Instructor: Dr. Marm Kilpatrick
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Lecture: Cowell Clrm 131; Tu, Th 9:50am-11:25 am
Discussions:
W 4-5:05pm am N. Sci Annex 103
Th 3:20-4:25pm N. Sci Annex 102

Course Description: This is a class on problem solving and critical thinking. We will focus on problems related to the ecological and evolutionary processes that drive the transmission of pathogens between hosts; the impact of disease on host populations; and what causes the emergence of an infectious disease. The course content includes a theoretical framework, hands-on experience with field techniques, and a discussion of wildlife and human diseases including Zika, Ebola, influenza (swine flu, bird flu), malaria, West Nile virus, Lyme disease, HIV, Chikungunya, tuberculosis, chytridiomycosis, and many others.

Course Readings: There is no book. See schedule of readings below.

Quizzes: There will be a 5 minute quiz at the beginning of each lecture on the reading for that week. There will be questions on the two papers in columns I and II (see below), with questions on papers in column II providing extra credit for undergraduates. 4 things to get from each reading: 1) main question of paper, 2) type of study, 3) major finding, 4) major flaw(s). Quizzes are written so that you can't get answer from title/abstract, but it is obvious from reading paper.

Attendance: Attendance at lectures and discussion is mandatory and attendance will be taken. Course readings complement the lectures but only represent 25% of the material discussed in a given week, so if you miss a lecture you need to find a fellow student who will share their notes.

Grades: Quizzes 15%; Poster Project 15%; Midterm 25%; Discussion Activities: 15% Final: 30%.

Weekly Schedule. Everyone should read the paper in column I (before that class, except #1), grad students and undergrads looking for extra credit should read the paper in column II (columns I, II will be the material for the daily quizzes). Papers in column III are either advanced readings, or additional readings for those especially interested in the topic.

Wk	Day	Date	Topic	Readings I	II	III
1	Tue	Apr 4	What is disease ecology, and what is it good for?	1	2	3
1	Thu	Apr 6	Foundations of disease ecology: SIR models, R0, Frequency and density dependent transmission, Nth	4	5	6, 7
2	Tue	Apr 11	Directly transmitted human pathogens	8	9	10
2	Thu	Apr 13	Disease impacts on populations and ecosystems	11	12	13
3	Tue	Apr 18	Livestock, wildlife, zoonotic pathogens	14	15	
3	Thu	Apr 20	Plant pathogens	45	46	47
4	Tue	Apr 25	Disease control: Vaccination, Behavioral changes, culling	16	17	18
4	Thu	Apr 27	Building a model from data: Cholera	19,20		
5	Tue	May 2	Pathogen interactions via the immune system, and parasite caused changes in host behavior	21	22	
5	Thu	May 4	Evolution of virulence: hosts, pathogens, vectors	23	24	25-27
6	Tue	May 9	Managing wildlife disease: White nose syndrome	28	29	
6	Thu	May 11	Midterm			
7	Tue	May 16	Vector borne disease ecology I.	30	31	
7	Thu	May 18	Vector borne disease ecology II.	32	33	
8	Tue	May 23	Seasonality, climate change and transmission dynamics	34	35	36
8	Thu	May 25	Evolution antibiotic resistance	37	38	39
9	Tue	May 30	Multi-host pathogens, biodiversity and disease: the "dilution effect"	40	41	42
9	Thu	Jun 1	The ecology of emerging infectious diseases	43	44	
10	Tue	Jun 6	Disease and conservation	48	49	
10	Thu	Jun 8	Poster session			
11	Tu	Jun 13	Final Exam 4-7pm			

Readings

1 Kilpatrick, A. M. and Altizer, S., Disease Ecology. *Nature Education Knowledge* 1 (11), 13 (2010). Link to Article

2 Smith, K. F., Dobson, A. P., McKenzie, F. E., Real, L. A., Smith, D. L., and Wilson, M. L., Ecological theory to enhance infectious disease control and public health policy *Frontiers in Ecology and the Environment* 3 (1), 29 (2005). PDF

3 Plowright, R. K., Sokolow, S. H., Gorman, M. E., Daszak, P., and Foley, J. E., Causal inference in disease ecology: investigating ecological drivers of disease emergence *Frontiers in Ecology and the Environment* 6 (8), 420 (2008). PDF
4 Anderson, R. M. and May, R. M., A framework for discussing the population biology of infectious diseases in *Infectious diseases of humans. Dynamics and control.* (Oxford University Press, London, 1991), pp. 13. PDF
5 Lloyd-Smith, J. O., Cross, P. C., Briggs, C. J., Daugherty, M., Getz, W. M., Latto, J., Sanchez, M. S., Smith, A. B., and Swei, A., Should we expect population thresholds for wildlife disease?*Trends in Ecology & Evolution* 20 (9), 511 (2005).PDF
6 Anderson, R. M. and May, R. M., Population biology of infectious diseases I *Nature* 280 (5721), 361 (1979). PDF
7 May, R. M. and Anderson, R. M., Population Biology of Infectious-Diseases II *Nature* 280 (5722), 455 (1979).PDF
8 Woolhouse, M. E. J., Dye, C., Etard, J. F., Smith, T., Charlwood, J. D., Garnett, G. P., Hagan, P., Hii, J. L. K., Ndhlovu, P. D., Quinnell, R. J., Watts, C. H., Chandiwana, S. K., and Anderson, R. M., Heterogeneities in the transmission of infectious agents: Implications for the design of control programs *Proceedings of the National Academy of Sciences* 94 (1), 338 (1997).PDF
9. Aylward B, Barboza P, Bawo L, et al. Ebola Virus Disease in West Africa - The First 9 Months of the Epidemic and Forward Projections. *N Engl J Med* 2014; 371(16): 1481-95. PDF
10 Ferguson, N. M., Cummings, D. A. T., Fraser, C., Cajka, J. C., Cooley, P. C., and Burke, D. S., Strategies for mitigating an influenza pandemic *Nature* 442 (7101), 448 (2006). PDF
11 Hudson, P. J., Dobson, A. P., and Newborn, D., Prevention of population cycles by parasite removal *Science* 282 (5397), 2256 (1998).PDF
12 Holdo, R. M., Sinclair, A. R. E., Dobson, A. P., Metzger, K. L., Bolker, B. M., Ritchie, M. E., and Holt, R. D., A Disease-Mediated Trophic Cascade in the Serengeti and its Implications for Ecosystem C *Plos Biology* 7 (9), e1000210 (2009).PDF
13 LaDeau, S. L., Kilpatrick, A. M., and Marra, P. P., West Nile virus emergence and large-scale declines of North American bird populations *Nature* 447 (7145), 710 (2007). PDF
14 Hochachka WM, Dhondt AA. Density-dependent decline of host abundance resulting from a new infectious disease. *Proc Natl Acad Sci U S A* 2000; 97(10): 5303-6. PDF
15 Dobson, A. and Meagher, M., The population dynamics of brucellosis in the Yellowstone National Park *Ecology* 77 (4), 1026 (1996). PDF
16 Fraser, C., Riley, S., Anderson, R. M., and Ferguson, N. M., Factors that make an infectious disease outbreak controllable *Proceedings of the National Academy of Sciences of the United States of America* 101 (16), 6146 (2004). PDF
17 Donnelly, C. A., Woodroffe, R., Cox, D. R., Bourne, J., Gettinby, G., Le Fevre, A. M., McInerney, J. P., and Morrison, W. I., Impact of localized badger culling on tuberculosis incidence in British cattle *Nature* 426 (6968), 834 (2003). PDF
18 Galvani, A. P., Reluga, T. C., and Chapman, G. B., Long-standing influenza vaccination policy is in accord with individual self-interest but not with the utilitarian optimum *Proceedings of the National Academy of Sciences of the United States of America* 104 (13), 5692 (2007). PDF
19 Harris, J. B., R. C. LaRocque, F. Qadri, E. T. Ryan, and S. B. Calderwood. 2012. Cholera. Lancet 379:2466-2476. PDF

20 Cholera Model Homework assignment
21 Graham, A. L., Ecological rules governing helminth-microparasite coinfection *Proceedings of the National Academy of Sciences of the United States of America* 105 (2), 566 (2008). PDF
22 Mina, M. J., C. J. E. Metcalf, R. L. de Swart, A. Osterhaus, and B. T. Grenfell. 2015. Long-term measles-induced immunomodulation increases overall childhood infectious disease mortality. Science 348:694-699. PDF
23 Myxoma virus evolution of virulence homework
24 Grenfell, B. T., Pybus, O. G., Gog, J. R., Wood, J. L. N., Daly, J. M., Mumford, J. A., and Holmes, E. C., Unifying the epidemiological and evolutionary dynamics of pathogens *Science* 303(5656), 327 (2004). PDF
25 Woolhouse, M. E. J., Webster, J. P., Domingo, E., Charlesworth, B., and Levin, B. R., Biological and biomedical implications of the co-evolution of pathogens and their hosts *Nature Genetics*32 (4), 569 (2002). PDF
26 Mackinnon, M. J., Gandon, S., and Read, A. F., Virulence evolution in response to vaccination: The case of malaria *Vaccine* 26, C42 (2008). PDF
27 Ewald, P. W., *Evolution of infectious disease*. (Oxford University Press, Oxford, 1994).
28 Metcalf, C. J. E., M. Ferrari, A. L. Graham, and B. T. Grenfell. 2015. Understanding Herd Immunity. Trends in Immunology 36:753-755. PDF
30 Wonham, M. J., de-Camino-Beck, T., and Lewis, M. A., An epidemiological model for West Nile virus: invasion analysis and control applications *Proceedings of the Royal Society of London Series B-Biological Sciences* 271 (1538), 501 (2004). PDF
31. Sachs, J. and Malaney, P., The economic and social burden of malaria *Nature* 415 (6872), 680 (2002). PDF
32 Ostfeld, R. S., Canham, C. D., Oggenfuss, K., Winchcombe, R. J., and Keesing, F., Climate, deer, rodents, and acorns as determinants of variation in Lyme-disease risk *Plos Biology* 4 (6), 1058 (2006). PDF
33. Alonso PL, Brown G, Arevalo-Herrera M, et al. A Research Agenda to Underpin Malaria Eradication. *PLoS Med* 2011; 8(1) e1000400.PDF
34. Mordecai EA, Paaijmans KP, Johnson LR, et al. Optimal temperature for malaria transmission is dramatically lower than previously predicted. *Ecol Lett* 2013; **16**(1): 22-30. PDF
35. Gething, P. W., D. L. Smith, A. P. Patil, A. J. Tatem, R. W. Snow, and S. I. Hay. 2010. Climate change and the global malaria recession. Nature 465:342-346. PDF
36. Rohr, J. R., Raffel, T. R., Romansic, J. M., McCallum, H., and Hudson, P. J., Evaluating the links between climate, disease spread, and amphibian declines *Proceedings of the National Academy of Sciences of the United States of America* 105 (45), 17436 (2008). PDF
37. Levy SB, Marshall B. Antibacterial resistance worldwide: causes, challenges and responses. *Nat Med* 2004; **10**(12): S122-S9.PDF
38. Read AF, Day T, Huijben S. The evolution of drug resistance and the curious orthodoxy of aggressive chemotherapy. *Proc Natl Acad Sci U S A* 2011; **108**: 10871-7. PDF
39. Read AF, Lynch PA, Thomas MB. How to Make Evolution-Proof Insecticides for Malaria Control. *PLoS Biol* 2009; **7**(4): e1000058. PDF
40. Johnson PTJ, Preston DL, Hoverman JT, Richgels KLD. Biodiversity decreases disease through predictable changes in host community competence. *Nature* 2013; **494**(7436): 230-3. PDF

41. Logiudice K, Duerr STK, Newhouse MJ, Schmidt KA, Killilea ME, Ostfeld RS. Impact of host community composition on Lyme disease risk. *Ecology* 2008; **89**(10): 2841-9. PDF
42. Keesing F, Holt RD, Ostfeld RS. Effects of species diversity on disease risk. *Ecol Lett* 2006; **9**(4): 485-98. PDF
43. Wolfe ND, Dunavan CP, Diamond J. Origins of major human infectious diseases. *Nature* 2007; **447**(7142): 279-83. PDF
44. Faria NR, Rambaut A, Suchard MA, et al. The early spread and epidemic ignition of HIV-1 in human populations. *Science* 2014; **346**(6205): 56-61. PDF
45. Parker IM, Saunders M, Bontrager M, et al. Phylogenetic structure and host abundance drive disease pressure in communities. *Nature* 2015; **520**(7548): 542-4 PDF
46. Gilbert GS, Webb CO. Phylogenetic signal in plant pathogen-host range. *Proc Natl Acad Sci U S A* 2007; 104(12): 4979-83.PDF
47. Parker IM, Gilbert GS. The evolutionary ecology of novel plant-pathogen interactions. *Annu Rev Ecol Evol Syst* 2004; **35**: 675-700.PDF
48. Langwig KE, Frick WF, Bried JT, Hicks AC, Kunz TH, Kilpatrick AM. Sociality, density-dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. *Ecol Lett* 2012; **15**: 1050-7. PDF
49. McCallum H. Disease and the dynamics of extinction. *Philos Trans R Soc B-Biol Sci* 2012; **367**(1604): 2828-39. PDF