

Global Change Biology

In the year 2000, atmospheric chemist Paul Crutzen suggested that humans had fundamentally changed Earth systems so much that it was time to declare a new Geological epoch: the Anthropocene. While this proposal has yet to be formally accepted, the impact of the statement has given rise to a whole new scientific sub-discipline seeking to understand the impact of these massive Earth systems changes on living organisms: Global Change Biology. This course is roughly divided into three parts. In part one, we will discuss the drivers and physical effects of anthropogenic change. In **part two**, we will focus on how these changes impact organisms and ecosystems. In **part three**, we will explore some of the anthropogenic responses to global change that are aimed to mitigate the detrimental effects on organisms.

Course Objective: The goals of this class are to broadly expose students to the drivers of effects of global change on life. Specifically, students should expect to:

- Obtain a broad foundation for the study of Earth Systems and drivers of global change.
- Gain an understanding of the range of possible effects of global change on organisms and the complexity of interacting drivers.
- Increase comfort reading primary literature and learn to evaluate the current state of global change science with all of its limitations and promises.

Required Text: Because of the diversity of topics covered, we will approach our study of global change biology through the developing body of primary scientific literature rather than through a single text book. Many lectures will pair with suggested readings (italicized below) from the text:

Levin, Simon A., et al., editors. *The Princeton Guide to Ecology*. Princeton University Press, 2009.

These readings will augment and clarify the background information covered in lectures, and are highly recommended.

Course structure: This course will meet twice per week for 75 minutes. This first half will consist of a lecture from the instructor, with the second half consisting of student facilitated discussions on relevant papers.

Prerequisites: A course in introductory biology or permission of instructor.

Topic	Reading(s)
1] Introduction to our changing climate system	IPCC 2001, IPCC 2014
2] Paleoclimate: the effects of rapid climate change in deep time	Knoll 2007
3] Predicting Future Climates	Bonan 2018, <i>Newman Ch.2 (Canvas)</i>
4] Feedbacks, sources and sinks	Cox 2000, <i>Levin IV.7</i>
5] Localized impacts: Disturbance	Kurz 2008, <i>Levin IV.1</i>
6] Land Use Change	Foley 2005, <i>Levin VII.7</i>
7] Nutrient cycling	Vitousek 1997, <i>Levin II.10</i>
8] Marine effects	Anthony2008, Kroeker 2013
9] Interacting drivers	Hoff 2011, Mantyka-pringle 2011 <i>Newman Ch. 13 (Can</i>
10] Plant physiology	Korner 2006, <i>Levin III.9</i>
11] Terrestrial ecosystem productivity	Norby 2011
12] Thermal tolerance	Kaliq 2014, <i>Levin I.2-3</i>
13] Plasticity and phenological shifts	Cleland 2012, <i>Levin I.9</i>
14] Global change and Evolution	Logan 2014, <i>Levin III.19</i>
15] Distributions, Fragmentation and Migration	Chen 2011, <i>Levin I.6 and 12</i>
16] Invasion	Liu 2017, <i>Levin VII.8</i>
17] The 6th extinction	Plotnick 2016 <i>Levin V.1</i>
18] Novel ecosystem and communities	Hobbs 2009, Clavel 2010,
19] Conservation I: Who, what, where, why?	Chan 2006
20] Conservation II: How?	McGwire 2016, Shwartz 2012
21] Ecological Restoration	Cannon 2018, Harris 2006
22] Conservation Policy	Diaz 2015
22] Spotlight REDD+	Visseren-Hamakers 2012
24] Communicating science in an era of global change	Knowlton 2017, Godet 2018

References

- Anthony, K.R.N., Kline, D.I., Diaz-Pulido, G., Dove, S. & Hoegh-Guldberg, O. (2008) Ocean acidification causes bleaching and productivity loss in coral reef builders. *Proceedings of the National Academy of Sciences* **105**, 17442–17446.
- Cannon, J.B., Barrett, K.J., Gannon, B.M., Addington, R.N., Battaglia, M.A., Fornwalt, P.J., Aplet, G.H., Cheng, A.S., Underhill, J.L., Briggs, J.S. & Brown, P.M. (2018) Collaborative restoration effects on forest structure in ponderosa pine-dominated forests of colorado. *Forest Ecology and Management* **424**, 191 – 204.
- Chan, K.M.A., M., P.R., Ranganathan, J., Boggs, C.L., Chan, Y.L., Ehrlich, P.R., Haff, P.K., E., H.N.,

- Karim, A.K. & P., M.D. (2006) When agendas collide: Human welfare and biological conservation. *Conservation Biology* **21**, 59–68.
- Cleland, E.E., Allen, J.M., Crimmins, T.M., Dunne, J.A., Pau, S., Travers, S.E., Zavaleta, E.S. & Wolkovich, E.M. (2012) Phenological tracking enables positive species responses to climate change. *Ecology* **93**, 1765–1771.
- Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A. & Totterdell, I.J. (2000) Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *Nature* **408**, 184 EP –.
- Diaz, R.J. & Rosenberg, R. (2008) Spreading dead zones and consequences for marine ecosystems. *Science* **321**, 926–929.
- Diaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J.R., Arico, S., Baldi, A., Bartuska, A., Baste, I.A., Bilgin, A., Brondizio, E., Chan, K.M.A., Figueroa, V.E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G.M., Martin-Lopez, B., Okumura, M., Pacheco, D., Pascual, U., Perez, E.S., Reyers, B., Roth, E., Saito, O., Scholes, R.J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z.A., Akosim, C., Al-Hafedh, Y., Allahverdiyev, R., Amankwah, E., Asah, S.T., Asfaw, Z., Bartus, G., Brooks, L.A., Caillaux, J., Dalle, G., Darnaedi, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A.M.M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavorel, S., Lichtenstein, G., Mala, W.A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J.P., Mikissa, J.B., Moller, H., Mooney, H.A., Mumby, P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A.A., Pataki, G., Roue, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y. & Zlatanova, D. (2015) The IPBES Conceptual Framework - connecting nature and people. *Current Opinion in Environmental Sustainability* **14**, 1–16.
- Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N. & Snyder, P.K. (2005) Global consequences of land use. *Science* **309**, 570–574.
- Harris, J.A., Hobbs, R.J., Higgs, E. & Aronson, J. (2006) Ecological restoration and global climate change. *RESTORATION ECOLOGY* **14**, 170–176.
- Hof, C., Araújo, M.B., Jetz, W. & Rahbek, C. (2011) Additive threats from pathogens, climate and land-use change for global amphibian diversity. *Nature* **480**, 516–519.
- Joanne, C., Romain, J. & Vincent, D. (2011) Worldwide decline of specialist species: toward a global functional homogenization? *Frontiers in Ecology and the Environment* **9**, 222–228.
- Khaliq, I., Hof, C., Prinzinger, R., Böhning-Gaese, K. & Pfenninger, M. (2014) Global variation in thermal tolerances and vulnerability of endotherms to climate change. *Proceedings of the Royal Society of London B: Biological Sciences* **281**.

- Körner, C. (2006) Plant co2responses: an issue of definition, time and resource supply. *New Phytologist* **172**, 393–411.
- Kroeker, K.J., Kordas, R.L., Crim, R., Hendriks, I.E., Ramajo, L., Singh, G.S., Duarte, C.M. & Gattuso, J.P. (2013) Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming. *Global Change Biology* **19**, 1884–1896.
- Liu, Y., Oduor, A.M.O., Zhang, Z., Manea, A., Tooth, I.M., Leishman, M.R., Xu, X. & van Kleunen, M. (2017) Do invasive alien plants benefit more from global environmental change than native plants? *Global Change Biology* **23**, 3363–3370.
- Pachauri, R. & Meyer, L. (2014) Ipcc, 2014: Climate change 2014: Synthesis report. contribution of working groups i, ii and iii to the fifth assessment report of the intergovernmental panel on climate change. Tech. rep., IPCC, Geneva, Switzerland.
- Visseren-Hamakers, I.J., McDermott, C., Vijge, M.J. & Cashore, B. (2012) Trade-offs, co-benefits and safeguards: current debates on the breadth of redd+. *Current Opinion in Environmental Sustainability* **4**, 646 – 653, 4/6 Climate systems.
- Willis, S.G., Hill, J.K., Thomas, C.D., Roy, D.B., Fox, R., Blakeley, D.S. & Huntley, B. (2009) Assisted colonization in a changing climate: a test-study using two UK butterflies. *CONSERVATION LETTERS* **2**, 45–51.