

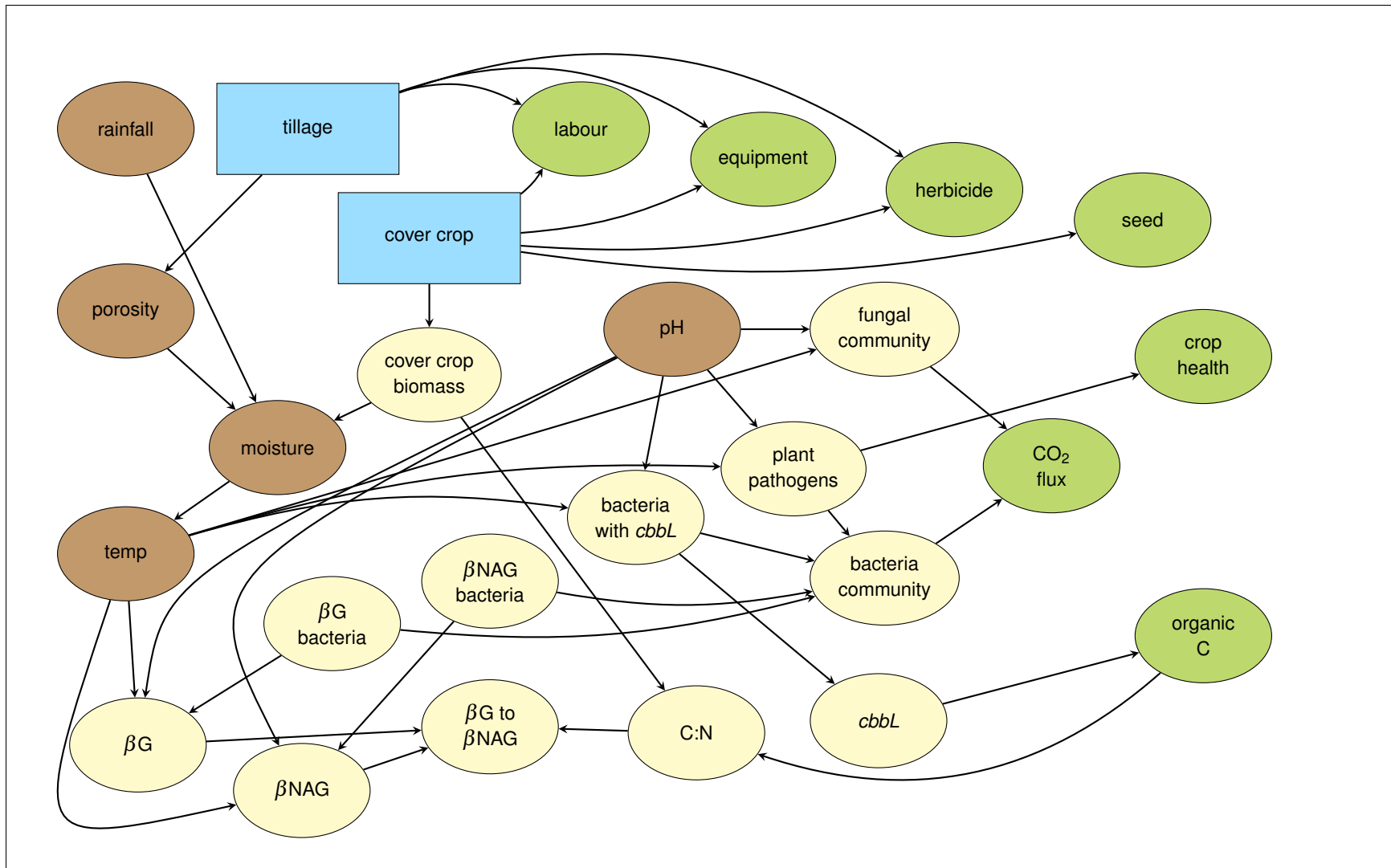
## **Supporting Information 1: Conceptual Model for the Outcome of Tillage and Cover Crop actions on Downstream Trade-offs Between Yield and Carbon Credit Utility**

### **Balancing trade-offs in climate smart-agriculture: can on-farm actions store organic carbon and maximize net utility by selling carbon credits?**

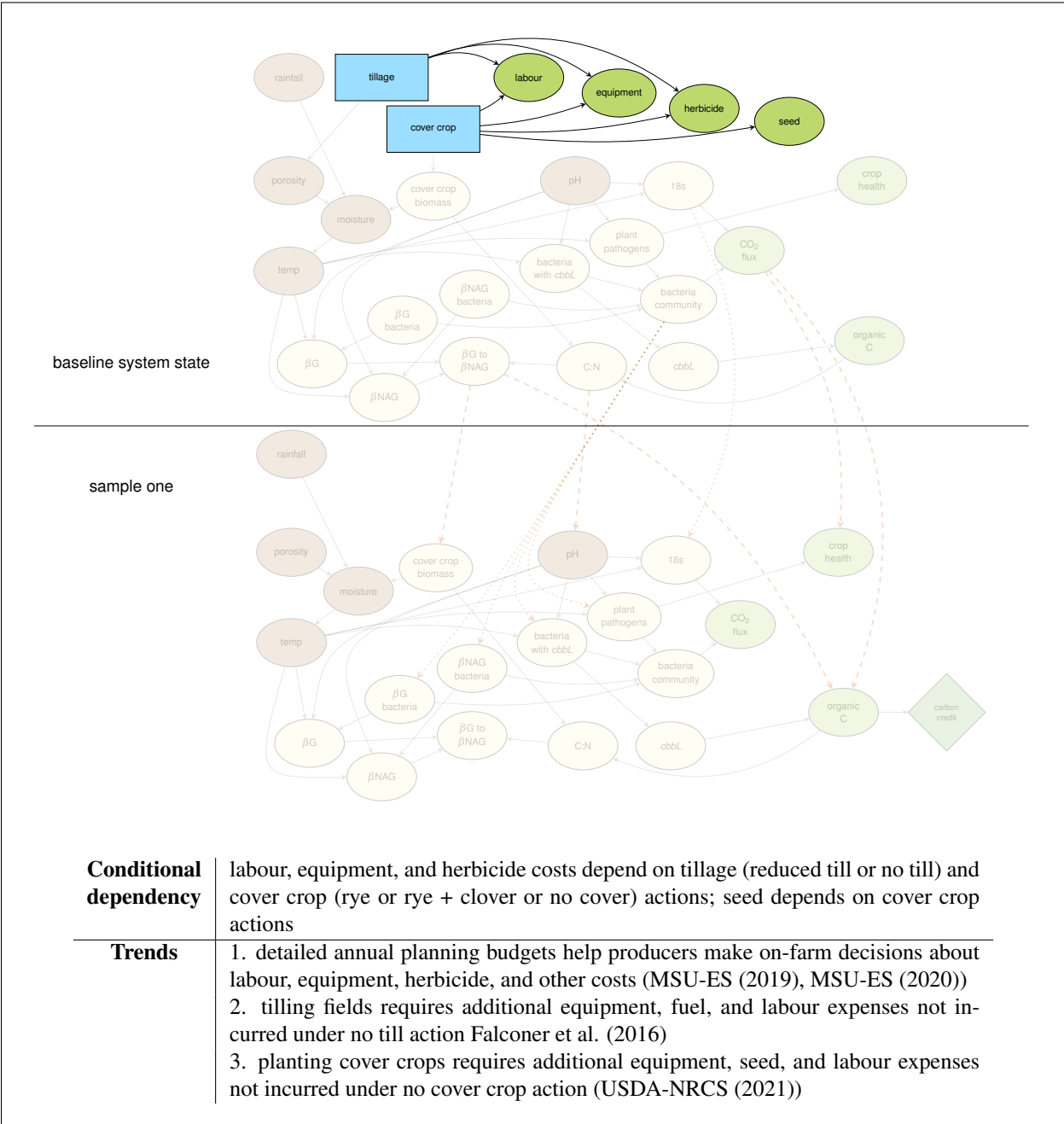
This supplement contains a detailed description of our conceptual model that was designed to show how tillage and cover crop actions affect current soil conditions (abiotic and structural), downstream soil organic storage (SOC), and yield. The model was designed as a Bayesian Network (BN) and then extended to a Bayesian Decision Network (BDN) by adding nodes for actions and utility. See main text for a description of BNs and BDNs.

The conceptual model was constructed from several sub-models that represent known pathways of SOC storage in soil under different management actions. These include (1) the direct effects of actions on soil structure and abiotic conditions, (2) the indirect effects of actions on organic matter decomposition and eventual SOC, (3) the indirect effects of actions on bacterial carbon fixation potential of soils, (4) the indirect effects of actions on microbial community dynamics and function (enzyme production, gene expression, respiration, death and turnover), and (5) the indirect effects of actions on microbial pathogens and their effects on yield.

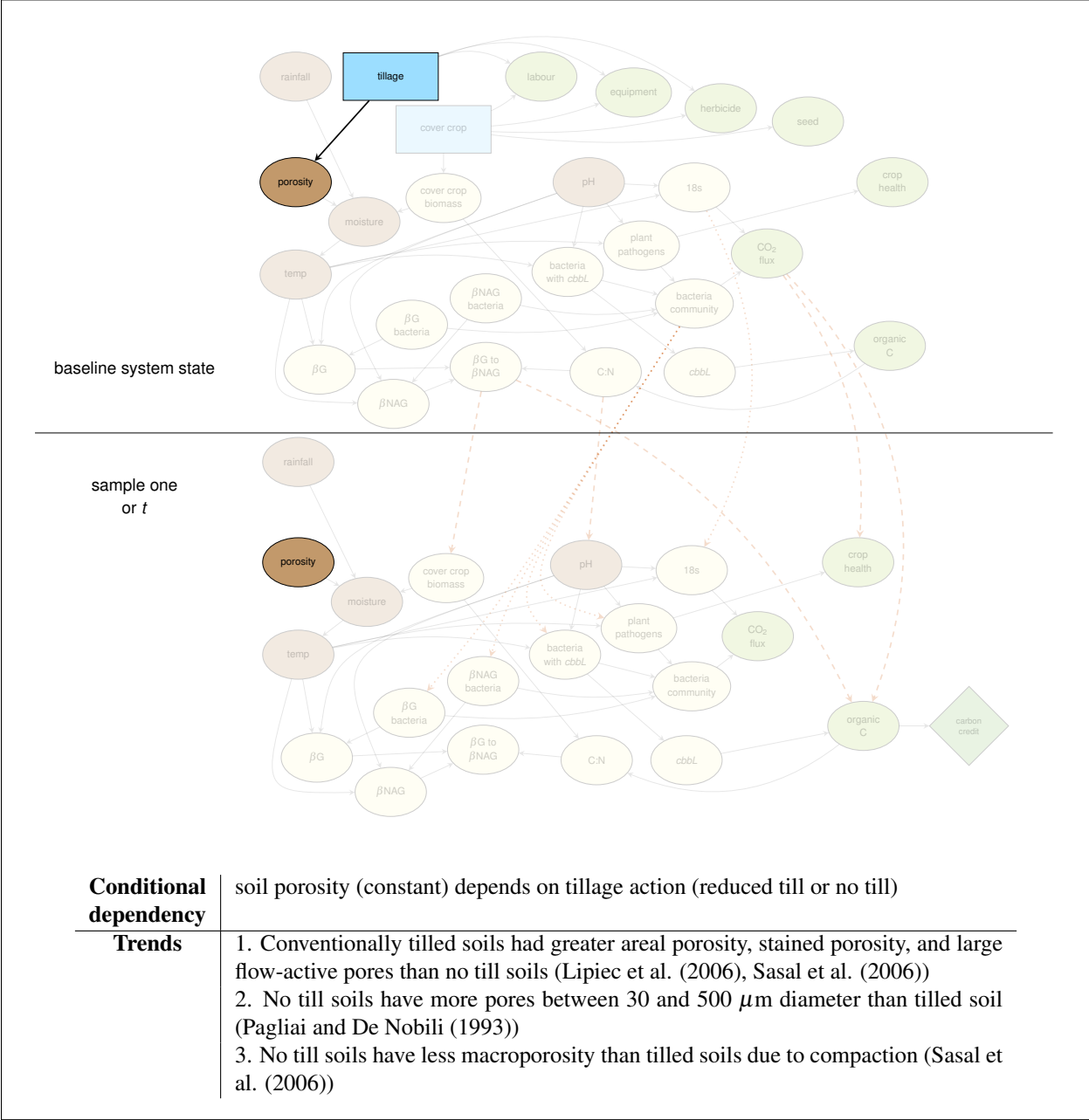
Figure S1 shows the baseline system state representing time zero in the carbon cycle (unsampled state). Figure S2 shows carbon flow through the growing season using intra- and inter- arcs within and between, respectively, five samples ( $t = 1, \dots, 5$ ). Each sample has the same nodes and intra-arcs. Inter-arcs between consecutive samples represent cyclic dynamics including organic matter decomposition, enzyme activity, carbon fixation, microbe respiration, and microbe community dynamics. Inter-arcs are orange dashed lines for all cyclic dynamics except microbe community dynamics (orange dotted lines).



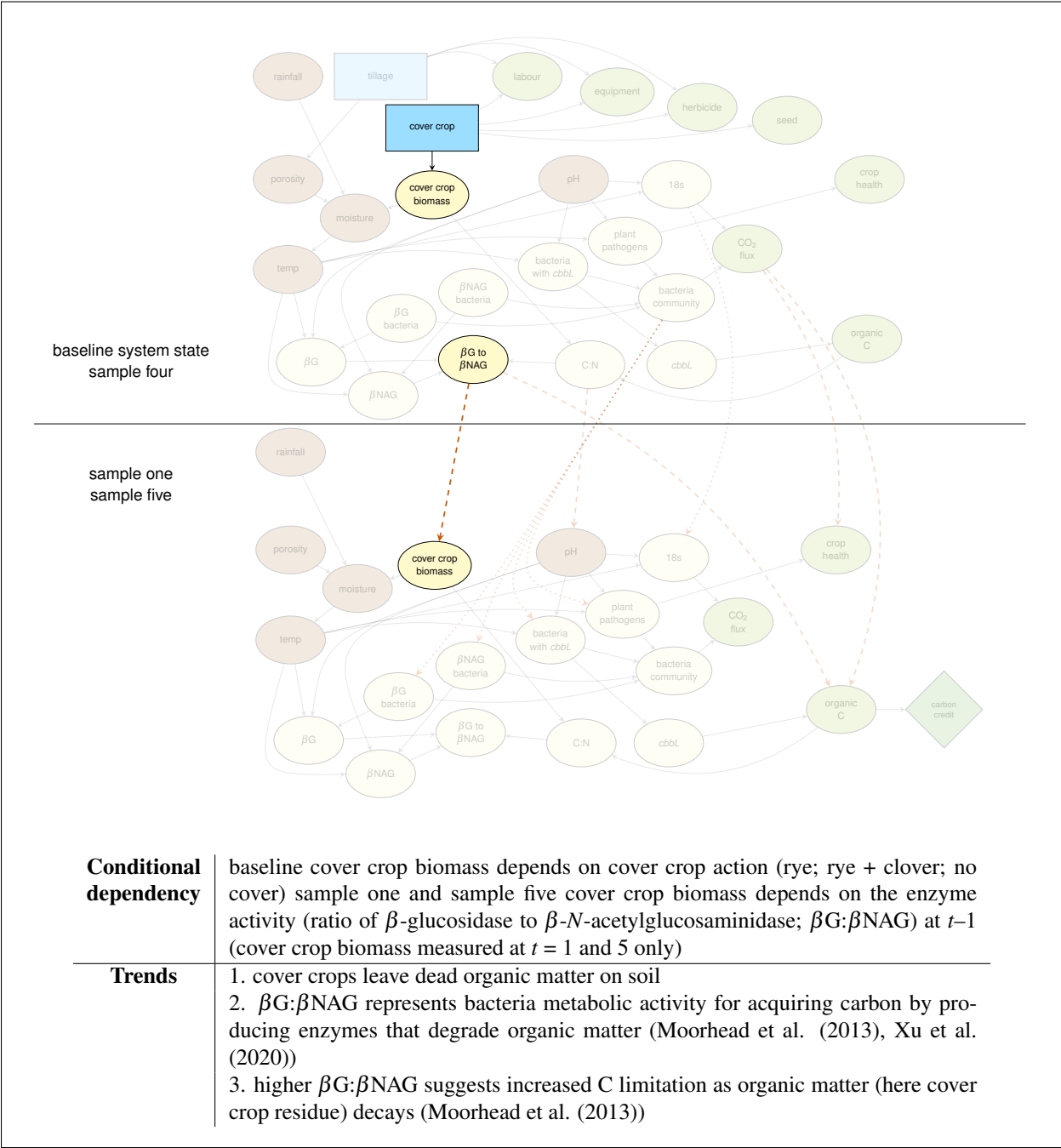
**Figure S1.1.** BDN with causal relations linking tillage and cover crop actions to expenses and soil carbon storage in the baseline system state. The field was recently tilled (or not), and cover crop residues were just placed on the soil (or not). Actions (blue) affect net yield utility (not shown) via expenses (light green) and crop yield. Actions affect carbon credit utility by changing SOC via effects on soil abiotic (brown) and biotic (yellow) conditions. Nodes coloured light green are used to calculate utility at the end of the growing season. Intra-arcs between nodes indicate conditional dependencies. See Figure S2.2 for system dynamics between samples and variable descriptions.



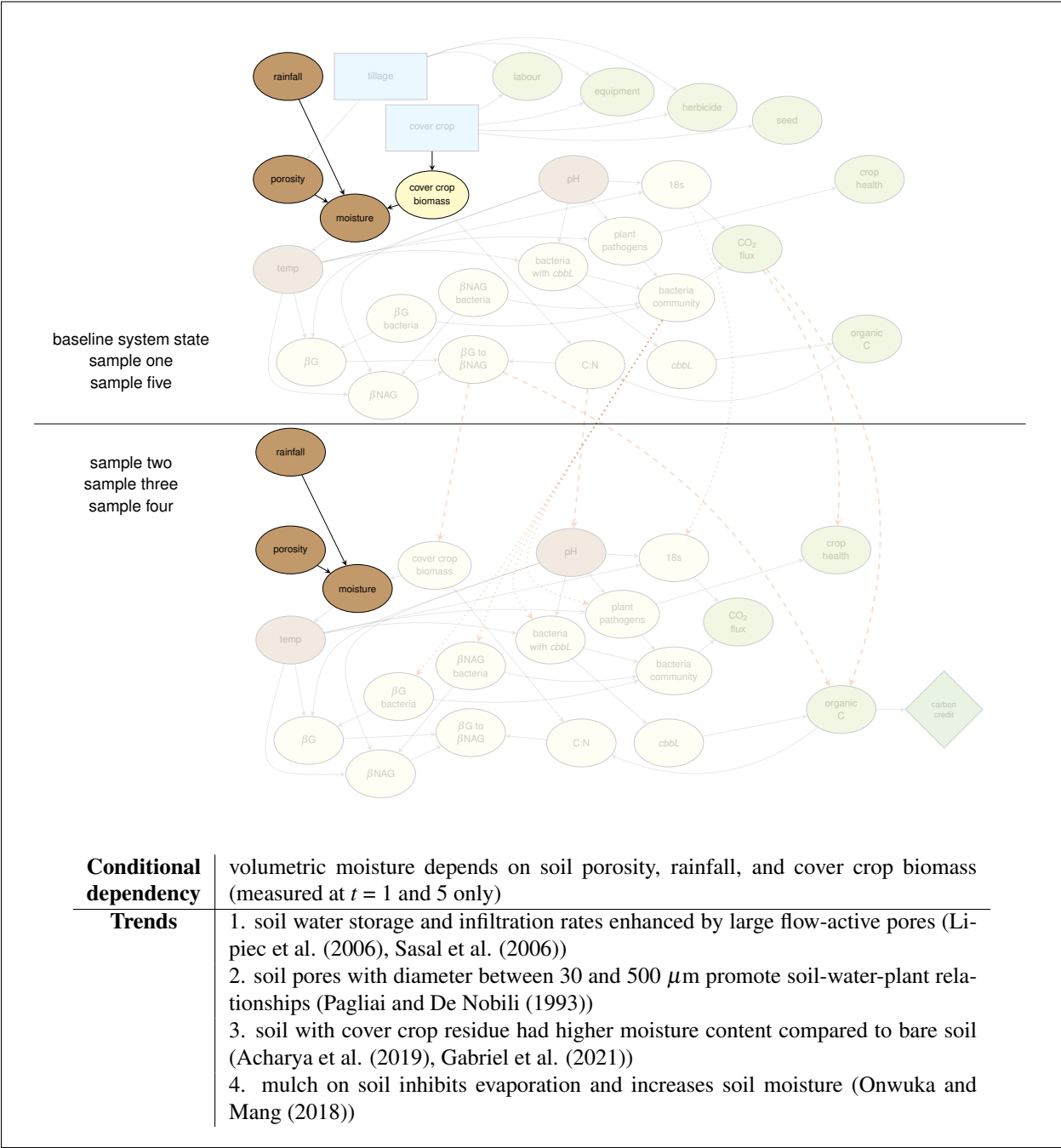
**Figure S2.2.a.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage.



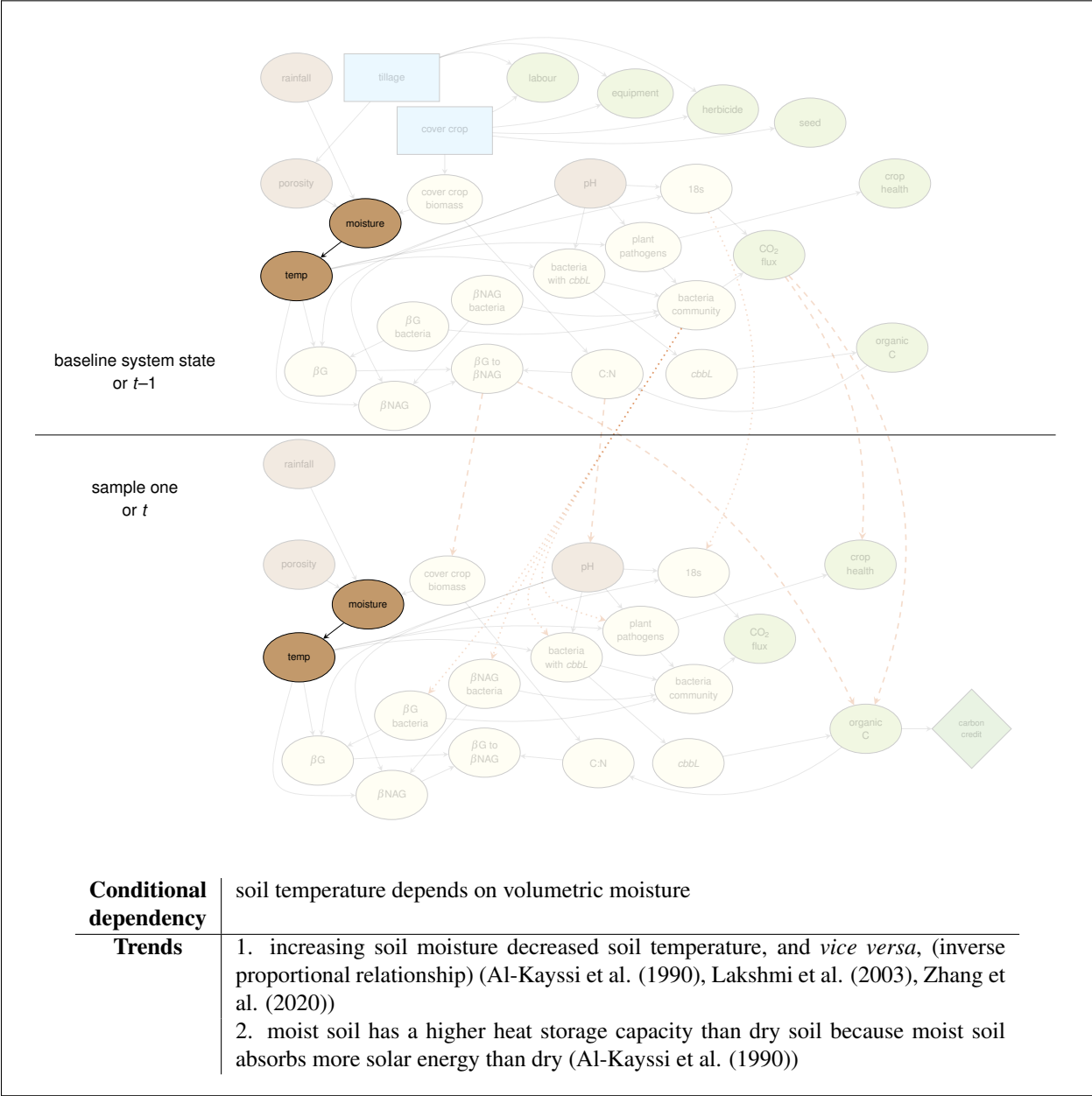
**Figure S2.2.b.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



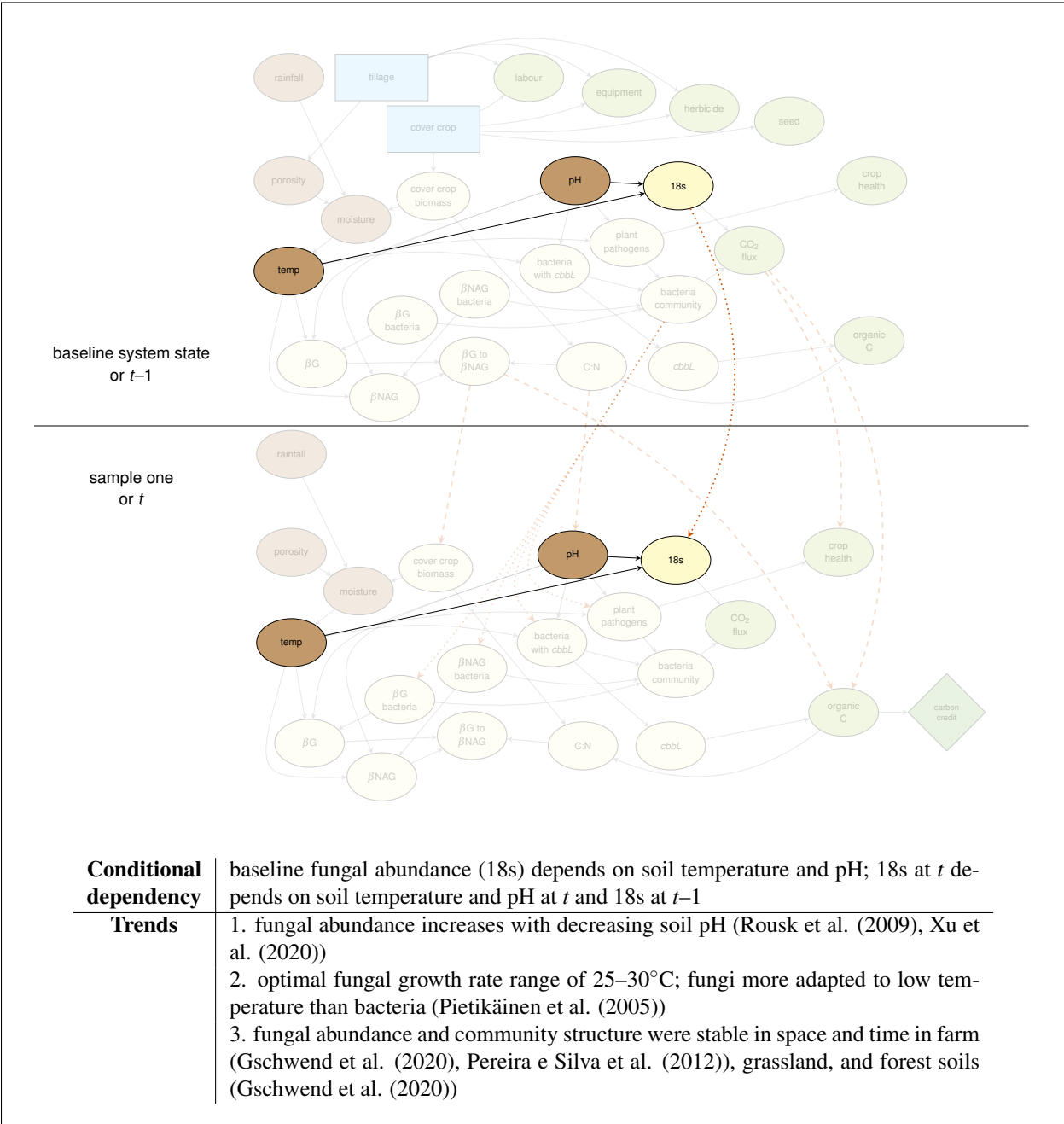
**Figure S2.2.c.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



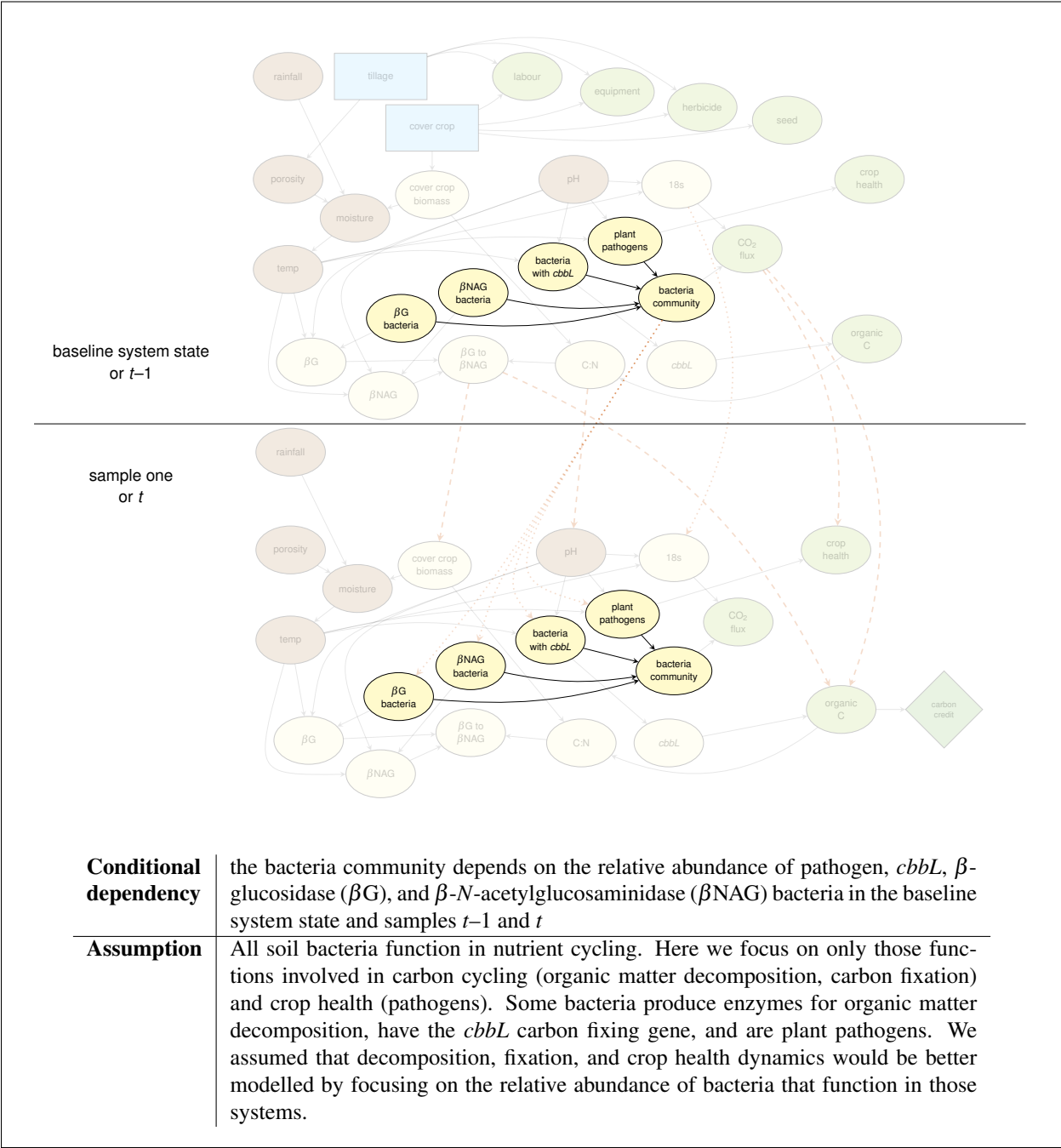
**Figure S2.2.d.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



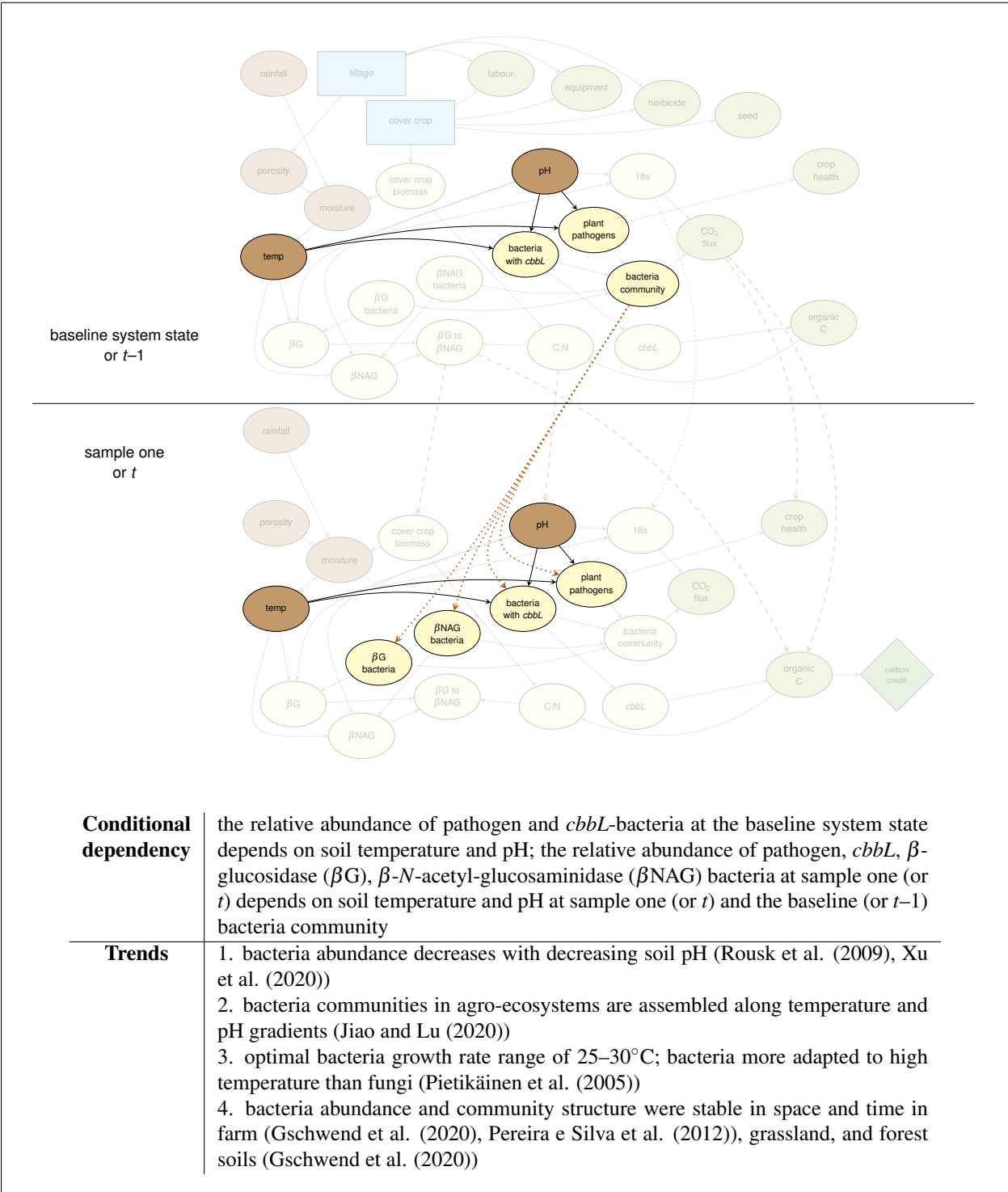
**Figure S2.2.e.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



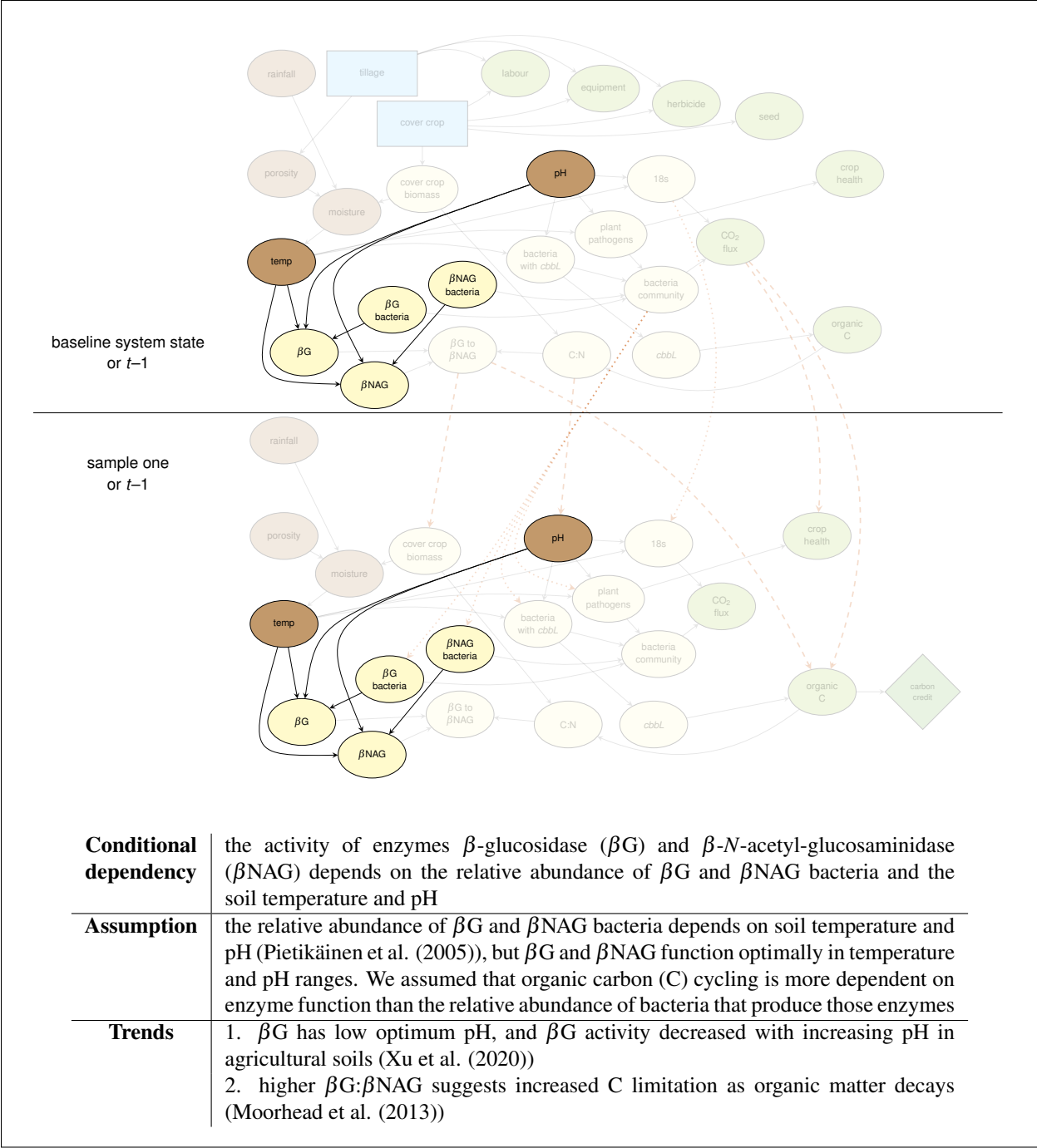
**Figure S2.2.f.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



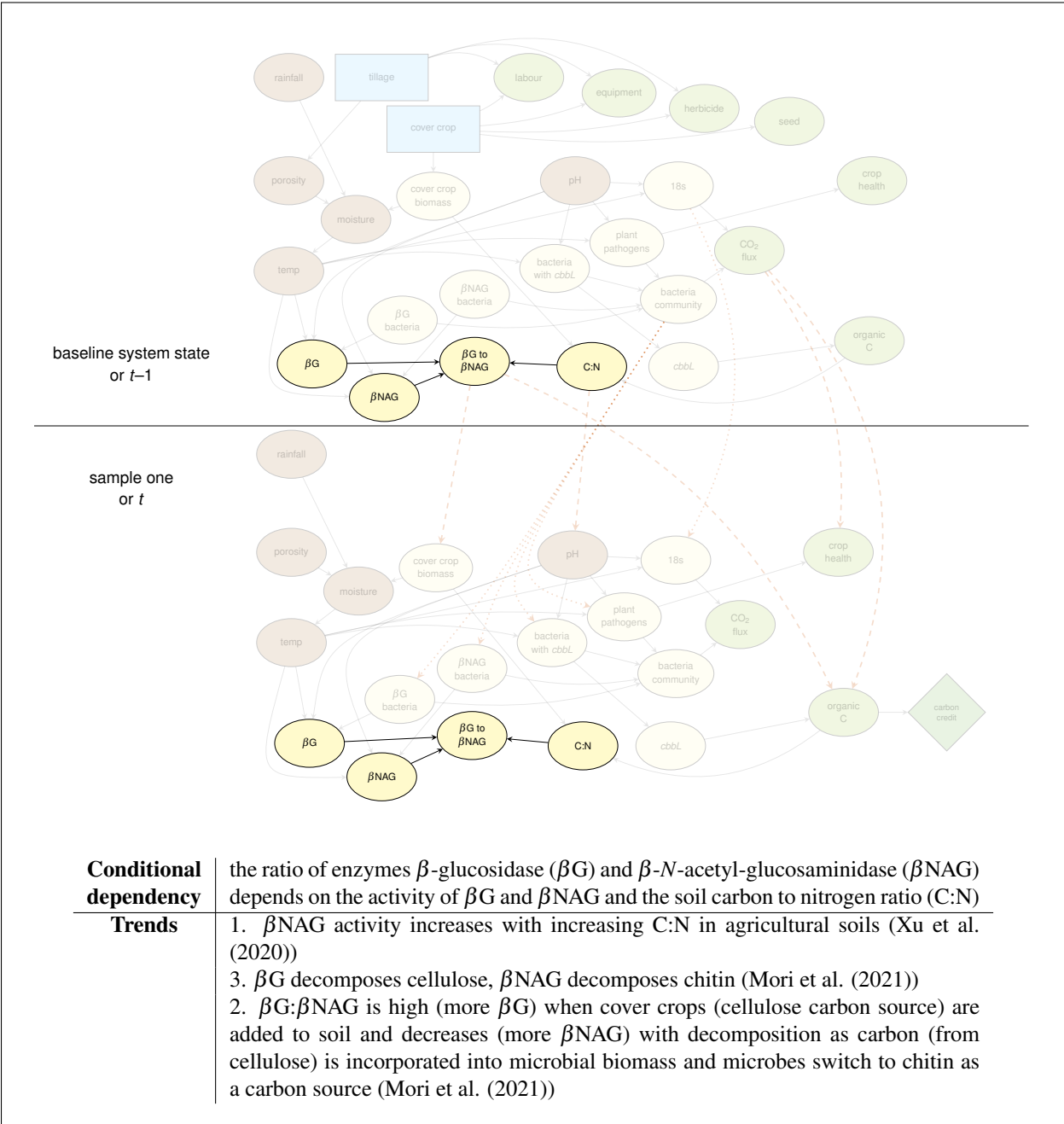
**Figure S2.2.g.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



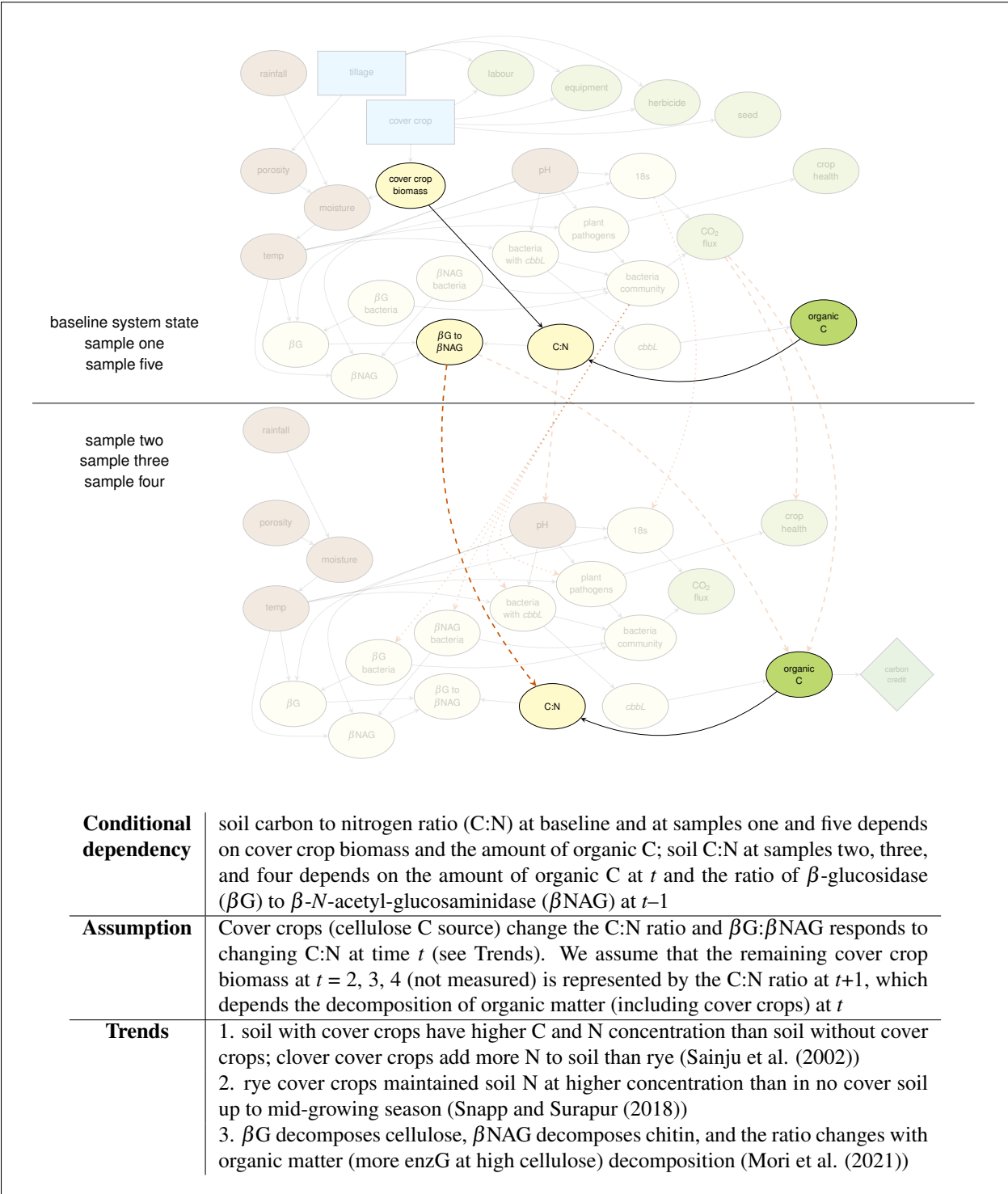
**Figure S2.2.h.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



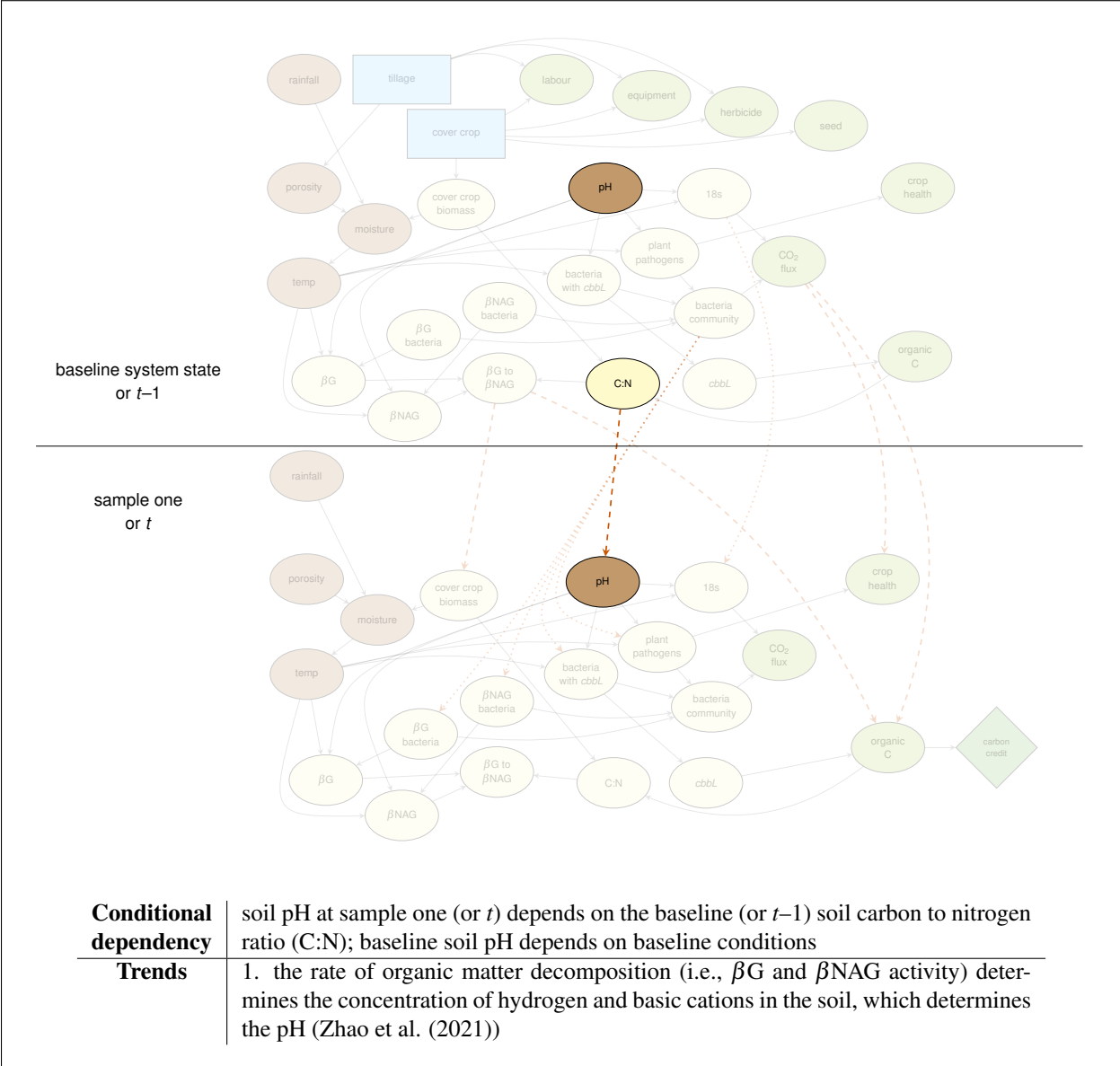
**Figure S2.2.i.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



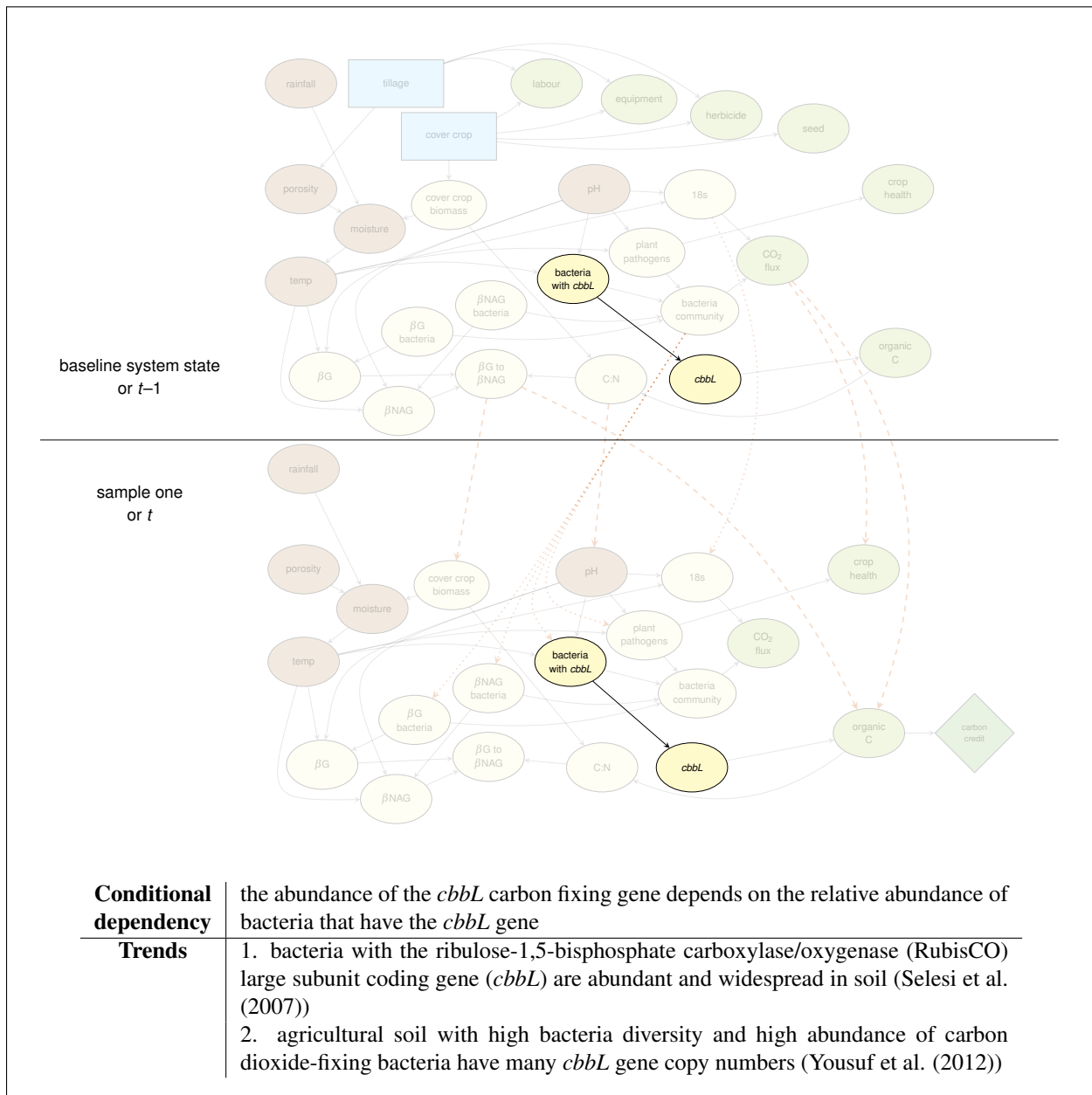
**Figure S2.2.j.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



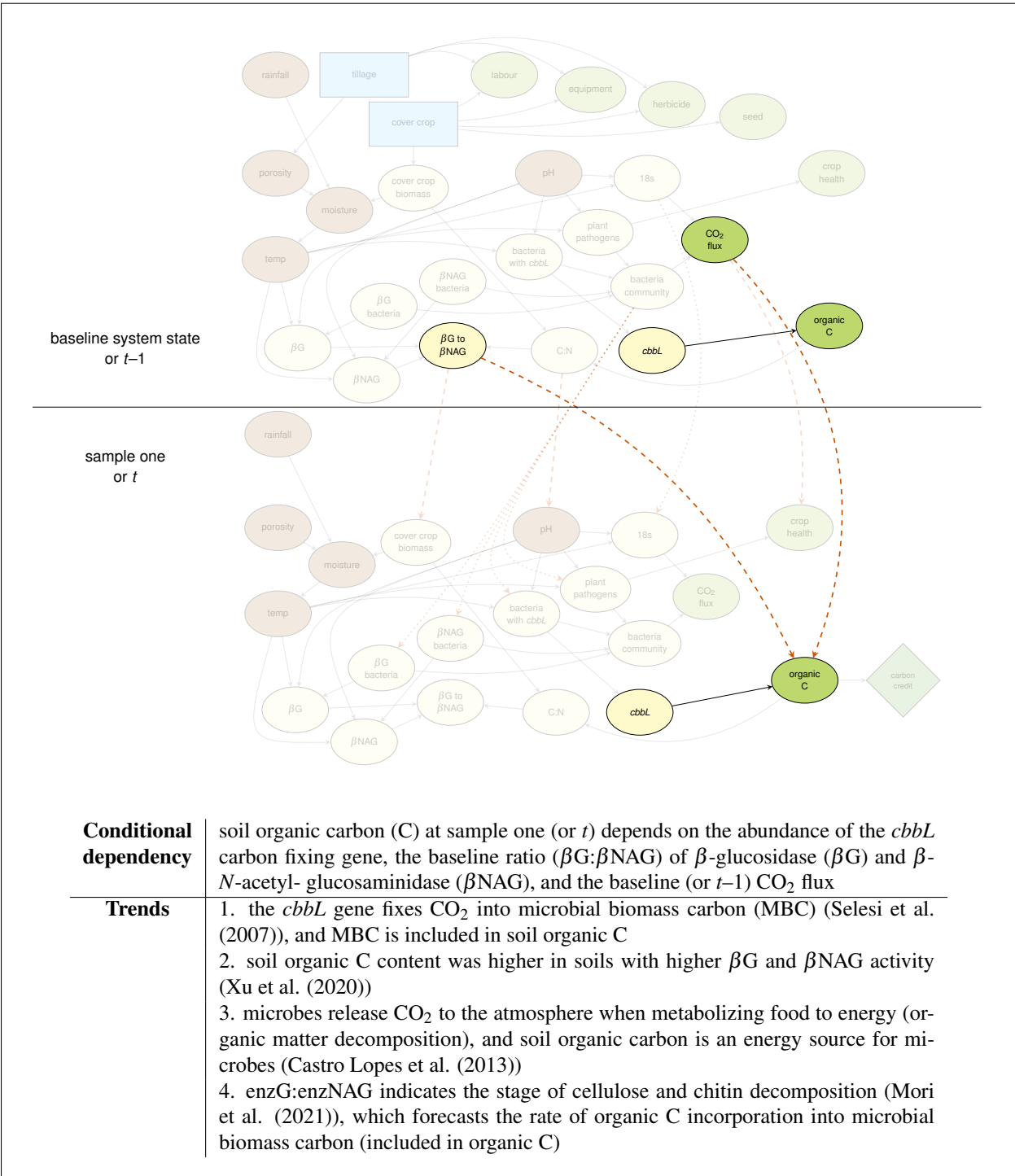
**Figure S2.2.k.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



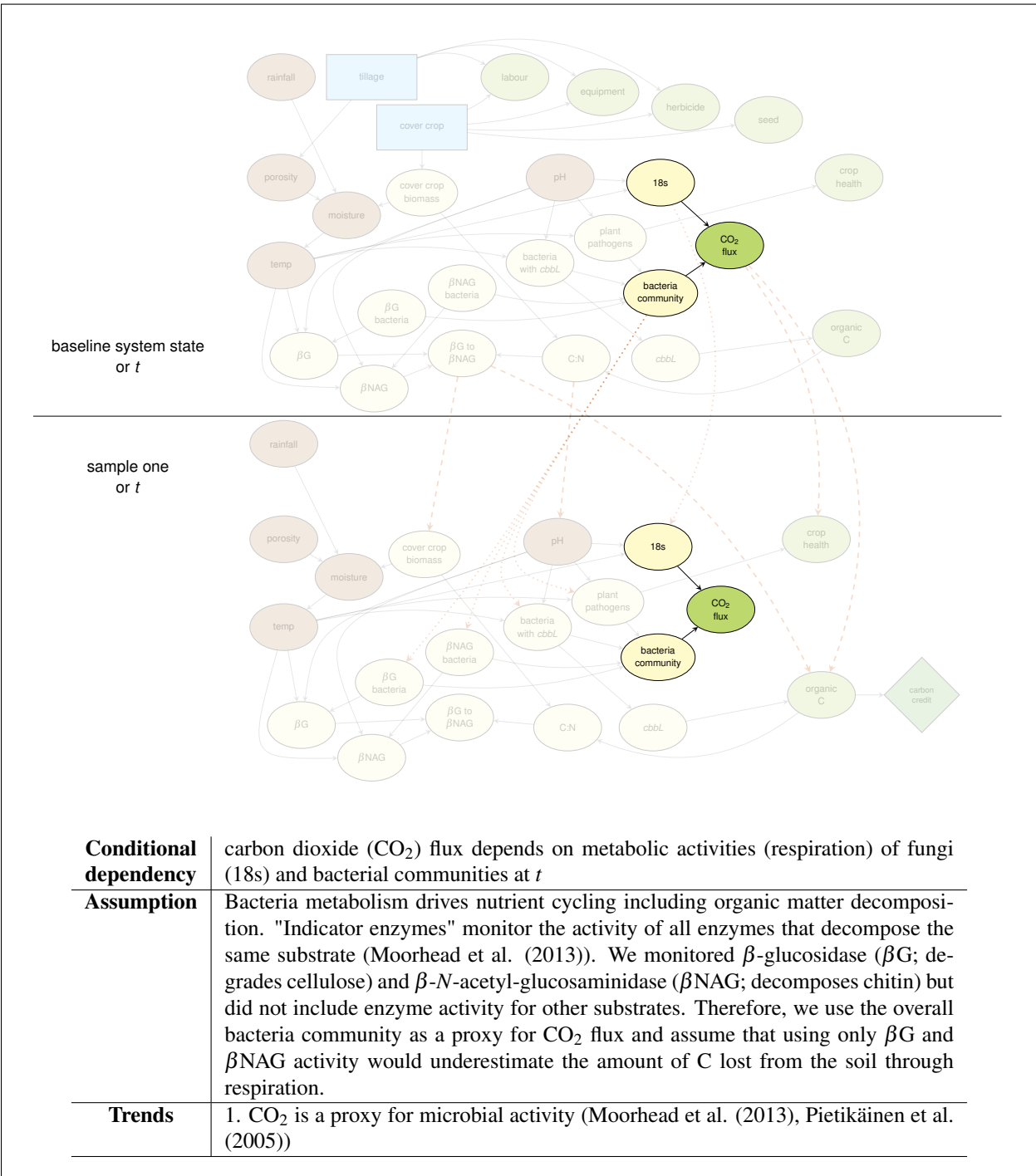
**Figure S2.2.1.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



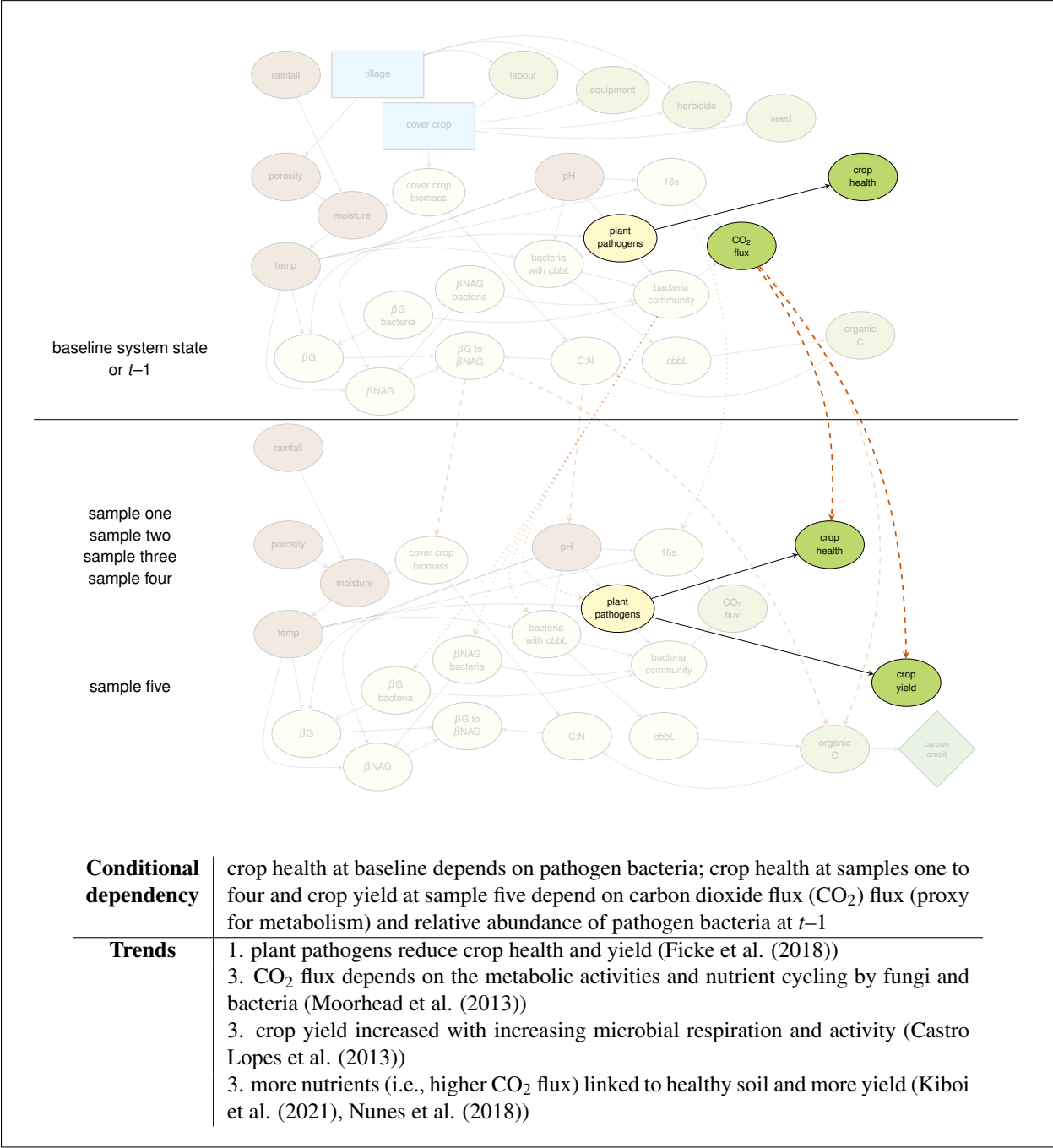
**Figure S2.2.m.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



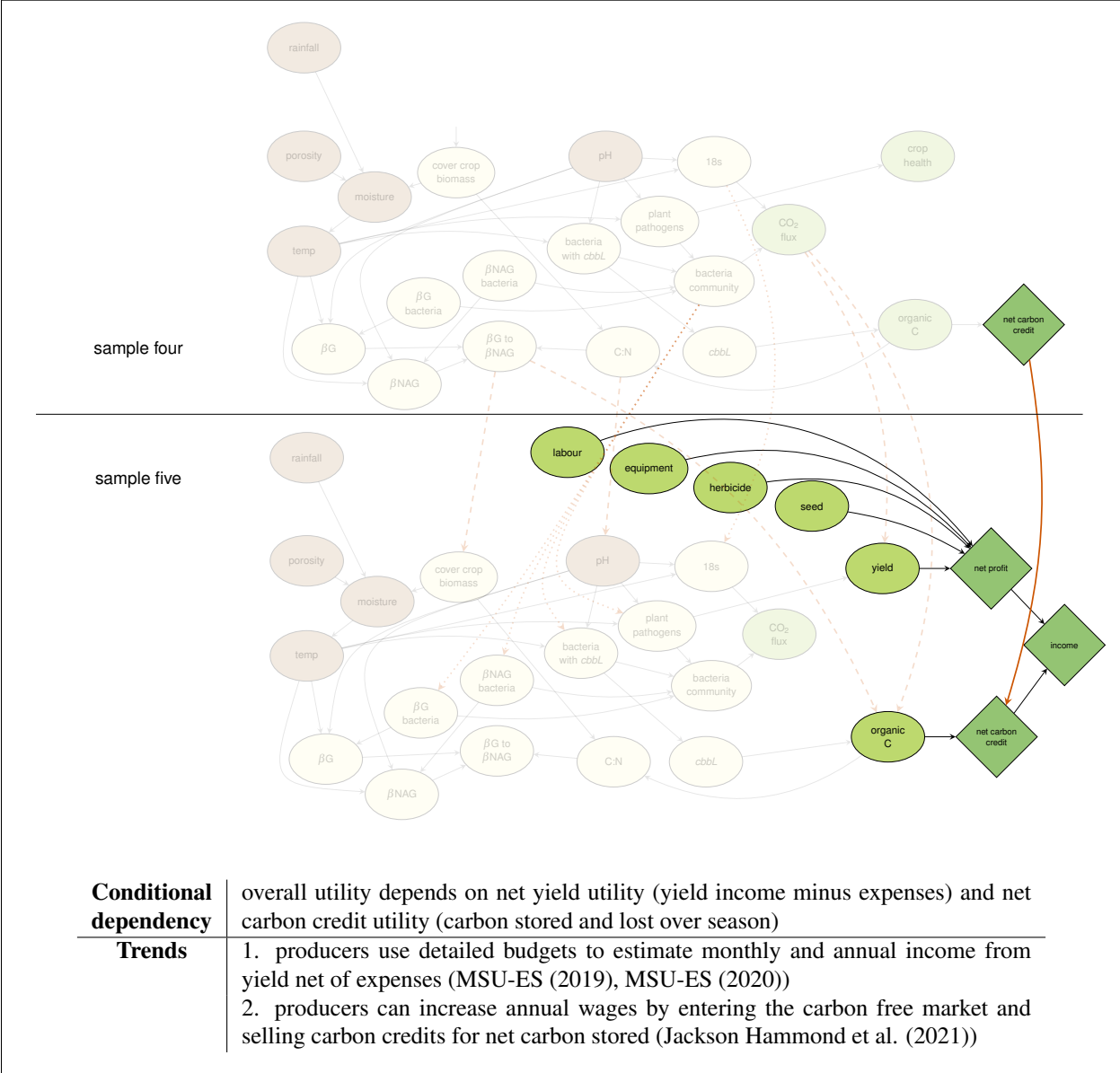
**Figure S2.2.n.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



**Figure S2.2.o.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



**Figure S2.2.p.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*



**Figure S2.2.q.** Trends and possible mechanisms underlying conditional dependencies in the conceptual BDN linking tillage and cover crop actions to net yield utility (crop health) and carbon credit utility from SOC storage. *continued*

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