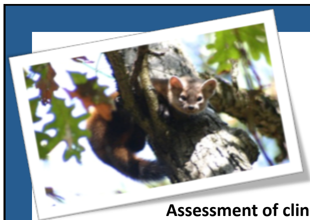


Assessment of clinical pathology, pathogen exposure, and impact of mercury in two reintroduced populations of American marten in Michigan

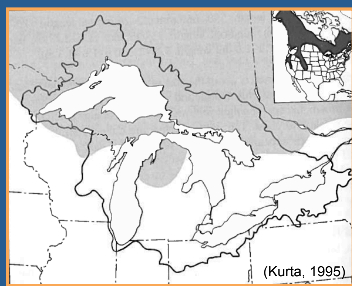
Maria Spriggs, DVM
Graduate student (Ph.D.)
Department of Forestry, Wildlife and Fisheries
University of Tennessee
Room 160 PBB, 12:20 P.M., March 20, 2013

Introduction: *Martes americana*

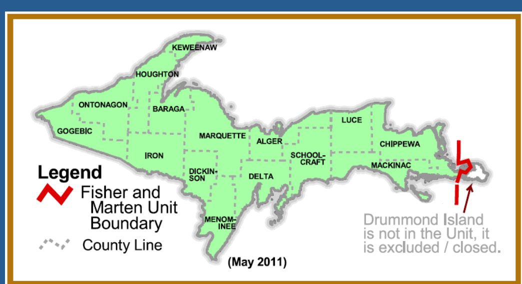
- Family Mustelidae
- Males 900-1300 gm
- Females 600-900 gm
- Mesocarnivore
- Forest habitat
- 1-4 kits born in spring

North American distribution of marten

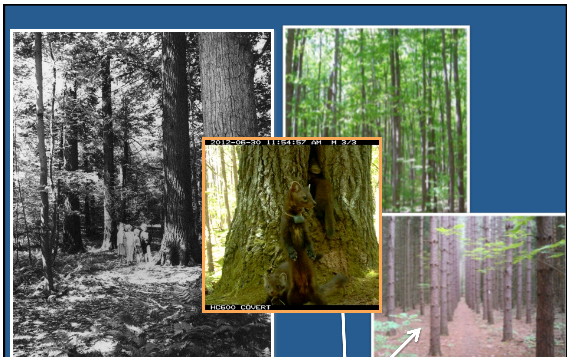
Source: Michigan Nature Association



American marten range in Michigan



Michigan DNR: http://www.michigan.gov/dnr/0,4570,7-153-10363_10880_10995---,00.html



Old-growth forest still present in Upper Peninsula

Examples of Lower Peninsula today

Collaborative Research



Disease in marten in Michigan?

Veine-Smith, A.M., J. Bird, and J.L. Belant. 2011. Patterns of endoparasite infections in American martens (*Martes americana*) of the Upper Peninsula of Michigan, U.S.A. Comparative Parasitology 78: 225-232.

Expanding the search:

Bourque, M. 1985. A survey of *Trichinella spiralis* in wild carnivores in Southwestern Quebec. The Canadian Veterinary Journal 26: 203-204.

Bremle, G., P. Larsson, and J.O. Helldin. 1997. Polychlorinated biphenyls in a terrestrial predator, the pine marten (*Martes martes*). Environmental Toxicology and Chemistry 16: 1779-1784.

Desmarchelier, M., M. Cheveau, L. Imbeau, and S. Lair. 2007. Field use of isoflurane as an inhalant anesthetic in the American marten (*Martes americana*). Journal of Wildlife Diseases 43: 719-725.

Frolich, K., O. Czupalla, L. Haas, J. Hentschke, J. Dedek, and J. Fickel. 2000. Epizootiological investigations of canine distemper virus in free-ranging carnivores from Germany. Veterinary Microbiology 74: 283-292.

Frolich, K., W.J. Streich, J. Fickel, S. Jung, U. Truyen, J. Hentschke, J. Dedek, D. Prager, and N. Latz. 2005. Epizootiological investigations of parvovirus infections in free-ranging carnivores from Germany. Journal of Wildlife Diseases 41: 231-235.

Gabriel, M.W., G.M. Wengert, and R.N. Brown. 2012. Pathogens and parasites of *Martes* species: management and conservation implications. *In* Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis, K.B. Aubry, W.J. Zielinski, M.G. Raphael, G. Proulx, and S.W. Buskirk (eds.). Cornell University Press, Ithaca, New York, pp. 138-185.

Hathaway, S.C., and D.K. Blackmore. 1981. Failure to demonstrate the maintenance of leptospires by free-living carnivores. New Zealand Veterinary Journal 29: 115-116.

Hoberg, E.P., K.B. Aubry, and J.D. Brittell. 1990. Helminth parasitism in martens (*Martes americana*) and ermines (*Mustela erminea*) from Washington, with comments on the distribution of *Trichinella spiralis*. Journal of Wildlife Diseases 26: 447-452.

Holmes, J.C. 1963. Helminth parasites of pine marten, *Martes americana*, from the district of Mackenzie. Canadian Journal of Zoology 41: 333.

Moinet, M., C. Fournier-Chambrillon, G. Andre-Fontaine, S. Aulagnier, A. Mesplede, B. Blanchard, V. Descarsin, P. Dumas, Y. Dumas, C. Coic, L. Couzi, and P. Fournier. 2010. Leptospirosis in free-ranging endangered European mink (*Mustela lutreola*) and other small carnivores (Mustelidae, Viverridae) from south-western France. Journal of Wildlife Diseases 46: 1141-1151.

Philippa, J., C. Fournier-Chambrillon, P. Fournier, W. Schaftenaar, M. van de Bildt, R. van Herweijnen, T. Kuiken, M. Liabeuf, S. Ditcharry, L. Joubert, M. Begnier, and A. Osterhaus. 2008. Serologic survey for selected viral pathogens in free-ranging endangered European mink (*Mustela lutreola*) and other mustelids from south-western France. Journal of Wildlife Diseases 44: 791-801.

Poole, B.C., K. Chadee, and T.A. Dick. 1983. Helminth parasites of pine marten, *Martes americana*, from Manitoba, Canada. Journal of Wildlife Diseases 19: 10-13.

Seville, R.S., and E.M. Addison. 1995. Nongastrointestinal helminths in marten (*Martes americana*) from Ontario, Canada. Journal of Wildlife Diseases 31: 529-533.

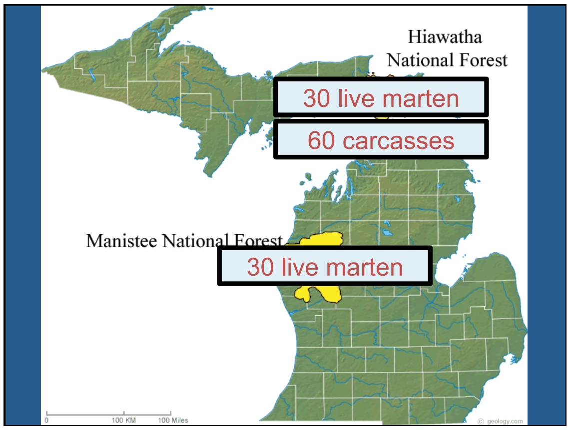
Zarnke, R.L., J.S. Whitman, R.W. Flynn, and J.M. Ver Hoef. 2004. Prevalence of *Soboliphyme baturini* in marten (*Martes americana*) populations from three regions of Alaska, 1990-1998. Journal of Wildlife Diseases 40: 452-455.

Research Justification

- American marten numbers in the Lower Peninsula are not recovering post-reintroduction as they did in the Upper Peninsula
- There are no previous studies examining baseline hematologic parameters, disease exposure or mercury concentrations in American marten in Michigan
- Additional re-introduction of marten to the Lower Peninsula is being considered
- American marten are culturally and economically important as a fur-bearing species and management recommendations are being requested

Research Objectives

1. Establish baseline health information including reference intervals for hematologic and biochemical parameters.
2. Determine pathogen exposure.
3. Assess mercury exposure.
4. Evaluate any differences between the two study sites.
5. Publish data that can be referenced for future management recommendations.



Methods: Sample collection

•Isoflurane anesthesia (Desmarchelier et al., 2007)

•Samples collected:
- Blood
- Urine
- Feces
- Hair
- Ear punch biopsy

•Sterile permanent microchip

Objectives

1. **Establish baseline health information including reference intervals for hematologic and biochemical parameters.**
   - **Cell blood count**
   - **Blood gas analysis**
   - **Serum chemistries**
2. **Determine pathogen exposure.**
3. **Assess impact of mercury exposure.**
4. **Evaluate any differences between the two study sites.**
5. **Publish data that can be referenced for future management recommendations.**

Clinical Pathology

- **No published reference intervals for *Martes americana***

Null Hypothesis:

There will be no difference in hematologic, blood gas, and serum chemistry values between the sexes, age categories, study sites, or collaring status.

Methods

- •American Society of Veterinary Pathologists reference interval guidelines (Friedrichs et al., 2012)
- •In the field:
  - •Blood smear
  - •Blood gas analysis
  - •Serum chemistries
  - •Hematocrit
- •In the lab:
  - •Cell blood count

Methods

- •Reference interval exclusion criteria:
  - •Radio-collared
  - •Unhealthy on physical exam
  - •Sample interference

ANOVA to determine differences between the study sites, sex, age categories in the parameters.

Use correlation and regression to examine influence of variables of interest on each other.

Objectives

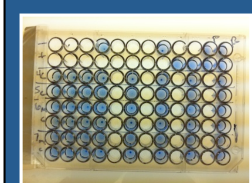
1. Establish baseline health information including reference intervals for hematologic and biochemical parameters.
2. Determine pathogen exposure.
   - *Toxoplasma gondii*
   - Canine distemper virus
   - Leptospirosis
   - Endoparasitism
3. Assess mercury exposure.
4. Evaluate any differences between the two study sites.
5. Publish data that can be referenced for future management recommendations.

Toxoplasma gondii

- Protozoal parasite with felid as definitive host
- Cause of mortality in other mustelids (Pridham and Belcher, 1958; Cole et al., 2000; Burns et al., 2003b)
- Subclinical effects are important as well (McAllister, 2005; Larkin et al., 2011; Gabriel et al., 2012)

Hypothesis:

Marten in the Manistee NF will have higher seroprevalence of toxoplasmosis compared to the Hiawatha NF due to increased proximity of the Manistee NF to residential areas.

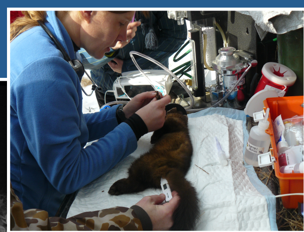


Canine distemper virus

- Morbillivirus, carnivore hosts
- Mustelids are particularly susceptible
- Vaccination strategies employed for black-footed ferret, free-ranging sea otters, Siberian polecat (Williams et al., 1996; Wimsatt et al., 2003; Jessup et al., 2009)

Hypothesis:

Consistent with other species of *Mustelidae*, American marten in both study sites will have a low or zero seroprevalence of canine distemper virus, as infected animals are likely to die.

Leptospirosis

- Rodents are primary hosts
- Possible factor in decline of European mink (Moinet et al., 2010)
- Present in wildlife in Michigan but impact on American marten is unknown (Michigan DNR, 2012)

Hypothesis:

American marten will have a similar seroprevalence to *Leptospira spp.* in both study sites and infected marten have the potential to shed the organism in urine.

Endoparasites

- Parasite fauna of martens in Lower Peninsula is unknown
- Local ecological factors were important in determining parasite prevalence and richness in the Upper Peninsula (Veine-Smith et al., 2011)

Hypothesis:

American marten in the Manistee National Forest will have a different parasite community than those of the Hiawatha National Forest as local ecological factors are different in each site.

Chi-square or t-test to determine differences between sex, age categories, or study site and seropositive titer or presence of a parasite infection.

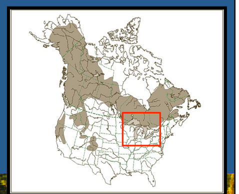
Prevalence of each parasite may be compared between the study sites using ANOVA.

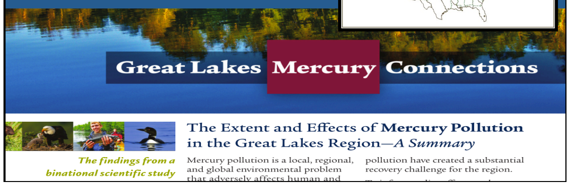
Objectives

1. Establish baseline health information including reference intervals for hematologic and biochemical parameters.
2. Determine pathogen exposure.
3. Assess mercury exposure.
   - Mercury concentrations
   - Selenium concentrations
   - Nitrogen stable isotope ratio
4. Evaluate any differences between the two study sites.
5. Publish data that can be referenced for future management recommendations.

Mercury in the Great Lakes

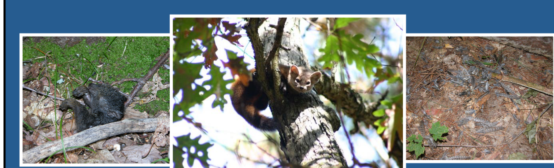
- Anthropogenic mercury emissions
- Persistent in the environment
- Bioaccumulates up the food chain
- Fish advisory in place





Mercury, selenium, stable isotopes

- Mercury concentrations vary between tissues (Brookens et al., 2008)
- Selenium reduces toxic effects (Woshner et al., 2011b)
- Isotopic concentrations reflect diet and trophic position (Brookens et al., 2008)



Hypotheses:

Concentration of mercury and selenium in hair will correlate with liver and kidney concentration.

Mercury concentration will be reflective of trophic position as determined by nitrogen stable isotope ratio, $\delta^{15}N$.

Methods

- Mercury & selenium concentrations in hair, liver, kidney
- Nitrogen stable isotope ratio in packed red blood cells, hair, liver

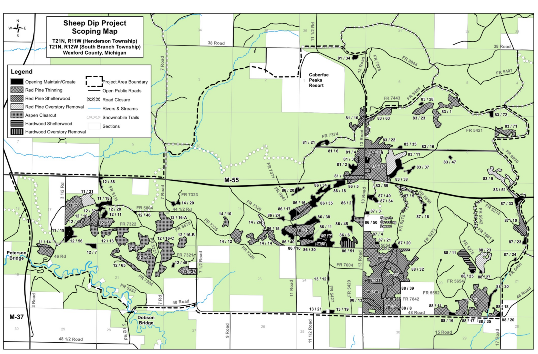
Chi-square will be used to determine differences in concentrations between different tissue types. Correlation can be used to determine relationship between mercury and selenium.

Linear regression to examine relationship between $\delta^{15}N$ and mercury.

Objectives

1. Establish baseline health information including reference intervals for hematologic and biochemical parameters.
2. Determine pathogen exposure.
3. Assess mercury exposure.
4. Evaluate any differences between the two study sites.
5. Publish data that can be referenced for future management recommendations.

Conserving marten through management



References

Bagenstose, LM, M.M. Mentink-Kane, A. Brittingham, D.M. Mosser, and M. Monestier. 2001. Mercury enhances susceptibility to murine leishmaniasis. Parasite Immunology 23: 633-640.

Bal, A.E., C. Gravekamp, R.A. Hartskeerl, J. De Mezza-Brewster, H. Korver, and W.J. Terpstra. 1994. Detection of leptospires in urine by PCR for early diagnosis of leptospirosis. Journal of Clinical Microbiology 32: 1894-1898.

Bergey, L., J.S. Weis, and P. Weis. 2002. Mercury uptake by the estuarine species *Palaemonetes pugio* and *Fundulus heteroclitus* compared with their parasites, *Probopyrus pandalicola* and *Eustrongylides* sp. Marine Pollution Bulletin 44: 1046-1050.

Brookens, T.J., J.T. Harvey, and T.M. O'Hara. 2007. Trace element concentrations in the Pacific harbor seal (*Phoca vitulina richardii*) in central and northern California. Science of the Total Environment 372: 676-692.

Brookens, T.J., T.M. O'Hara, R.J. Taylor, G.R. Bratton, and J.T. Harvey. 2008. Total mercury body burdens in Pacific harbor seal, *Phoca vitulina richardii*, pups from central California. Marine Pollution Bulletin 56: 27-41.

Brown, K.M., and J.R. Arthur. 2001. Selenium, selenoproteins and human health: a review. Public Health Nutrition 4: 593-599.

Burns, R., E.S. Williams, D. O'Toole, and J.P. Dubey. 2003b. *Toxoplasma gondii* infections in captive black-footed ferrets (*Mustela nigripes*), 1992-1998: clinical signs, serology, pathology, and prevention. Journal of Wildlife Diseases 39: 787-797.

Cole, R.A., D.S. Lindsay, D.K. Howe, C.L. Roderick, J.P. Dubey, N.J. Thomas, and L.A. Baeten. 2000. Biological and molecular characterization of *Toxoplasma gondii* strains obtained from southern sea otters (*Enhydra lutris nereis*). Journal of Parasitology 86: 526-530.

References

Desmarchelier, M., M. Cheveau, L. Imbeau, and S. Lair. 2007. Field use of isoflurane as an inhalant anesthetic in the American marten (*Martes americana*). Journal of Wildlife Diseases 43: 719-725.

Evans, D.W., S.W.B. Irwin, and S. Fitzpatrick. 2001. The effect of digenean (Platyhelminthes) infections on heavy metal concentrationsin *Littorina littorea*. Journal of the Marine Biological Association of the United Kingdom 81: 349-350.

Evers, D.C., J.G. Wiener, N. Basu, R.A. Bodaly, H.A. Morrison, and K.A. Williams. 2011. Mercury in the Great Lakes region: bioaccumulation, spatiotemporal patterns, ecological risks, and policy. Ecotoxicology 20: 1487-1499.

Friedrichs, K.R., K.E. Harr, K.P. Freeman, B. Szladovits, R.M. Walton, K.F. Barnhart, and J. Blanco-Chavez. 2012. ASVCP reference interval guidelines: determination of de novo reference intervals in veterinary species and other related topics. Veterinary Clinical Pathology 41: 441-453.

Fry, B. 2006. Stable Isotope Ecology. Springer Science + Business Media, LLC, New York, New York.

Gabriel, M.W., G.M. Wengert, and R.N. Brown. 2012. Pathogens and parasites of *Martes* species: management and conservation implications. *In* Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis, K.B. Aubry, W.J. Zielinski, M.G. Raphael, G. Proulx, and S.W. Buskirk (eds.). Cornell University Press, Ithaca, New York, pp. 138-185.

Gaydos, J.K., P.A. Conrad, K.V.K. Gilardi, G.M. Blundell, and M. Ben-David. 2007. Does human proximity affect antibody prevalence in marine-foraging river otters (*Lontra canadensis*)?. Journal of Wildlife Diseases 43: 116-123.

Jessup, D.A., M.J. Murray, D.R. Casper, D. Brownstein, and C. Kreuder-Johnson. 2009. Canine distemper vaccination is safe and useful preventive procedure for southern sea otters (*Enhydra lutra nereis*). Journal of Zoo and Wildlife Medicine 40: 705-710.

Klenavic, K., L. Champoux, M. O'Brien, P. Daoust, R.D. Evans, and H.E. Evans. Mercury concentrations in wild mink (*Mustela vison*) and river otters (*Lontra canadensis*) collected from eastern and Atlantic Canada: Relationship to age and parasitism. Environmental Pollution 156: 359-366.

References

McHuron, E.A., J.T. Harvey, J.M. Castellini, and T.M. O'Hara. 2012. Hair sampling location in harbor seals (*Phoca vitulina*) affects selenium and mercury concentrations: implications for study design of trace element determination in pinnipeds. Marine Pollution Bulletin In press: http://dx.doi.org/10.1016/j.marpolbul.2012.08.027

Michigan Department of Natural Resources. 2012. Canine and feline distemper. <http://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26505--,00.html>

Michigan Department of Natural Resources. 2012. Leptospirosis. http://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26943--,00.html

Moinet, M., C. Fournier-Chambrillon, G. Andre-Fontaine, S. Aulagnier, A. Mesplede, B. Blanchard, V. Descarsin, P. Dumas, Y. Dumas, C. Coic, L. Couzi, and P. Fournier. 2010. Leptospirosis in free-ranging endangered European mink (*Mustela lutreola*) and other small carnivores (Mustelidae, Viverridae) from south-western France. Journal of Wildlife Diseases 46: 1141-1151.

Knott K.K., D. Boyd, G.M. Ylitalo, and T.M. O'Hara. 2011. Concentrations of mercury and polychlorinated biphenyls in blood of Southern Beaufort Sea polar bears (*Ursus maritimus*) during spring: variations with lipids and stable isotope ($\delta^{15}N$, $\delta^{13}C$) values. Canadian Journal of Zoology 89: 999-1012.

Kurta, A. 1995. Mammals of the Great Lakes Region. University of Michigan Press, Ann Arbor, Michigan.

Larkin, J.L., M. Gabriel, R.W. Gerhold, M.J. Yabsley, J.C. Wester, J.G. Humphreys, R. Beckstead, and J.P. Dubey. 2011. Prevalence to *Toxoplasma gondii* and *Sarcocystis* spp. in a reintroduced fisher (*Martes pennanti*) population in Pennsylvania. Journal of Parasitology. 97: 425-429.

Martin, P.A., T.V. McDaniel, K.D. Hughes, and B. Hunter. 2011. Mercury and other heavy metals in free-ranging mink of the lower Great Lakes basin, Canada, 1998-2006. Ecotoxicology 20: 1701-1712.

McAllister, M.M. 2005. A decade of discoveries in veterinary protozoology changes our concept of "subclinical" toxoplasmosis. Veterinary Parasitology 132: 241-247.

McFadden, L.M. 2007. Home-range dynamics and habitat selection of American martens (*Martes americana*) in Michigan's northern Lower Peninsula. Masters Thesis. Central Michigan Univeristy. Mt. Pleasant, MI.

References

Pridham, T.J., and J. Belcher. 1958. Toxoplasmosis in mink. Canadian Journal of Comparative Medicine and Veterinary Science 22: 99-106.

Tan, S.W., J.C. Meiller, and K.R. Mahaffey. 2009. The endocrine effects of mercury in humans and wildlife. Critical Reviews in Toxicology 39: 228-269.

Veine-Smith, A.M., J. Bird, and J.L. Belant. 2011. Patterns of endoparasite infections in American martens (*Martes americana*) of the Upper Peninsula of Michigan, U.S.A. Comparative Parasitology 78: 225-232.

Williams, E.S., E.T. Thorne, M.J.G. Appel, and D.W. Belitsky. 1988. Canine distemper in black-footed ferrets (*Mustela nigripes*) from Wyoming. Journal of Wildlife Diseases 24: 385-398.

Williams, E.S., S.L. Anderson, J. Cavender, C. Lynn, K. List, C. Hearn, and M.J.G. Appel. 1996. Vaccination of black-footed ferret (*Mustela nigripes*) x Siberian polecat (*M. eversmanni*) hybrids and domestic ferrets (*M. putorius furo*) against canine distemper. Journal of Wildlife Diseases 32: 417-423.

Wimsatt, J., D. Biggins, K. Innes, B. Taylor, and D. Garell. 2003. Evaluation of oral and subcutaneous delivery of an experimental canarypox recombinant canine distemper vaccine in the Siberian polecat. Journal of Zoo and Wildlife Medicine 34: 25-35.

Wolfe, M.F., S. Schwarzbach, and R.A. Sulaiman. 1998. Effects of mercury on wildlife: a comprehensive review. Environmental Toxicology and Chemistry 17: 146-160.

Woshner, V.M., T.M. O'Hara, G.R. Bratton, and V.R. Beasley. 2011b. Concentrations and interactions of selected essential and non-essential elements in ringed seals and polar bears of Arctic Alaska. Journal of Wildlife Diseases 37: 711-721.

Wren, C.D., D.B. Hunter, J.F. Leatherland, and P.M. Stokes. 1987. The effects of polychlorinated biphenyls and methylmercury, singly and in combination, on mink. I: Uptake and toxic responses. Archives of Environmental Contamination and Toxicology 16: 441-447.

Acknowledgments

Dr. Debra Miller
Dr. Rick Gerhold
Dr. Paul Keenlance
Dr. Becky Wilkes
Bob Sanders
Eric Clark

Gratefully acknowledged for financial support:
Evansville Zoological Society
Mesker Park Zoo & Botanic Garden
Minnesota Zoo
Pittsburgh Zoo & PPG Aquarium


Questions?
mspriggs@utk.edu