



Public Lands Service Coalition
Before/After-Control/Impact (BACI)
Ecosystem Management Evaluation

American Conservation Experience
Final Report

November 2023



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Cover photo provided by American Conservation Experience during field data collection.

Executive Summary

Millions of acres of public lands across the United States are imperiled by invasive species and wildfires, which reduce ecosystem health, decrease the productivity of public lands for wildlife, diminish recreation assets, and threaten the safety of communities. There is a need to manage public lands to sustain ecosystem services and enhance human safety. Agencies responsible for managing these lands, including the Forest Service, National Park Service, Bureau of Land Management, state parks, and others often complete such mission-critical work through collaboration with partners such as AmeriCorps members who can assist agencies in mitigating the spread of invasive weeds and reducing wildfire fuel loads that threaten communities and ecosystem services. For this evaluation, a cohort of conservation AmeriCorps programs (i.e., the Public Lands Service Coalition or PLSC) conducted a nationwide evaluation to assess the impact AmeriCorps members have on reducing invasive species and minimizing wildfire fuel loads on public lands.

For this evaluation, a Before-After-Control-Impact (BACI) quasi-experimental design was utilized to strengthen evidence of AmeriCorps members' environmental stewardship. The evaluation measured outcomes on project sites treated by AmeriCorps members and assessed ecosystem indicators for comparison sites. Assessment of treatment, or impact, plots and control plots was performed before and after treatment. This evaluation focused on the ability of AmeriCorps members to reduce invasive species populations and reduce wildfire risk on public lands.

To conduct this evaluation, each participating PLSC program identified at least one project during the 2022/23 season to evaluate, either an invasive species or fuel load management project on public lands. For the identified project, treatment areas (where Corps members would be performing work) and comparable control areas were established. Within both treatment and control areas, Corps members established 30x30 meter plots and, within each plot, four (4) thirty meter transects. Corps members then collected data along those transects. For invasive species projects vegetation cover metrics were recorded. For fuel projects, a number of metrics were collected including litter depth, canopy cover, lowest live branch, and circumference at breast height. Data were collected in both control and treatment areas prior to work starting in the treatment areas, again about three months after work was completed in the treatment area, and finally one year after work had been completed in treatment areas. This

yielded a ‘before,’ ‘short-term after,’ and ‘moderate-term after’ data set for both the ‘treatment’ and ‘control’ areas.

Data were analyzed descriptively and then using inferential statistics to explore significant differences between plots before and after treatment and between control and treatment areas. Analysis was completed at the plot level, wherein an average for each outcome of interest was computed. Then, t-tests and a regression model that accounted for initial differences between control and treatment areas was employed to detect statistically significant changes in the outcome variables.

Results for this report highlight the environmental outcomes of an invasive species management project administered by American Conservation Experience AmeriCorps members in the Grand Teton National Park in Wyoming. Results reveal that ecosystem management techniques performed by the American Conservation Experience AmeriCorps members did significantly reduce the cover of invasive species in both short and moderate term evaluation time periods. Additionally, in short term evaluations, beneficial species cover significantly increased in areas treated by AmeriCorps members. **This demonstrates that the activities implemented by AmeriCorps members are having positive outcomes on the landscape by reducing the prevalence of target invasive species for up to a year following treatment and by increasing (in the short term) or maintaining (in the moderate term) the prevalence of beneficial species across the landscape.**

Background

Existing studies have demonstrated that invasive species reduce biological diversity and have negative impacts on human well-being (Rai & Singh, 2020; Pysek & Richardson, 2010) and wildfire fuels reduction can positively benefit wildlife (Fontaine & Kennedy, 2012; Pilliod et al., 2008) as well as enhance the safety of built environments in the wildland-urban interface (Stevens et al., 2014). Public land management agencies consider ecosystem management, including the control of invasive species and fuel loads, mission-critical work and central to their agency's purpose. Often, public land management personnel partner with external entities, such as AmeriCorps conservation corps programs to complete such mission-critical tasks (McCreary et al., 2012). Understanding how AmeriCorps partnerships contribute to these objectives through collaborative management with public land management agency sponsors, will establish the role of AmeriCorps members in contributing to positive environmental outcomes on public lands (e.g., Conner, 2016, Davis, 2015).

Evaluation Procedures

The overall aim of the proposed evaluation was to examine the outcomes of AmeriCorps members on at-risk ecosystems, specifically those in need of invasive species management. This was assessed via a quasi-experimental design (QED), before-after control-impact (BACI) evaluation approach comparing treated plots managed by American Conservation Experience AmeriCorps members at Grand Teton National Park to comparison control plots. The work assessed through this evaluation was completed by a conservation corps, consisting of 7 crew members working on a total of 262 acres in the national park.

The long-term outcomes of these types of habitat management projects include enhancing biodiversity including native flora and fauna. Evaluating long-term outcomes would require an evaluation approach spanning several years as these outcomes are not evident until many years after treatment. Instead, this evaluation focused on assessing the short- and moderate-term outcomes of habitat management by American Conservation Experience AmeriCorps members. The primary research questions of this evaluation are:

- Do areas of land treated for invasive species removal by AmeriCorps members demonstrate **less invasive species cover in near-term** evaluations compared to similar plots of untreated land?

- Do areas of land treated for invasive species removal by AmeriCorps members demonstrate **more native plant growth in *near-term*** evaluations compared to similar plots of untreated land?
- Do areas of land treated for invasive species removal by AmeriCorps members demonstrate **less invasive species cover in *moderate-term*** evaluations compared to similar plots of untreated land?
- Do areas of land treated for invasive species removal by AmeriCorps members demonstrate **more native plant growth in *moderate-term*** evaluations compared to similar plots of untreated land?

Sampling Approach

For this evaluation, the American Conservation Experience collected field data to assess the impact their AmeriCorps members have in reducing invasive species populations on public lands. Specifically, this evaluation assessed a project wherein American Conservation Experience AmeriCorps members treated 262 acres of land situated within Grand Teton National Park over 3,762 work hours.

The crew worked all season (May 15- August 3, 2022) treating a range of rocky mountain invasive grasses and forbs including smooth brome, cheatgrass, houndstongue, and spotted knapweed. The primary target species for invasive species removal activities was spotted knapweed. The crew applied used foliar herbicide as the primary form of treatment. Specifically, Milestone, a pre and post emergent herbicide used for grassland restoration and controlling established populations of invasive forbs was used in this project. Due to cooler than normal spring conditions, most of the knapweed plants encountered and treated by the crew were not mature.

Data were collected at three times: (1) July 2022, before work commenced in the project treatment area; (2) September 2022, after work was completed in the treatment area; and (3) July 2023, one year after work was completed in the treatment area.

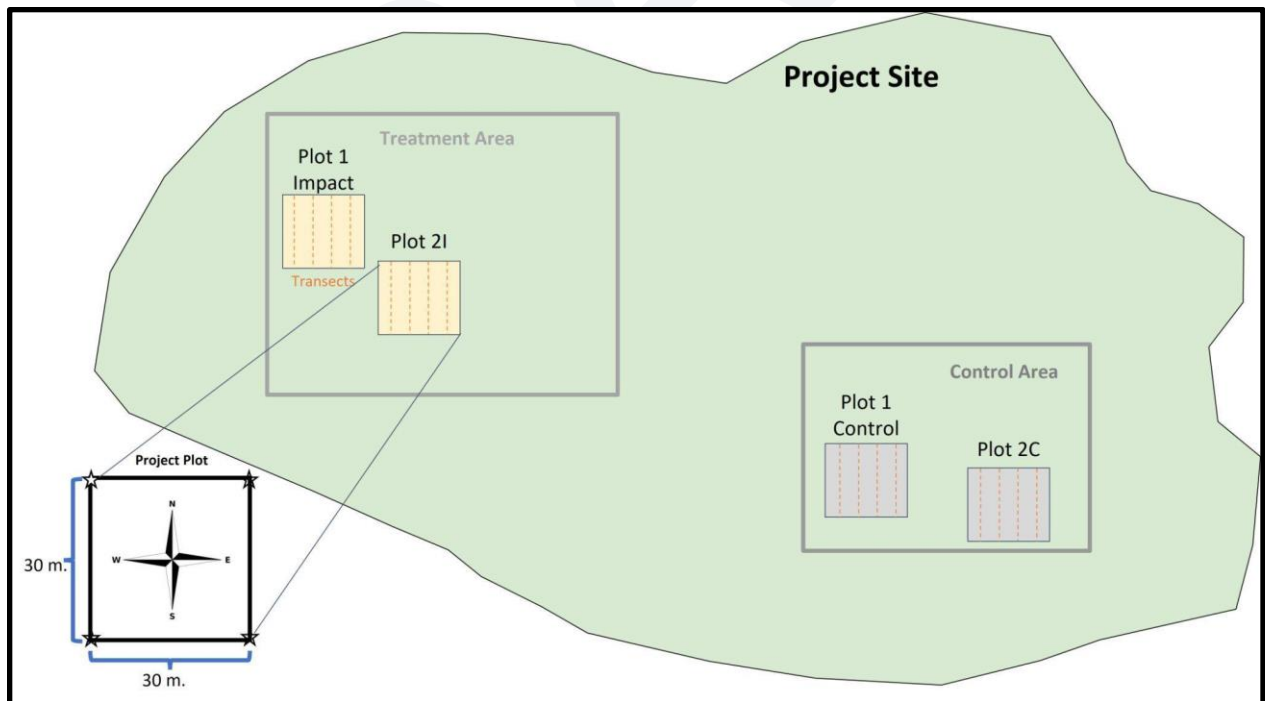
Control and Treatment Areas

Together, American Conservation Experience, their agency sponsor, and the evaluation team, identified project areas including “treatment” areas where AmeriCorps members would be

completing invasive species management tasks and comparable “control” areas where no work would be completed in the 2022/23 season. Control areas were selected based on similarity to treatment areas in terms of slope, aspect, and vegetation composition and density. Within each control and treatment area, American Conservation Experience AmeriCorps members established 30x30 meter plots. Then, within each of those plots, four (4) thirty-meter transects per plot were established, each spaced 6 meters apart vertically, see sampling design illustration in Figures 1 and 2 below.

Using the QED, BACI approach, plot areas were not randomly assigned within the corps’ habitat management project. Corps program staff coordinated with the evaluators and public land management agency sponsors to determine the location of both treatment and control plots. The location of the plots was distributed throughout the project area to coincide with both areas where work was and was not performed and to capture efforts in areas in which it was safe and efficient to collect data.

Figure 1. Illustration of sample site with treatment and control areas defined and paired plots with transects delineated.



A power analysis, using the R package Emon and function power BACI (e.g., Barry

et al., 2017), to determine the number of plots, transects, and data collection points was conducted following pilot testing of the sampling approach in summer-fall 2021. Based on these findings, a final sampling approach was designed for invasive species removal projects, see Figure 2 below. An initial assessment using the percent changes observed within plots evaluated by two pilot Corps in 2021 suggest that approximately 9-14 total transects would be required to detect large effect sizes (>0.8) with 80% power. Therefore, most PLSC members submitted data for 16 transects (8 control and 8 treatment) both before and after work was conducted in the project area.

Ecosystem Improvement Indicators

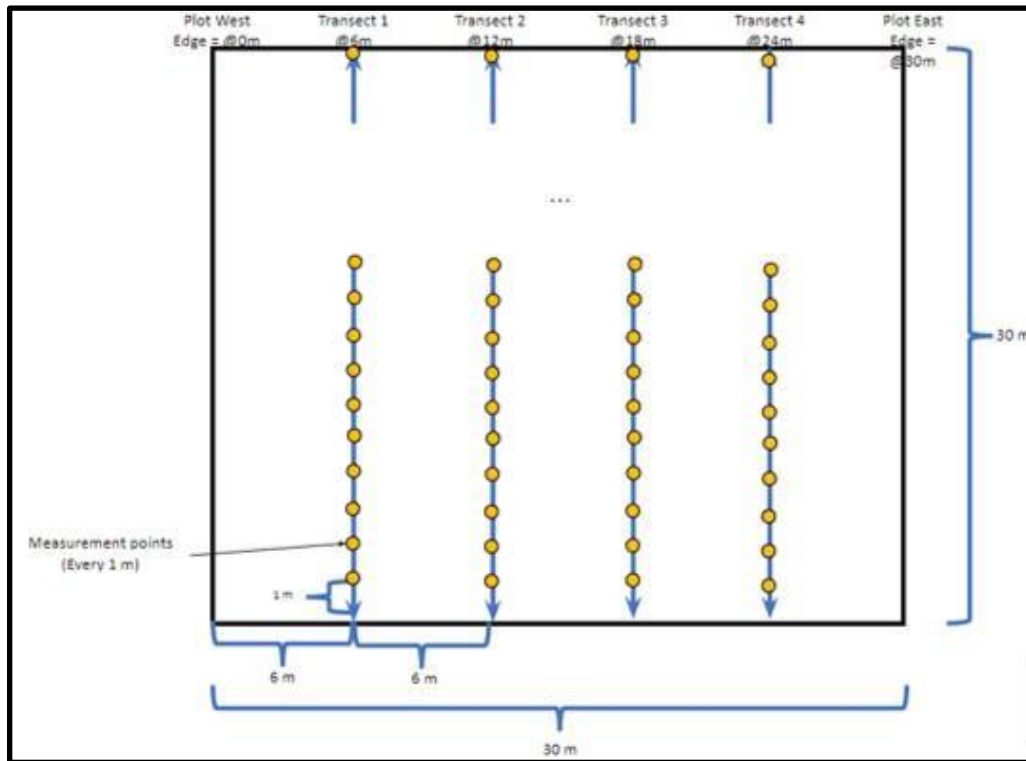
An assessment protocol for invasive species management projects was designed by the external evaluation team who trained corps staff in protocol application. Professional corps employees managed the data collection to ensure consistent application of sampling protocols and data collection procedures. The external evaluators monitored data collection to ensure rigor in data management and analysis.

For invasive species management plots, data was collected at every 1-meter interval, along each of the four transects within a plot (see Figure 2). At each of these points, crew members indicated whether the prevailing land cover consisted primarily of either:

- The target invasive species cover
- Another invasive species cover
- Beneficial vegetation cover
- Bare ground cover

Corps members collected data at these designated points along each transect in plots in both the treatment and matched control area using a ‘paired design’ (Tubbesing et al., 2019). “Before” data was collected in July 2022. Short-term “after” data was collected in September 2022 and moderate-term “after” was collected in July 2023. Multiple collections of field data were made, as previous research found that “power was consistently lower when only a single ‘after’ survey was carried out and increased with both two and three ‘after’ surveys” (Fisher et al., 2019).

Figure 2. An illustration of invasive species project sampling protocols.



Analysis

Field data were submitted by the corps program to the evaluation team using an offline/online data collection interface (Kobo Toolbox). Data were downloaded from the server to an Excel spreadsheet and organized by the evaluation team, checking for completeness and identification of plots following the paired sampling design strategy. Data were then uploaded into R statistical computing software to run descriptive statistics and inferential statistical tests.

Descriptive Statistics

In R, the proportion of each land cover class (beneficial species, target species, other weeds, and bare ground) was calculated for each plot by dividing the total number of microplots dominated by each land cover class by the number of microplots sampled (i.e., 120 landcover class observation points per plot). Then, the mean proportion of each land cover class for control and impact plots at each time point of measurement was calculated: before treatment, near-term after treatment, and moderate-term after treatment. Next, the change in mean proportions of each

land cover class was calculated to determine variance between each of the three time periods (before to near-term after treatment, before to moderate-term after treatment, and between near-term to moderate-term after treatment) by subtracting the mean value of the earlier proportion from the mean value of the later proportion. For example, a plot that consisted of 50% target species in July 2022 and later 20% target species in July 2023 would show a change of (negative) -30%, or a 30% decrease in target species present on that plot 12 months after the treatment was conducted. Bar charts were created to visualize these changes between control and impact plots and over time.

Inferential Statistics

T-tests are often used to test for significant differences between the means of two groups. For BACI studies in particular, t-tests can be used to look for significant differences in changes of measurements between the control and impact plots over time. Therefore, separate t-tests were utilized to examine if there were significant differences in the changes of the proportions of prevailing land cover (beneficial species, target species, other weed species, and bare ground) over the three study time periods: before to near-term treatment, before to moderate-term after treatment, and between near-term and moderate-term after treatment. A series of four t-tests per period were conducted, for a total of 12 t-tests. Additionally, linear regression models were employed to further investigate the statistical significance of these changes and provide an estimate of the effect of the management strategy on the change in each measurement. The results from these t-tests and linear regression were used to accept or reject the following hypotheses:

- Treatment did not affect invasive species cover.
- Treatment did not affect native/non-invasive cover.

Results

For this report, field data collected by American Conservation Experience was analyzed. This included analysis of field data collected within an invasive species management project which consisted of the foliar herbicide applications by AmeriCorps members to reduce the presence of invasive species (target species: spotted knapweed) within a project in Grand Teton

National Park. To determine outcomes of the project, data were inspected for descriptive qualities and then inferential analyses were conducted to look for statistically significant changes in areas where AmeriCorps members completed invasive species management tasks.

Descriptive statistics

Descriptive analysis, including the measure of proportional distribution of the land cover classes (see Figure 3 and Table 1 below), reveals that control plots were composed of 1% bare ground, 89% beneficial species and 10% target species (knapweed) before treatment began (July 2022). In September 2022, control plots were 83% beneficial species, 15% target species, and 2% other invasive species. In July 2023, controls plots were composed of 86% beneficial species, 13% target species and 1% other weeds. This shows, overall, an increase in invasive species, including the target species and a decrease in beneficial species in control plots during the evaluation period.

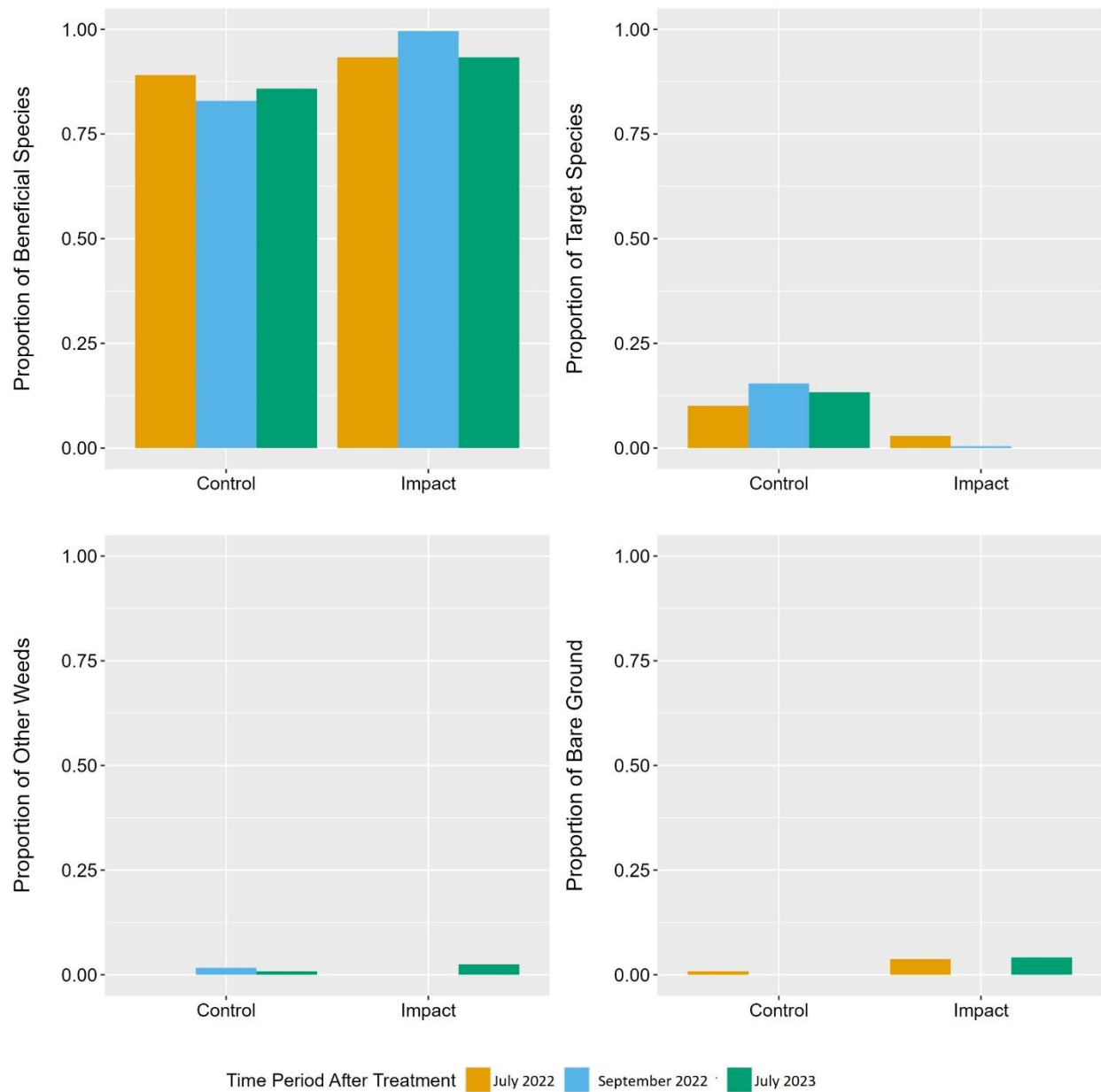
Table 1. Proportions of beneficial species, target species, other weeds, and bare ground on plot before and in short- and moderate-term after points after treatment.

Before/After	Control/ Impact	Bare Ground	Beneficial Species	Target Invasive	Other Weed
B: 07/2022	Control	1%	89%	10%	0
B: 07/2022	Impact	4%	93%	3%	0
A: 09/2022	Control	0	83%	15%	2%
A: 09/2022	Impact	0	100%	0	0
A: 07/2023	Control	0	86%	13%	1%
A: 07/2023	Impact	4%	93%	0	3%

Impact or treatment plots were composed of 93% beneficial species, 4% bare ground, and 3% target species before treatment was applied (July 2022). After treatment was applied, in September 2022, treatment plots were composed of 100% beneficial species. One-year post-treatment (July 2023), treatment plots were composed of 93% beneficial species, 4% bare ground and 3% other weeds. This demonstrates that in the short term, invasive species were eliminated from treatment plots but in one year after treatment (non-target) invasive species levels had resumed to pre-treatment levels of 3%. However, overall, beneficial species proportions remain

higher and invasive species proportions remain lower for treatment plots when compared to control plots in both short- and moderate-term time points.

Figure 3. Proportions of beneficial species, target species, other weeds, and bare ground on plot before and in short- and moderate-term after points after treatment.



Inferential statistics

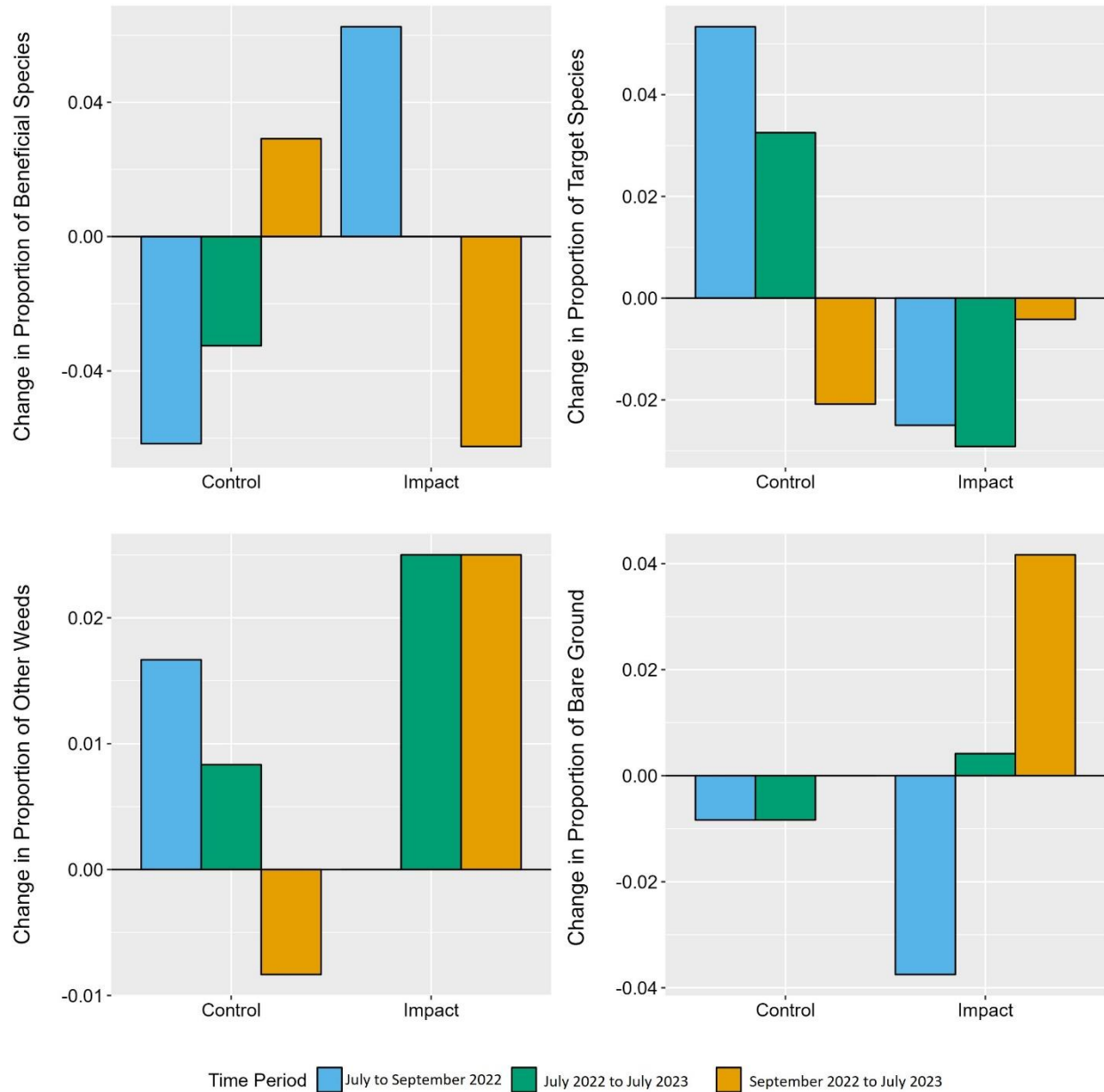
Inferential statistics were computed to understand the change over time between control and impact areas. Controlling for differences that existed in pre-treatment stand characteristics of control and treatment plots, a t-test and a regression model were used to test for statistically significant differences in change over time for control and treatment areas. See Figure 4 and Tables 2 and 3 below.

Table 2. T-test results showing statistically significant changes in vegetation cover before and in near and moderate-term periods after treatment.

Time	Measure	Summary stats			t-test		
		Mean (change over time)	SD	t-value	Df	P-value	
Before to near-term after	Bare ground	Control	-0.01	0	1.00	1.00	0.50
		Impact	-0.04	0.04			
	Target species	Control	0.05	0.01	8.08	1.63	0,03
		Impact	-0.03	0.01			
	Beneficial species	Control	-0.06	0.02	-5.20	1.57	0.06
		Impact	0.06	0.03			
	Other weeds	Control	0.02	0.02	1.00	1.00	0.50
		Impact	0	0			
	Bare ground	Control	-0.01	0	-0.33	1.00	0.79
		Impact	0.004	0.05			
Before to moderate- term after	Target species	Control	0.03	0.01	7.17	1.56	0.04
		Impact	-0.03	0.01			
	Beneficial species	Control	-0.03	0.01	-1.25	1.18	0.41
		Impact	0	0.04			
	Other weeds	Control	0.01	0	-2.00	1.00	0.30
		Impact	0.03	0.01			

*Statistically significant

Figure 4. Changes in proportions of beneficial species, target species, other weeds, and bare ground in near and moderate-term periods after treatment.



Near-Term Outcomes

For the period of time before treatment until near-term after data was collected (i.e., July to September 2022), control plots had a decrease (-1%) in bare ground, an increase (+5%) in target species, a decrease (-6%) in beneficial species, and an increase (+2%) in other weeds. For that same time period, treatment plots had a decrease (-4%) in bare ground, a decrease (-3%)

in target species, an increase (+6%) in beneficial species, and no change in the proportion of other weeds. While these changes in proportions demonstrate practical differences across all land cover categories, t-tests (Table 2) reveal that change was statistically significant for target species proportions, with control plots increasing in target species coverage in near-term evaluations while target species decreased in treatment plots. Linear regression models (Table 3) also show that target species proportions differed significantly in near-term evaluations and further demonstrate that change in the proportion of beneficial species coverage was also significant between July and September 2022, with control plots having a lower proportion of beneficial species while treatment plots experience an increase in the proportion of beneficial species.

Evaluation data illustrate that in areas treated by AmeriCorps members, target invasive species cover decreased and remained suppressed up to a year after treatment.

In comparison control areas, invasive species cover increased.

Moderate-Term Outcomes

For the period before treatment until moderate term after data was collected (i.e., July 2022 to July 2023), control plots had a decrease in (-1%) in bare ground, an increase (+3%) in target species, a decrease (-3%) in beneficial species, and an increase in (+1%) in other weeds. For that same period, treatment plots had a slight increase (0.4%) in bare ground, a decrease (-3%) in target species, no change in beneficial species, and an increase (+3%) in the proportion of other weeds. This shows that in moderate-term (i.e., 1 year after treatment) evaluations the change in bare ground stayed the same as measurements taken 3 months after treatment and that the reductions in target species in treatment plots persisted, while the increase in beneficial species in treatment plots dropped from an increase of 6% back to pre-treatment proportions. The proportion of other weeds dropped slightly for control plots in the moderate term while they rose in treatment plots for the same period. T-tests and the regression model illustrate that target species changes were statistically significant, with control plots experiencing increases in target

species in moderate term (i.e., one year) evaluations, while impact plot proportions of target species declined in the year following treatment.

Based on the results of this study we fail to accept the null hypothesis that *treatment did not affect invasive species cover*. Results demonstrate that the changes in the prevalence of invasive species cover in treatment areas over time and compared to control areas are statistically significant. In areas where AmeriCorps members are performing work, invasive species cover is significantly reduced. We partially accept the second null hypothesis that *treatment did not affect native/non-invasive cover*. Results show that in the short-term beneficial species populations increased significantly in treatment areas but this change was not detected in moderate-term observations.

Table 3. Linear regression results showing statistically significant changes in vegetation cover before and in near and moderate-term periods after treatment.

Time	Measure	Linear Regression (ref = Control)		
		beta	CI	p-value
Before to near-term after	Bare ground	-0.03	-0.15-0.1	0.42
	Target species	-0.08	-0.12—0.04	0.02 *
	Beneficial species	0.12	0.02-0.23	0.04 *
	Other weeds	-0.02	-0.09-0.06	0.42
Before to moderate-term after	Bare ground	0.01	-0.15-0.17	0.77
	Target species	-0.06	-0.10-0.02	0.02 *
	Beneficial species	0.03	-0.08-0.14	0.34
	Other weeds	0.02	-0.02-0.05	0.18

*Statistically significant

Conclusions

This evaluation provides strong evidence that American Conservation Experience AmeriCorps members are effectively contributing to ecosystem management on public lands,

particularly in regard to invasive species management. Evaluation results show that in both near-term (July to September 2022) and moderate term (July 2022 to July 2023) evaluations, AmeriCorps members reduced invasive species cover, with lasting impacts. Using foliar herbicide to decrease invasive species prevalence, American Conservation Experience has utilized best practices to improve ecosystem structure and function. In summary, over a one-year period, AmeriCorps members were able to:

- Decrease target invasive species cover by 3% in treatment areas compared to a 3% increase of target invasive species in control areas, and
- Maintain prevalence of beneficial species in treatment areas, compared to 3% decrease in beneficial species in control areas.

These results demonstrate the ecosystems outcomes that are a result of the energy and expertise provided by AmeriCorps members.

While there were differences in control and treatment areas at the onset of this evaluation, a linear regression model that accounted for these differences still shows changes in vegetation cover over time, and in regard to target invasive species cover this difference in change over time between control and treatment areas is statistically significant. This evaluation provides evidence to support the continued treatment of public lands by AmeriCorps members to produce beneficial ecosystem outcomes. When comparing the short term to moderate-term evaluation results, we see slight losses in the in the proportion of beneficial species gains in treatment plots however. This may illustrate that annual treatment can keep target invasive species cover down but to increase beneficial species cover, more frequent treatment intervals (e.g., every 3 to 6 months) might be needed.

There are limitations to this evaluation. For example, control and treatment areas were not randomly selected. Also, natural variation occurs in the areas where this evaluation was performed and may have influenced results to some degree. Additionally, management techniques were those commonly used in this area for this type of task, testing other types of management techniques to reduce invasive species cover may yield different results. Another potentially limiting factor is that when field data were initially collected, the study area was experiencing a cooler than normal spring weather pattern. This may have led to increased emergence of knapweed in treatment areas following the treatment. Continuing, longitudinal

evaluation of ecosystem management outcomes will be needed to make long-term conclusions about the scope and impact of AmeriCorps members' contributions.

In conclusion, this evaluation did produce strong evidence that AmeriCorps members are effectively contributing to ecosystem management, namely invasive species cover reduction. For American Conservation Experience, this evaluation data can illustrate key short and moderate term outcomes of their efforts and guide future project identification and implementation. Additionally, techniques may be adopted to further influence those metrics that were not statistically significant in this evaluation (e.g., the prevalence of 'other weeds') to further improve their impact with ecosystem management.

While there are practical differences in all four types of vegetation cover –after treatment and in comparison plots– target species cover emerged as *statistically significant* in both short and moderate term evaluations.

Conservation efforts by American Conservation Experience AmeriCorps members are making practical and statistically significant impacts in the areas where they perform ecosystem management.

Appendices

Appendix 1 – References

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Appendix 2 – Data Collection Instruments

[Project Summary Form](#)

[Invasive Species Data Collection Form](#)

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