Networks and the Environment
Worksheet 1
Answer Guide

Following are some suggestions to help answer the questions in Worksheet 1. This document is meant to be used as a general guide. Please note that there are many ways to answer some of the questions on Worksheet 1.

1. What is a food web?
   - Flow chart of predator-prey relationships.
   - More realistic to represent as a network of interactions than a single food chain.
2. How do you draw a food web as a network? What are the nodes? What are the edges?
   - Nodes: species (or groups of species with similar predators/prey).
   - Edges: energy flows.
3. Is the network directed? Which way do the arrows point?
   - Yes, it is a directed network.
   - By convention, arrows point in the direction of energy flow (i.e. from prey to predator) (Newman 2010).
4. How could analysing food webs help answer questions about the environment? What kinds of questions might we be interested in?
   - Applications for conservation policies and planning, etc.
   - Identify 'keystone' species (i.e. critical nodes).
5. What does it mean for a species to have many links going out (i.e. a high out-degree)? Many links coming in (i.e. a high in-degree)? A low out-degree? A low in-degree? What if the in-degree is zero? What if the out-degree is zero?
   - Links in: number of prey species the node has. This is the in-degree of a node.
     - High in-degree: many prey species; less affected by the loss of one prey species; measure of robustness for that species.

  - Low in-degree: few prey species; vulnerable to loss of prey species.
  - In-degree of zero: No prey species (i.e. not included in the food web; loss of info; e.g. sun or nutrients in the soil). These are primary producers.
- Links out: number of predator species the node has. This is the out-degree of a node.
  - High out-degree: many predators; lots of other species rely on this node for food; may be one indicator of a keystone species.
  - Low out-degree: few predators.
  - Out-degree of zero: No predators (top of the food chain).
- Connectance = number of edges / total number of possible edges
  - More connected suggests more generalists and fewer specialists, therefore the overall the ecosystem is less vulnerable to disturbance.

6. Observations/comments from analysing your food web. Which species are the most vulnerable? How might climate change affect the food web? Any mitigation options? Other thoughts?

   - This answer will be specific to your food web.

7. What are the limitations of the analysis so far? What information is missing / could be improved?
   Possible responses include:

   - edge weights (to reflect the relative importance of each edge);
   - nutrients as another trophic level; and
   - self-loops (intraspecies competition).

8. What are some other applications of network theory to the environment?
   Possible responses include:

   - landscape and habitat connectivity;
   - animal social networks;
   - animal movement patterns; and
   - disease spread.

References

Newman, M.E.J. (2010). *Networks: an introduction.* Oxford University Press Inc., New York.