EAS 517 CONSERVATION BIOLOGY
Syllabus, Winter 2019

Time & Location: Mon & Wed, 11:30am - 1:00pm, 2024 Dana Hall

Instructor: Dr. Brad Cardinale (bradcard@umich.edu)
Office hours: Th 11:30am - 12:30pm

Graduate Student Instructor: Zoe Goodrow (zgoodrow@umich.edu)
Office hours: MW 1-3pm

Course description. During the 3.6 billion year history of life, Earth has become filled with a spectacular variety of lifeforms. But loss of the biological diversity is now one of the most rapid forms of environmental change in the modern era. This course covers the causes and consequences of biodiversity loss, and prepares students science-based careers in Conservation Biology. The class begins by exploring why biodiversity is so important and valuable, including the intrinsic, relational, and instrumental arguments commonly used to justify conservation. The class then turns attention towards the main causes of biodiversity loss, focusing on how practitioners mitigate these impacts. The final portion of the course trains students in the most common models, tools, and techniques that are used to conserve biological diversity, including reserve design, population viability analysis, sustainable harvest models, ecological economic analyses, species distribution modeling, meta-population models, and more.

Course goals. The goal of this course is to help students master five key skills that are needed to obtain and be successful in a job working as a conservation biologist in a government agency, non-profit organization, or academia:

1. Have sufficient mastery of the common arguments used to justify conservation that one can use those arguments interchangeably in discussions with stake-holders who hold divergent world views on natural resource management.
2. Have sufficient understanding of the biological and social factors that control of biodiversity, as well as the modern drivers of biodiversity change, that one can recognize and use scientifically credible information in decision-making.

3. Become sufficiently proficient in the conceptual and quantitative foundations of conservation that one can apply the models, tools, and techniques of many different theories to real-world conservation problems.

4. Learn how combine information and approaches from a variety of disciplines in the natural and social sciences, as well as from engineering, to develop effective conservation planning.

5. Be able to read and critically evaluate peer-reviewed literature so that one can keep abreast of emerging problems, new techniques, and modern controversies that will form the foundation for extended learning throughout one's career.

Course level and prerequisites. This is an advanced, science-based course designed for future practitioners of conservation biology. It is appropriate for early-career graduate students, or advanced undergraduates, who have a background in biology or ecology, and who are planning for a science-based career in conservation. Therefore:

1. Students should have a solid foundation in ecology, having completed an introductory course such as EAS 509 (or equivalent).

2. Students should have math proficiency equivalent to college-level algebra (calculus not required). Several good math refreshers and tutorials are available at:

   Math Review for Standardized Tests, 2nd ed. by Jerry Bobrow ($11 on Amazon). Covers basic arithmetic, geometry, algebra, and basic statistics (no trig, no pre-calculus, or calculus).

   The Ultimate Math Refresher for GRE, GMAT, and SAT by Lighthouse Review, Inc ($14 on Amazon). Covers basic arithmetic, geometry and algebra.

   Math refresher for Scientists and Engineers by Fanchi ($10 on Amazon). Assumes students know basic arithmetic, and then covers algebra, geometry, trigonometry, calculus, and basic statistics.

   coolmath.com/index.html , *www.sosmath.com/*, *www.khanacademy.org/math*

3. Students should be proficient with the use of data spreadsheets such as Microsoft Excel. Good tutorials are available at:

   Modeling with spreadsheets, www.uvm.edu/rsenr/vtcfwru/spreadsheets/?Page=pom/pom1.htm
   Introduction to Excel, http://www.excel-easy.com/introduction.html

Recommended textbooks. There is no required text for the class. Much of the course content will come directly from the peer-reviewed literature, which will be available as pdf's on the course website https://umich.instructure.com/courses/269261. However, students may find the following textbooks helpful: Essentials of Conservation Biology, 6th ed. (Primack. 2014. Sinauer) is an introductory textbook widely used for undergraduate level courses in conservation. Principles of Conservation Biology, 3rd ed. (Groom. 2005. Sinauer) and Conservation Biology, 2nd ed. (van Dyke. 2008. Springer) are advanced texts that are more appropriate for instruction of upper division undergraduate, or graduate-level courses.

Course website. Course materials will on Canvas (https://umich.instructure.com/courses/269261). Piazza is an online forum within the Canvas site where you can share ideas and get answers quickly and efficiently from classmates and instructors. Please use Piazza instead of email to ask questions or share resources. You can opt to send messages privately and/or anonymously.

Course grading. There are 400 total points available in this class with a grading scale of A = 90-100%, B = 80-89.9%, C = 70-79.9%, D = 60-69.9%. We reserve the right to curve grades at the end of the course if necessary; however, this scale gives the minimum percentages required to assure a particular grade. Grades will be assigned based on the student's performance in three categories:

1. Exams (200 pts): There will be two exams – a midterm, and a non-cumulative final. Exams will test whether students have mastered the broad base of fundamentals covered in lecture and the readings associated with each lecture. Questions on the exams will include matching, true/false, short-answer, calculations, and essay questions taken from lectures and discussion readings.

2. Exercises (10 exercises x 15 points = 150 pts). There are 12 quantitative exercises designed to build expertise in the use of models, tools, and techniques that are commonly used by conservation biologists in real-world scenarios. Students may drop their two lowest scores from the exercises.

3. Class discussions (50 pts): Class discussions focus on teaching students how to read and critique peer-reviewed literature in order to evaluate contemporary controversies and claims about conservation practices. Discussions are student led, with grades based on two factors:

   Leading a discussion (25 pts). One to two students will sign up to lead discussion for each lecture date. Student discussion leaders are responsible for …
   - Thoroughly reading and understanding the assigned paper(s).
   - Posting 3-5 discussion questions on the Canvas website 3-days before the discussion date.
   - Providing a concise (5 min) summary at the beginning of discussion.
   - Facilitating an engaging class discussion.

   Participation (25 pts). Each student must come to class having read the assigned paper(s), with answers to the discussion questions ready, and with additional questions or comments. Participation will be monitored.

Late & make-up policy. Deadlines will be strictly enforced, with extensions only granted for those who provide documentation of a valid, university approved hardship or extenuating circumstance. Late work turned in after the deadline will have grades deducted at 10% per day.

Course Expectations

1. Time commitment. According to the Rackham Graduate School, *"it is assumed that each hour of class time spent in a lecture or seminar will be accompanied by 2 to 3 hours of time spent in independent preparation (readings, papers, etc.)."* Please plan for roughly this time commitment.

2. Attendance and participation. Students are expected to attend all classes and be actively engaged. For class discussions, students are expected to have read the assigned paper(s) and come to class having answered the assigned questions and ready to add to a thoughtful discussion. Missing class, poor participation, or lack of preparation or effort will result in a low participation grade.

1. Technology. Please refrain from using cell phones, laptops, or other device in any way that is not directly related to class. Not only is it disrespectful to the professor and your colleagues, it wastes your time!

2. Academic integrity. Students are expected to be familiar with the University of Michigan standards on professional academic behavior (http://www.rackham.umich.edu/current-students/policies/academic-policies/section10). Cheating, copying, and plagiarism are all grounds for expulsion from the program.

3. Student support & accommodations: All students have the right to a positive learning environment. Please contact the professor if any resources or support are needed to optimize your academic experience and performance.

   If you need an accommodation for a disability, please let the professor know as soon as possible, so that he can work with the Services for Students with Disabilities (SSD) office to determine appropriate academic accommodations. 734-763-3000; http://ssd.umich.edu

   If English is not your first language, meet with professor and graduate instructor often to ensure you understand the material. In addition, consider contacting the English Language Institute (https://lsa.umich.edu/eli/), which provides resources for international students, or the Sweetland Center for Writing (http://lsa.umich.edu/sweetland) where you can receive feedback to improve your written work.

   Diminished mental health, including significant stress, mood changes, or problems with eating and/or sleeping can interfere with your course experience and optimal academic performance. The Counseling and Psychological Services (http://caps.umich.edu/) office provides free and confidential support and counseling options for students. If there are specific events or needs related to your academic performance that you think I can help with, please come and talk with me.

4. Inclusive classroom. SEAS students represent a diversity of individual beliefs, backgrounds, and experiences. I try to use a variety of teaching approaches and examples, and I ask that in all activities every member and instructor of this class show respect for others. If you have a concern about an event, comment, or course content that affects your own or another student's comfort or learning experience, please speak with an instructor about it.

Course Schedule

Date	Lecture topic	Discussion readings	Supplemental readings	Exercise (due date*)
Part 1	**Foundations of Conservation Biology**			
W, 1/9	Introduction to course			
M, 1/14	State of our planet	[1]	[2-4]	
W, 1/16	Rise of Conservation Biology	[5, 6]	[7]	
M, 1/21	*No class - Martin Luther King Holiday*			
W, 1/23	Biodiversity concepts & measurement	[8]	[9, 10]	Estimating biodiversity (due 1/30)
M, 1/28	Global patterns and drivers of diversity			Island biogeography (due 2/4)
Part 2	**Importance of Biodiversity**			
W, 1/30	The values of biodiversity	[11]		Structured decision making (due 2/6)
M, 2/4	Biodiversity and ecosystem functioning	[12, 13]	[14-20]	
W, 2/6	Biodiversity and ecosystem services	[21]	[22-31]	
M, 2/11	Ecological economics	[32]		Hedonic pricing (due 2/18)
Part 3	**Threats to Biodiversity**			
W, 2/13	Extinction	[33, 34]	[35-47]	IUCN Red List (2/20)
M, 2/18	Habitat loss	[48]	[49-53]	Meta-population dynamics (2/25)
W, 2/20	Habitat fragmentation & degradation	[54]		Fragmentation (due 2/27)
M, 2/25	Review			
W, 2/27	Midterm exam			
3/4 - 3/6	*No class - Spring break*			
M, 3/11	Overexploitation	[55]	[56, 57]	Sustainable harvest models (due 3/18)
W, 3/13	Invasive alien species	[58]	[59-66]	
M, 3/18	Climate change	[67]	[68-73]	Climate envelope modeling (3/25)
Part 4	**Approaches to Conservation**			
W, 3/20	Legal foundations of conservation	[74]	[75-78]	
M, 3/25	Conservation of genetic diversity	[79]	[80-82]	Effective pop size (4/1)
W, 3/27	Conservation of species populations	[83]	[84, 85]	Population viability analysis (4/3)
M, 4/1	Conservation of communities & ecosystems	[86]	[87-92]	
W, 4/3	Managing landscapes and networks	[93]		Reserve design (4/10)
M, 4/8	Ex situ conservation	[94, 95]	[96-101]	
W, 4/10	Restoration and resurrection	[102]	[103, 104]	
W, 4/17	The future of conservation	[105]		
M, 4/22	Review			
M, 4/29	Final exam, 4-6 pm			

*All exercises must be submitted via Canvas prior to the start of class on their due date.

Course Readings

Pdf's of all required readings will be posted on the course website. Students are responsible for reading materials before class, and being prepared to engage in discussion.

1. Cardinale, B.J., *Critical reading of the scientific literature*. 2011. p. 1-4.
2. Bloom, D.E., *7 Billion and Counting.* Science, 2011. **333**(6042): p. 562-569.
3. MEA, *Ecosystems and Human Well-being: Synthesis*, in *The Millennium Ecosystem Assessment*, M.E. Assessment, Editor. 2005, World Resources Institute: Washington D.C. p. 86.
4. Kennedy, D., ed. *Science Magazine's "State of Our Planet"*. ed. D.a.t.e.o.S. Kennedy. 2006, Island Press: Washington D.C. 201.
5. Soule, M.E., *What is conservation biology?* Bioscience, 1985. **35**(11): p. 727-734.
6. Kareiva, P. and M. Marvier, *What is conservation science?* Bioscience, 2012. **62**(11): p. 962-969.
7. Meine, C., M. Soule, and R.F. Noss, *"A mission-driven discipline": the growth of conservation biology.* Conservation Biology, 2006. **20**(3): p. 631-651.
8. Mora, C., et al., *How many species are there on Earth and in the ocean?* PLoS Biology, 2011. **9**(8): p. e1001127.
9. May, R.M., *How many species are there on Earth.* Science, 1988. **241**(4872): p. 1441-1449.
10. Gaston, K.J., *Global patterns in biodiversity.* Nature, 2000. **405**(6783): p. 220-227.
11. Diaz, S., et al., *The IPBES Conceptual Framework - connecting nature and people.* Current Opinion in Environmental Sustainability, 2015. **14**: p. 1-16.
12. Tilman, D. and J.A. Downing, *Biodiversity and stability in grasslands.* Nature, 1994. **367**(6461): p. 363-365.
13. Huston, M.A., *Hidden treatments in ecological experiments: Re-evaluating the ecosystem function of biodiversity.* Oecologia, 1997. **110**(4): p. 449-460.
14. Cardinale, B.J., et al., *The functional role of producer diversity in ecosystems.* American Journal of Botany, 2011. **98**(3): p. 572-592.
15. Cardinale, B.J., et al., *Effects of biodiversity on the functioning of trophic groups and ecosystems.* Nature, 2006. **443**(7114): p. 989-992.
16. Stachowicz, J., J.F. Bruno, and J.E. Duffy, *Understanding the effects of marine biodiversity on communities and ecosystems.* Annual Review of Ecology, Evolution and Systematics, 2007. **38**(1): p. 739-766
17. Hooper, D.U., et al., *Effects of biodiversity on ecosystem functioning: A consensus of current knowledge.* Ecological Monographs, 2005. **75**(1): p. 3-35.
18. Loreau, M., et al., *Biodiversity and ecosystem functioning: Current knowledge and future challenges.* Science, 2001. **294**(5543): p. 804-808.
19. Naeem, S., *Ecosystem consequences of biodiversity loss: The evolution of a paradigm.* Ecology, 2002. **83**(6): p. 1537-1552.
20. Tilman, D., *The ecological consequences of changes in biodiversity: a search for general principles.* Ecology, 1999. **80**: p. 1455-1474.
21. Cardinale, B.J., et al., *Biodiversity loss and its impact on humanity.* Nature, 2012. **486**(7401): p. 59-67.
22. Worm, B., et al., *Impacts of biodiversity loss on ocean ecosystem services.* Science, 2006. **314**(5800): p. 787-790.
23. Balvanera, P., et al., *Quantifying the evidence for biodiversity effects on ecosystem functioning and services.* Ecology Letters, 2006. **9**(10): p. 1146-1156.
24. Cardinale, B.J., *Biodiversity improves water quality through niche partitioning.* Nature, 2011. **472**(7341): p. 86-89.

25. Snyder, W.E., et al., *Predator biodiversity strengthens herbivore suppression.* Ecology Letters, 2006. **9**(7): p. 789-796.
26. Saslis-Lagoudakis, C.H., et al., *Phylogenies reveal predictive power of traditional medicine in bioprospecting.* Proceedings of the National Academy of Sciences, 2012. **109**(39): p. 15835-15840.
27. Garibaldi, L.A., et al., *Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance.* Science, 2013.
28. Chan, K.M.A., T. Satterfield, and J. Goldstein, *Rethinking ecosystem services to better address and navigate cultural values.* Ecological Economics, 2012. **74**: p. 8-18.
29. Daniel, T.C., et al., *Contributions of cultural services to the ecosystem services agenda.* Proceedings of the National Academy of Sciences, 2012. **109**(23): p. 8812-8819.
30. Wallace, K.J., *Classification of ecosystem services: Problems and solutions.* Biological Conservation, 2007. **139**(3-4): p. 235-246.
31. Mace, G.M., K. Norris, and A.H. Fitter, *Biodiversity and ecosystem services: a multilayered relationship.* Trends in ecology & evolution, 2012. **27**(1): p. 19-26.
32. Naidoo, R., et al., *Effect of biodiversity on economic benefits from communal lands in Namibia.* Journal of Applied Ecology, 2011. **48**(2): p. 310-316.
33. Dornelas, M., et al., *Assemblage time series reveal biodiversity change but not systematic loss.* Science, 2014. **344**(6181): p. 296-299.
34. Newbold, T., et al., *Global effects of land use on local terrestrial biodiversity.* Nature, 2015. **520**(7545): p. 45-50.
35. Sala, O.E., et al., *Global biodiversity scenarios for the year 2100.* Science, 2000. **287**(5459): p. 1770-1774.
36. Pimm, S.L., et al., *The biodiversity of species and their rates of extinction, distribution, and protection.* Science, 2014. **344**(6187).
37. Pereira, H.M., et al., *Scenarios for global biodiversity in the 21st century.* Science, 2010. **330**(6010): p. 1496-1501.
38. Stork, N.E., *Re-assessing current extinction rates.* Biodiversity and Conservation, 2010. **19**(2): p. 357-371.
39. Hubbell, S.P., et al., *How many tree species and how many of them are there in the Amazon will go extinct?* Proceedings of the National Academy of Sciences of the United States of America, 2008. **105**: p. 11498-11504.
40. Pimm, S.L. and P. Raven, *Biodiversity - Extinction by numbers.* Nature, 2000. **403**(6772): p. 843-845.
41. Ricciardi, A. and J.B. Rasmussen, *Extinction rates of North American freshwater fauna.* Conservation Biology, 1999. **13**(5): p. 1220-1222.
42. Smith, F.D.M., et al., *Estimating extinction rates.* Nature, 1993. **364**(6437): p. 494-496.
43. Barnosky, A.D., et al., *Has the Earth's sixth mass extinction already arrived?* Nature, 2011. **471**(7336): p. 51-57.
44. Dirzo, R., et al., *Defaunation in the Anthropocene.* Science, 2014. **345**(6195): p. 401-406.
45. Vellend, M., et al., *Global meta-analysis reveals no net change in local-scale plant biodiversity over time.* Proceedings of the National Academy of Sciences, 2013. **110**(48): p. 19456-19459.
46. McGill, B.J., et al., *Fifteen forms of biodiversity trend in the Anthropocene.* Trends in Ecology & Evolution, 2015. **30**(2): p. 104-113.
47. Murphy, G.E.P. and T.N. Romanuk, *A meta-analysis of declines in local species richness from human disturbances.* Ecology and Evolution, 2014. **4**(1): p. 91-103.

48. Kuussaari, M., et al., *Extinction debt: a challenge for biodiversity conservation.* Trends in Ecology & Evolution, 2009. **24**(10): p. 564-571.
49. Tewksbury, J.J., S.J. Hejl, and T.E. Martin, *Breeding productivity does not decline with increasing fragmentation in a western landscape.* Ecology, 1998. **79**(8): p. 2890-2903.
50. Fahrig, L., *Effects of habitat fragmentation on biodiversity.* Annual Review of Ecology Evolution and Systematics, 2003. **34**: p. 487-515.
51. Bender, D.J., T.A. Contreras, and L. Fahrig, *Habitat loss and population decline: A meta-analysis of the patch size effect.* Ecology, 1998. **79**: p. 517-533.
52. Rudnick, e.a., *The Role of Landscape Connectivity in Planning and Implementing Conservation and Restoration Priorities*. 2012.
53. Krauss, J., et al., *Habitat fragmentation causes immediate and time-delayed biodiversity loss at different trophic levels.* Ecology Letters, 2010. **13**(5): p. 597-605.
54. Haddad, N.M., et al., *Habitat fragmentation and its lasting impact on Earth's ecosystems.* Science Advances, 2015. **1**(2): p. e1500052.
55. Worm, B., et al., *Rebuilding Global Fisheries.* Science, 2009. **325**(5940): p. 578-585.
56. Pauly, D., et al., *Fishing down marine food webs.* Science, 1998. **279**(5352): p. 860-863.
57. Hilborn, R., et al., *State of the world's fisheries.* Annual Review of Environment and Resources, 2003. **28**: p. 359-399.
58. Sax, D.F., S.D. Gaines, and J.H. Brown, *Species invasions exceed extinctions on islands worldwide: A comparative study of plants and birds.* American Naturalist, 2002. **160**(6): p. 766-783.
59. McKinney, M.L. and J.L. Lockwood, *Biotic homogenization: a few winners replacing many losers in the next mass extinction.* Trends in Ecology & Evolution, 1999. **14**(11): p. 450-453.
60. Lodge, D.M., et al., *Biological invasions: Recommendations for US policy and management.* Ecological Applications, 2006. **16**(6): p. 2035-2054.
61. Sax, D.F. and S.D. Gaines, *Species diversity: from global decreases to local increases.* Trends in Ecology & Evolution, 2003. **18**(11): p. 561-566.
62. Gurevitch, J. and D.K. Padilla, *Are invasive species a major cause of extinctions?* Trends in Ecology & Evolution, 2004. **19**(9): p. 470-474.
63. Sakai, A.K., et al., *The population biology of invasive species.* Annual Review of Ecology and Systematics, 2001. **32**: p. 305-332.
64. Rejmanek, M. and D.M. Richardson, *What attributes make some plant species more invasive?* Ecology, 1996. **77**(6): p. 1655-1661.
65. Pimentel, D., R. Zuniga, and D. Morrison, *Update on the environmental and economic costs associated with alien-invasive species in the United States.* Ecological Economics, 2005. **52**(3): p. 273-288.
66. Mack, R.N., et al., *Biotic invasions: Causes, epidemiology, global consequences, and control.* Ecological Applications, 2000. **10**(3): p. 689-710.
67. Thomas, C.D., et al., *Extinction risk from climate change.* Nature, 2004. **427**(6970): p. 145-148.
68. Maclean, I.M.D. and R.J. Wilson, *Recent ecological responses to climate change support predictions of high extinction risk.* Proceedings of the National Academy of Sciences, 2011. **108**(30): p. 12337-12342.
69. Vitousek, P.M., *GLOBAL ENVIRONMENTAL-CHANGE - AN INTRODUCTION.* Annual Review of Ecology and Systematics, 1992. **23**: p. 1-14.
70. Parmesan, C. and G. Yohe, *A globally coherent fingerprint of climate change impacts across natural systems.* Nature, 2003. **421**(6918): p. 37-42.
71. Tylianakis, J.M., et al., *Global change and species interactions in terrestrial ecosystems.* Ecology Letters, 2008. **11**(12): p. 1351-1363.

72. Visser, M.E. and C. Both, *Shifts in phenology due to global climate change: the need for a yardstick.* Proceedings of the Royal Society B-Biological Sciences, 2005. **272**(1581): p. 2561-2569.
73. Harte, J. and R. Shaw, *SHIFTING DOMINANCE WITHIN A MONTANE VEGETATION COMMUNITY - RESULTS OF A CLIMATE-WARMING EXPERIMENT.* Science, 1995. **267**(5199): p. 876-880.
74. Ferraro, P.J., C. McIntosh, and M. Ospina, *The effectiveness of the US endangered species act: An econometric analysis using matching methods.* Journal of Environmental Economics and Management, 2007. **54**(3): p. 245-261.
75. Waples, R.S., et al., *A Tale of Two Acts: Endangered Species Listing Practices in Canada and the United States.* BioScience, 2013. **63**(9): p. 723-734.
76. *The Legal Foundations of Conservation Biology*, in *Conservation Biology*. 2008, Springer Netherlands. p. 57-82.
77. de Klemm, C. and C. Shine, *Biological Diversity Conservation and the Law*, I.T.W.C. Union, Editor. 1993: Gland, Switzerland and Cambridge, UK.
78. Evans, e.a., *Species recovery in the United States: Increasing the effectiveness of the endangered species act*, in *Issues in Ecology*, E.S.o. America, Editor. 2016: Washington, D.C.
79. Allendorf, F.W., P.A. Hohenlohe, and G. Luikart, *Genomics and the future of conservation genetics.* Nat Rev Genet, 2010. **11**(10): p. 697-709.
80. Frankham, R., *Conservation genetics.* Annual Review of Genetics, 1995. **29**: p. 305-327.
81. Hedrick, P.W., *Conservation genetics: where are we now?* Trends in Ecology & Evolution, 2001. **16**(11): p. 629-636.
82. de Groot, P.J.V., et al., *Conservation genetics of the black rhinoceros, Diceros bicornis bicornis, in Namibia.* Conservation Genetics, 2011. **12**(3): p. 783-792.
83. Brook, B.W., et al., *Predictive accuracy of population viability analysis in conservation biology.* Nature, 2000. **404**(6776): p. 385-387.
84. Fallon, S.M., *Genetic data and the listing of species under the US endangered species act.* Conservation Biology, 2007. **21**(5): p. 1186-1195.
85. Roemer, G.W. and R.K. Wayne, *Conservation in conflict: The tale of two endangered species.* Conservation Biology, 2003. **17**(5): p. 1251-1260.
86. Williams, J., C. ReVelle, and S. Levin, *Spatial attributes and reserve design models: A review.* Environmental Modeling & Assessment, 2005. **10**(3): p. 163-181.
87. Cabeza, M. and A. Moilanen, *Design of reserve networks and the persistence of biodiversity.* Trends in Ecology & Evolution, 2001. **16**(5): p. 242-248.
88. Lamberson, R.H., et al., *Reserve Design for Territorial Species: The Effects of Patch Size and Spacing on the Viability of the Northern Spotted Owl.* Conservation Biology, 1994. **8**(1): p. 185-195.
89. Csuti, B., et al., *A comparison of reserve selection algorithms using data on terrestrial vertebrates in Oregon.* Biological Conservation, 1997. **80**(1): p. 83-97.
90. Ferson, S. and M.A. Burgman, *Quantitative methods for conservation biology*. 2000, New York: Springer. xi, 322 p.
91. Halpern, B.S., et al., *Accounting for uncertainty in marine reserve design.* Ecology Letters, 2006. **9**(1): p. 2-11.
92. Christensen, N.L., et al., *The report of the ecological society of America committee on the scientific basis for ecosystem management.* Ecological Applications, 1996. **6**(3): p. 665-691.
93. Claire, K., *Reframing the land-sparing/land-sharing debate for biodiversity conservation.* Annals of the New York Academy of Sciences, 2015. **1355**(1): p. 52-76.
94. Conde, D.A., et al., *An Emerging Role of Zoos to Conserve Biodiversity.* Science, 2011. **331**(6023): p. 1390-1391.

95. Friese, C. and C. Marris, *Making De- Extinction Mundane?* PloS Biology, 2014. **12**(3).
96. Hoban, S. and C. Vernesi, *Challenges in global biodiversity conservation and solutions that cross sociology, politics, economics and ecology.* Biology Letters, 2012. **8**(6): p. 897-899.
97. Balmford, A., G.M. Mace, and N. Leader-Williams, *Designing the Ark: Setting Priorities for Captive Breeding.* Conservation Biology, 1996. **10**(3): p. 719-727.
98. Fraser, D.J., *How well can captive breeding programs conserve biodiversity? A review of salmonids.* Evolutionary Applications, 2008. **1**(4): p. 535-586.
99. Gusset, M. and G. Dick, *The Global Reach of Zoos and Aquariums in Visitor Numbers and Conservation Expenditures.* Zoo Biology, 2011. **30**(5): p. 566-569.
100. Rahbek, C., *Captive breeding—a useful tool in the preservation of biodiversity?* Biodiversity & Conservation, 1993. **2**(4): p. 426-437.
101. Balmford, A. and R.M. Cowling, *Fusion or failure? The future of conservation biology.* Conservation Biology, 2006. **20**(3): p. 692-695.
102. Donlan, C.J., et al., *Pleistocene Rewilding: An Optimistic Agenda for Twenty-First Century Conservation.* The American Naturalist, 2006. **168**(5): p. 660-681.
103. Nogués-Bravo, D., et al., *Rewilding is the new Pandora's box in conservation.* Current Biology, 2016. **26**(3): p. R87-R91.
104. Toledo, D., M.S. Agudelo, and A.L. Bentley, *The Shifting of Ecological Restoration Benchmarks and Their Social Impacts: Digging Deeper into Pleistocene Re-wilding.* Restoration Ecology, 2011. **19**(5): p. 564-568.
105. Doak, D.F., et al., *What is the future of conservation?* Trends in Ecology & Evolution, 2014. **29**(2): p. 77-81.