomonas gallinae				Y			
Trichomonas gallinarum			Y	Y		Y	
Trichostrongylus tenuis			Y	Y	Y		Y
Trypanosoma sp.	Y						
West Nile Virus							
Western equine encephalitis						Y	
Yersina pseudotuberculosis			Y	Y	Y		Y

References for the above include (Calnek, 1997), (Tompkins et al., 2001), (Williams et al., 2000), (Kellogg et al., 1971), (Erbeck et al., 1999), (Swarbrick, 1985), (Pennycott, 2000), (Trampel et al., 2002), (Hewitt, 1967), (Rosene, 1969), (Davis et al., 1971), (Wieliczko et al., 2003), (Perkins et al., 2001), (Adewuyi et al., 1989), (Christensen, Barnes et al., 1983), (Clapham, 1957), (Dubey et al., 1994), (Dubey et al., 1993), (Moore et al., 1986), (Wentworth et al., 1989)

APPENDIX 3: INFECTIOUS DISEASE-CAUSING AGENTS ELIMINATED FROM THE RISK ASSESSMENT AFTER PRELIMINARY CONSIDERATION.

Aegyptianella pullorum: This has only been described once in wild turkeys in Texas (Castle and Christensen, 1985). Source populations do not include Texas or surrounding States.

Amoebotaenia cuneata: This cestode has not been documented in wild turkeys and is only mildly pathogenic (Reid and McDougald, 1997).

Amphimerus elongatus: Although this fluke can cause liver and bile duct pathology, damage typically is proportional to the number of flukes present (Reid and McDougald, 1997) and no reports are published in wild turkeys.

Argas persicus: These ticks are limited to the southern US outside of potential source populations (Arends, 1997).

Avian encephalomyelitis: This virus has not been reported in wild turkeys and transmission is thought to be primarily vertical or via fomites or contact with infected farms (Calnek et al., 1997).

Avian paramyxoviruses 2 & 3: These viruses have not been reported in wild turkeys and have only been reported from commercial poultry.

Borrelia anserina: This is primarily a southern disease, frequently in association with fowl ticks (*Argas* sp.) (Barnes, 1997). Source turkeys would not come from endemic areas.

Ceratophyllus niger: This western flea does not live east of Alberta within potential source areas (Arends, 1997).

Cheliopistes meleagridis: This parasite is not reported in wild turkeys and requires close contact for spread.

Cheilospirura hamulosa: This nematode is relatively non-pathogenic (Ruff and Norton, 1997) and not documented in wild turkeys. It can also infect ring-necked pheasants. If already present in Nova Scotia, risk to introduced turkeys would be very low given the low pathogenicity.

Choanotaenia infundibulum: Pathogenicity is not well studied in poultry, but this parasite is not pathogenic to ruffed grouse (Wentworth and Davidson, 1989). There are no published accounts in wild turkeys.

Collyriclum faba: This parasite is not documented in wild turkeys and only encysts in skin (Reid and McDougald, 1997).

Cryptosporidium spp.: This parasite is not reported in wild turkeys and is only a problem when high densities of birds cause heavy fecal contamination of the environment.

Cyrnea colini: This parasite is considered non-pathogenic (Ruff and Norton, 1997). It has only been documented in southern wild turkeys (Appendix 1).

Cytodites nudus: This air sac mite is not common (Arends, 1997) and has not been reported in wild turkeys.

Dermanyssus gallinae: This parasite is generally found in warm climates and is not reported in wild turkeys.

Drepanidotaenia watsoni: There are no reports of pathogenicity in wild turkeys and only turkeys in States outside of source populations have been infected (Davidson and Wentworth, 1992).

Echidnophaga gallinacea: This parasite has not been reported in wild turkeys. It is primarily a southern US parasite (although it has been reported in New York).

Freyana chanayi: There are no reports in wild turkeys.

Gongylonema ingluvicola: This parasite only causes minor burrowing lesions in the crop (Ruff and Norton, 1997) and has only been documented once in wild turkeys in Alabama (Maxfield et al., 1963).

Imparmargo baileyi: This is a wild turkey cestode with no known pathogenicity (Davidson and Wentworth, 1992). It is not documented in wild turkeys from potential source States.

Knemidocoptes mutans: This has only been reported in wild turkeys from Texas.

Laminosioptes cysticola: This is primarily a chicken mite and is not reported in wild turkeys.

Menacanthus stramineus: This louse requires close contact for transmission and has not been reported in wild turkeys from potential source populations.

Neoschongastia americana: Although it parasitizes turkeys and wild birds, it is confined to the southern States and is only active in the summer (Arends, 1997).

Ornithonyssus sylvarium: Although not reported in wild turkeys, this is a very common mite in commercial poultry the US (Arends, 1997).

Ornithorhinobacterium rhinotracheale: This bacterium is not reported in wild turkeys.

Oxyspiura mansoni: Although reported in ruffed grouse (Wentworth and Davidson, 1989), this eye nematode has not been reported in wild turkeys.

Pasteurella anatipestifer: This is primarily a disease of waterfowl and has not been reported in wild turkeys.

Postharmostomum gallinum: Although large numbers have been associated with a hemorrhagic typhlitis, this trematode has only been reported in wild turkeys in New Mexico (Pence, 1994) and North Carolina (Davidson and Wentworth, 1992).

Rotavirus: This virus has not been reported in wild turkeys and there is no evidence of a carrier state in birds (McNulty, 1997).

Strongyloides avium: Although infection can be serious, only a single wild turkey has been documented with infection and this was in Florida (Maxfield et al., 1963).

Subulura brumpti: No pathologic lesions have been reported in poultry (Ruff and Norton, 1997) and this nematode has never been documented in wild turkeys.

Syringophilus bipectinatus: Although this mite can cause feather loss in severe infestations (Arends, 1997), it has not been reported in wild turkeys.

Trypanosoma sp.: These protozoans are minimally or non-pathogenic to birds (Springer, 1997). However, effects of parasites on wild bird populations (e.g. on reproduction) are difficult to assess and this is discussed in Section 3.

Turkey viral enteritis: Although an emerging disease in commercial turkeys (Reynolds, 1997), it has not been reported in wild turkeys.

Turkey viral hepatitis: This is a subclinical disease that usually manifests itself during stress or with concurrent other infection (Guy, 1997). It has not been reported from wild turkeys.

Yersinia pseudotuberculosis: This has not been reported in wild turkeys and is considered of minor economic importance in the poultry industry (Rimler and Glisson, 1997b). It is widespread in the environment.

APPENDIX 4: SURVEILLANCE AND DISEASE IN SOURCE POPULATIONS

Note: The information presented in Appendix 4 includes summary statistics and personal opinions that have not been subjected to peer review.

Ontario

The following information was provided by K. Bellamy (pers. comm.). Turkey translocation began in 1984 and birds came from six states, including New York, New Jersey, Michigan, Missouri, Vermont and Iowa. An additional 507 wild turkeys were brought in from Tennessee in 2001 and 2002. In total, 1174 turkeys have been tested prior to translocation to Ontario for *Mycoplasma gallisepticum* and *Pasteurella multocida*. None were positive.

Between 1987 and 1991, 363 wild turkeys were caught in Ontario and moved within the province. All were tested for *M. gallisepticum* and *P. multocida*. None were positive.

In 1995, an outbreak of *M. gallisepticum* was reported in Ontario in house finches. Although continued testing of wild turkeys was offered to reassure poultry producers, that practice was seen as unnecessary. Instead, a protocol has been developed with trained turkey trappers. Any suspicious birds are to be submitted to CCWHC, Ontario Veterinary College for necropsy. Check station operators have been advised to do the same. (K. Bellamy, pers. comm.)

All birds coming into Ontario were required by CFIA to be tested for *Salmonella gallinarum* (M. Malhiot, pers. comm.). *S. pullorum* is detected by the same testing protocol (see risk assessment discussion), therefore all birds entering Ontario were free from both *S. gallinarum* and *S. pullorum*.

Following new turkey introductions, post-card observation forms were often distributed to rural households to monitor the new releases. Since 1992, all deer hunters in southern Ontario must include total numbers of turkeys seen during the season on their mandatory report. Similar observations are solicited from provincial mail surveys to deer hunters and antlerless deer tag holders (Bellamy and Malhiot, 2002). There is therefore some degree of post-release follow-up of wild turkeys.

<u>Wild turkey mortalities:</u> (submitted to CCWHC, OVC, D. Campbell, pers. comm.)

Trauma:	4 turkeys
Emaciation:	3 turkeys
Capture myopathy:	1 turkeys
Histomonas meleagridis:	1 turkeys
Zinc phosphide toxicity:	1 case of several birds
Frostbite:	3 turkeys
Unknown:	3 turkeys
Total:	14 cases

Connecticut

There is no disease testing for trap and transfer within this state (J. Pedersen, pers. comm.)

No testing for disease in wild turkeys is currently done. A few years ago, a number of turkeys were caught to look for Avian Influenza and *Mycoplasma* spp. No tests were positive. (M. Khan, pers. comm.)

During his career as a poultry pathologist in Connecticut, L. van der Heide has never seen any clinical disease in wild turkeys. There have been no mass mortality events to his knowledge. There is currently a very large wild turkey population in Connecticut. If there were mortality events, they would be noticed/reported. In his many dealings with turkey hunters, he has never received reports of gross lesions externally or internally or clinical signs of disease (L. van der Heide, pers. comm.).

The following diagnoses were made on wild turkeys submitted to the University of Connecticut for necropsy (S. De Guise, pers. comm.). The only records of wild turkey submissions are from 1997 and 2001. Infectious agents causing the lesion, if known, were not specified.

Air sacculitis:	1
Ulcerative dermatitis:	1
Enteritis:	1
Hepatitis:	1
Infectious sinusitis:	1
Meningitis:	1
Epithelioma:	1
Trauma:	2
Hepatic granuloma:	1
No diagnosis:	3
Total:	13 turkeys

Michigan

Michigan does pre-transfer testing on wild turkeys. It is typically done on a flock basis, but testing of all individual birds captured from a flock has been done in the past (T. Cooley, pers. comm.). Birds were tested in 2002 before being shipped to Ontario. Tests routinely done on wild turkeys include *S. pullorum* (RPA) (which includes *S. gallinarum* by default) and *M. gallisepticum*, *M. meleagridis* and *M. synoviae* (RPA). (T. Cooley, pers. comm.). Turkeys are monitored via dead birds found and submitted for necropsy. Diseases thus far documented include Histomoniasis and Avian Pox (T. Cooley, pers. comm.). There has been a high incidence of avian pox in the southwest corner of Michigan and wild turkeys were not translocated from here. Otherwise, wild turkeys have been healthy (T. Cooley, pers. comm.).

New York

As reported by W. Stone (pers. comm.), New York does pre-transfer testing of wild turkeys and provides health certificates. Routine testing includes *S. pullorum* (and therefore *S. gallinarum*) by RPA on all birds and examination for external parasites. All birds have been negative. New York has not been routinely testing for *M. gallisepticum*.

Diseases documented in wild turkeys thus far include Histomoniasis and avian pox (W. Stone, pers. comm.). Areas with avian pox outbreaks have been avoided during trapping for transfer. A single case of *M. gallisepticum* (infectious sinusitis) was documented once in a wild turkey within the past 35 years ago. W. Stone (pers. comm.) believes *M. gallisepticum* is not seen in wild turkeys because this bacterium requires direct transmission (environmental survival is poor). Wild turkeys commonly have *Haemoproteus meleagridis* and/or *Leucocytozoon smithi* infection, but *Plasmodium* spp. infections are rare. There are only a few cases of turkey toxicity following ingestion of insects sprayed with insecticides (W. Stone, pers. comm.). There have been no reports of disease transmission from wild turkeys to backyard poultry flocks (W. Stone, pers. comm.).

Vermont

There is no surveillance or current testing of wild turkeys (D. Blodgett, pers. comm.). In the past, Vermont has exported turkeys to Ontario, other northeastern States and Germany. Testing for *S. pullorum* (and *S. gallinarum*) resulted in two positives a number of years ago (D. Blodgett, pers. comm.). In 1986, a number of birds were exported to Michigan and were tested for *M. gallisepticum*, *M. meleagridis and M. synoviae*. None were positive (D. Blodgett, pers. comm.). In the early 1990s, Vermont tested some turkeys for *Salmonella typhimurium* DT104 because they were feeding in bunker silos. All birds tested were negative (D. Blodgett, pers. comm.). Dead turkeys have been found, but the biggest problem has been zinc phosphide poisoning. Two other dead turkeys had fungal infections (*Mucor* and *Aspergillus*) (D. Blodgett, pers. comm.).

Wild turkey populations have expanded in the past 8-9 years. There have not been concerns from the poultry industry, but there have been nuisance complaints from cattle farmers in the winter. There are frequent wild turkey sightings and the general impression is that they seem to be healthy (D. Blodgett, pers. comm.).

Minnesota

Minnesota transports wild turkeys (50-600/yr) both within the State and to other States (R. Kimmel, pers. comm.). Pre-transport testing is performed routinely on wild turkey flocks and no positive results have been found. Wild turkeys seem to be exceptionally healthy (R. Kimmel, pers. comm.)

Typically one to two birds per group trapped have been tested prior to transfer and this is done each year for every transferred flock (G. Nelson, pers. comm.). Testing includes *M. gallisepticum* and *M. meleagridis* (RPA), Newcastle Disease Virus (HI), *Salmonella pullorum and S. typhimurium* (RPA). There has never been a positive result (G. Nelson, pers. comm.). In 1978/9, a hunted bird tested positive for a *Mycoplasma* species. Health surveillance otherwise is opportunistic. Sick or dead birds are sent to

the diagnostic laboratory at the University of Minnesota for necropsy. Parasites or starvation are the most common reports (G. Nelson, pers. comm.).

Massachusetts

No work is currently being done on diseases of wild turkeys in Massachusetts (J. Cardoza, pers. comm.).

A few case reports from dead turkeys submitted for necropsy exist, but cause of death has usually been trauma (M. Pokras, pers. comm.).

No disease testing of wild turkeys has been done in recent years (J. Pedersen, pers. comm.).

New Hampshire

No disease testing of wild turkeys has been done in recent years (J. Pedersen, pers. comm.).

Wisconsin

Opportunistic surveillance is done by performing necropsies on any sick or dead wild turkeys reported (K. Beheler, pers. comm.). Wisconsin no longer has an active surveillance program for wild turkeys because health monitoring over 15 years did not identify any significant population health problems (K. Beheler, pers. comm.). The following information on post-mortem findings in wild turkeys was provided by K. Beheler:

Wild turkeys examined in Wisconsin from 1984 to 2003 (225 birds in total):

Capture or other trauma with no disease or abnormalities:	107 birds
Avian pox:	32 birds
Emaciation/starvation:	29 birds
Gout/gastro-intestinal problems (not specified):	17 birds
Systemic bacterial infection (mostly *E. coli*):	17 birds
Bacterial skin infection (mostly *Staphylococcus spp.*):	7 birds
Liver disease (including hepatic neoplasia and *E. coli* hepatitis):	8 birds
Internal and external parasite infection (not specified):	2 birds
Pesticide poisoning (diazinon):	2 birds
Blackhead (*Histomonas meleagridis*):	1 bird
Avian tuberculosis:	1 bird
Pasteurella multocida:	1 bird
Salmonella typhimurium:	1 bird

Similar information for Wisconsin wild turkeys was provided by J. Pedersen (pers. comm.) for 2000-2002:

2002: 7 found dead
2 were positive for avian pox
1 had peritonitis
2001: 14 found dead

4 were positive for avian pox
2000: 23 tested (some for transfer, some found dead)
10 positive for avian pox
1 positive for *S. typhimurium* (was found dead)

Tennessee

Wild turkeys have been tested in the past before transfer (L. Markham, pers. comm.). Wild turkeys were last shipped to Ontario 2-3 years ago. Birds have also been moved to Texas and Louisianna and more are scheduled for transfer to Maryland (L. Markham, pers. comm.). Routine testing was only done for *S. pullorum* (and therefore *S. gallinarum*) by RPA. No birds tested positive and every bird shipped was tested (L. Markham, pers. comm.). Surveillance is opportunistic. Any sick or dead birds are sent to SCWDS in Georgia for necropsy. (L. Markham, pers. comm.).

Maine

There are no reports from Maine.