Supplemental materials

Supplemental Figures S1-12 and Table S1 for Ossanna & Gornish (2022), Efficacy of labile carbon addition to reduce exotic invasive plants: A review and meta-analysis
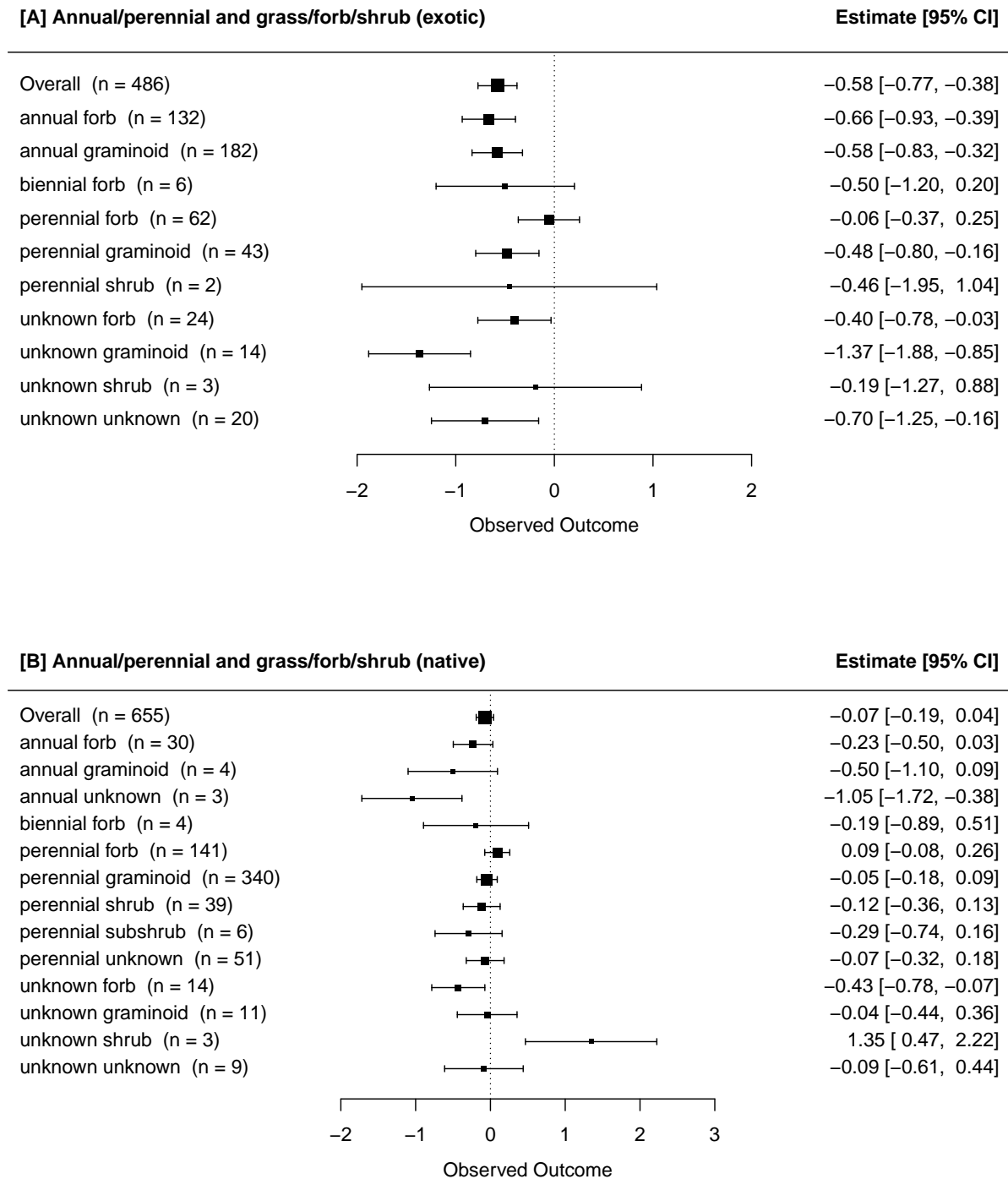
[A] Annual/perennial and grass/forb/shrub (exotic)   **Estimate [95% CI]**

	Estimate [95% CI]
Overall (n = 486)	−0.58 [−0.77, −0.38]
annual forb (n = 132)	−0.66 [−0.93, −0.39]
annual graminoid (n = 182)	−0.58 [−0.83, −0.32]
biennial forb (n = 6)	−0.50 [−1.20, 0.20]
perennial forb (n = 62)	−0.06 [−0.37, 0.25]
perennial graminoid (n = 43)	−0.48 [−0.80, −0.16]
perennial shrub (n = 2)	−0.46 [−1.95, 1.04]
unknown forb (n = 24)	−0.40 [−0.78, −0.03]
unknown graminoid (n = 14)	−1.37 [−1.88, −0.85]
unknown shrub (n = 3)	−0.19 [−1.27, 0.88]
unknown unknown (n = 20)	−0.70 [−1.25, −0.16]

[B] Annual/perennial and grass/forb/shrub (native)   **Estimate [95% CI]**

	Estimate [95% CI]
Overall (n = 655)	−0.07 [−0.19, 0.04]
annual forb (n = 30)	−0.23 [−0.50, 0.03]
annual graminoid (n = 4)	−0.50 [−1.10, 0.09]
annual unknown (n = 3)	−1.05 [−1.72, −0.38]
biennial forb (n = 4)	−0.19 [−0.89, 0.51]
perennial forb (n = 141)	0.09 [−0.08, 0.26]
perennial graminoid (n = 340)	−0.05 [−0.18, 0.09]
perennial shrub (n = 39)	−0.12 [−0.36, 0.13]
perennial subshrub (n = 6)	−0.29 [−0.74, 0.16]
perennial unknown (n = 51)	−0.07 [−0.32, 0.18]
unknown forb (n = 14)	−0.43 [−0.78, −0.07]
unknown graminoid (n = 11)	−0.04 [−0.44, 0.36]
unknown shrub (n = 3)	1.35 [0.47, 2.22]
unknown unknown (n = 9)	−0.09 [−0.61, 0.44]

Figure S1. Standardized mean Hedges' g effect size ± 95% confidence interval (CI) for exotic (A) and

1

native plant abundance (B) as a response to C addition, categorized by plant lifeform and duration (annual/perennial and grass/forb/shrub). CIs that do not overlap zero are considered significant.
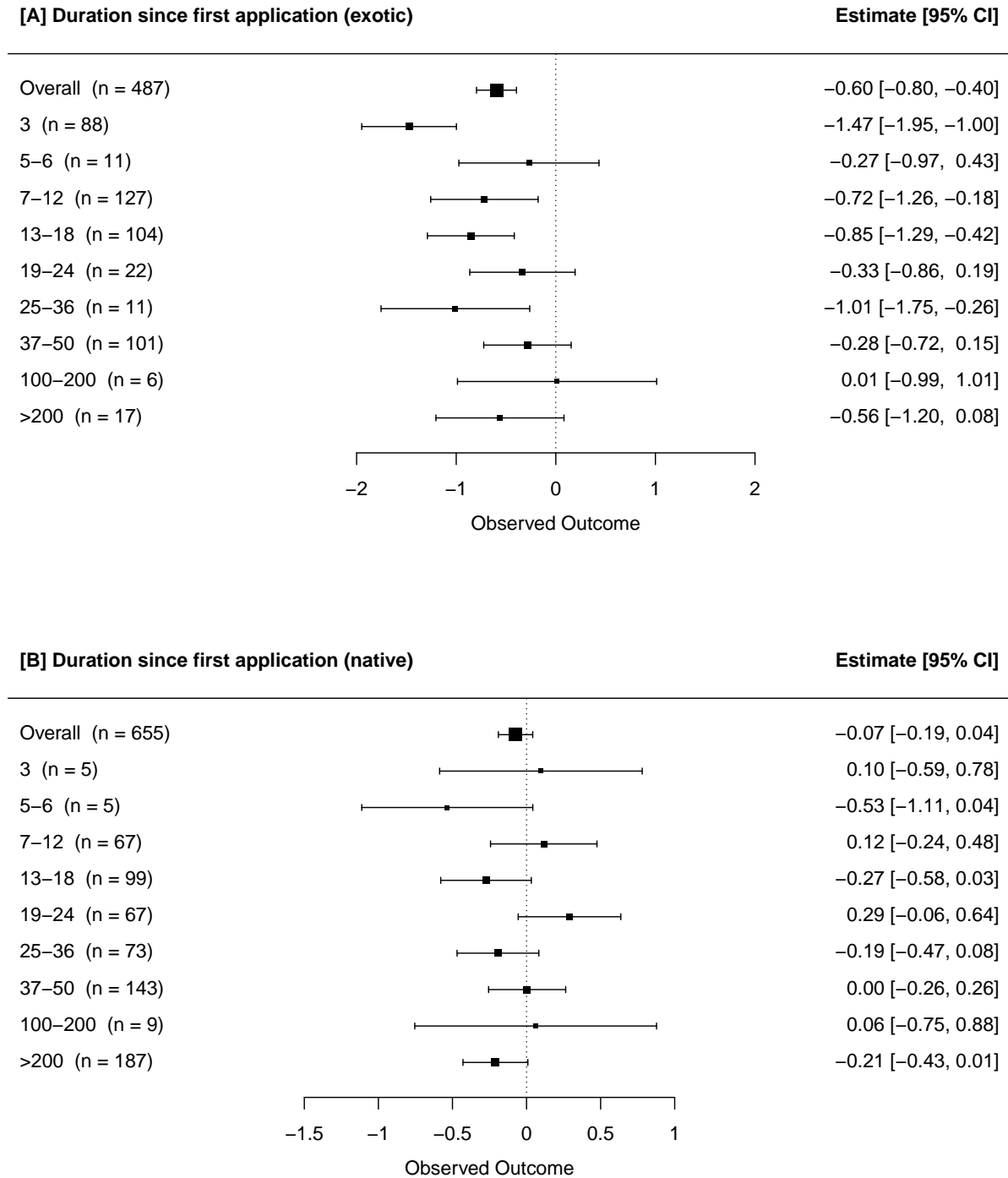
[A] Duration since first application (exotic)   **Estimate [95% CI]**

Overall (n = 487)	−0.60 [−0.80, −0.40]
3 (n = 88)	−1.47 [−1.95, −1.00]
5−6 (n = 11)	−0.27 [−0.97, 0.43]
7−12 (n = 127)	−0.72 [−1.26, −0.18]
13−18 (n = 104)	−0.85 [−1.29, −0.42]
19−24 (n = 22)	−0.33 [−0.86, 0.19]
25−36 (n = 11)	−1.01 [−1.75, −0.26]
37−50 (n = 101)	−0.28 [−0.72, 0.15]
100−200 (n = 6)	0.01 [−0.99, 1.01]
>200 (n = 17)	−0.56 [−1.20, 0.08]

Observed Outcome (−2, −1, 0, 1, 2)

[B] Duration since first application (native)   **Estimate [95% CI]**

Overall (n = 655)	−0.07 [−0.19, 0.04]
3 (n = 5)	0.10 [−0.59, 0.78]
5−6 (n = 5)	−0.53 [−1.11, 0.04]
7−12 (n = 67)	0.12 [−0.24, 0.48]
13−18 (n = 99)	−0.27 [−0.58, 0.03]
19−24 (n = 67)	0.29 [−0.06, 0.64]
25−36 (n = 73)	−0.19 [−0.47, 0.08]
37−50 (n = 143)	0.00 [−0.26, 0.26]
100−200 (n = 9)	0.06 [−0.75, 0.88]
>200 (n = 187)	−0.21 [−0.43, 0.01]

Observed Outcome (−1.5, −1, −0.5, 0, 0.5, 1)

Figure S2. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by study duration (months from first C application to when first plant measurements taken). CIs that do not overlap zero are considered significant.
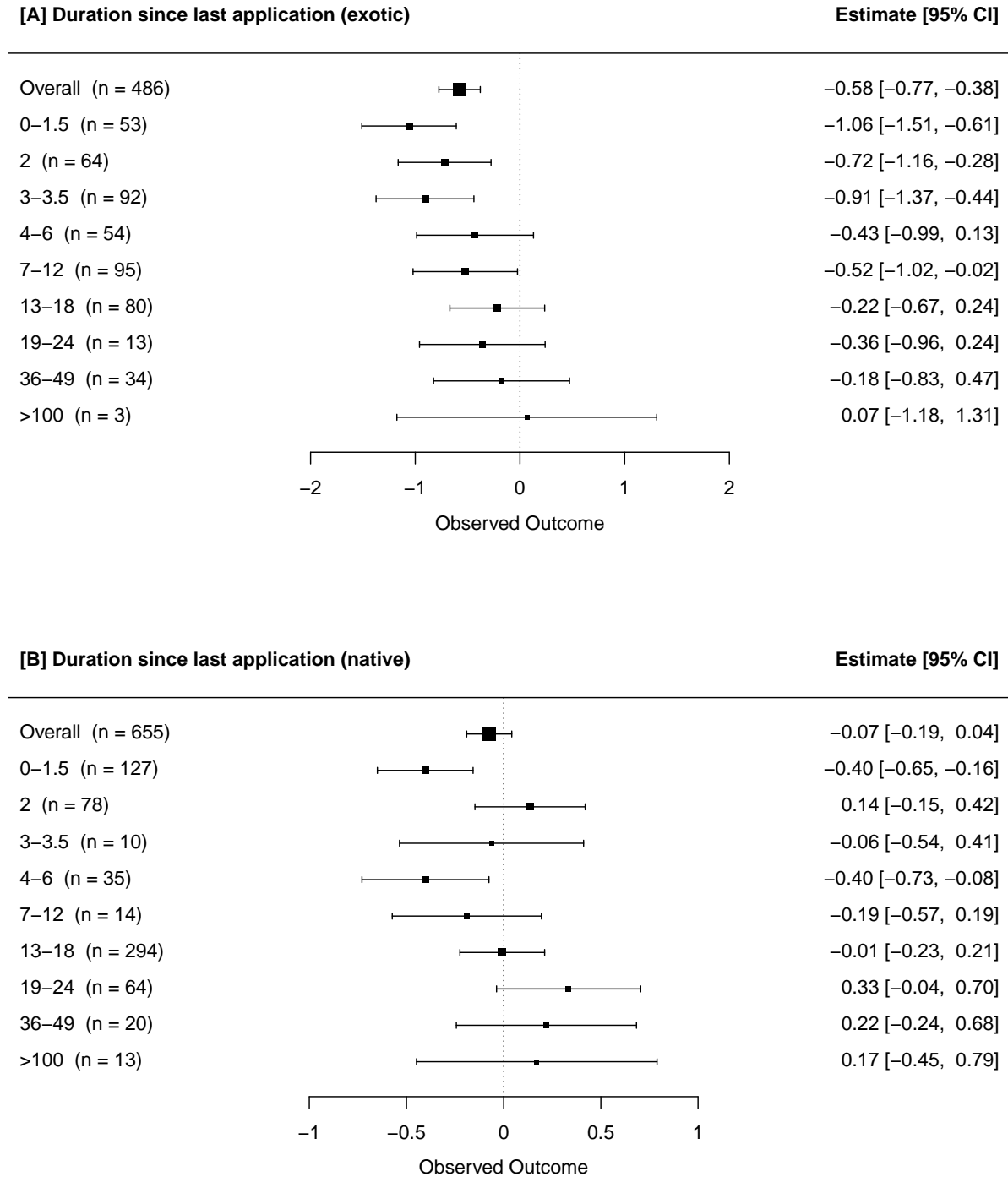
[A] Duration since last application (exotic)   **Estimate [95% CI]**

Overall (n = 486)	−0.58 [−0.77, −0.38]
0–1.5 (n = 53)	−1.06 [−1.51, −0.61]
2 (n = 64)	−0.72 [−1.16, −0.28]
3–3.5 (n = 92)	−0.91 [−1.37, −0.44]
4–6 (n = 54)	−0.43 [−0.99, 0.13]
7–12 (n = 95)	−0.52 [−1.02, −0.02]
13–18 (n = 80)	−0.22 [−0.67, 0.24]
19–24 (n = 13)	−0.36 [−0.96, 0.24]
36–49 (n = 34)	−0.18 [−0.83, 0.47]
>100 (n = 3)	0.07 [−1.18, 1.31]

Observed Outcome

[B] Duration since last application (native)   **Estimate [95% CI]**

Overall (n = 655)	−0.07 [−0.19, 0.04]
0–1.5 (n = 127)	−0.40 [−0.65, −0.16]
2 (n = 78)	0.14 [−0.15, 0.42]
3–3.5 (n = 10)	−0.06 [−0.54, 0.41]
4–6 (n = 35)	−0.40 [−0.73, −0.08]
7–12 (n = 14)	−0.19 [−0.57, 0.19]
13–18 (n = 294)	−0.01 [−0.23, 0.21]
19–24 (n = 64)	0.33 [−0.04, 0.70]
36–49 (n = 20)	0.22 [−0.24, 0.68]
>100 (n = 13)	0.17 [−0.45, 0.79]

Observed Outcome

Figure S3. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by study duration (months from first C application to when last plant measurements taken). CIs that do not overlap zero are considered significant.
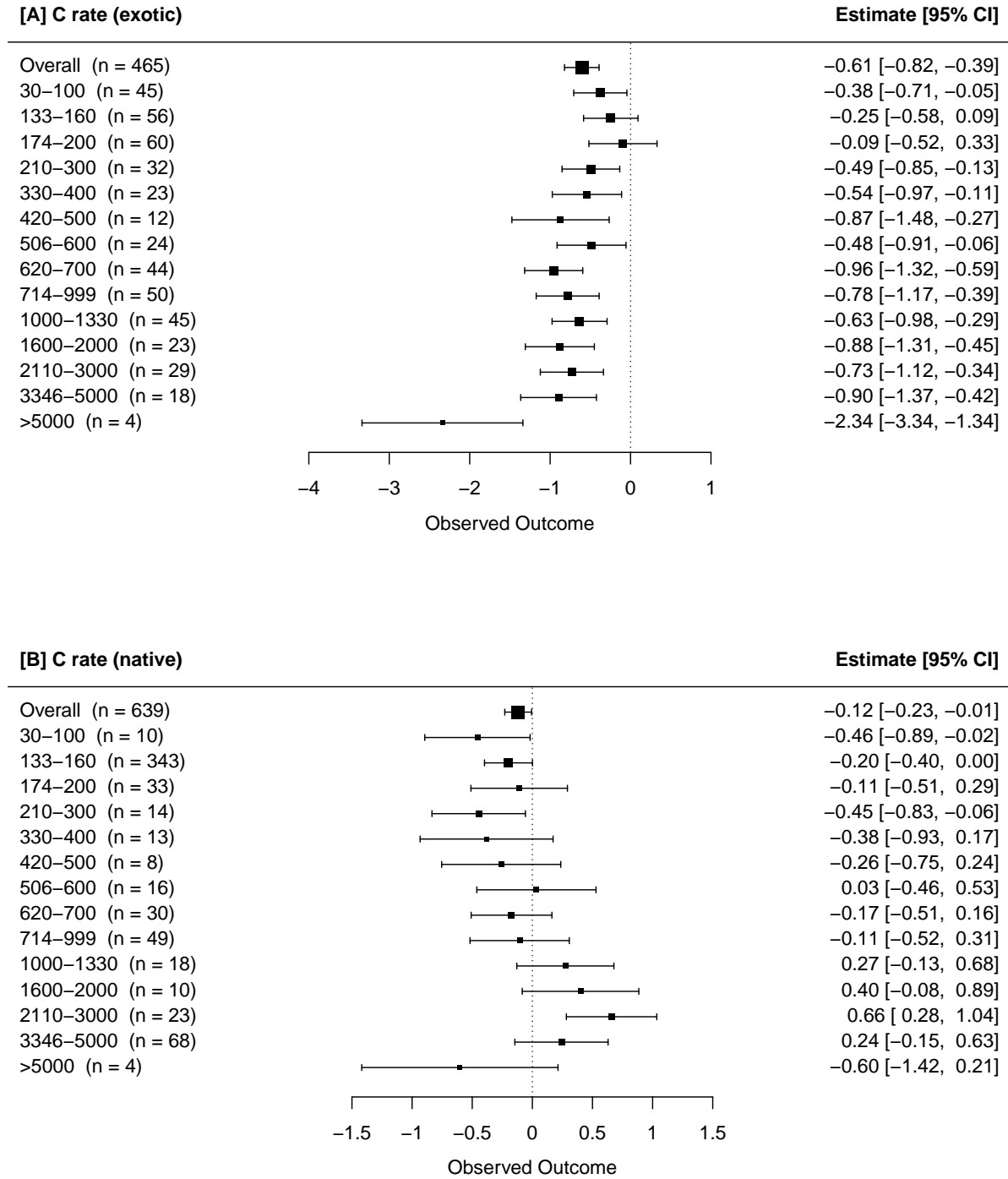
3

[A] C rate (exotic)   **Estimate [95% CI]**

Overall (n = 465)   −0.61 [−0.82, −0.39]
30–100 (n = 45)   −0.38 [−0.71, −0.05]
133–160 (n = 56)   −0.25 [−0.58, 0.09]
174–200 (n = 60)   −0.09 [−0.52, 0.33]
210–300 (n = 32)   −0.49 [−0.85, −0.13]
330–400 (n = 23)   −0.54 [−0.97, −0.11]
420–500 (n = 12)   −0.87 [−1.48, −0.27]
506–600 (n = 24)   −0.48 [−0.91, −0.06]
620–700 (n = 44)   −0.96 [−1.32, −0.59]
714–999 (n = 50)   −0.78 [−1.17, −0.39]
1000–1330 (n = 45)   −0.63 [−0.98, −0.29]
1600–2000 (n = 23)   −0.88 [−1.31, −0.45]
2110–3000 (n = 29)   −0.73 [−1.12, −0.34]
3346–5000 (n = 18)   −0.90 [−1.37, −0.42]
>5000 (n = 4)   −2.34 [−3.34, −1.34]

Observed Outcome: −4 −3 −2 −1 0 1

[B] C rate (native)   **Estimate [95% CI]**

Overall (n = 639)   −0.12 [−0.23, −0.01]
30–100 (n = 10)   −0.46 [−0.89, −0.02]
133–160 (n = 343)   −0.20 [−0.40, 0.00]
174–200 (n = 33)   −0.11 [−0.51, 0.29]
210–300 (n = 14)   −0.45 [−0.83, −0.06]
330–400 (n = 13)   −0.38 [−0.93, 0.17]
420–500 (n = 8)   −0.26 [−0.75, 0.24]
506–600 (n = 16)   0.03 [−0.46, 0.53]
620–700 (n = 30)   −0.17 [−0.51, 0.16]
714–999 (n = 49)   −0.11 [−0.52, 0.31]
1000–1330 (n = 18)   0.27 [−0.13, 0.68]
1600–2000 (n = 10)   0.40 [−0.08, 0.89]
2110–3000 (n = 23)   0.66 [0.28, 1.04]
3346–5000 (n = 68)   0.24 [−0.15, 0.63]
>5000 (n = 4)   −0.60 [−1.42, 0.21]

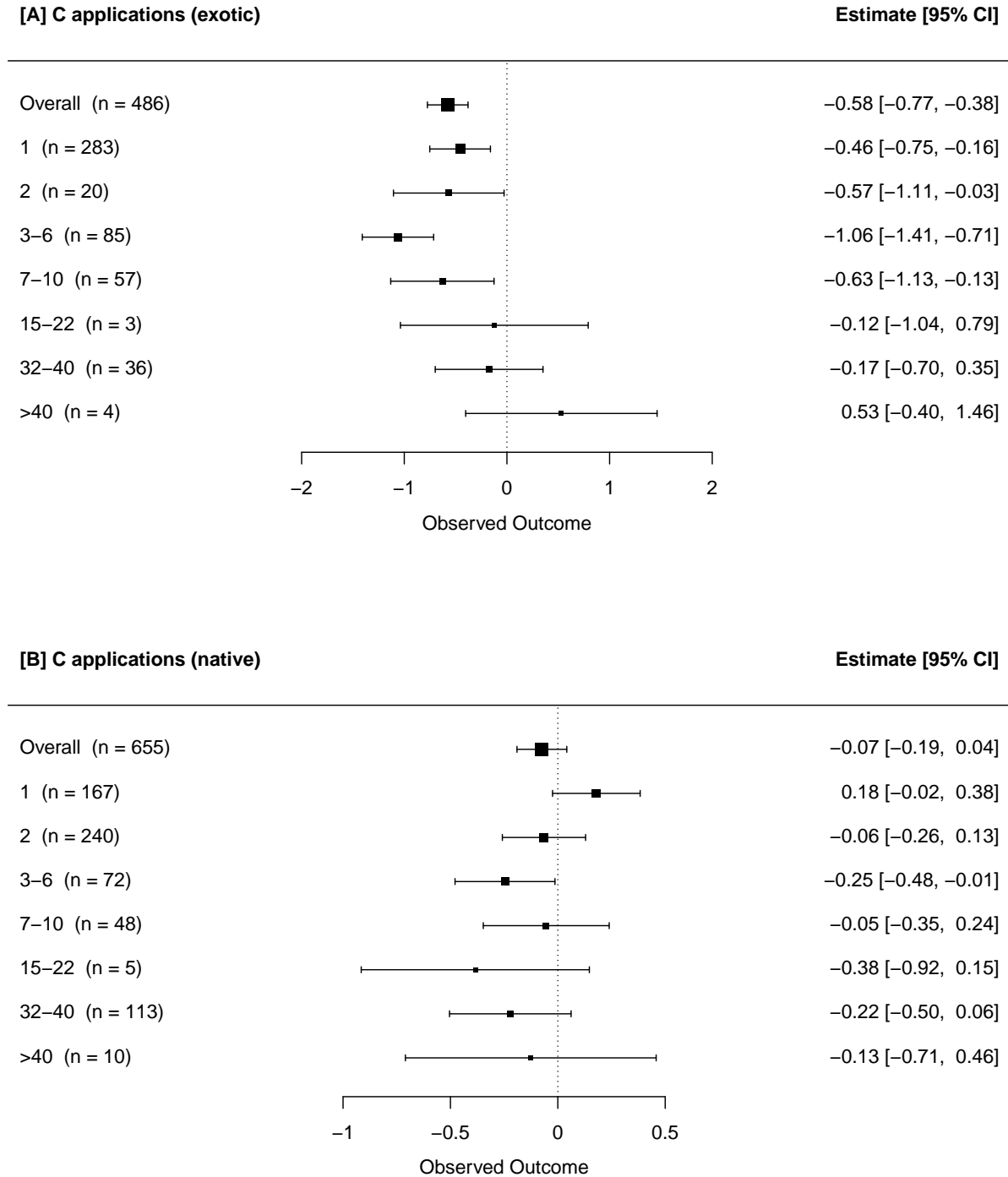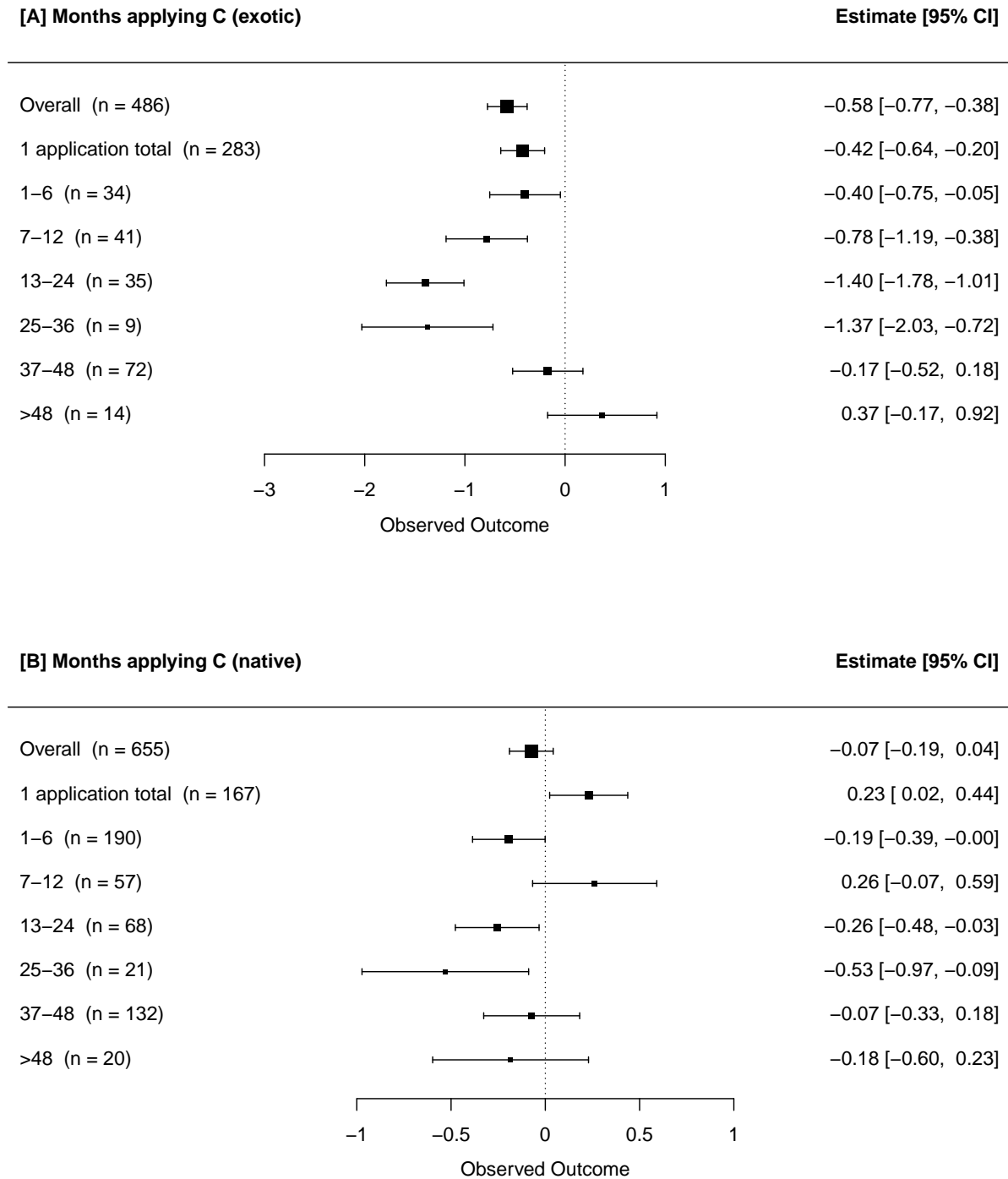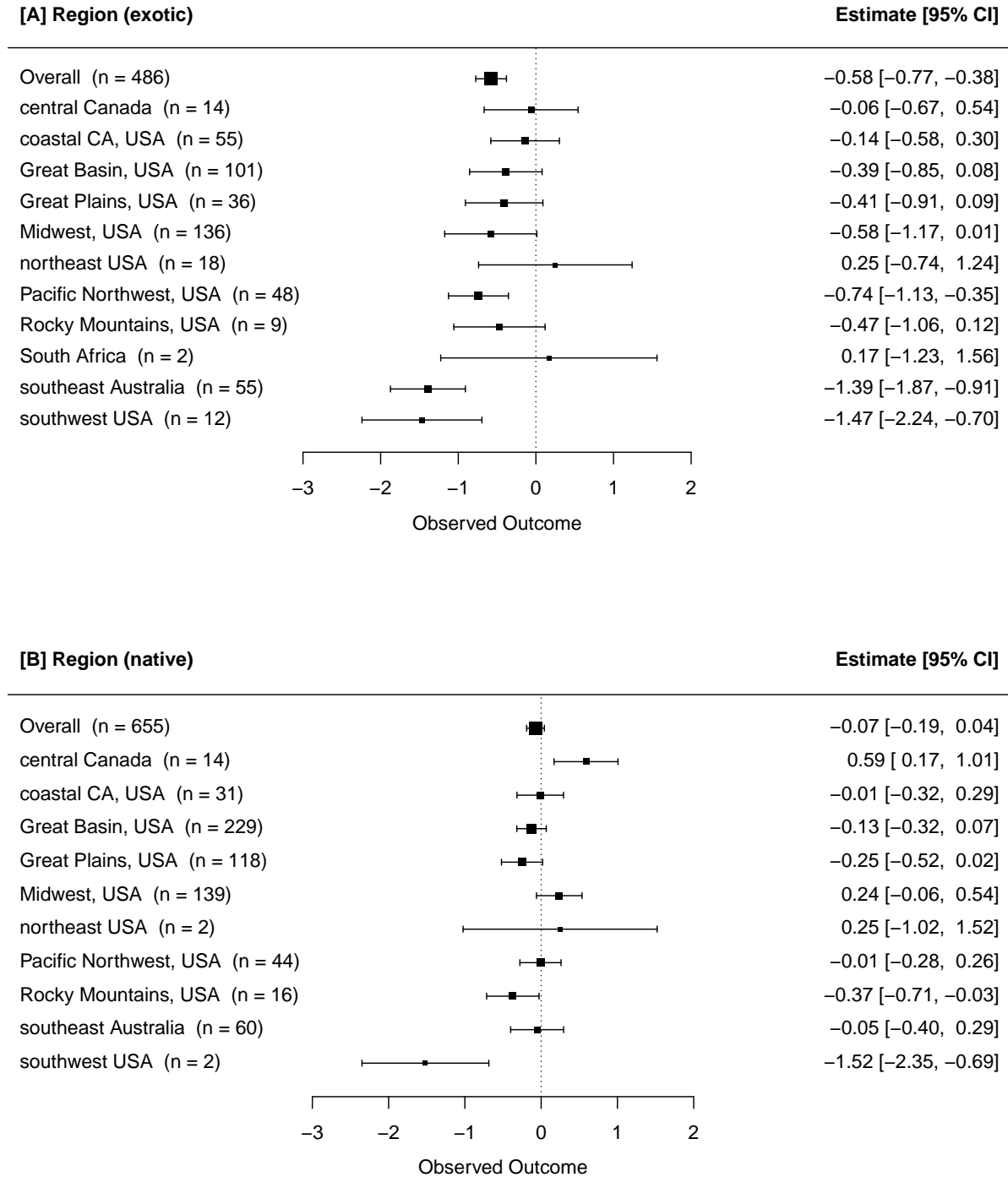Observed Outcome: −1.5 −1 −0.5 0 0.5 1 1.5

Figure S4. Standardized mean Hedges' g effect size ± 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by C rate (g C m^{-2} y^{-1}). CIs that do not overlap zero are considered significant.

[A] C applications (exotic)   **Estimate [95% CI]**

Overall (n = 486)   −0.58 [−0.77, −0.38]

1 (n = 283)   −0.46 [−0.75, −0.16]

2 (n = 20)   −0.57 [−1.11, −0.03]

3–6 (n = 85)   −1.06 [−1.41, −0.71]

7–10 (n = 57)   −0.63 [−1.13, −0.13]

15–22 (n = 3)   −0.12 [−1.04, 0.79]

32–40 (n = 36)   −0.17 [−0.70, 0.35]

>40 (n = 4)   0.53 [−0.40, 1.46]

$$-2 \quad -1 \quad 0 \quad 1 \quad 2$$

Observed Outcome

[B] C applications (native)   **Estimate [95% CI]**

Overall (n = 655)   −0.07 [−0.19, 0.04]

1 (n = 167)   0.18 [−0.02, 0.38]

2 (n = 240)   −0.06 [−0.26, 0.13]

3–6 (n = 72)   −0.25 [−0.48, −0.01]

7–10 (n = 48)   −0.05 [−0.35, 0.24]

15–22 (n = 5)   −0.38 [−0.92, 0.15]

32–40 (n = 113)   −0.22 [−0.50, 0.06]

>40 (n = 10)   −0.13 [−0.71, 0.46]

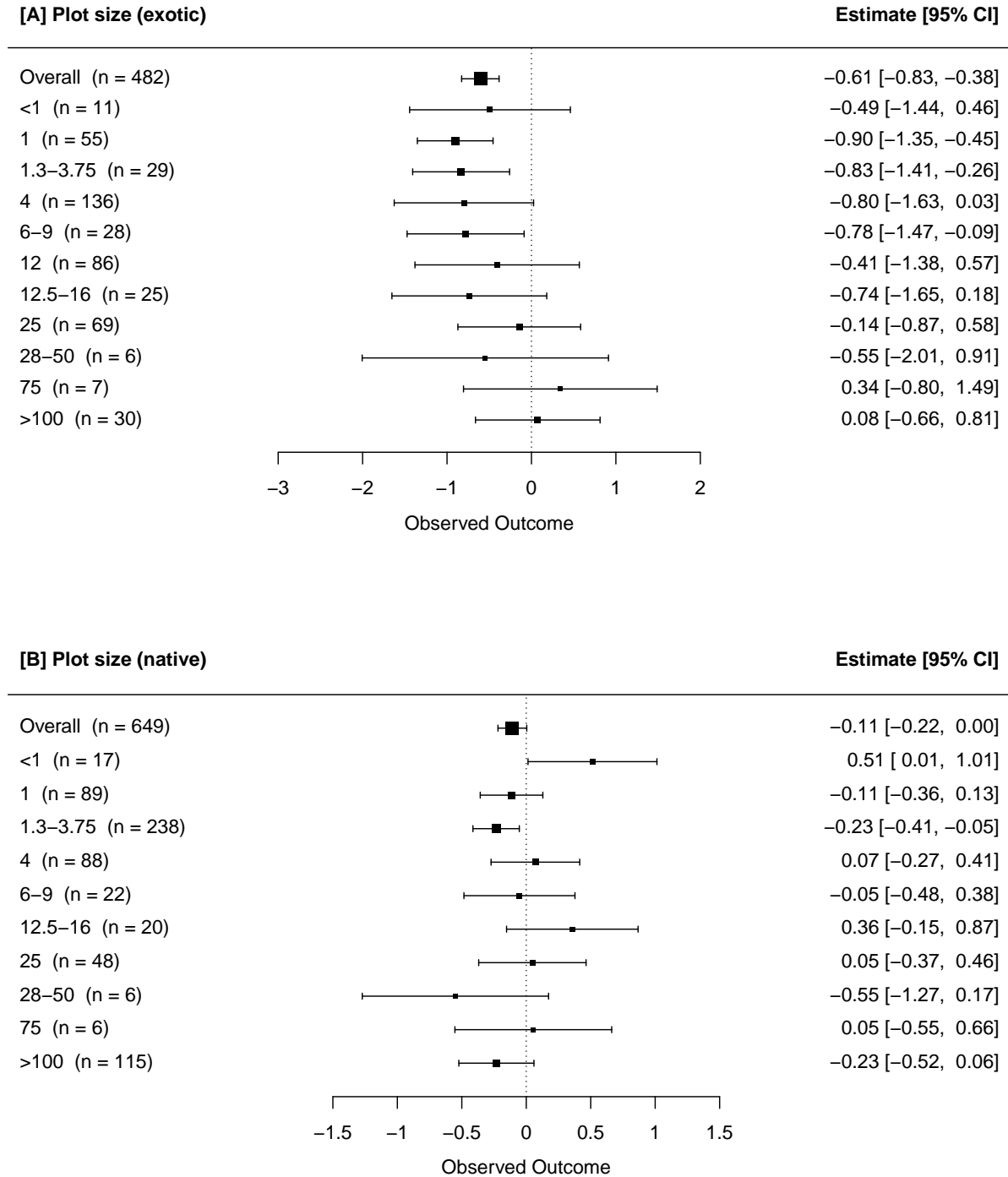$$-1 \quad -0.5 \quad 0 \quad 0.5$$

Observed Outcome

Figure S5. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by total number of C applications. CIs that do not overlap zero are considered significant.

[A] Months applying C (exotic)   **Estimate [95% CI]**

Overall (n = 486)   −0.58 [−0.77, −0.38]

1 application total (n = 283)   −0.42 [−0.64, −0.20]

1−6 (n = 34)   −0.40 [−0.75, −0.05]

7−12 (n = 41)   −0.78 [−1.19, −0.38]

13−24 (n = 35)   −1.40 [−1.78, −1.01]

25−36 (n = 9)   −1.37 [−2.03, −0.72]

37−48 (n = 72)   −0.17 [−0.52, 0.18]

>48 (n = 14)   0.37 [−0.17, 0.92]

```
        −3      −2      −1       0       1
                Observed Outcome
```

[B] Months applying C (native)   **Estimate [95% CI]**

Overall (n = 655)   −0.07 [−0.19, 0.04]

1 application total (n = 167)   0.23 [0.02, 0.44]

1−6 (n = 190)   −0.19 [−0.39, −0.00]

7−12 (n = 57)   0.26 [−0.07, 0.59]

13−24 (n = 68)   −0.26 [−0.48, −0.03]

25−36 (n = 21)   −0.53 [−0.97, −0.09]

37−48 (n = 132)   −0.07 [−0.33, 0.18]

>48 (n = 20)   −0.18 [−0.60, 0.23]

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        −1     −0.5      0      0.5      1
                Observed Outcome
```
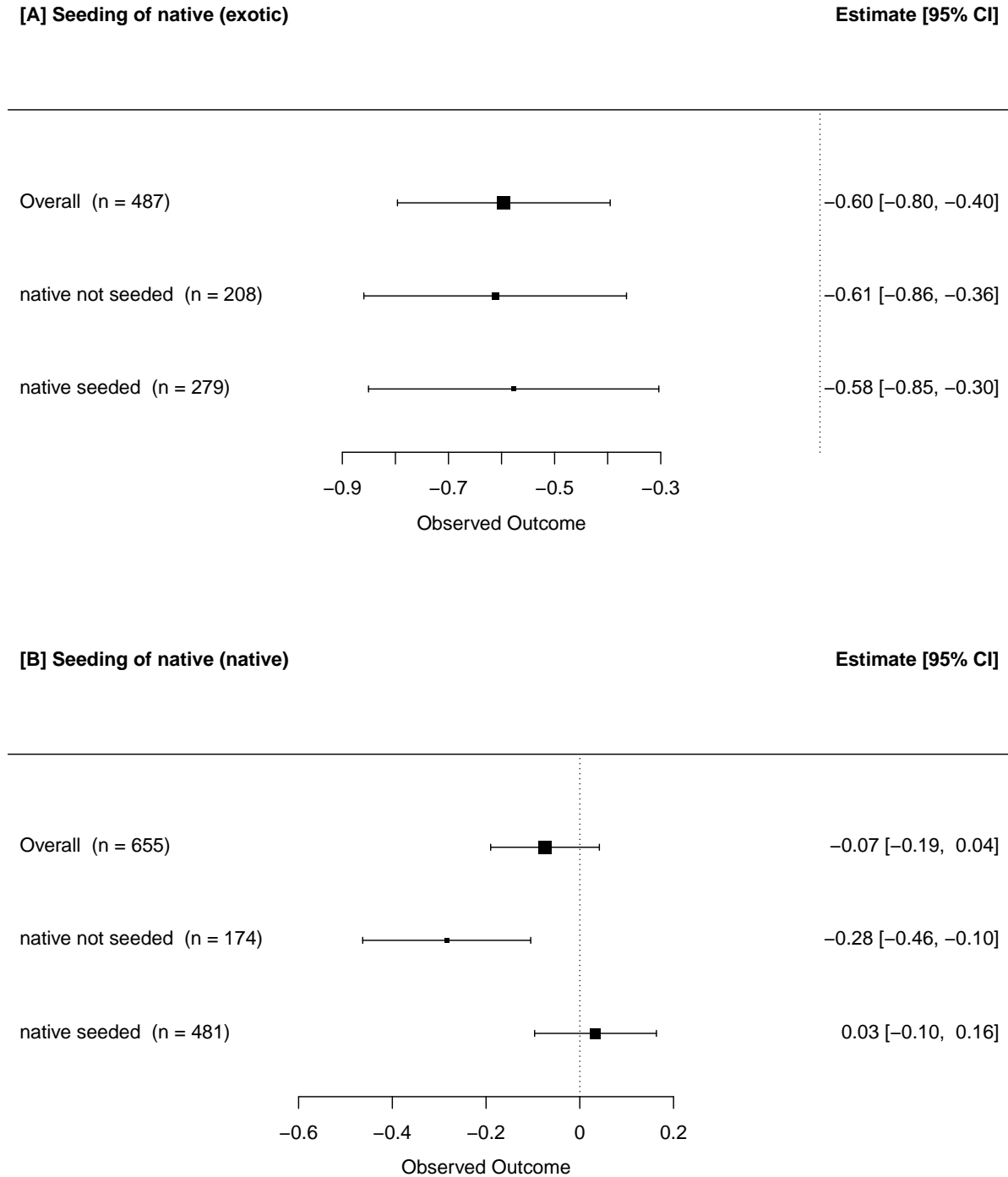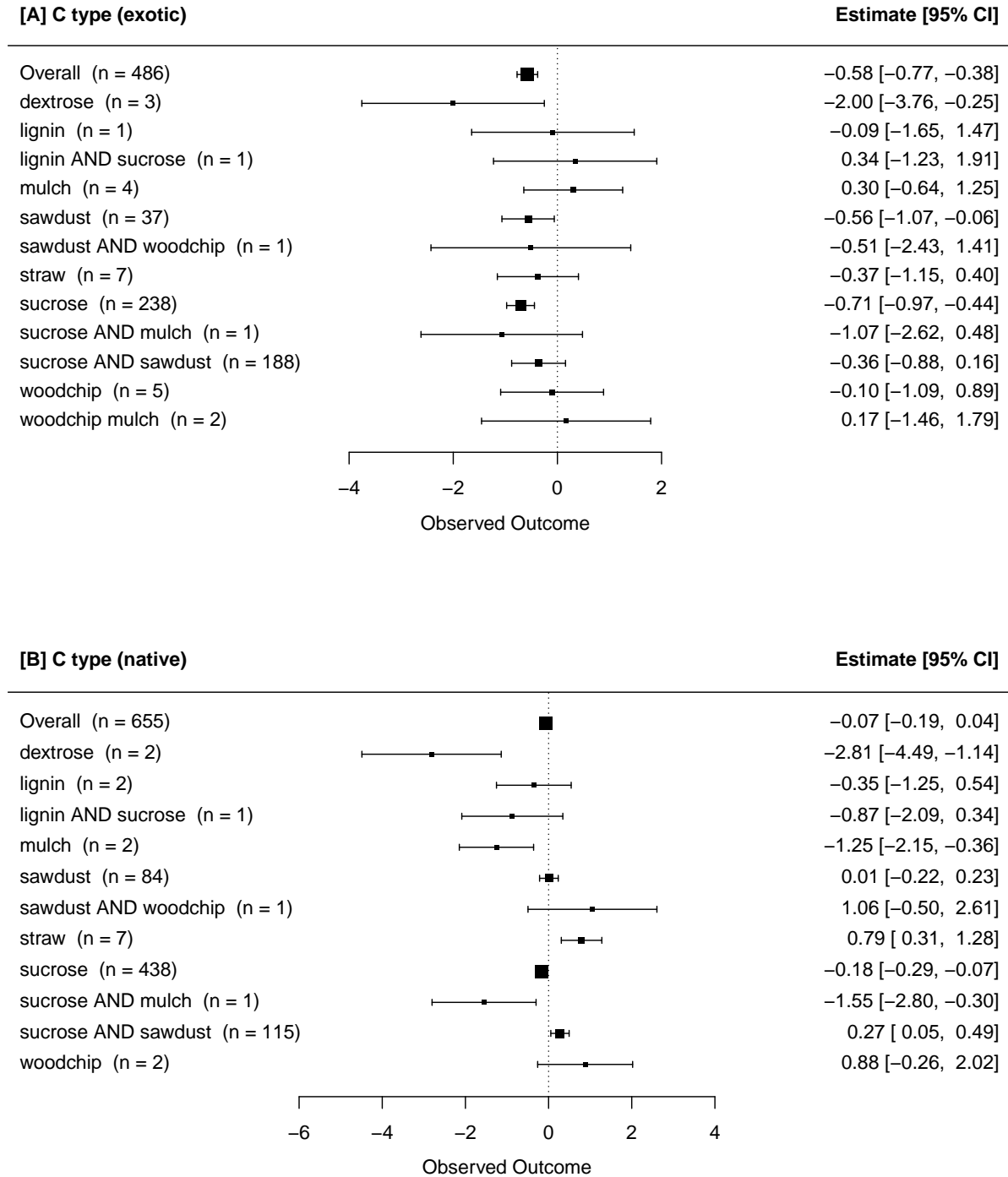
Figure S6. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by number of months applying C (takes into account reapplication and study duration). CIs that do not overlap zero are considered significant.

[A] Region (exotic)   **Estimate [95% CI]**

Overall (n = 486)	−0.58 [−0.77, −0.38]
central Canada (n = 14)	−0.06 [−0.67, 0.54]
coastal CA, USA (n = 55)	−0.14 [−0.58, 0.30]
Great Basin, USA (n = 101)	−0.39 [−0.85, 0.08]
Great Plains, USA (n = 36)	−0.41 [−0.91, 0.09]
Midwest, USA (n = 136)	−0.58 [−1.17, 0.01]
northeast USA (n = 18)	0.25 [−0.74, 1.24]
Pacific Northwest, USA (n = 48)	−0.74 [−1.13, −0.35]
Rocky Mountains, USA (n = 9)	−0.47 [−1.06, 0.12]
South Africa (n = 2)	0.17 [−1.23, 1.56]
southeast Australia (n = 55)	−1.39 [−1.87, −0.91]
southwest USA (n = 12)	−1.47 [−2.24, −0.70]

Observed Outcome

[B] Region (native)   **Estimate [95% CI]**

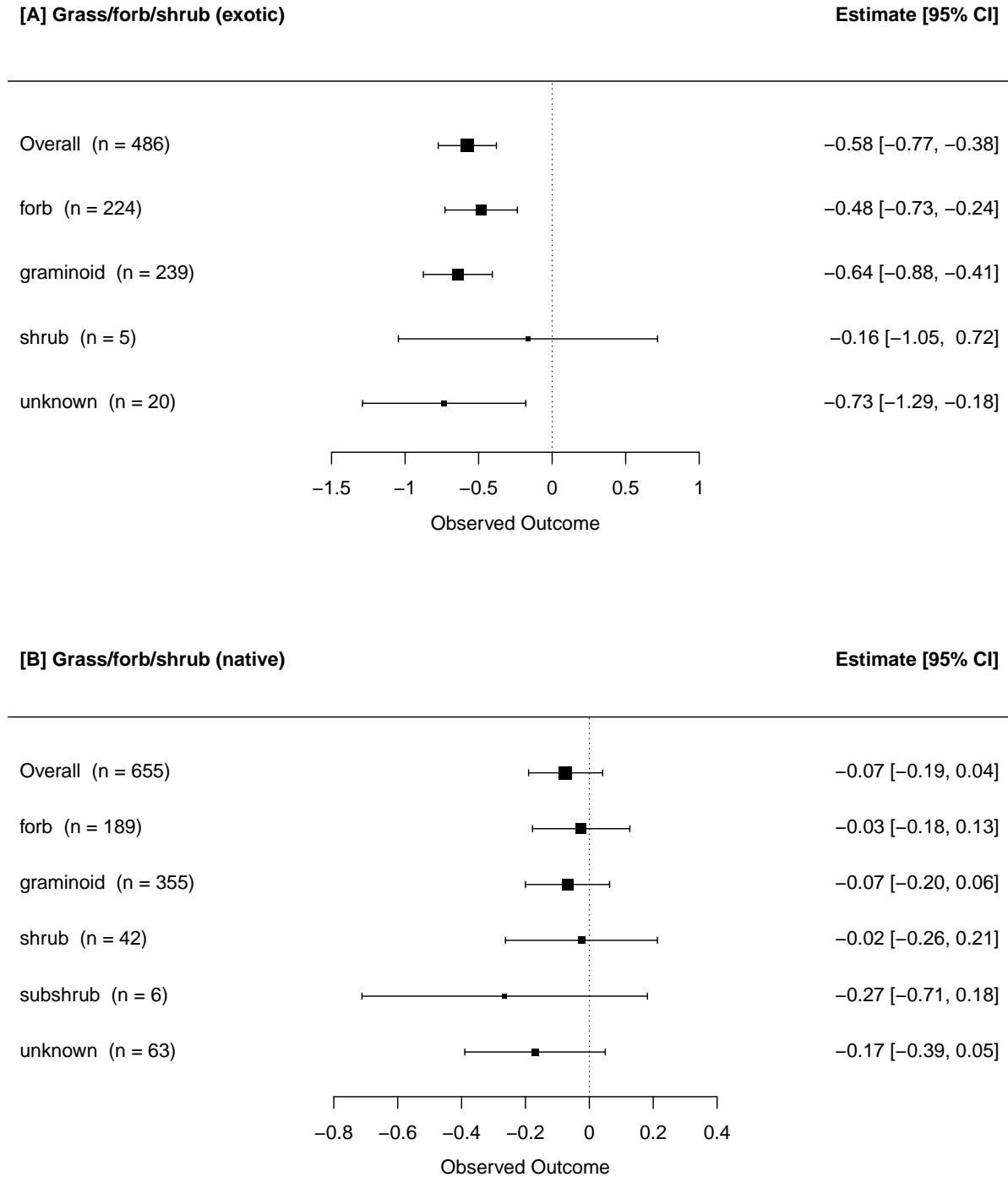|	
Overall (n = 655)	−0.07 [−0.19, 0.04]
central Canada (n = 14)	0.59 [0.17, 1.01]
coastal CA, USA (n = 31)	−0.01 [−0.32, 0.29]
Great Basin, USA (n = 229)	−0.13 [−0.32, 0.07]
Great Plains, USA (n = 118)	−0.25 [−0.52, 0.02]
Midwest, USA (n = 139)	0.24 [−0.06, 0.54]
northeast USA (n = 2)	0.25 [−1.02, 1.52]
Pacific Northwest, USA (n = 44)	−0.01 [−0.28, 0.26]
Rocky Mountains, USA (n = 16)	−0.37 [−0.71, −0.03]
southeast Australia (n = 60)	−0.05 [−0.40, 0.29]
southwest USA (n = 2)	−1.52 [−2.35, −0.69]

Observed Outcome

Figure S7. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by study region. CIs that do not overlap zero are considered significant.

[A] Plot size (exotic)   **Estimate [95% CI]**

Overall (n = 482)	−0.61 [−0.83, −0.38]
<1 (n = 11)	−0.49 [−1.44, 0.46]
1 (n = 55)	−0.90 [−1.35, −0.45]
1.3–3.75 (n = 29)	−0.83 [−1.41, −0.26]
4 (n = 136)	−0.80 [−1.63, 0.03]
6–9 (n = 28)	−0.78 [−1.47, −0.09]
12 (n = 86)	−0.41 [−1.38, 0.57]
12.5–16 (n = 25)	−0.74 [−1.65, 0.18]
25 (n = 69)	−0.14 [−0.87, 0.58]
28–50 (n = 6)	−0.55 [−2.01, 0.91]
75 (n = 7)	0.34 [−0.80, 1.49]
>100 (n = 30)	0.08 [−0.66, 0.81]

−3   −2   −1   0   1   2

Observed Outcome

[B] Plot size (native)   **Estimate [95% CI]**

Overall (n = 649)	−0.11 [−0.22, 0.00]
<1 (n = 17)	0.51 [0.01, 1.01]
1 (n = 89)	−0.11 [−0.36, 0.13]
1.3–3.75 (n = 238)	−0.23 [−0.41, −0.05]
4 (n = 88)	0.07 [−0.27, 0.41]
6–9 (n = 22)	−0.05 [−0.48, 0.38]
12.5–16 (n = 20)	0.36 [−0.15, 0.87]
25 (n = 48)	0.05 [−0.37, 0.46]
28–50 (n = 6)	−0.55 [−1.27, 0.17]
75 (n = 6)	0.05 [−0.55, 0.66]
>100 (n = 115)	−0.23 [−0.52, 0.06]

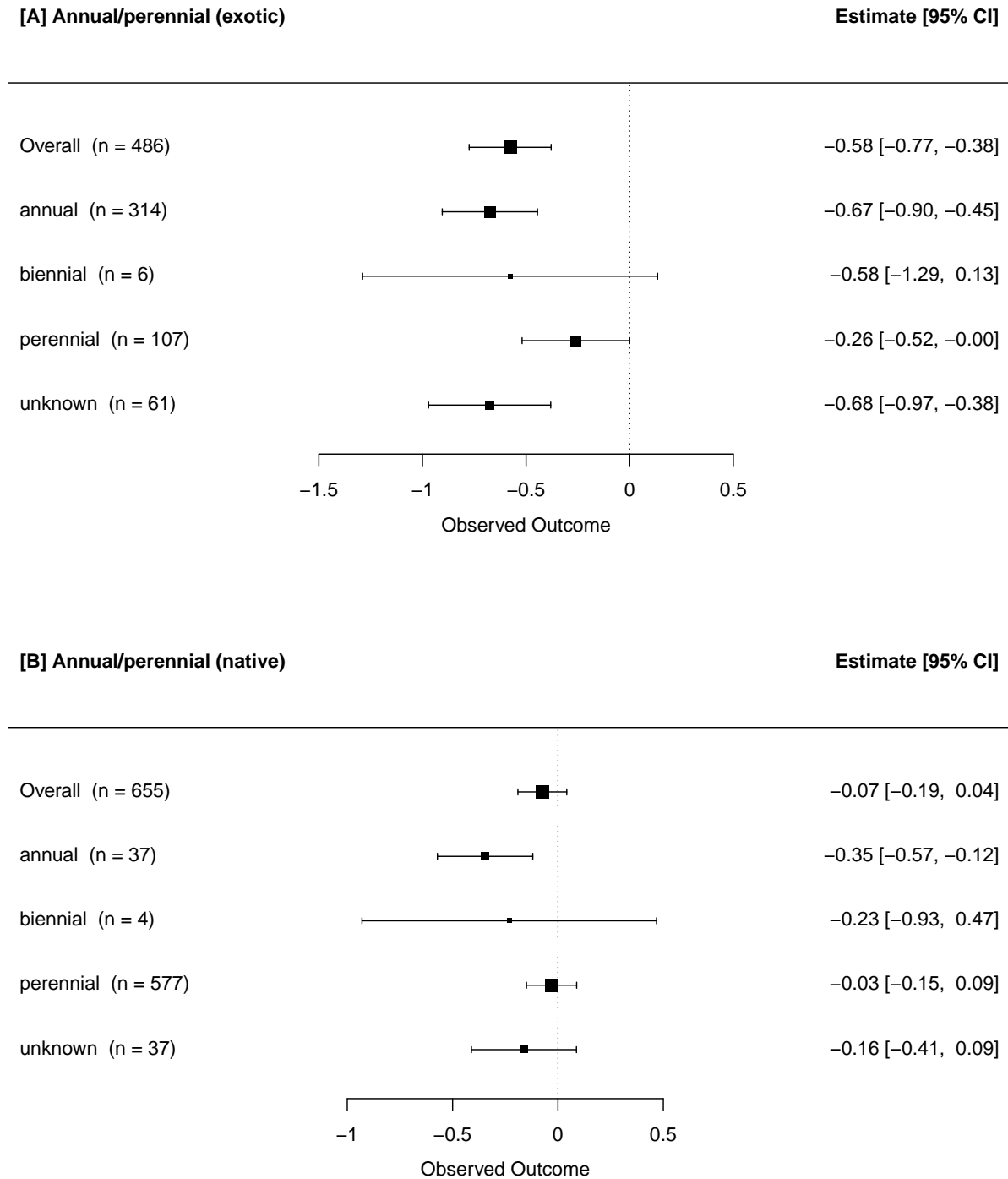−1.5   −1   −0.5   0   0.5   1   1.5

Observed Outcome

Figure S8. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by plot size (m^2). CIs that do not overlap zero are considered significant.

[A] Seeding of native (exotic)

Estimate [95% CI]

Overall (n = 487) −0.60 [−0.80, −0.40]

native not seeded (n = 208) −0.61 [−0.86, −0.36]

native seeded (n = 279) −0.58 [−0.85, −0.30]

−0.9   −0.7   −0.5   −0.3

Observed Outcome

[B] Seeding of native (native)

Estimate [95% CI]

Overall (n = 655) −0.07 [−0.19, 0.04]

native not seeded (n = 174) −0.28 [−0.46, −0.10]

native seeded (n = 481) 0.03 [−0.10, 0.16]

−0.6   −0.4   −0.2   0   0.2

Observed Outcome

Figure S9. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by seeding of native plant species (seeded/not seeded). CIs that do not overlap zero are considered significant.

[A] C type (exotic)   **Estimate [95% CI]**

Overall (n = 486)	−0.58 [−0.77, −0.38]
dextrose (n = 3)	−2.00 [−3.76, −0.25]
lignin (n = 1)	−0.09 [−1.65, 1.47]
lignin AND sucrose (n = 1)	0.34 [−1.23, 1.91]
mulch (n = 4)	0.30 [−0.64, 1.25]
sawdust (n = 37)	−0.56 [−1.07, −0.06]
sawdust AND woodchip (n = 1)	−0.51 [−2.43, 1.41]
straw (n = 7)	−0.37 [−1.15, 0.40]
sucrose (n = 238)	−0.71 [−0.97, −0.44]
sucrose AND mulch (n = 1)	−1.07 [−2.62, 0.48]
sucrose AND sawdust (n = 188)	−0.36 [−0.88, 0.16]
woodchip (n = 5)	−0.10 [−1.09, 0.89]
woodchip mulch (n = 2)	0.17 [−1.46, 1.79]

Observed Outcome (−4, −2, 0, 2)

[B] C type (native)   **Estimate [95% CI]**

Overall (n = 655)	−0.07 [−0.19, 0.04]
dextrose (n = 2)	−2.81 [−4.49, −1.14]
lignin (n = 2)	−0.35 [−1.25, 0.54]
lignin AND sucrose (n = 1)	−0.87 [−2.09, 0.34]
mulch (n = 2)	−1.25 [−2.15, −0.36]
sawdust (n = 84)	0.01 [−0.22, 0.23]
sawdust AND woodchip (n = 1)	1.06 [−0.50, 2.61]
straw (n = 7)	0.79 [0.31, 1.28]
sucrose (n = 438)	−0.18 [−0.29, −0.07]
sucrose AND mulch (n = 1)	−1.55 [−2.80, −0.30]
sucrose AND sawdust (n = 115)	0.27 [0.05, 0.49]
woodchip (n = 2)	0.88 [−0.26, 2.02]

Observed Outcome (−6, −4, −2, 0, 2, 4)

Figure S10. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by C type. CIs that do not overlap zero are considered significant.

[A] Grass/forb/shrub (exotic)   **Estimate [95% CI]**

Overall (n = 486)   −0.58 [−0.77, −0.38]

forb (n = 224)   −0.48 [−0.73, −0.24]

graminoid (n = 239)   −0.64 [−0.88, −0.41]

shrub (n = 5)   −0.16 [−1.05, 0.72]

unknown (n = 20)   −0.73 [−1.29, −0.18]

```
       −1.5    −1    −0.5    0    0.5    1
```
Observed Outcome

[B] Grass/forb/shrub (native)   **Estimate [95% CI]**

Overall (n = 655)   −0.07 [−0.19, 0.04]

forb (n = 189)   −0.03 [−0.18, 0.13]

graminoid (n = 355)   −0.07 [−0.20, 0.06]

shrub (n = 42)   −0.02 [−0.26, 0.21]

subshrub (n = 6)   −0.27 [−0.71, 0.18]

unknown (n = 63)   −0.17 [−0.39, 0.05]

```
    −0.8  −0.6  −0.4  −0.2   0   0.2   0.4
```
Observed Outcome

Figure S11. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by plant lifeform (grass/forb/shrub). CIs that do not overlap zero are considered significant.

[A] Annual/perennial (exotic) **Estimate [95% CI]**

Overall (n = 486) −0.58 [−0.77, −0.38]

annual (n = 314) −0.67 [−0.90, −0.45]

biennial (n = 6) −0.58 [−1.29, 0.13]

perennial (n = 107) −0.26 [−0.52, −0.00]

unknown (n = 61) −0.68 [−0.97, −0.38]

Observed Outcome

[B] Annual/perennial (native) **Estimate [95% CI]**

Overall (n = 655) −0.07 [−0.19, 0.04]

annual (n = 37) −0.35 [−0.57, −0.12]

biennial (n = 4) −0.23 [−0.93, 0.47]

perennial (n = 577) −0.03 [−0.15, 0.09]

unknown (n = 37) −0.16 [−0.41, 0.09]

Observed Outcome

Figure S12. Standardized mean Hedges' g effect size $\pm$ 95% confidence interval (CI) for exotic (A) and native plant abundance (B) as a response to C addition, categorized by plant duration (annual/perennial). CIs that do not overlap zero are considered significant.

Table S3. Heterogeneity statistics

Model	QE	QE_df	QE_p	QM	QM_df	QM_p	QM_QT
Summary							
Exotic	1013.0	485	0.0e+00	32.680	1	0.0000000	0.031260
Native	925.8	654	0.0e+00	1.573	1	0.2097000	0.001697
Region							
Exotic	871.4	485	0.0e+00	71.990	11	0.0000000	0.076320
Native	841.8	654	3.0e-07	32.480	10	0.0003331	0.037150
Duration since first C app							
Exotic	959.4	486	0.0e+00	60.610	9	0.0000000	0.059420
Native	884.8	654	0.0e+00	13.620	9	0.1364000	0.015160
Duration since last C app							
Exotic	954.6	487	0.0e+00	64.110	9	0.0000000	0.062940
Native	883.2	654	0.0e+00	23.030	9	0.0061220	0.025420
C type							
Exotic	948.4	487	0.0e+00	42.870	12	0.0000238	0.043240
Native	814.0	654	5.6e-06	56.400	11	0.0000000	0.064800
C rate							
Exotic	879.8	464	0.0e+00	72.930	14	0.0000000	0.076540
Native	799.4	638	2.6e-06	41.870	14	0.0001297	0.049770
Total C applications							
Exotic	956.7	487	0.0e+00	49.720	7	0.0000000	0.049400
Native	875.6	654	0.0e+00	12.450	7	0.0867700	0.014020
Months applying C							
Exotic	890.9	487	0.0e+00	98.500	7	0.0000000	0.099550
Native	866.5	654	0.0e+00	19.860	7	0.0058790	0.022410
Grass/forb/shrub							
Exotic	1003.0	487	0.0e+00	48.880	4	0.0000000	0.046450
Native	909.1	654	0.0e+00	10.630	4	0.0310600	0.011560
Annual/perennial							
Exotic	1034.0	487	0.0e+00	33.070	4	0.0000012	0.030980
Native	918.8	654	0.0e+00	4.090	5	0.5365000	0.004432
Annual/perennial and grass/forb/shrub							
Exotic	973.9	487	0.0e+00	68.770	10	0.0000000	0.065950
Native	881.2	654	0.0e+00	37.230	13	0.0003817	0.040530
Plot size							
Exotic	937.3	481	0.0e+00	37.840	11	0.0000833	0.038800
Native	824.1	648	9.0e-07	18.570	10	0.0461400	0.022030
Seeding of native							
Exotic	1005.0	486	0.0e+00	33.420	2	0.0000001	0.032190
Native	894.7	654	0.0e+00	10.240	2	0.0059620	0.011320

QE, unexplained heterogeneity (dispersion); *QE_df*, corresponding degrees of freedom; *QE_p*, corresponding p-value; *QM*, heterogeneity explained by the model; *QM_df*, corresponding degrees of freedom; *QM_p*, corresponding p-value; *QM/QT*, proportion of observed (total) heterogeneity explained by the model.