Appendix S2
"Applying the structural causal model (SCM) framework for observational causal inference in ecology" *Ecological Monographs*
Suchinta Arif and Aaron MacNeil

Section S1 - Testing DAG-data consistency:

Once a DAG has been created, it can be directly tested against observational data to ensure

DAG-data consistency, which is when data are consistent with all independencies implied by a

given DAG. For example, there are 28 independencies that are implied by our forest species

abundance DAG (Figure 3):

1. Carbon Sequestration ⊥ Distance to Roads and Cities | Fire, Logging, Poaching

2. Carbon Sequestration ⊥ Distance to Roads and Cities | Forest Species Abundance, Logging

3. Carbon Sequestration ⊥ Protected Area | Fire, Logging, Poaching

4. Carbon Sequestration ⊥ Protected Area | Forest Species Abundance, Logging

5. Carbon Sequestration ⊥ Elevation | Distance to Roads and Cities, Logging, Protected Area

6. Carbon Sequestration ⊥ Elevation | Fire, Logging, Poaching

7. Carbon Sequestration ⊥ Elevation | Forest Species Abundance, Logging

8. Carbon Sequestration ⊥ Fire | Forest Species Abundance, Logging

9. Carbon Sequestration ⊥ Poaching | Forest Species Abundance, Logging

10. Carbon Sequestration ⊥ Slope | Distance to Roads and Cities, Logging, Protected Area

11. Carbon Sequestration ⊥ Slope | Fire, Logging, Poaching

12. Carbon Sequestration ⊥ Slope | Forest Species Abundance, Logging

13. Distance to Roads and Cities ⊥ Forest Species Abundance | Fire, Logging, Poaching

14. Distance to Roads and Cities ⊥ Elevation

15. Distance to Roads and Cities ⊥ Slope

16. Forest Species Abundance ⊥ Protected Area | Fire, Logging, Poaching

17. Forest Species Abundance ⊥ Elevation | Distance to Roads and Cities, Logging, Protected Area

18. Forest Species Abundance ⊥ Elevation | Fire, Logging, Poaching

19. Forest Species Abundance ⊥ Slope | Distance to Roads and Cities, Logging, Protected Area

20. Forest Species Abundance ⊥ Slope | Fire, Logging, Poaching

21. Elevation ⊥ Fire | Distance to Roads and Cities, Protected Area

22. Elevation ⊥ Poaching | Distance to Roads and Cities, Protected Area

23. Elevation ⊥ Slope

24. Fire ⊥ Logging | Distance to Roads and Cities, Protected Area

25. Fire ⊥ Poaching | Distance to Roads and Cities, Protected Area

26. Fire ⊥ Slope | Distance to Roads and Cities, Protected Area

27. Logging ⊥ Poaching | Distance to Roads and Cities, Protected Area

28. Poaching ⊥ Slope | Distance to Roads and Cities, Protected Area

We use the R package 'dagitty' to test if these 28 independencies coincide with our simulated data (R code on Figshare at https://doi.org/10.6084/m9.figshare.19541059.v1). All 28 independencies are consistent with our simulated data, ensuring DAG-data consistency.

Section S2 - Applying the backdoor criterion using www.dagitty.net

The backdoor criterion can be employed to determine the sufficient set(s) for adjustment required to quantify causal estimates between variables of interest. Since the application of the backdoor criterion can become complex and time consuming, users can use www.dagitty.net as a resource to draw their DAG (instructions within site). Given a DAG, and specified predictor and response variables, this website will automatically generate the backdoor adjustment set without needing to do it by hand. A saved version of our forest species abundance DAG (Fig 3) can be found here: dagitty.net/m18S_bV. Given this DAG, let's use this website to determine the effect of protected area on forest species abundance:

1. To select the predictor variable, protected areas, click on this variable, then select "exposure" under the Variable tab on the top left of the screen.

2. To select the response variable, forest species abundance, click on this variable, then select "outcome" under the Variable tab on the top left of the screen.

3. Under the 'Causal effect identification' tab on the top right of the screen, select 'Adjustment (total effect)'. The backdoor adjustment set will be noted here. Given our DAG, to determine the effect of protected are of forest species abundance, distance to roads and cities, elevation, and slope must be adjusted for.