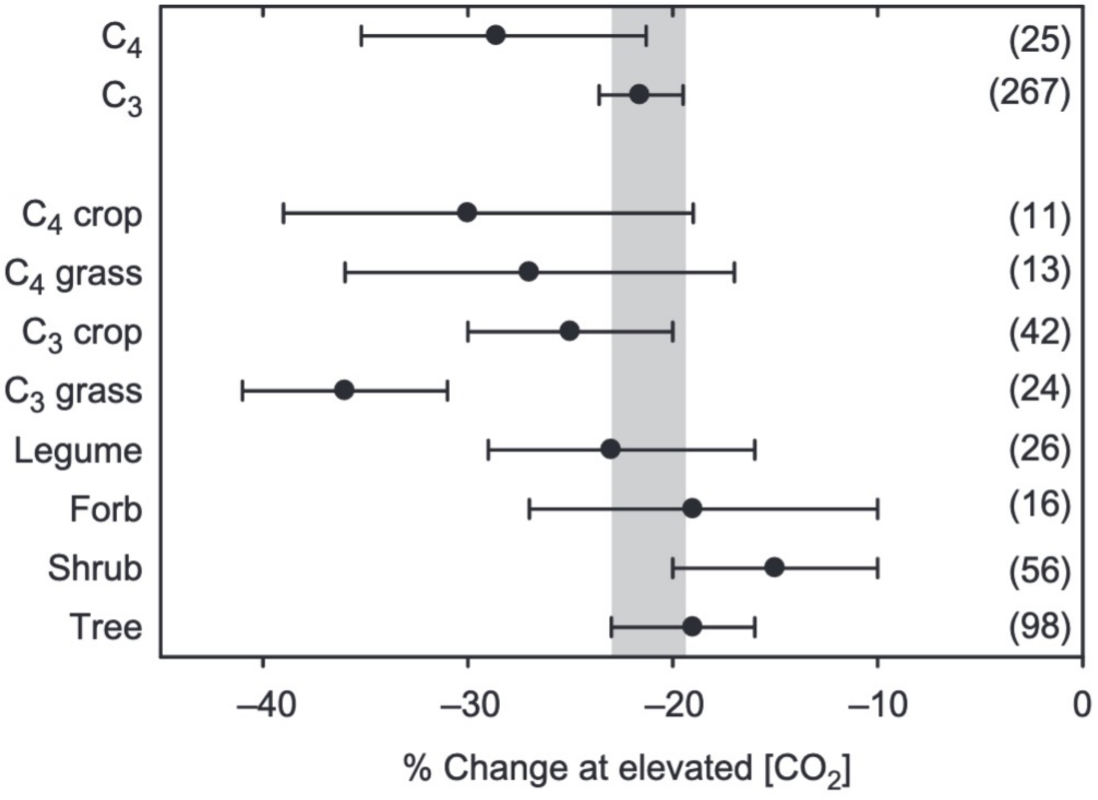
N x CO_2 x BNF growth chamber experiment

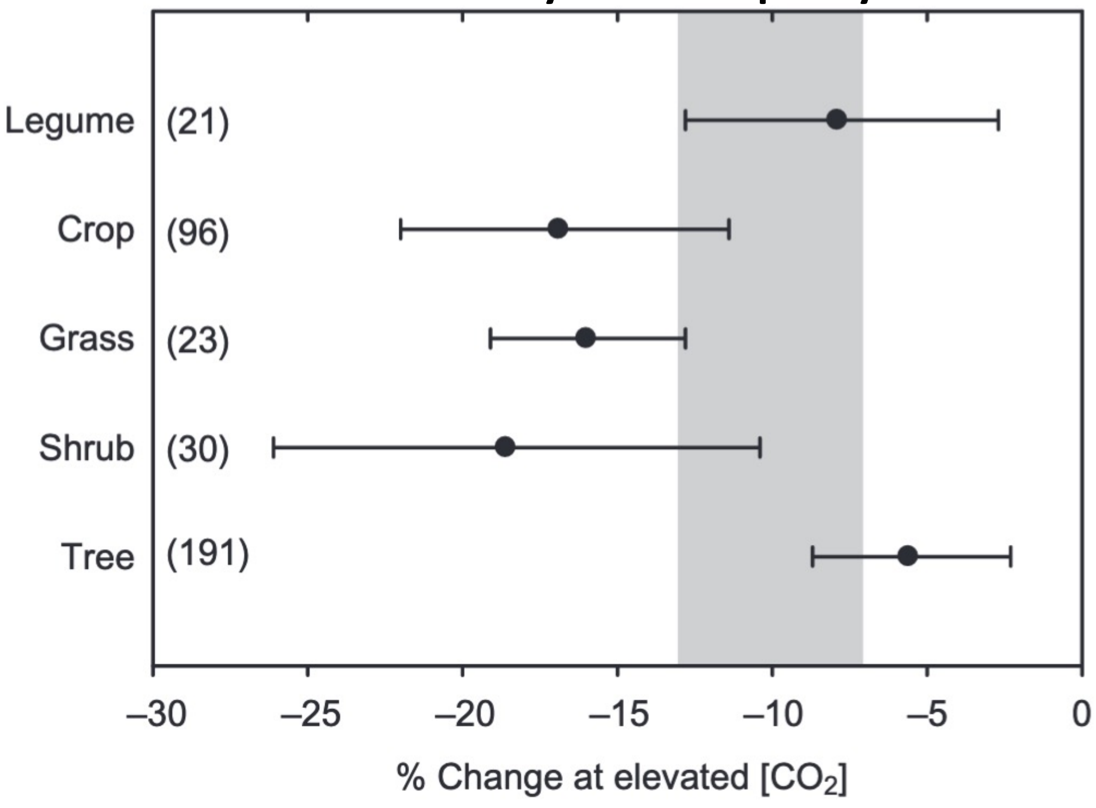
LEMONTREE Experimental Working Group – March 01, 2022

Increasing CO_2 generally decreases stomatal conductance and photosynthetic capacity…

Stomatal conductance



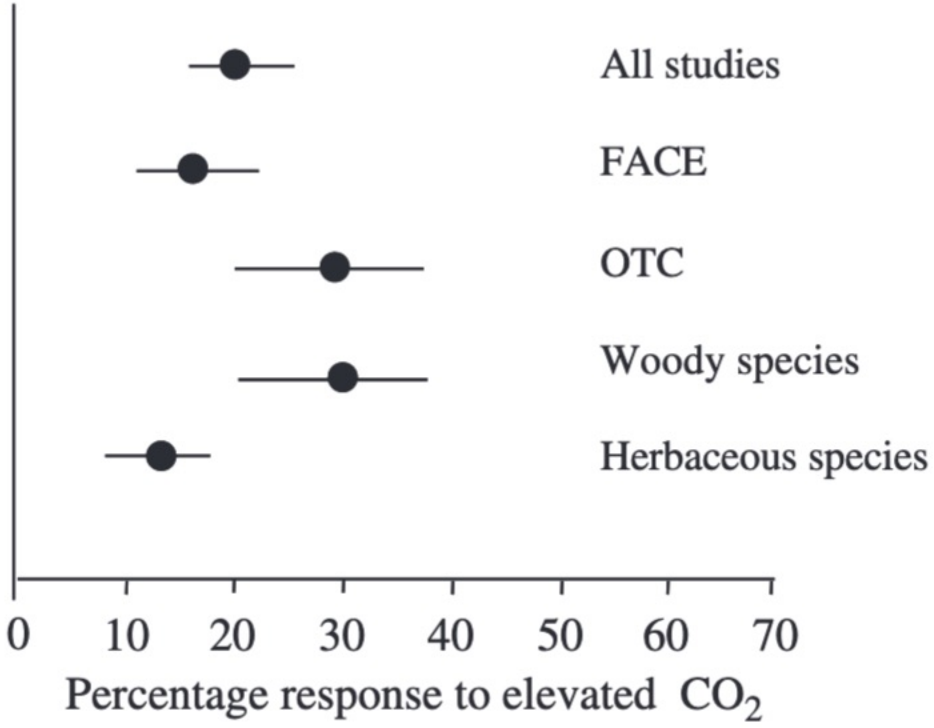
Photosynthetic capacity



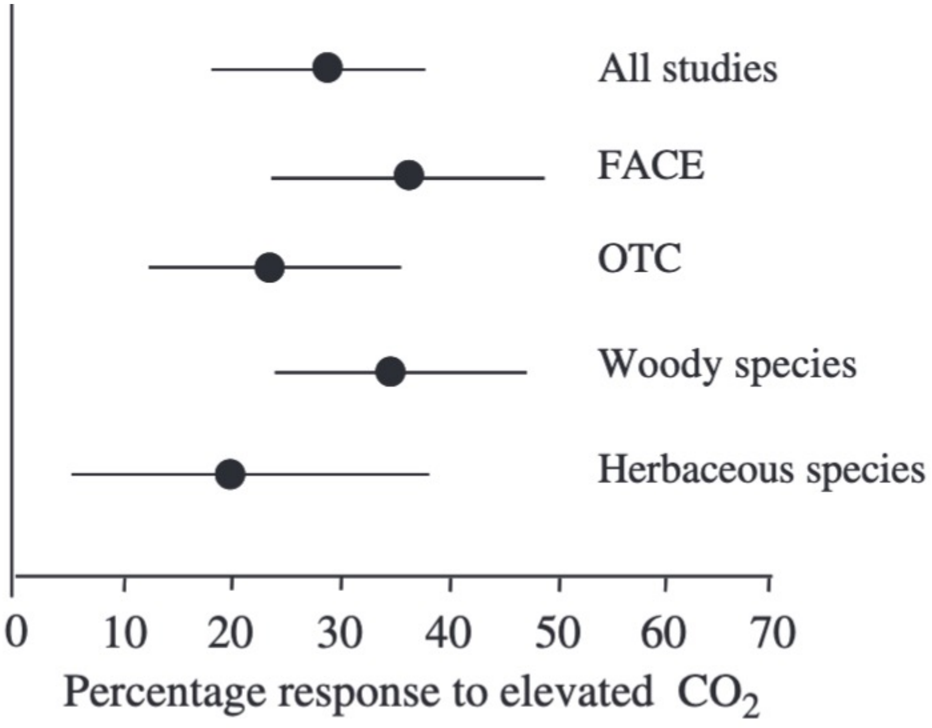
Ainsworth & Rogers (2007) *Plant, Cell & Environment*

… which tends to correspond with stimulations in whole plant growth

Aboveground biomass

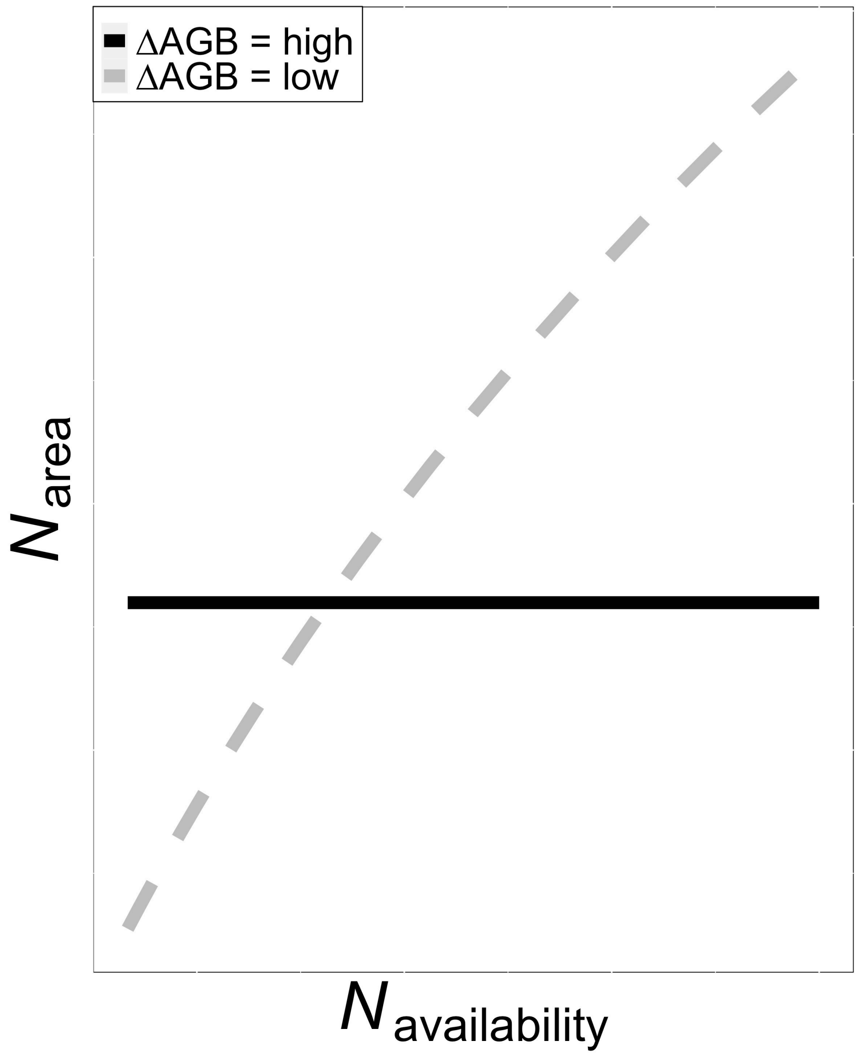


Belowground biomass



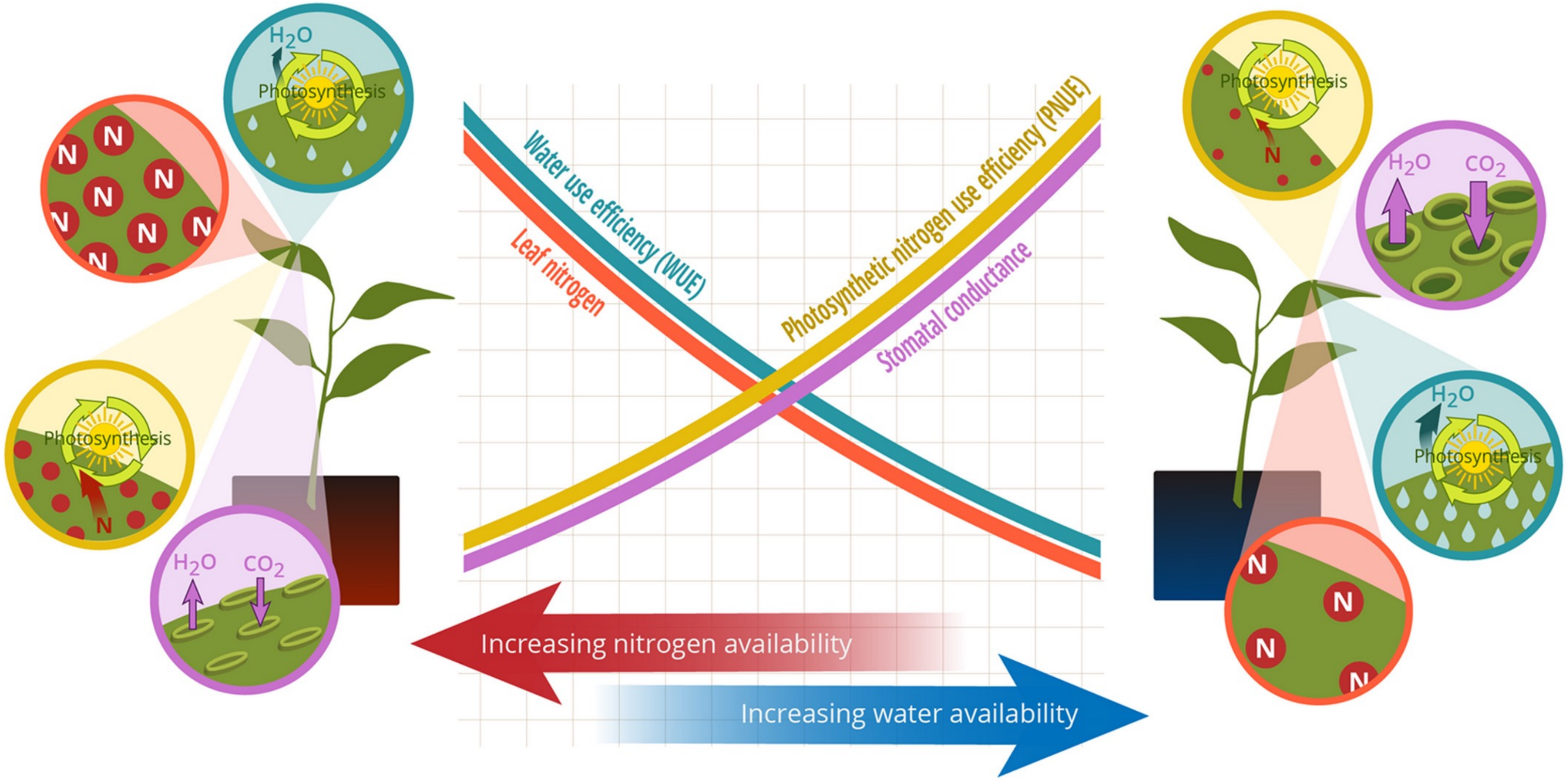
de Graaf et al. (2006) *Global Change Biology*

Discrepancies in leaf and whole plant responses to CO_2 may lead to tradeoffs between leaf and whole plant nutrient allocation



Smith et al. (in prep)

Maintain photosynthesis with greater water use efficiency at expense of nitrogen use efficiency, or vice versa



Bialic-Murphy et al. (2021) *Ecology Letters*

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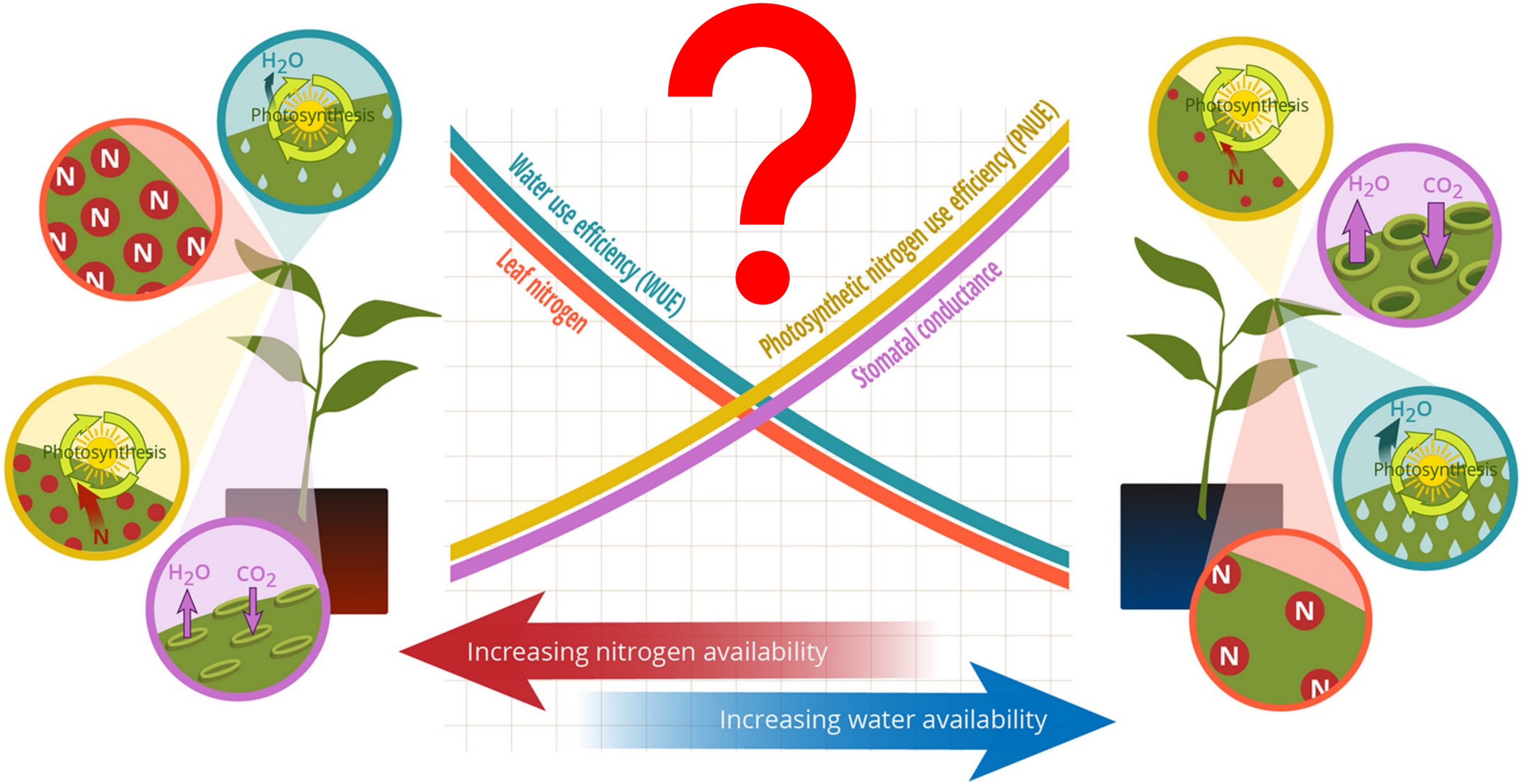

Bialic-Murphy et al. (2021) *Ecology Letters*

Key questions

How does atmospheric CO_2 modify effects of soil nutrient availability on tradeoffs between leaf nutrient allocation and whole plant growth?

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To what extent does inoculation with nitrogen-fixing bacteria influence the two questions listed above?

Experimental setup

- Growth chamber experiment
- Individually potted soybean (*Glycine max* L.)
- Planted in unfertilized, steam sterilized potting soil
- Will grow at maximum light setting on 16:8 light: dark schedule and constant temperature (25°C) for 8-week period

Experimental setup

Nutrient acquisition strategy treatments

- + BNF
- - BNF

Soil nitrogen treatments

- 0 ppm N
- 70 ppm N
- 140 ppm N
- 210 ppm N
- 280 ppm N
- 350 ppm N

Atmospheric carbon dioxide treatments

- 400 ppm CO_2
- 1000 ppm CO_2

All treatments will be combined in a full-factorial design with 6 reps per treatment combination (n = 144 total)

Plant measurements

Leaf measurements

- Leaf nitrogen allocation (N_{mass}; SLA; N_{area})
- A_{net}, V_{cmax25}, J_{max25}, g_s, R_{d25}
- J_{max25}:V_{cmax25}; R_{d25}:V_{cmax25}; stomatal limitation
- PNUE, χ (from leaf $\delta^{13}C$), N_{area}:g_s, V_{cmax}:g_s

Whole plant measurements

- Carbon costs to acquire nitrogen (Root carbon mass / whole plant nitrogen mass)
- Whole plant biomass
- Total leaf area
- Root nodule number, root nodule biomass

Timeline for Experiment 4

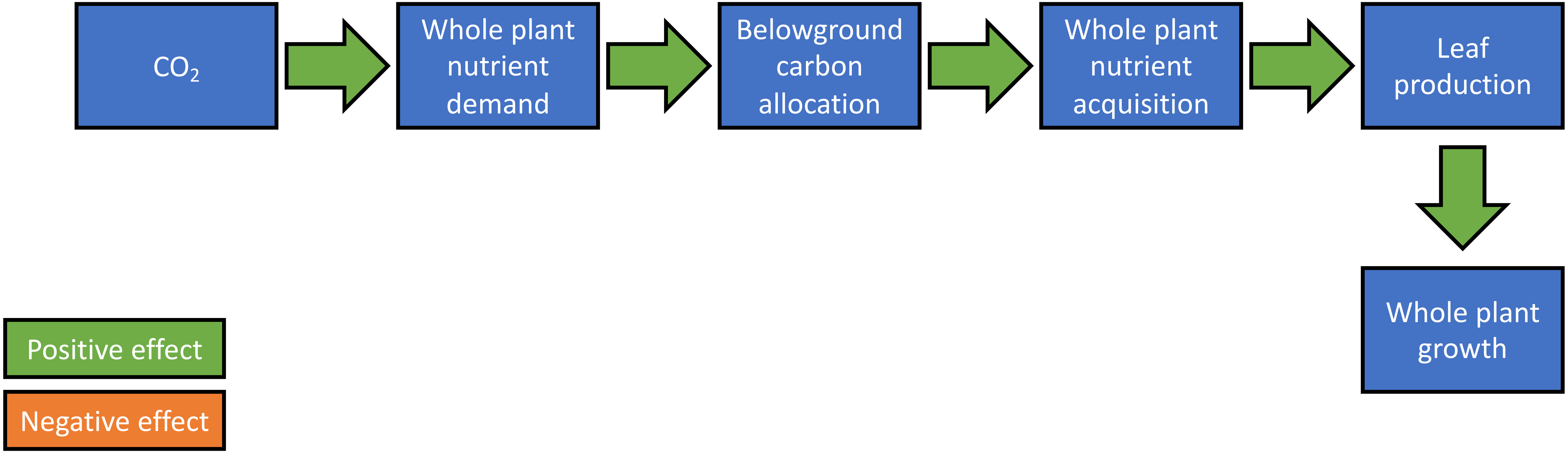
- Start experiment in March/April 2022; end in May/June 2022

- Harvest and tissue processing finished by August 2022

- Data analysis finished by September 2022
  - Could perhaps lead a working group meeting on results

Extra slides

Hypothesis 1a: Increasing CO_2 should increase leaf production and whole plant growth through a stimulation in whole plant nutrient demand



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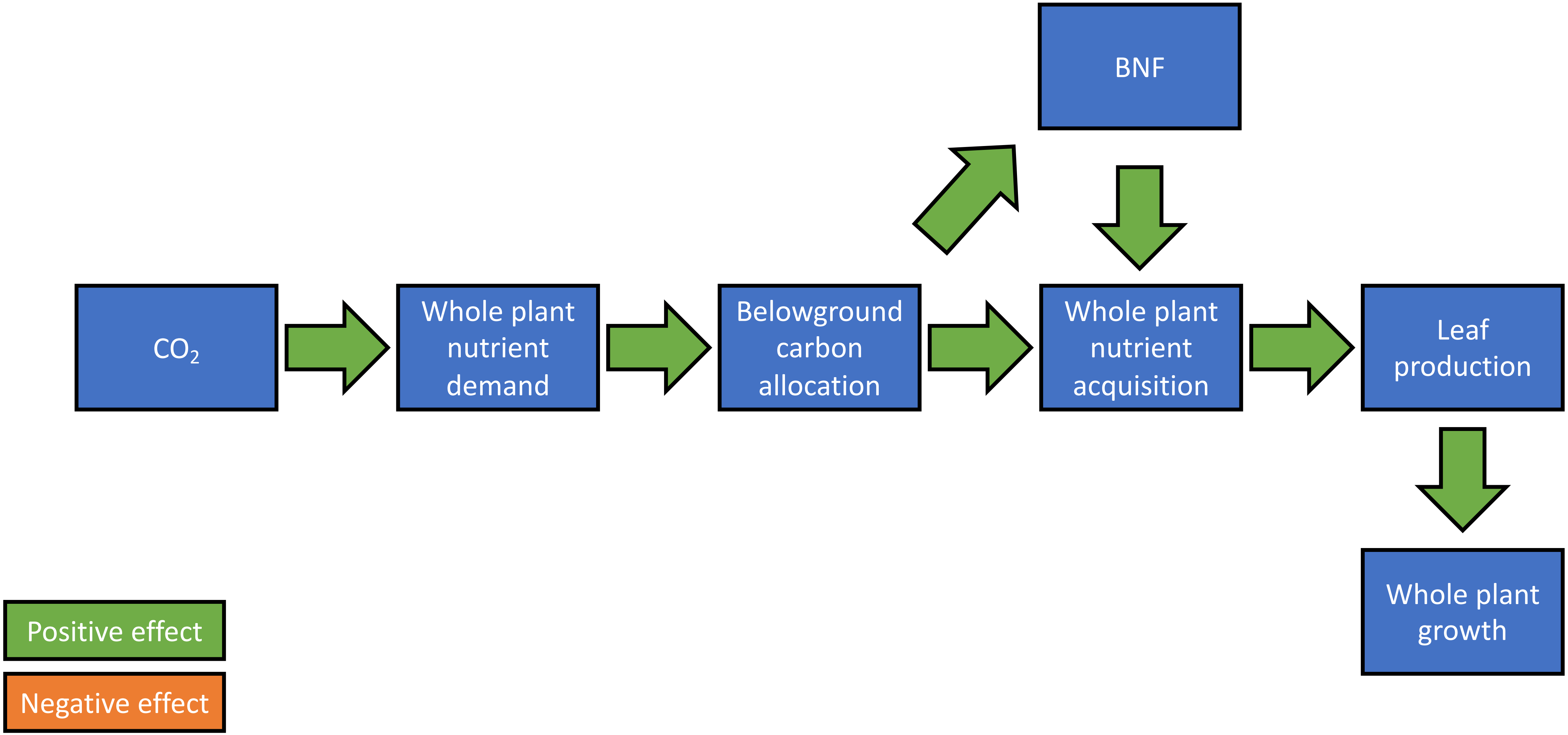
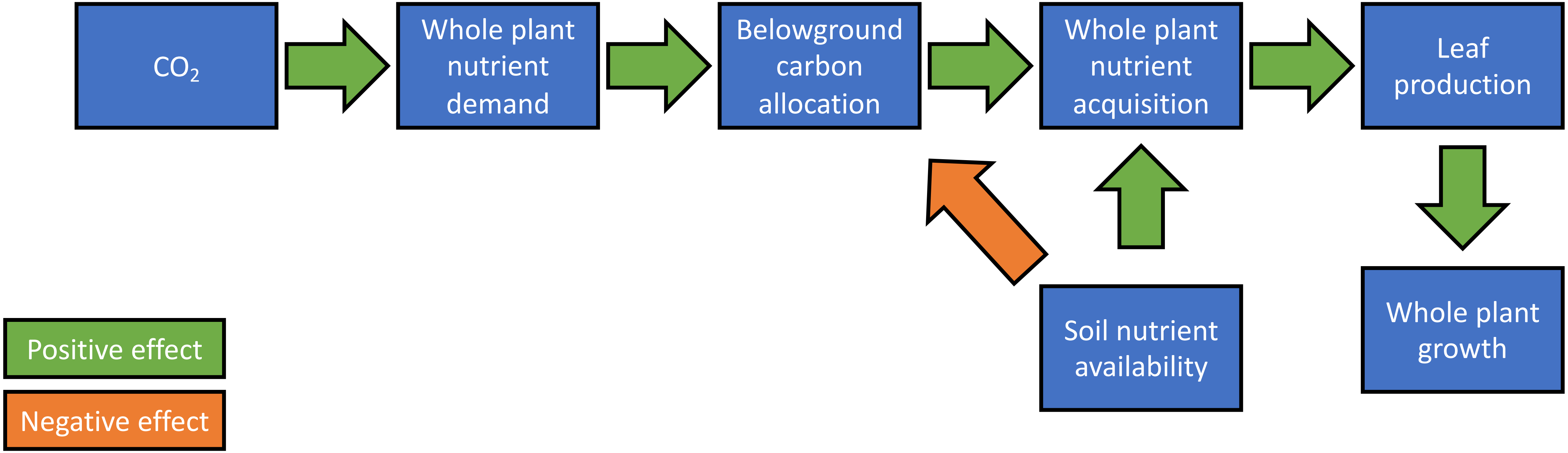
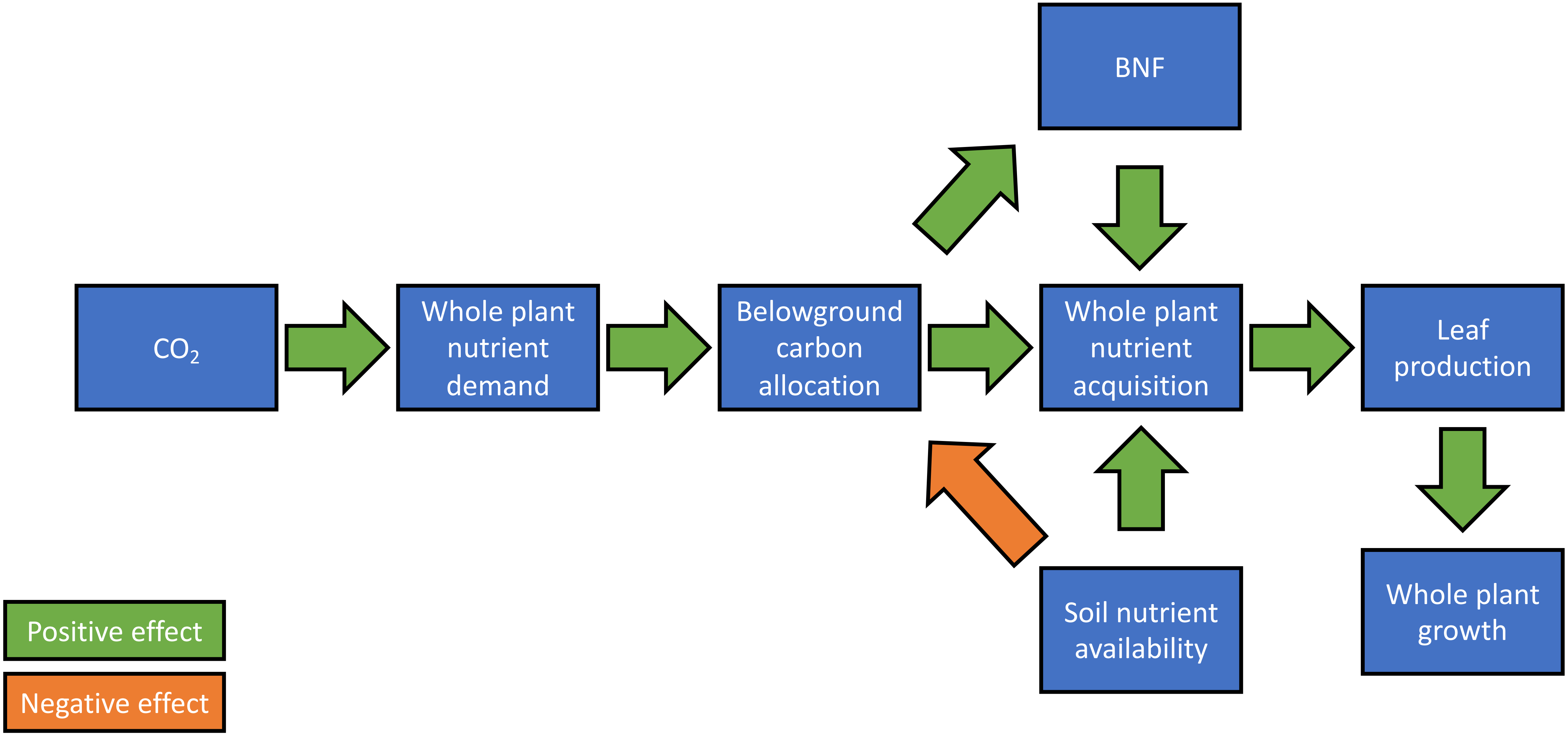


Hypothesis 1b: Increased soil nutrient supply should increase the positive effect of eCO_2 on leaf production and whole plant growth



Hypothesis 1b: Increased soil nutrient supply should increase the positive effect of eCO_2 on leaf production and whole plant growth, **but will depend on whether individuals associate with nitrogen-fixing bacteria**



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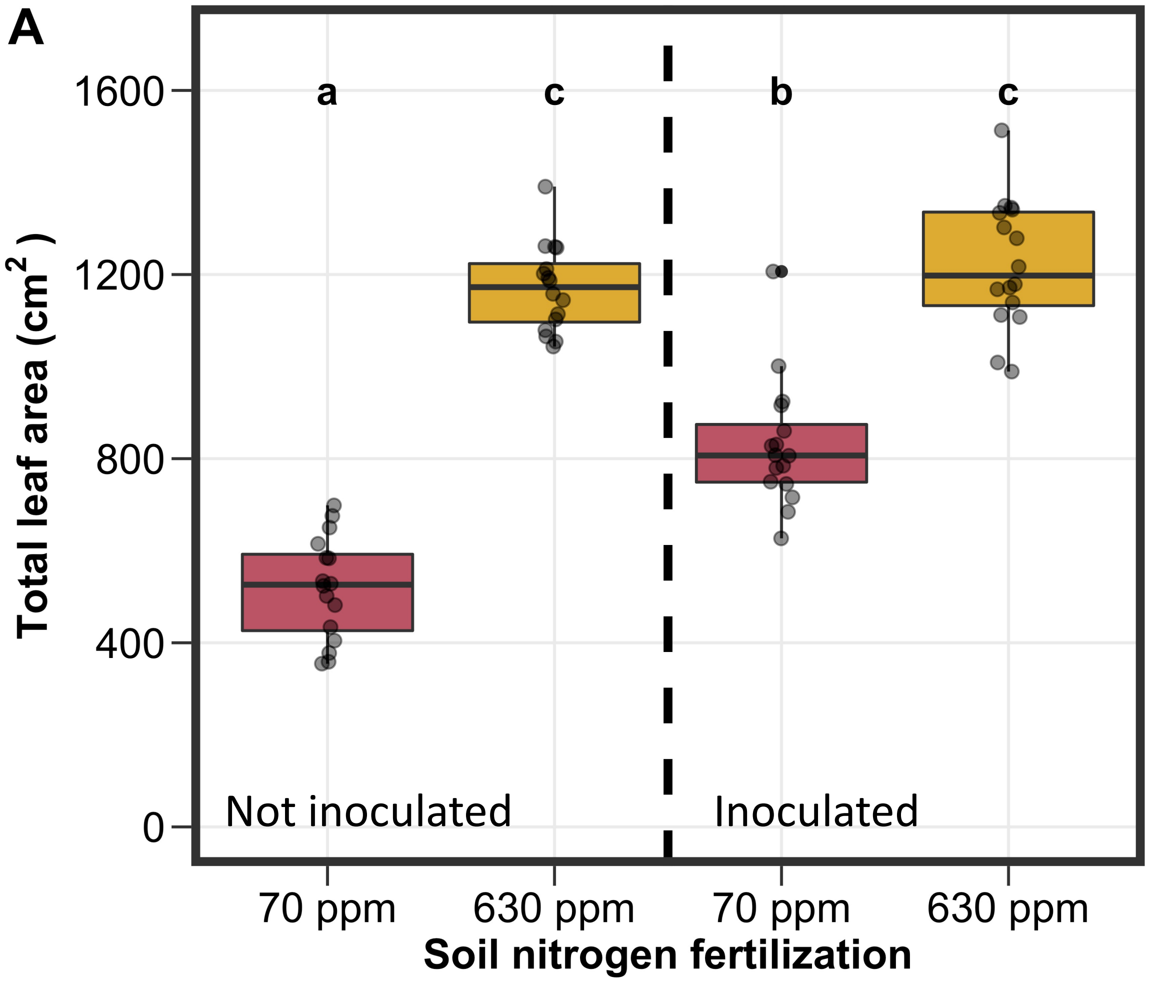
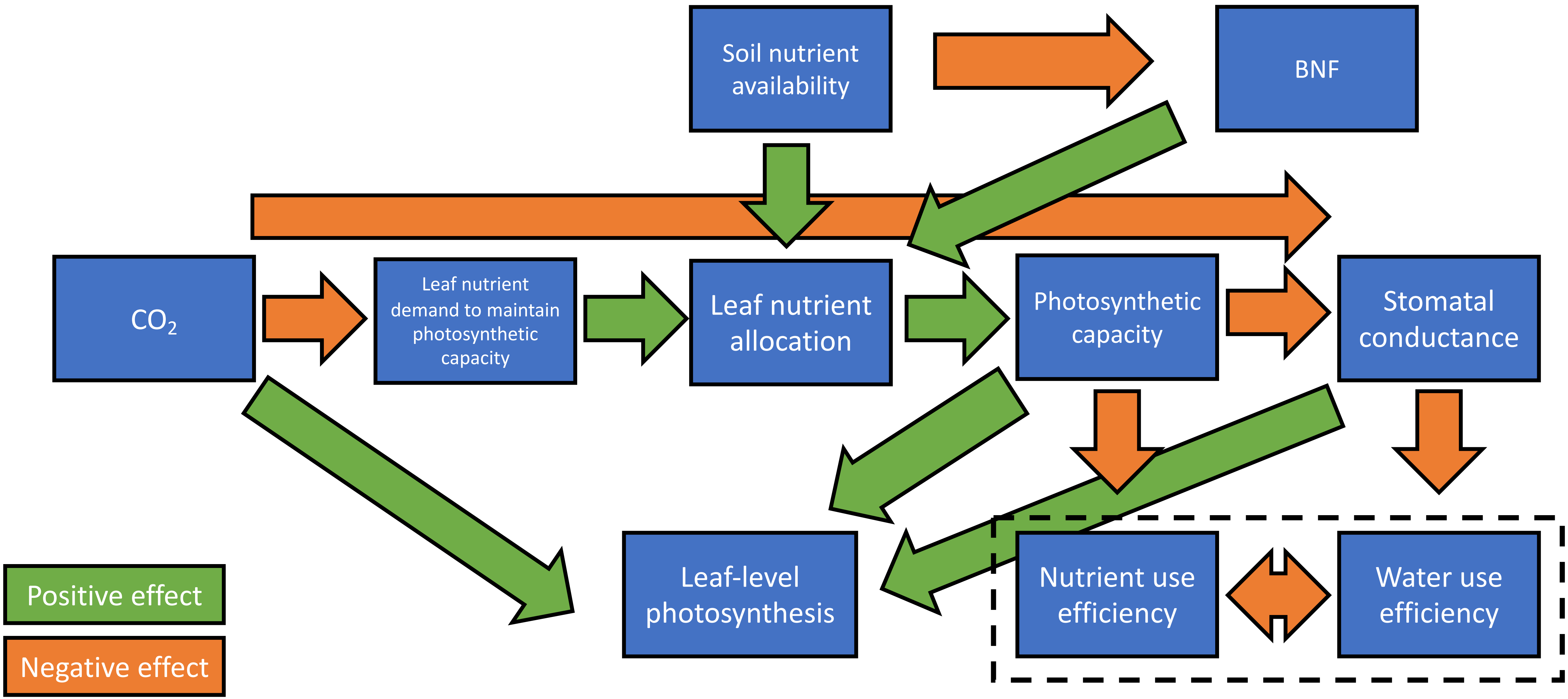
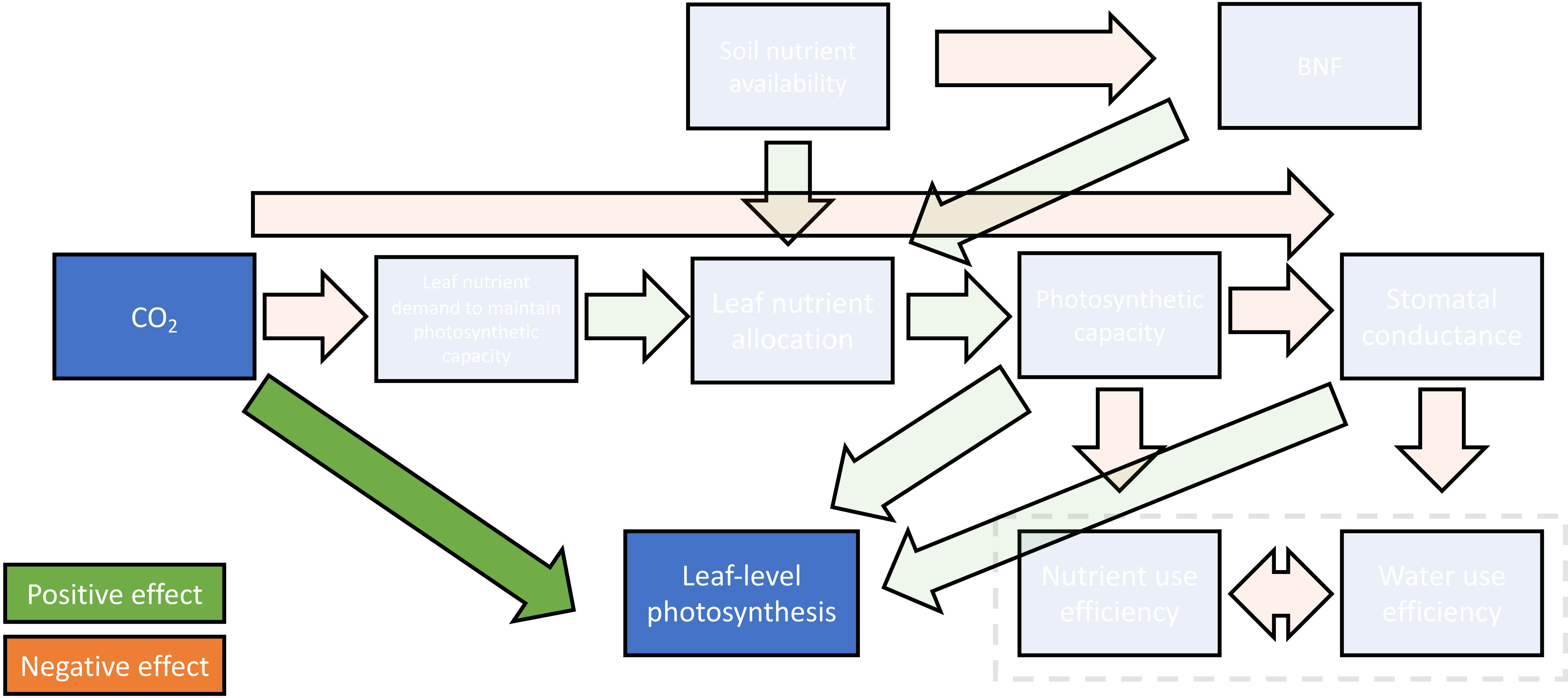


Inoculation with BNF should increase total leaf area and growth under low soil nutrients, but have similar total leaf area and growth under high soil nutrients

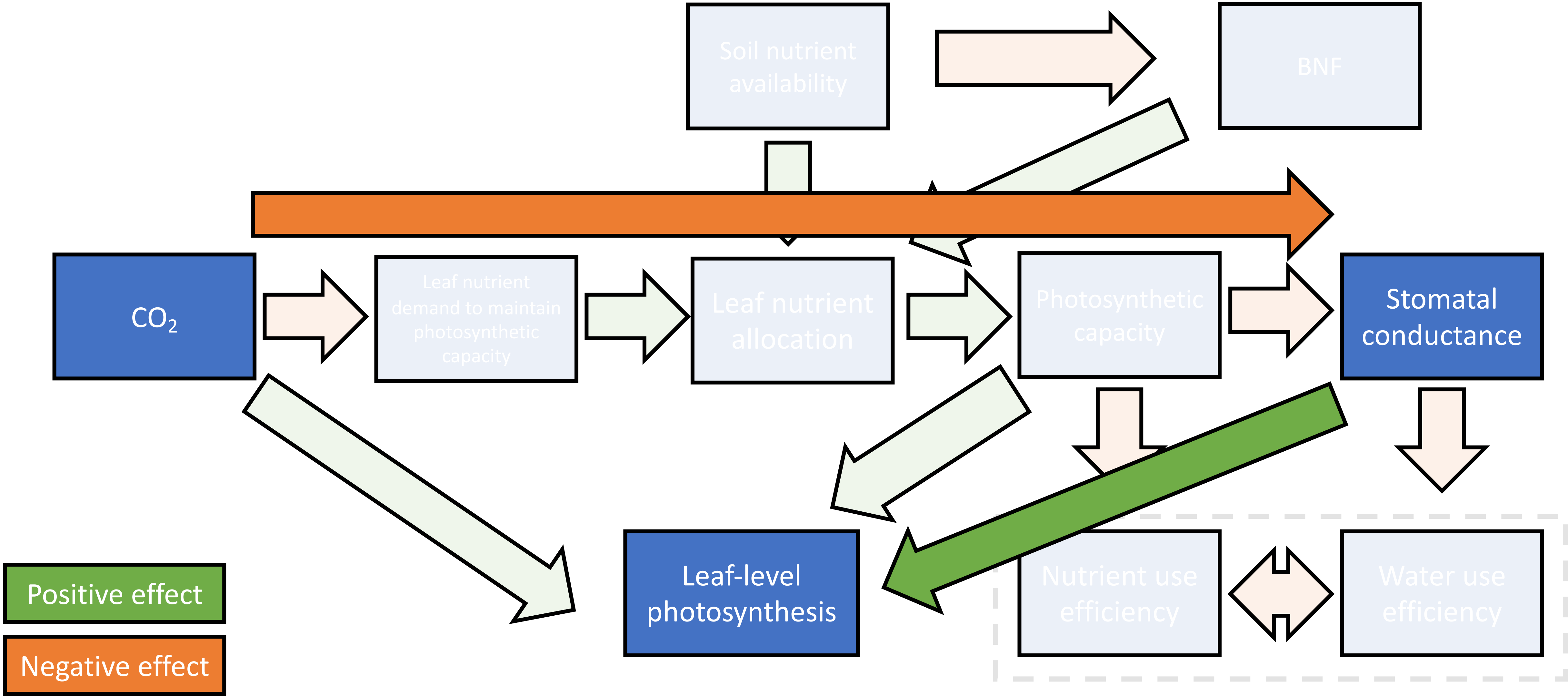
Hypothesis 2



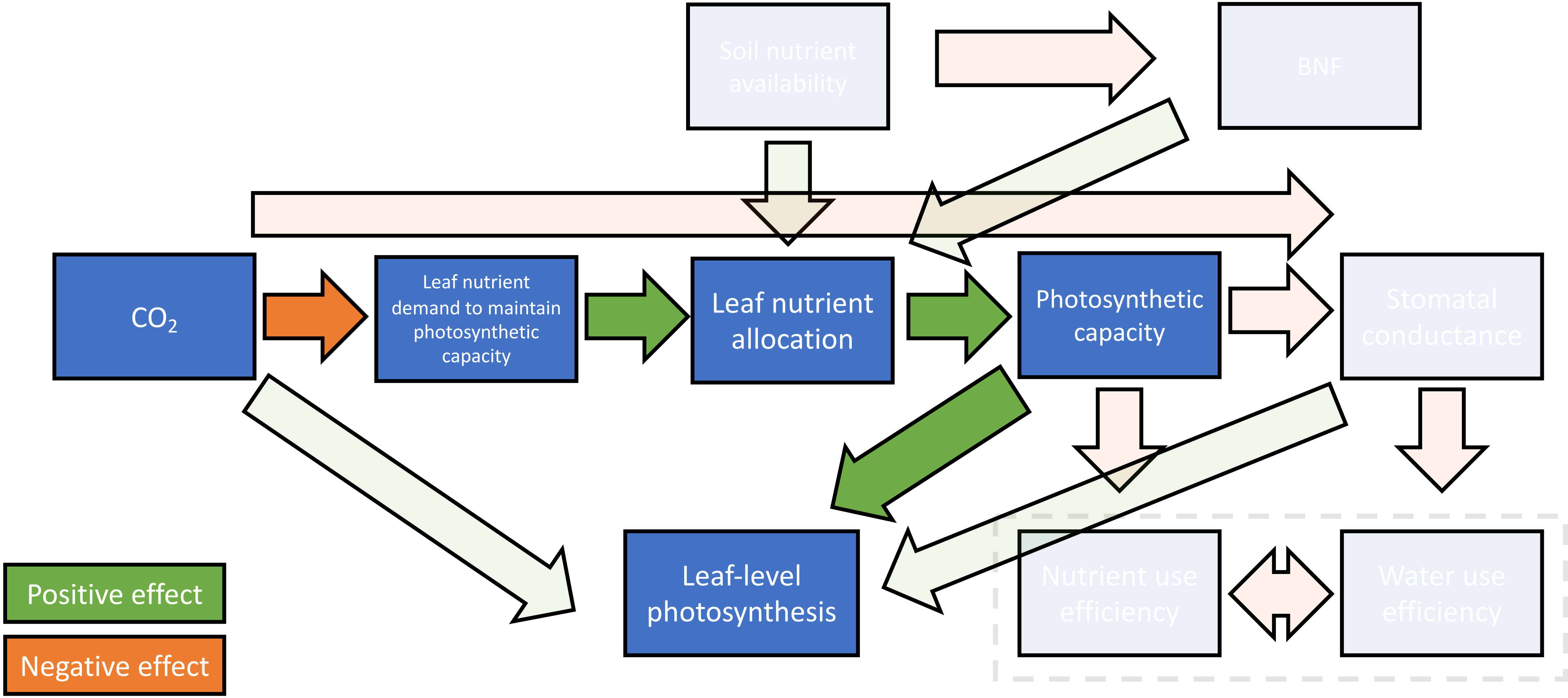
Hypothesis 2a: Increasing CO_2 will have a direct positive effect on leaf-level photosynthesis due to increased substrate needed to drive photosynthesis forward



Hypothesis 2b: Increasing CO_2 will decrease leaf-level photosynthesis as a function of reduced stomatal conductance



Hypothesis 2c: Increasing CO_2 will decrease leaf-level photosynthesis as a function of reduced maintenance costs for photosynthetic capacity



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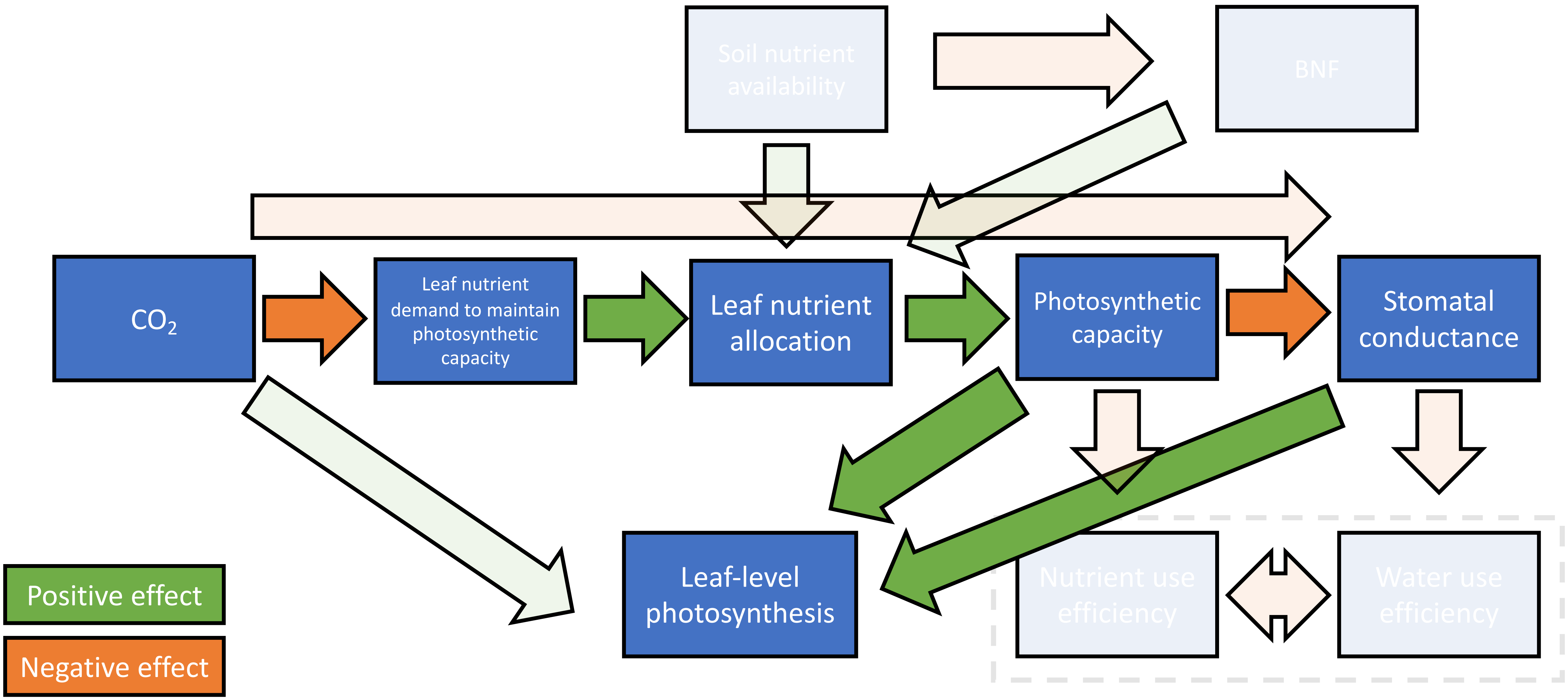

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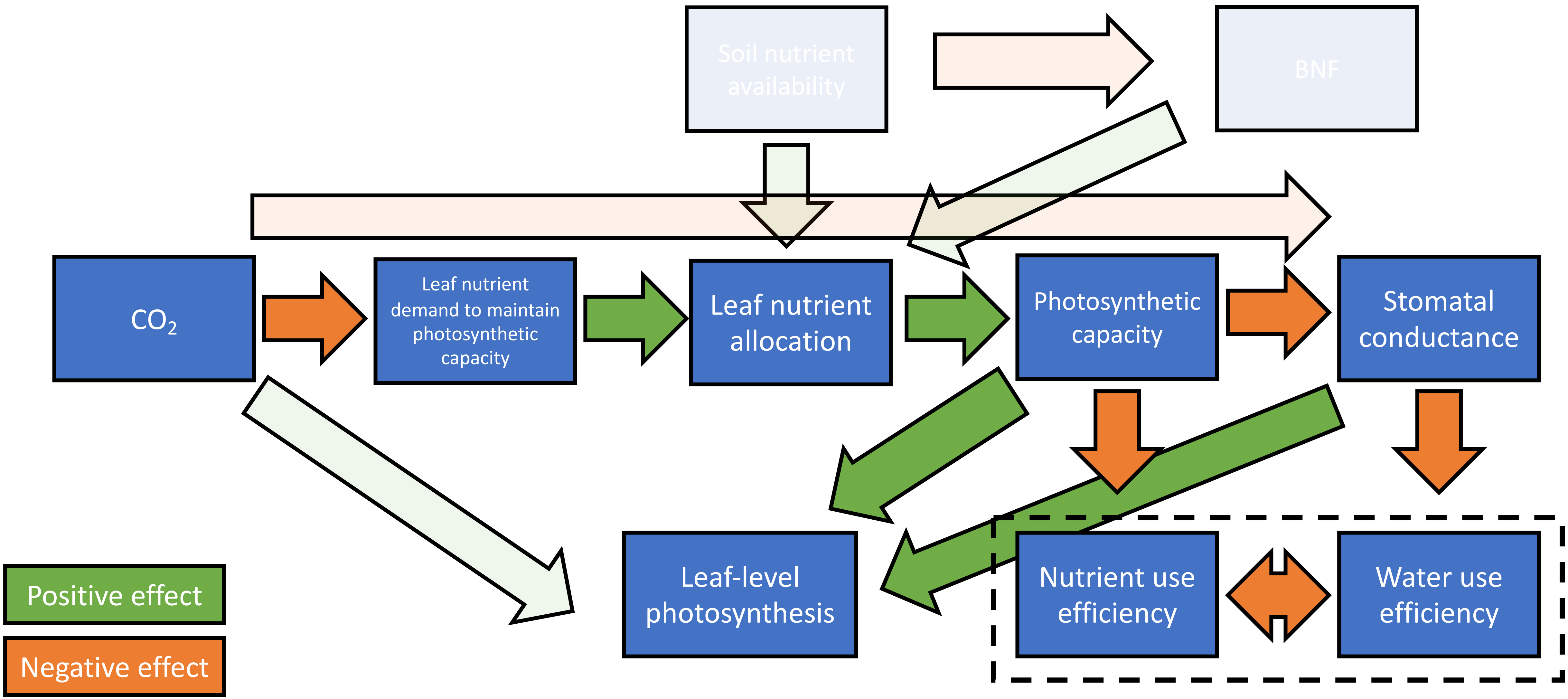

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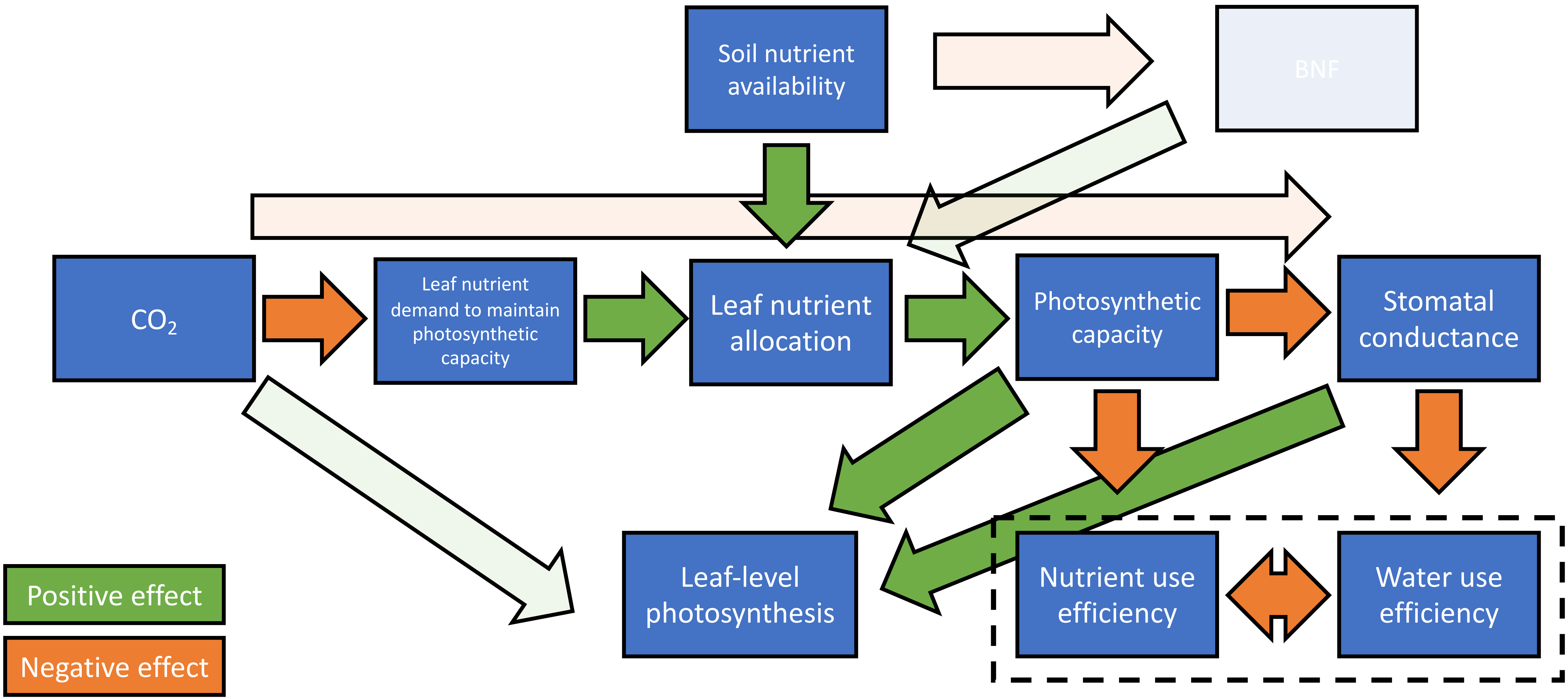

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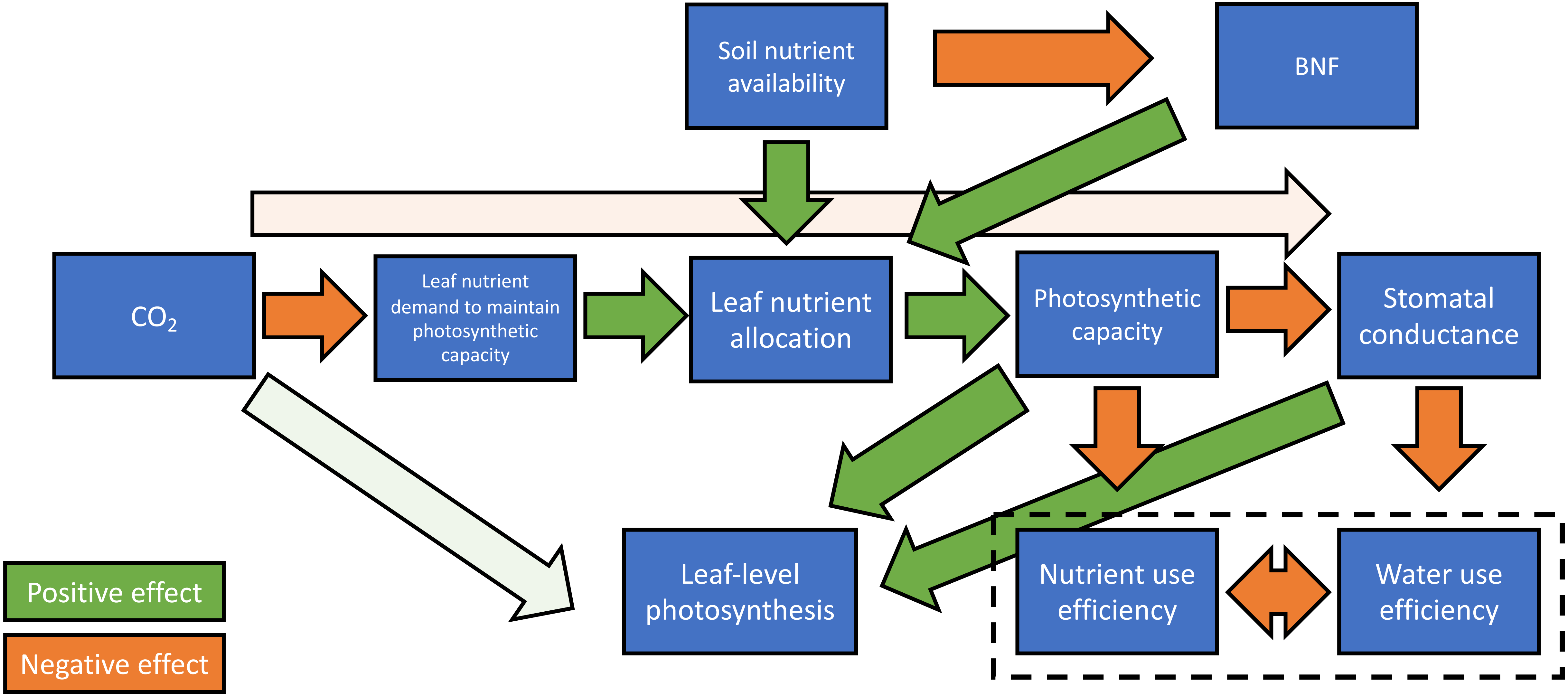
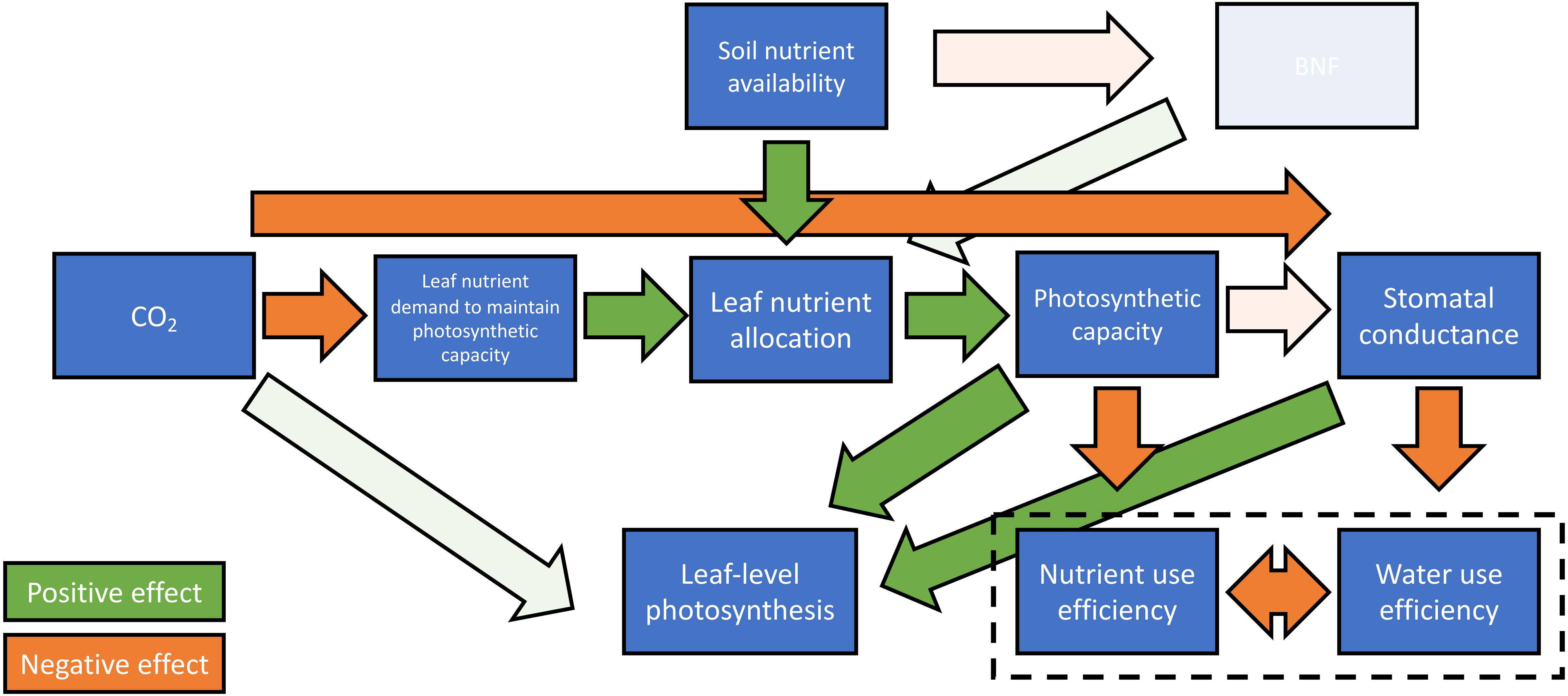


Hypothesis 2d: Increasing CO_2 will decrease leaf-level photosynthesis as a function of reduced maintenance costs for photosynthetic capacity and reduced stomatal conductance



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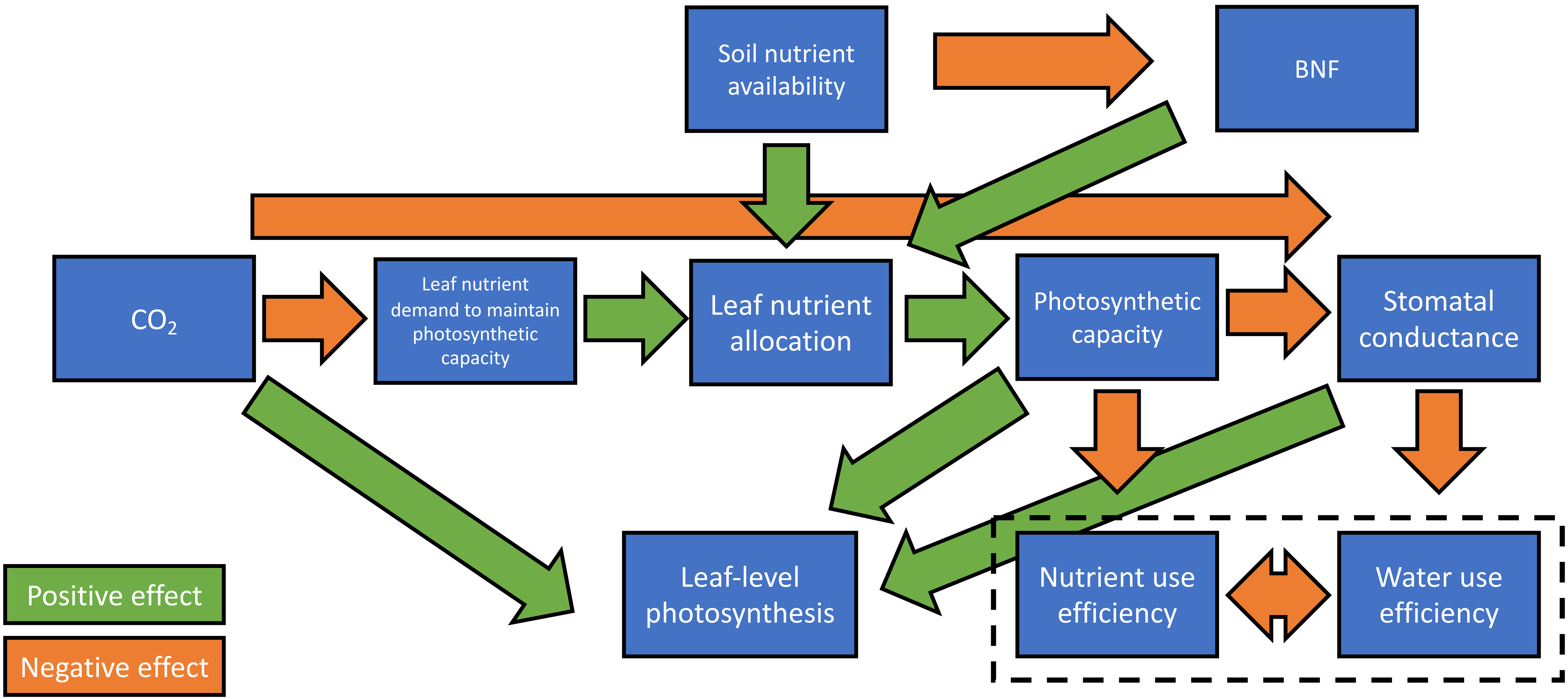

Timeline for Experiment 4

- Start experiment in March/April 2022 using growth chambers in ESB I
- Only one growth chamber available
  - Two separate trial runs for each CO_2 treatment (2 months each)
  - Temperature, relative humidity, and PAR sensors set up through both trials
- Harvest and tissue processing should take another 2 months
- Data analysis, manuscript draft finished by end of calendar year?

Products from Experiment 4

- 1-2 publications
  - Structural carbon costs to acquire nitrogen responses to N fixation, N fertilization, and CO_2
  - Leaf and whole plant nitrogen allocation responses to N fixation, N fertilization, and CO_2
- A few conferences in winter 2022 (AGU?) and summer 2023 (BSA/ESA)