2017 Public Lands Service Coalition Habitat Evaluation Report

NC STATE UNIVERSITY

Executive Summary

INTRODUCTION The nature of environmental stewardship corps programs presents unique conditions for evaluation and monitoring. To address these challenges and provide rigorous evaluation of corps programs, a collaboration between The Corps Network, member organizations of the Public Lands Service Coalition (PLSC), and North Carolina State University (NCSU), developed and implemented standardized measures of habitat improvement projects on public and private lands. Projects focused on changes occurring in assessed indicators of habitat health following work by Conservation Corps crews. Trained crew members documented project-level outcomes and systematically evaluated conditions within sample plots using both visual and measurement-based assessment techniques prior to and immediately following work. **Results provide information on the efforts and outcomes of corps fieldwork and identify opportunities for future evaluation.**

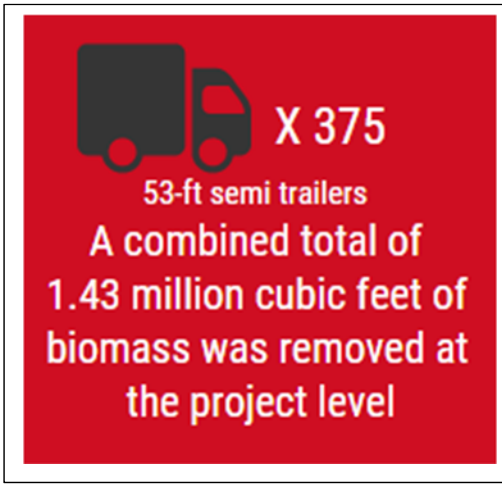
PROCEDURES Evaluation focused on improving ecosystem health and visitor experience through six objectives (see box at right). Data were collected both at the **project-level**, which incorporated overall work including acres covered, crew members involved, and activity objectives, and at the **plot level (within projects)**, which used a systematic approach to sample work impacts. The number of plots placed in each project was based on the homogeneity of the entire project area and three plots were to be placed per area type. Assessments were based on observation and objective measures. Plot-level data focused specifically on invasive species management and forest fuels reduction.

Activity Objectives

1. Encouraging or improving habitat for native plants
2. Encouraging or improving habitat for native animals
3. Discouraging or removing invasive plants from habitats
4. Discouraging or removing invasive animals from habitats
5. Reducing forest fuels to mitigate wildfire risk and severity
6. Restoring or creating habitat

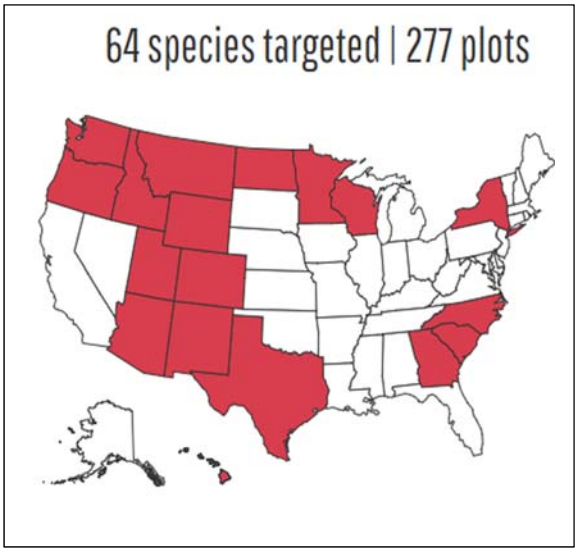
Project-Level Findings

Findings are based on **149 habitat projects** conducted by 10 corps between April 1 and November 15, 2017. Projects covered almost 26,000 acres of forest, grassland, and aquatic habitats across the US, and involved 1,461 crewmembers who contributed almost 38,000 hours in 19 states.



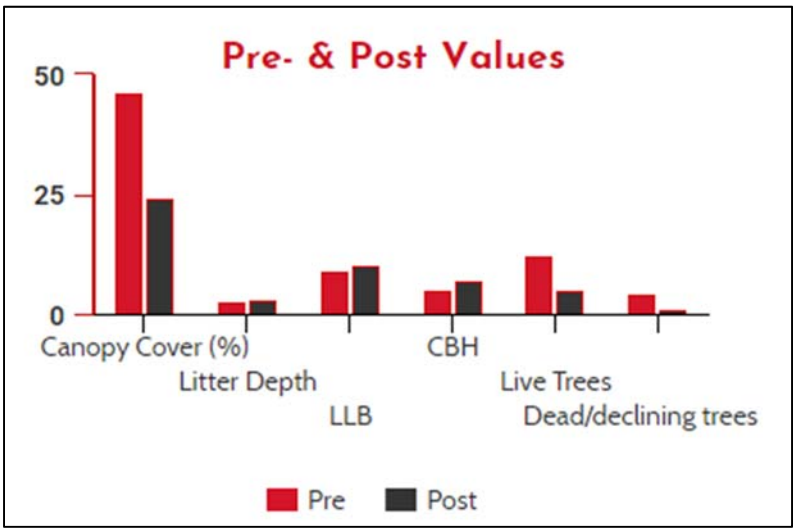
Invasive Species Management Findings

277 invasive species management plots were evaluated, employing chemical controls (n=168), manual/mechanical removal (n=44), and mixed methods (n=65). Pre-work and post-work assessments were conducted on plots that employed manual and mechanical removal methods (n=109 plots). The **overall percent change** in the total coverage of invasive species averaged **-81% and was statistically significant.** The majority of plots were reported as being treated prior to seed maturation and the equivalent of 335 semi-trailers of biomass was reported as being removed from plots. **Results indicate that corps work contributed significantly to the goal of reducing invasive species impact on ecosystem health.**



Forest Fuels Reduction Findings

123 forest fuels reduction plots were evaluated. Pre-work and post-work assessments evaluated canopy cover, litter depth, height of the lowest live branch (LLB), tree circumference at breast height (CBH), and number of live and dead or dying trees. **All but one indicator exhibited statistically significant changes** due to work. Changes in these indicators represent a **reduction in forest fuels from evaluated plots and progress towards mitigating fire risk and severity**.



Conclusions

This evaluation provides evidence of positive impacts to habitats by Conservation Corps field crews in relation to invasive species management and forest fuels reduction, contributing to overall ecosystem health and resilience. The protocols introduced in this study are meant to support corps in ongoing evaluation efforts and are recommended for future application.

PUBLIC LANDS SERVICE COALITION

NC STATE UNIVERSITY

The CorpsNetwork
Strengthening America through service and conservation

2017 Public Lands Service Coalition Habitat Evaluation Report

February 7, 2018

Dr. Michael B. Edwards, Dr. Chelsey Walden-Schreiner, Elizabeth Oliphant, Dr. Gary Blank, Dr. Yu-Fai Leung, Dr. Erin Seekamp, and Katelin McArdle

NC STATE UNIVERSITY College of Natural Resources

Table of Contents

Table of Figures

Table of Tables

Acknowledgements

Participating Public Lands Service Coalition corps and The Corps Network funded this evaluation, with leadership from Conservation Legacy. We also thank all corps and crew members for their time and dedicated efforts in developing, testing, refining, and implementing this evaluation.

Cover photos clockwise from top left: 1. Manual removal of invasive European Beach Grass, Ocean Park, Washington, Northwest Youth Corps; 2. Chemical control of invasive species Houndstongue, Ashwood, Oregon, Heart of Oregon Corps; 3. Spraying invasive species Yellow Star Thistle, Capitol Hill, Salt Lake City, Utah, Utah Conservation Corps

Executive Summary

This report evaluates outcomes of Conservation Corps habitat improvement projects sampled during 2017. Specifically, evaluation focused on changes occurring in assessed indicators of habitat health following work by Conservation Corps crews. Trained crew members documented project-level outcomes and systematically evaluated conditions within sample plots using both visual and measurement-based assessment techniques prior to and immediately following work. Results provide information for communicating efforts and outcomes and identifying opportunities for future evaluation.

Findings presented in this report are based on **149 habitat projects** conducted by **10 corps** between April 1 and November 15, 2017. These projects covered **almost 26,000 acres** of forests, grassland, and aquatic habitats across the United States, and involved **1,461 crew members** who contributed **almost 38,000 hours** in **19 states**.

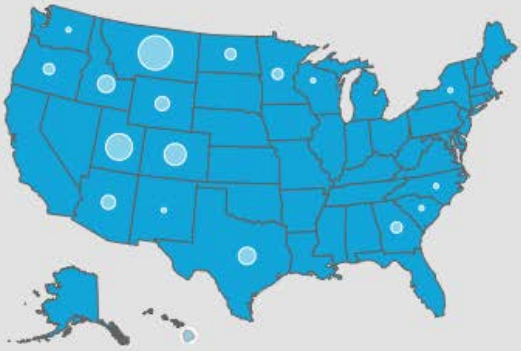
Corps*	Projects Sampled	Acres Treated	Total Hours**	Crew Members
Conservation Corps Minnesota & Iowa (CCMI)	4	77.25	347.50	33
Conservation Legacy (Cons. Legacy)	27	227.24	10,957.00	210
Kupu	9	193.53	7,936.00	563
Montana Conservation Corps (MCC)	62	12,665.42	3,524.50	375
Northwest Youth Corps (NYC)	3	3.50	1,123.00	15
Student Conservation Association (SCA)	1	3.00	441.00	9
Texas Conservation Corps at American YouthWorks (AYW-TXCC)	8	103.50	519.50	61
Utah Conservation Corps (UCC)	35	12,458.36	12,861.60	195
Grand Total	**149**	**25,731.79**	**37,710.10**	**1,461**

* Heart of Oregon Conservation Corps (HOC) and Rocky Mountain Youth Corps – New Mexico (RMYC) also contributed data at the plot level

** Note: Total hours are as reported by corps. This may include overall project hours as well as person-hours.

Habitat Projects

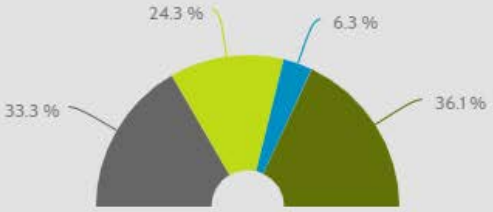
Key findings from the 2017 Conservation Corps Habitat Evaluation



149 Projects

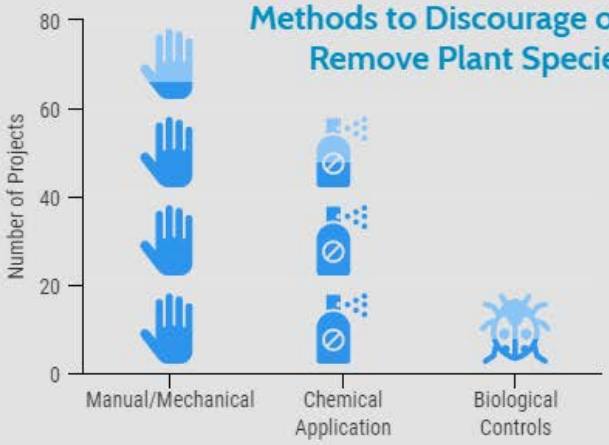
- 25,732 acres
- 37,710 hours
- 1,461 crew members
- 10 corps working in 19 states

Project Objectives



- Discouraging or removing plant species
- Reducing forest fuels
- Encouraging or improving habitat for plant species
- Multiple concurrent objectives

Methods to Discourage or Remove Plant Species



Materials Removed

847,443 cubic feet of invasive species biomass removed through manual or mechanical methods

582,000 cubic feet of forest fuel biomass removed through trimming, thinning and slash removal

x 375

53-ft semi trailers

Crews collected detailed data in sample plots for projects involving invasive species and forest fuel management. A total of **277 invasive species plots** targeted **64 plant species**, most often using chemical control (n=168) or manual/mechanical removal (n=44). Pre- and post-assessments of all treatments (excluding chemically treated only plots) revealed statistically significant reductions in invasive species percent cover. Corps work resulted in a **-81% change** in percent cover of invasive species.

Invasive Species Management

Seed Maturity

Only 26% of species targeted had mature seeds at the time of treatment.

1.279 million cu. ft.

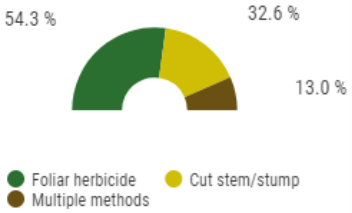
x 335

Biomass Removed from Plots

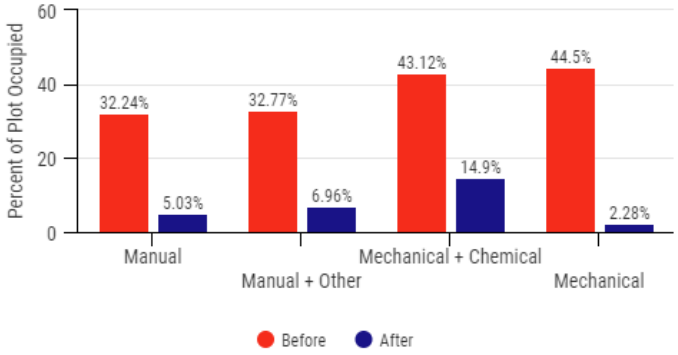
The amount of biomass removed would fill over 335 53-ft semi trailers

Chemical Applications

61% of plots were treated with chemicals alone

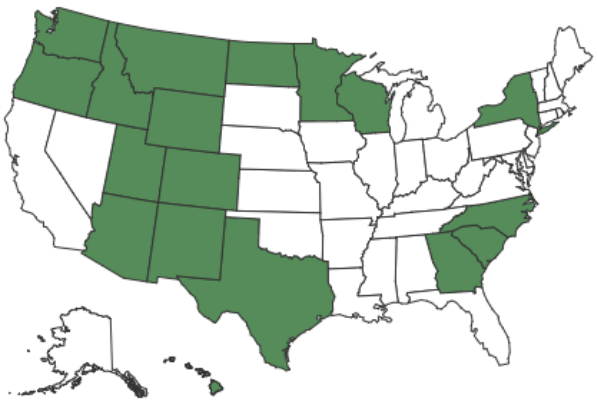


Average Invasive Species Percent Cover Before and After Crew Work



81% Reduction in Invasive Species Cover

64 species targeted | 277 plots



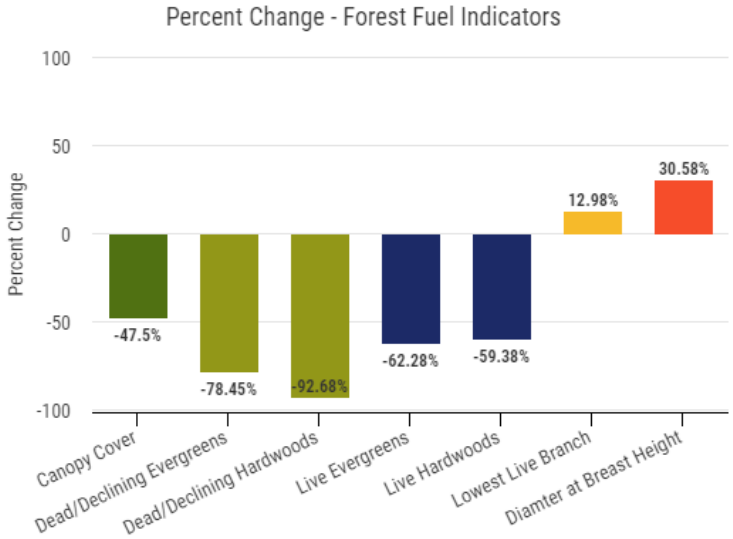
Crews also assessed the management of forest fuels in **123 forest fuel plots**. The average change across all indicators associated with fire risk was statistically significant, with the exception of one (i.e., lowest live branch). The **reduction in the number of trees** remaining in a plot, as well as the **reduction in canopy cover** both exhibited **large effect sizes**, highlighting the practical significance of the changes due to corps work.

Forest Fuel Reduction

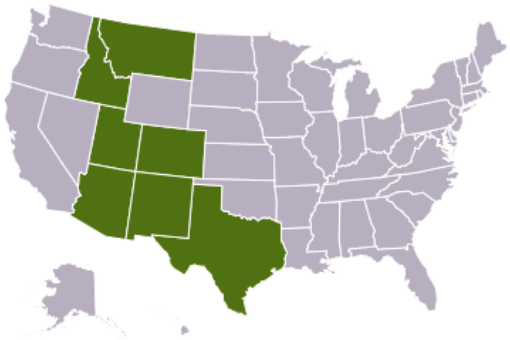
Decreasing tree crown density reduces risk of canopy fire and spread

Reducing ground, surface, and ladder fuels minimizes flame length and makes fires easier to control

Generally, increasing tree size reduces mortality due to fire



Forest Fuel Plot Locations



29K Cubic Feet of Forest Biomass Removed

Evaluation Procedures

The nature of environmental stewardship corps programs presents unique conditions for evaluation and monitoring. The practices and objectives of partner agencies set project priorities and techniques to accomplish project goals. The purposeful identification of work sites often precludes incorporating control sites in evaluation design. Crews conduct work in diverse habitats under dynamic conditions, complicating standardization and comparison.

To address these challenges and provide rigorous evaluation of corps programs, a collaboration between The Corps Network, member organizations of the Public Lands Service Coalition (PLSC), and North Carolina State University (NCSU), developed and implemented standardized measures of habitat improvement projects on public and private lands. Management goals identified through interviews and surveys with partner agencies and corps directed measurement selection. Specifically, this evaluation focused on improving ecosystem health and visitor experience through six objectives:

1. Encouraging or improving habitat for native plants
2. Encouraging or improving habitat for native animals
3. Discouraging or removing invasive plants from habitats
4. Discouraging or removing invasive animals from habitats
5. Reducing forest fuels to mitigate wildfire risk and severity
6. Restoring or creating habitat

This evaluation explores types and amounts of activities contributing to each of the objectives, as well as detailed data focused specifically on invasive plant species management and the reduction of forest fuels, as they were the most common project types among participating corps. Review of the literature from land management agencies (e.g., U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. National Park Service) and peer-reviewed journals identified salient indicators (i.e., measureable and manageable proxies for objectives) associated with ecosystem health and fire risk for in-depth evaluation of condition changes (see Appendix 1 for a list of references). Data were collected at both the **project-level**, which incorporated overall work including acres covered, crew members involved, and objectives, and at the **plot level (within projects)**, which used a systematic approach to sample work impacts. The number of plots placed in each project was based on the homogeneity of the entire project area and three plots were to be placed per area type. Due to limitations in data collection, not all projects reported three or more accompanying plots, and likewise, not all plots were reported with related project-level data. All data included in this report are based on the data provided by the corps.

Invasive Species Management

The goal of invasive species management is to reduce impacts from invasive species on ecosystems through detection, management, prevention, and restoration (USFS, 2009). Corps contribute to this goal by removing or reducing the number of targeted species (especially before seeds reach maturity) to manage, and/or prevent species persistence or proliferation (Davies & Sheley, 2007). Partners engaged corps to conduct one or a combination of the following treatment approaches:

- Manual removal (e.g., hand pulling)
- Mechanical removal (e.g., cutting, trimming, digging, mowing, chain saw)
- Chemical control (e.g., herbicide)

Manual removal of invasive species European Beach Grass, Ocean Park, Washington, Northwest Youth Corps

Measures to evaluate invasive species projects included:

- Describing the targeted species (e.g., name, type, life cycle)
- Documenting methods employed (e.g., prescribed burns, chemical application)
- Categorizing the composition of the plot (e.g., percent of invasive species cover within the plot, percent of total vegetated cover within the plot, and percent of bare ground or rock within the plot), and
- Estimations of biomass removed.

(Note: percent of total vegetation and bare ground were used to characterize plot conditions in order to validate pre- and post-work assessments and are not analyzed further for the purposes of this report)

Draft indicators were reviewed, pilot tested, and agreed upon by participating corps before implementation. Indicator descriptions and literature supporting their inclusion and quantification are located in Appendix 2.

Forest Fuel Reduction

The reduction of forest fuels attempts to prevent large, severe wildfires resulting from decades of fire suppression, preferential harvest of large trees, and land use changes that have increased fuel conditions (Stephens et al., 2012). Corps contribute to fuel reduction efforts through manual and mechanical efforts, as well as prescribed burns. The treatments partners engaged corps to complete include one or combinations of the following:

- Mechanical removal (e.g., trimming, thinning)
- Prescribed burns
- Cutting fire lines
- Chemical applications

Trimming and thinning Ponderosa Pine, Juniper, and Colorado Pinyon, Questa, NM, Rocky Mountain Youth Corps- NM

Several indicators selected from the literature are based on variables important to models of wildfire risk. These include measures of debris and vegetation in the understory, midstory and canopy (e.g., litter depth, lowest live branch height, canopy cover). Forests and plots are also characterized by forest type, tree size and overall health. Draft indicators were reviewed, pilot tested, and agreed upon by participating corps before implementation. Appendix 3 includes detailed descriptions and literature supporting indicator selection and measurement.

Results

Habitat Project-Level Findings

Preliminary reporting of work conducted April 1 to November 15, 2017, involved data sampled from **149 habitat improvement projects**, treating **25,737.79 acres**. Projects totaled **37,710.10 hours** and involved **1,461 crew members** (Table 1).

Table 1. Number of projects sampled between April 1 and November 15, 2017, including acres treated, hours worked, and crew members involved by corps.

Corps*	Number of Projects Sampled	Acres Treated	Hours to Complete Project**	Total Number of Crew Members
Conservation Corps Minnesota & Iowa (CCMI)	4	77.25	347.50	33
Conservation Legacy (Cons. Legacy)	27	227.24	10,957.00	210
Kupu	9	193.53	7,936.00	563
Montana Conservation Corps (MCC)	62	12,665.42	3,524.50	375
Northwest Youth Corps (NYC)	3	3.50	1,123.00	15
Student Conservation Association (SCA)	1	3.00	441.00	9
Texas Conservation Corps at American YouthWorks (AYW-TXCC)	8	103.50	519.50	61
Utah Conservation Corps (UCC)	35	12,458.36	12,861.60	195
Grand Total	**149**	**25,731.79**	**37,710.10**	**1,461**

* Heart of Oregon Conservation Corps (HOC) and Rocky Mountain Youth Corps – New Mexico (RMYC) contributed data at the plot level

** Note: Total hours are as reported by corps. This may include overall project hours as well as person-hours.

Project Locations and Area Types

Projects were conducted in **19 states** across the U.S. in forested (60%), non-forested (e.g., grassland) (31%), and aquatic ecosystems (5%) (Figure 1).

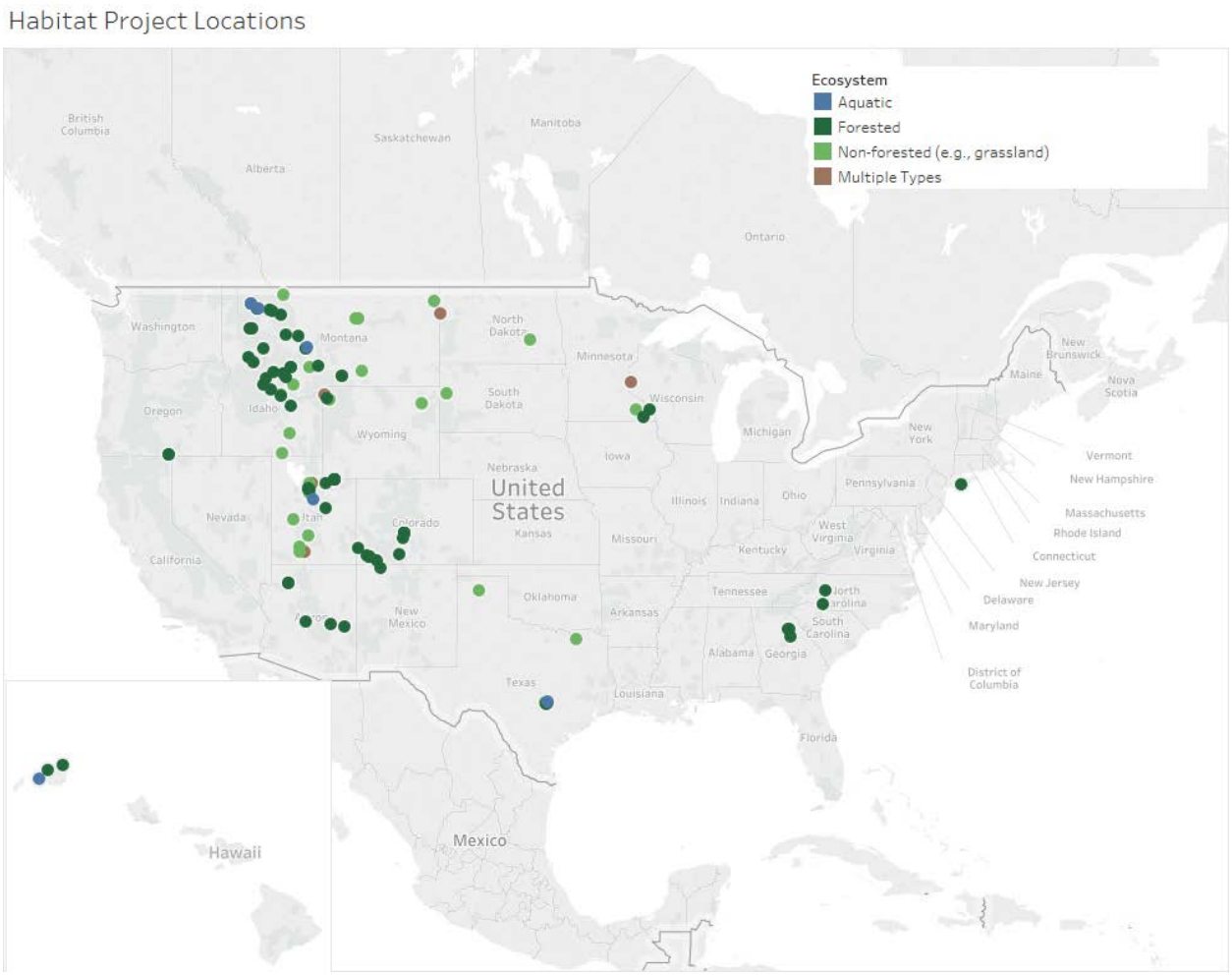


Figure 1. Locations of habitat improvement projects sampled by Conservation Corps (Note: Not all projects are included in the map. Of the 149 projects, 116 provided optional coordinates).

Over 30% of projects occurred in National Forests, followed by public lands managed by other entities (13%), National Parks (11%), and Bureau of Land Management (11%). Other area designations, including national, tribal, state, county, municipal, and private lands, comprised 36% of the sample (Figure 2).

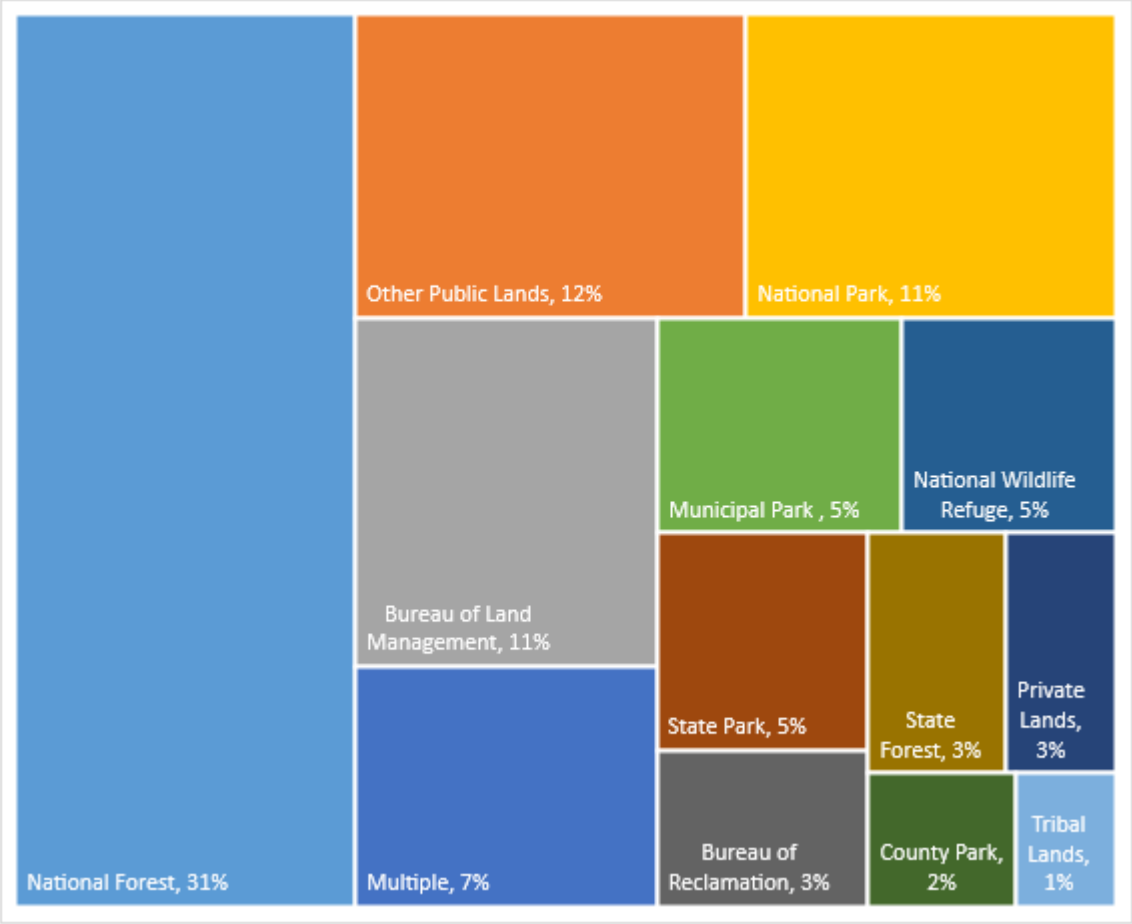


Figure 2. Treemap of percent of projects by area designation (n=149)

Project Objectives and Activities

Habitat projects were categorized into six objectives, with one or more objectives possible within the same project. Objectives included:

1. Encouraging or improving habitat for plant species
2. Discouraging or removing plant species from a habitat
3. Encouraging or improving habitat for animal species
4. Discouraging or removing animal species from a habitat
5. Reducing forest fuels
6. Restoring or creating habitat

Table 2 details the number of projects working toward each objective, or combination of objectives.

Table 2. Top 3 objectives included in Habitat Projects.

Objective	Number of Projects*
Discouraging or removing plant species	48
Reducing forest fuels	35
Encouraging or improving habitat for plant species	9
(Other Objectives and Combinations of Objectives)	*52 (See Appendix 4)*
Grand Total	**144**

* Five projects did not report objectives

Discouraging or removing plant species from a habitat was the most common project objective, either as the sole objective or in concert with others, in **84 projects (58%)**.

Reducing forest fuels was the second most common, either as the sole objective or in concert with others, in **49 projects (34%).**

Based on the average percent of total project hours for the 144 projects with objectives identified, discouraging or removing plant species from a habitat averaged nearly 50% of total project hours, followed by reducing forest fuels (29%), and encouraging or improving habitat for plant species (20%) (Figure 3).

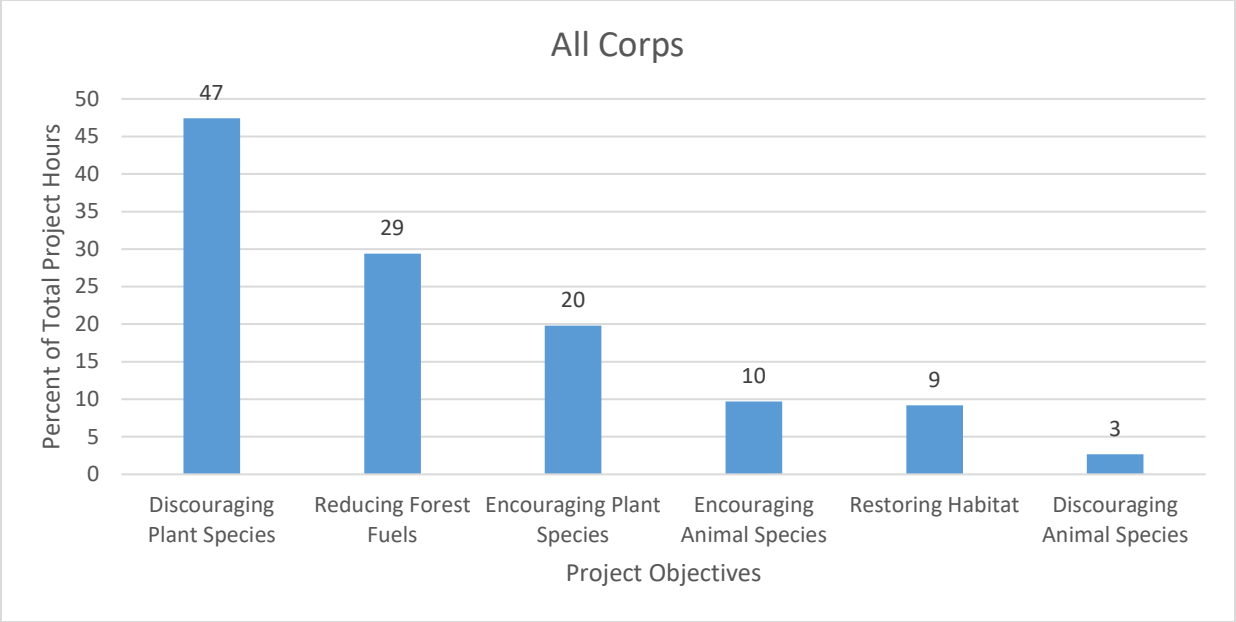


Figure 3. Average percent of project hours by objective (n = 149)

Encouraging or improving habitat for plant species

Thirty-six projects included activities intended to improve habitat for or encourage the success of **64 plant species or groupings of species (e.g., native grasses)**. The top three species targeted included native species, Cottonwood, and Golden Currant (Table 3). Project activities are listed in Table 4, with full details included in Appendices 5 and 6.

Table 3. Top 3 species encouraged in habitat projects

Plant Species	Number of Projects*
Native Species	9
Cottonwood (*Populus spp.*)	8
Golden Currant (*Ribes aureum*)	6
(Additional species)	*80 (see Appendix 5)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

Table 4. Activities performed to encourage plant species

Activities Performed	Number of Projects*	Number of Acres
Planting desired species	17	70.04
Chemical applications (e.g., Miracle Grow fertilizer)	1	0.01
Other activities	*13*	*(see Appendix 6)*

* Number of projects does not total 37 as some projects only reported hours, not activity, under this objective.

Discouraging or removing plant species from a habitat

The removal or discouragement of a plant species from a habitat was the most common objective across all projects sampled, targeting **86 plant species** in **83 projects**. The top three species targeted for removal or discouraged from a habitat included Houndstongue, Spotted Knapweed, and Canada Thistle (Table 5). The full list of species is included in Appendix 7. Activities employed to discourage or remove plant species are listed in Table 6.

Table 5. Top 3 plant species targeted for removal or discouraged from habitat

Common Name	Scientific Name	Number of Projects*
Houndstongue	Cynoglossum officinale	13
Spotted Knapweed	Centaurea maculosa	12
Canada Thistle	Cirsium arvense	11
(Additional species)		*149 (see Appendix 7)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

Table 6. Activities performed to discourage or remove plant species from habitat

Activities Performed	Number of Projects*	Number of Acres
Manual or Mechanical Removal of Species	65	5,435.49
Chemical Application	47	1,752.14
Employing Biological Controls	7	45.45

* For manual or mechanical activities, 3 projects provided acres without an activity and 4 projects reported an activity without corresponding acres. For chemical applications, 4 projects reported a chemical without the number of acres and 5 projects reported a method but no acres treated or chemical applied. All values provided are as reported in this table.

The most common method of **manual or mechanical removal** included doing so with a hand or chain saw (n=21) followed by hand pulling (n=9).

The most common **chemical application** included foliar herbicide (n=25), followed by cut stem/stump applications (n=15).

A full list of methods and combination of methods employed is included in Appendix 8, with details of which chemicals were applied in Appendix 9.

An estimated **847,443 ft^3 of invasive species biomass was removed** through manual/mechanical methods from the sample **projects** alone.

That is enough to fill nearly **1,733** commercial dump trucks.

Encouraging or improving habitat for animal species

Encouraging or improving habitat for animal species was an objective identified in **17 projects** and included **26 unique individual or groups of species** (e.g., all native species). The top three species targeted across projects are listed in Table 7 with a full list of all species included in Appendix 10. Activities performed are listed in Table 8, with full details included in Appendix 11.

Table 7. Top 3 animal species encouraged

Animal Species	Number of Projects*
All Native Species	3
Elk (*Cervus canadensis*)	3
Pronghorn (*Antilocapra americana)*	3
(Additional species)	*24 (see Appendix 10)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

Table 8. Activities performed to encourage animal species

Activities Performed	Number of Projects*	Quantity
Removal of barrier fencing	4	20.28 miles
Introduce animals to habitat	2	321 individuals
Planting of desired plant species	2	0.65 acres
(Other activities)	*6*	*(see Appendix 11)*

* Number of projects does not total 15 as some projects only reported hours, not activity, under this objective.

Discouraging or removing animals from habitat

Seven projects included discouraging or removing animal species from a habitat. The species targeted for removal or discouragement included bullfrogs (n=1), cats (n=2), cattle (n=1), dogs (n=1), mongoose (n=1), pigs (n=1), and rats (n=1).

Methods included constructing barrier fences to either restrict movement or exclude animals from an area (n=6), trapping (n=2), and culling (n=1). A total of 10.33 miles of barrier fence were constructed across six projects, 118 traps set in two projects, and 20 acres treated with a rodenticide (Diphacinone) in one project.

Forest fuel reduction

Forest fuel reduction was the second most common objective overall (n=49), as either the sole focus of a project or in conjunction with other objectives. The majority of projects focused on trimming or thinning (n=41) and slash removal (n=22). Activities and quantities are reported in Table 9.

Table 9. Activities performed to reduce fuel loads

Activities Performed	Number of Projects*	Quantity
Trimming or thinning	41	1,136.45 acres
Slash removal	22	1,069.64 acres
Cutting fire lines	5	3.69 miles
Maintaining fire lines	2	1.50 miles
Other	*7*	*(see Appendix 12)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

An estimated **582,000 ft^3 of forest fuel biomass was removed** through trimming, thinning, and slash removal.

The amount removed would fill over **6** Olympic-sized swimming pools.

Restoration or creation of habitat

Eighteen projects involved restoring or creating habitat. One mile of road was removed in one project, and the remaining projects involved a variety of landscaping, fence repair, trash removal, and other improvement projects. A full list is included in Appendix 13.

Plot-Level Findings

Plot level assessments were conducted for projects focused on invasive plant species management and forest fuel reduction. Plots were placed systematically throughout the project area based on criteria regarding landscape heterogeneity, needed sample sizes, and targeted species. Within each plot, crew members took several measures before and immediately after work to assess changes associated with project activities.

Hand pulling and chemical control applications to manage invasive species Buckthorn; Somerset, Wisconsin, Conservation Corps Minnesota & Iowa

Invasive Species Management

A total of **277 plots** were evaluated during the project period (Table 10). Nearly 60% (n=163) of plots had previously experienced work by the project sponsor or corps, and 38% of plots targeted at least two species concurrently (n=105).

Table 10. Number of invasive species plots by corps

Corps	Number of Plots
Conservation Corps Minnesota & Iowa	31
Conservation Legacy	3
Heart of Oregon	14
Kupu	5
Montana Conservation Corps	167
Northwest Youth Corps	4
Student Conservation Corps	3
Texas Conservation Corps at American YouthWorks	15
Utah Conservation Corps	35
Grand Total	**277**

Species Targeted

Sixty-four plant species were targeted across all plots and corps. The top three species targeted were Houndstongue, Canada Thistle, and Spotted Knapweed (Table 11). A complete list of all species is included in Appendix 14. The top three species targeted in each region are illustrated in Figure 4, with complete lists for each region included in Appendix 15.

Table 11. Top 3 invasive species targeted across all plots

Common Name	Scientific Name	Number of Plots*
Houndstongue	Cynoglossum officinale	66
Canada Thistle	Cirsium arvense	58
Spotted Knapweed	Centaurea maculosa/Centaurea stoebe	57
(Additional species)		*178 (see Appendix 14)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

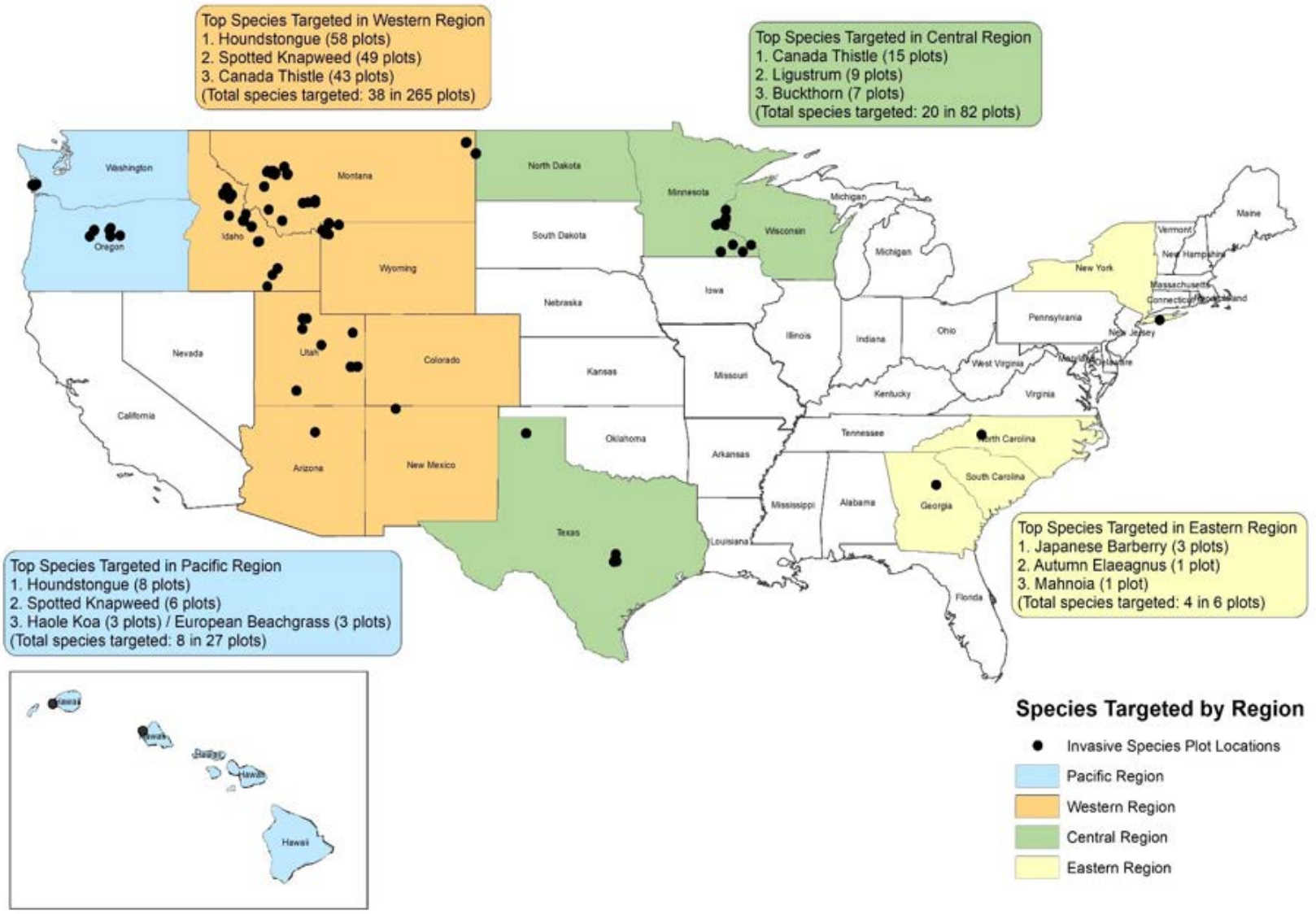


Figure 4. Targeted plant species and plot locations by region

Forbs, which include herbaceous and flowering plants, were **the most commonly targeted species type** (Figure 5), representing over three-quarters of the total sample.

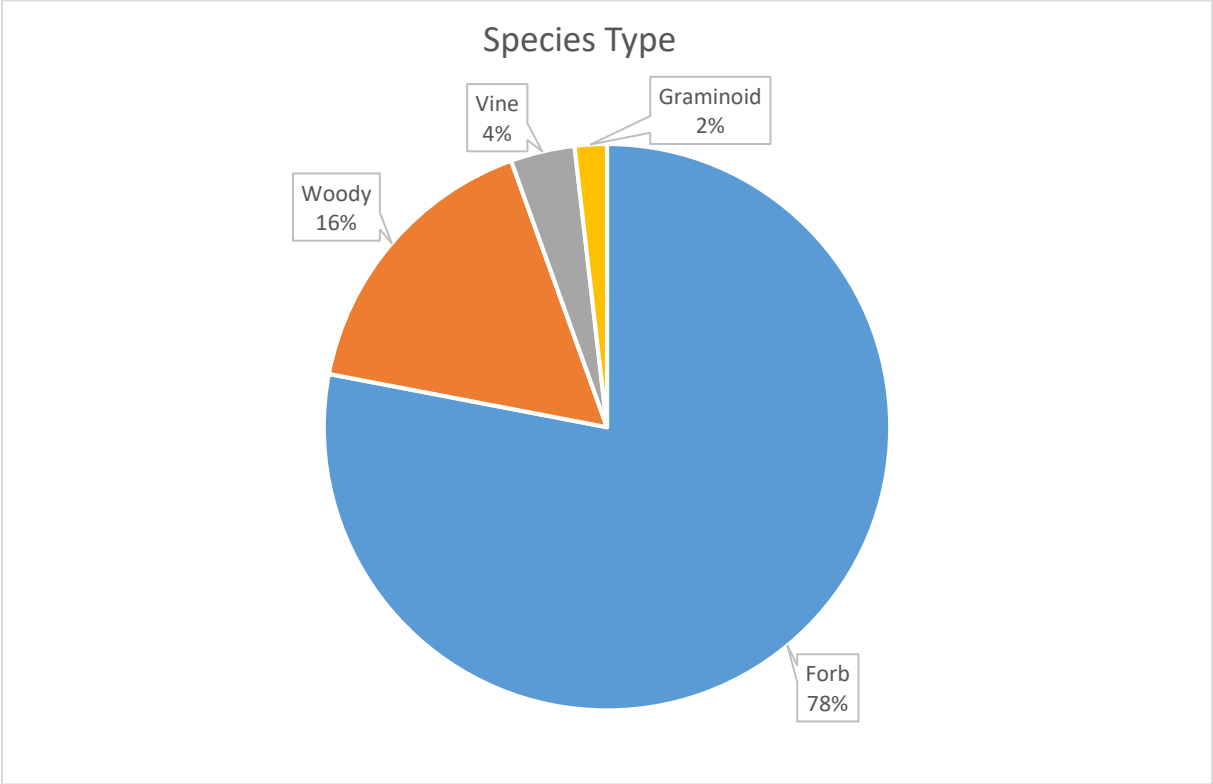


Figure 5. Proportion of invasive species by type

In almost **70%** of the plots sampled, the **seeds of the targeted species had not matured** (Figure 6) at the time of treatment. In general, implementing management tactics prior to seed maturity and entry into the seed bank is preferred (Davies & Sheley, 2007).

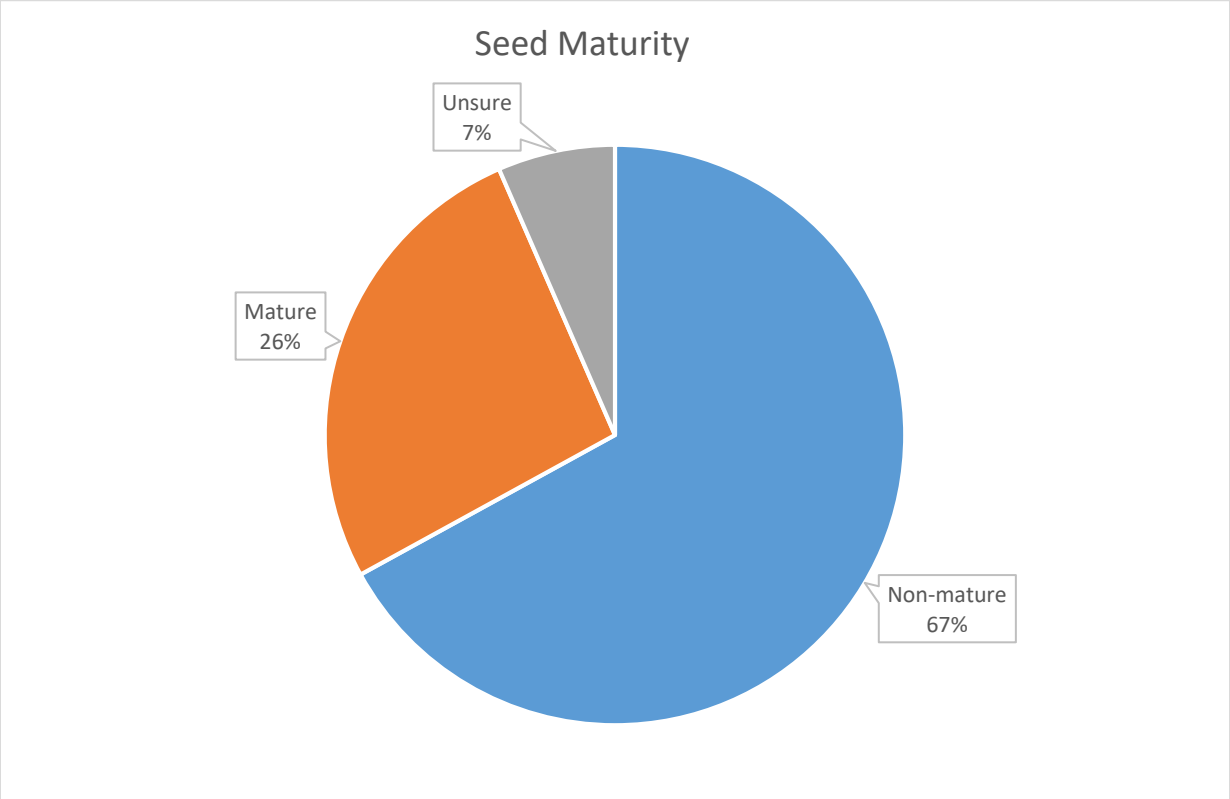


Figure 6. Seed maturity at time of treatment or removal

Before and After Treatment Plot Assessments

Pre-work and post-work assessments were conducted in all plots, with the exception of chemical control only plots (n=168). Due to the time required for chemical applications to generate changes and the location of corps work, post assessments were outside the scope of this evaluation.

Chemical Treatment Only: Of the 168 plots treated with chemicals alone**,** and where only a pre-work assessment was possible, invasive species percent cover averaged 27% (SD = 38.35) within the plots prior to treatment.

All Other Treatments: All other treatment approaches (n=109) included a pre- and post-work assessment. The **overall percent change** in the total **percent cover of invasive species** for all other treatment approaches (n=109) **averaged** -**81%** across plots and treatment types (Table 12).

- **Manual removal** (n=44), the most common treatment following chemical applications, experienced a **-81% change in invasive species percent cover**, with an average of 5% percent cover following work.

- **Mechanical removal** had the **greatest percent change, -95%, to an average of 2% cover** for the 20 plots in which it was employed as the **only treatment**. Note that plots in which mechanical approaches alone were used also contained the greatest average percent cover of invasive species (45%) before treatment.

The total percent cover of invasive species **experienced an overall change of -81%** across all methods employed.

The difference between the before and after work assessment was **statistically significant** and **exhibited a large effect sizes** for all methods**.**

Statistical significance

To examine if the changes in percent of invasive species cover were statistically significant, values were compared using the Wilcoxon Signed Rank test. Results presented represent sampled data. Due to the diversity of project objectives, habitats, and species, comparisons of which method is most effective are beyond the scope of this study. Across **all methods**, the **reductions in percent cover were statistically significant**[1] ($p<0.01$), and exhibited **large effect sizes**[2] (Table 12). Average percent cover of invasive species within sample plots before and after work, as well as the overall percent change, by treatment for primary invasive species cover within plots.

Table 12. Statistical analysis for invasive species management

Methods for Managing Primary Invasive Species *	n	Avg. Percent Cover Before	Avg. Percent Cover After	Percent Change	p-value	Effect Size**
Manual removal	44	32.24	5.03	-81.40	< 0.01	-0.54
Other: mixed manual methods***	24	32.77	6.96	-78.76	<0.01	-0.52
Mechanical removal + Chemical control	21	43.12	14.90	-65.45	<0.01	-0.54
Mechanical removal	20	44.50	2.28	-94.88	<0.01	-0.59
Grand Total	**109**	**36.70**	**6.85**	**-81.34**	**< 0.01**	**-0.54**

* Values for each method are provided for descriptive purposes only, as comparisons between methods are beyond the scope of this study.

** Measures of effect size are standardized measures (between -1.0 and 1.0) that assess the magnitude of this difference. Effect size is often used to determine whether a statistically significant difference is meaningful in practice with effect sizes further from zero, either positive or negative, suggesting greater practical importance. For this statistical test, the criteria for interpreting the absolute value of the r value (or the effect size) are: Small $\geq$ .10, Medium $\geq$.30, and Large $\geq$ .50)

*** Mixed manual methods included manual removal with chemical control (n=10), manual and mechanical removal (n=11), and manual and mechanical removal combined with chemical control (n=3).

[1] Statistical significance was calculated using the related-samples Wilcoxon Signed Rank Test, with a significance level (p-value) of 0.05. The p-value helps determine the statistical significance of the results. It is a measure of the likelihood of concluding that there is a statistically significant finding when one does not exist. For example, a p-value of less than or equal to 0.05 means that there is a 5% chance of concluding there is a significant difference when one does not exist. A value of less than or equal to 0.05 is commonly used as a threshold for determining statistical significance.

[2] Measures of effect size are standardized measures (between -1.0 and 1.0) that assess the magnitude of this difference. Effect size is often used to determine whether a statistically significant difference is meaningful in practice with effect sizes further from zero, either positive or negative, suggesting greater practical importance. For this statistical test, the criteria for interpreting the absolute value of the r value (or the effect size) are: Small ≥ .10, Medium ≥ .30, Large ≥ .50.

For plots where a **secondary species** was targeted, and a pre- and post-work assessment possible (n=35), manual removal was again the most common approach (n=16).These data were included and analyzed by the primary method indicated, though a breakdown of the treatment approaches for secondary species are included in Appendix 16.

When treatment options included removing biomass from plots, crews estimated the total volume extracted from the plot. From the sample plots, **crews removed an estimated 1,278,853 ft^3 of biomass**. This included 1,278,054 ft^3 of the primary species targeted, and 799 ft^3 of secondary species removed.

Pile of invasive species Common Mullein and Houndstongue removed manually, Kooskia, ID, Montana Conservation Corps

Over **1.279 million ft^3** of invasive species biomass was removed from the sample **plots**.

The volume of materials removed would fill over **335** 53-foot semi-trailers.

Forest Fuel Reduction

A total of **123 forest fuel reduction plots** were evaluated during the project period between April 1 and November 15, 2017 (Table 13). The majority of plots (85%) were in coniferous forests, concentrated in the western U.S. (Figure 7, Figure 8).

Forest fuels trimming and thinning, Pine Juniper, Cordes Lakes, AZ, Conservation Legacy

Table 13. Number of forest fuel reduction plots by corps

Corps	Number of Plots
Conservation Legacy	58
Montana Conservation Corps	26
Rocky Mountain Youth Corps – New Mexico	3
Texas Conservation Corps at American Youth Works	8
Utah Conservation Corps	28
Grand Total	**123**

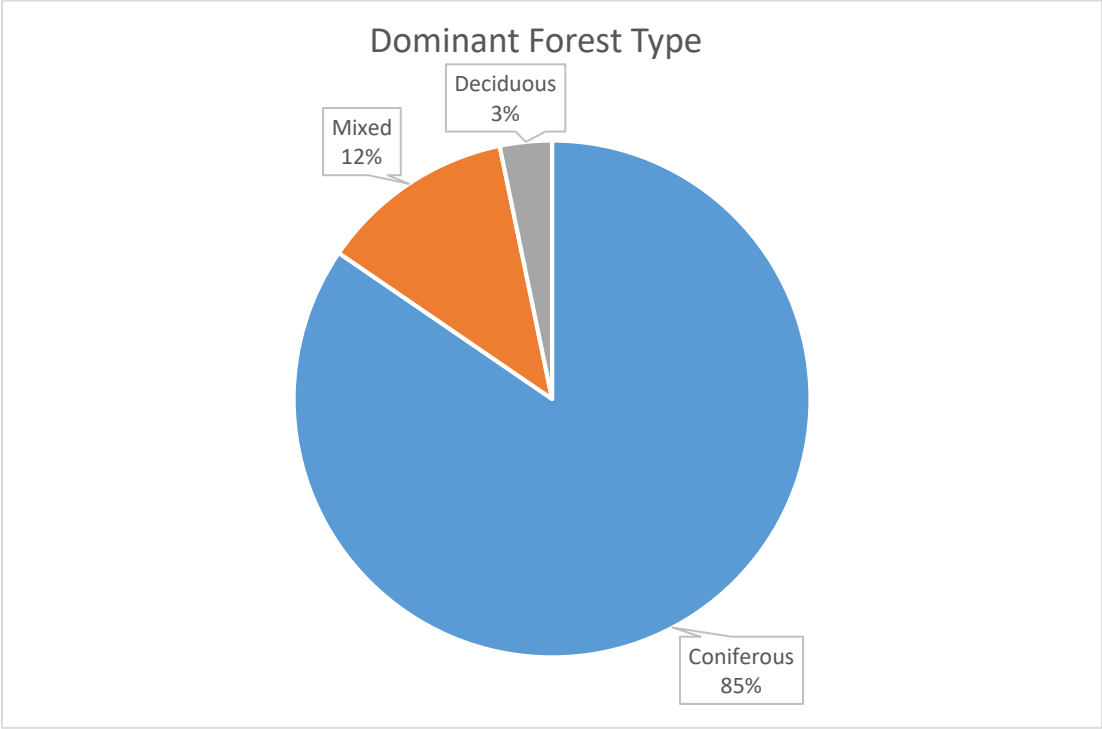


Figure 7. Pie chart illustrating the percentage of projects in coniferous, mixed, and deciduous forests.

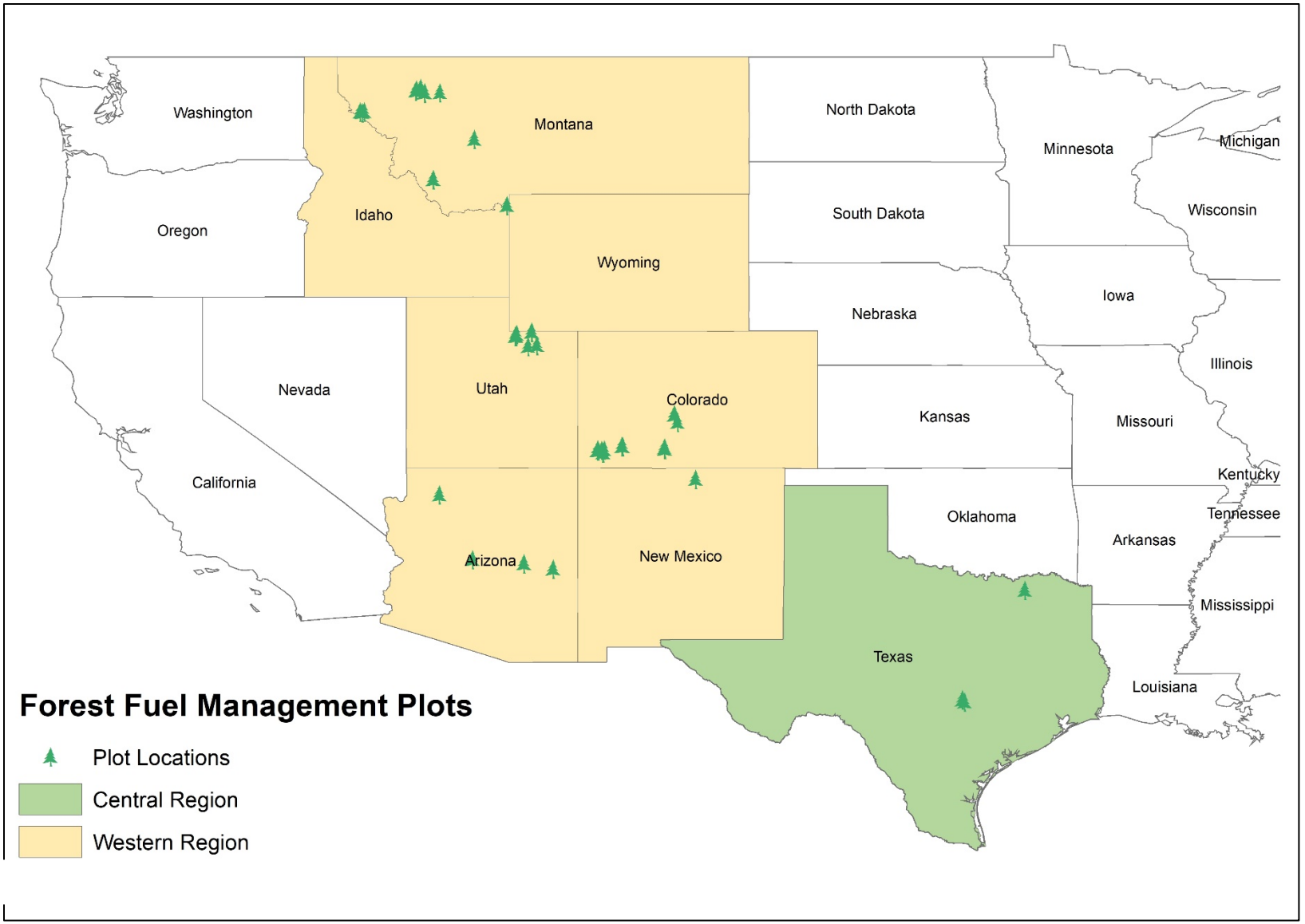


Figure 8. Location of forest fuel management plots sampled during the project period of April 1 through November 15, 2017.

Trimming and thinning were the most common activities performed by corps to manage forest fuels, included in **87% of plots**.

Trimming and thinning **helps prevent large, severe wildfires** and increases probabilities trees can withstand a fire by reducing fuels, increasing the height to the base of tree crowns, and increasing the spacing between trees.

Species Targeted

Seventeen species were targeted in forest fuel reduction plots across all corps. The top three species included Lodgepole Pine, Ponderosa Pine, and Douglas Fir (Table 14). A complete list is included in Appendix 17.

Nearly all plots (96%) included trimming and thinning to reduce fuel loads, either as a single approach (n=107) or in conjunction with additional methods (n=11) (Table 15).

Table 14. Species removed from forest fuel plots

Common Name	Scientific Name	Number of Plots*
Lodgepole Pine	Pinus Contorta	44
Ponderosa Pine	Pinus Ponderosa	40
Douglas Fir	Pseudotsuga Menziesii	38
(Additional species)		*59 (see Appendix 17)*

* Grand totals may be greater than the total number of projects reported for an objective due to multiple species or methods included within the same project.

Table 15. Number of plots associated with various methods employed to reduce fuel loads

Method(s) Employed to Reduce Fuel Loads	Number of Plots
Trimming/thinning	107
Cutting fire lines	5
Other: mixed methods (trimming/thinning plus additional method(s))*	11
Grand Total	**123**

* Mixed methods included trimming/thinning plus a chemical application (n=4), trimming/thinning plus cutting fire lines (n=4), trimming/thinning plus cutting fire lines and prescribed burn (n=2), and trimming/thinning plus prescribed burn (n=1).

Before and After Treatment Plot Assessments

Pre-work and post-work assessments were conducted in all 123 plots. Percent changes for forest fuel indicators by forest type are reported in Table 16. Results represent sampled data. Due to the diversity of project objectives, habitats, and species, comparisons of changes by forest type, species, or which treatment is most effective are beyond the scope of this study.

Canopy cover, reported as a percentage category, was converted to the range midpoint to calculate the change between the pre- and post-work assessments for all plots (n=123). Across all forest types, **canopy cover changed by -48%.**

More open canopies reduce the probability of intense fire moving from tree crown to tree crown.

Litter depth, reported in inches (in), documented the change in litter and debris on the ground within the plot and was reported for all plots. Litter is considered a combustible material and can contribute to the overall fuel load. Lower litter levels reduce the amount of ground fuels, limiting the potential for intense fire. The sample plots averaged a change in **litter depth of +0.58 in**, a 23% overall increase. The increase can be explained by debris remaining immediately following trimming and thinning operations. In some instances, some downed, woody debris can contribute to the creation of habitat for small mammals and reptiles and enough ground fuel can increase the probability a low-intensity fire can spread throughout an area, important for habitats with fire-dependent species (USDA, 2003).

Lowest live branch (LLB) height, reported in feet (ft), was reported for plots with at least five or more trees (n=55) remaining as the indicator required measuring the same five trees before and after work. In the sample of plots**, LLB changed an average of +1.19 ft** between the pre- and post-work assessments, representing a **13% increase**.

An increase in LLB height is desired as it minimizes the potential for fire to move from the ground into the tree canopy.

Circumference at breast height provided an efficient way to measure trees in the field, with values converted to the more commonly reported **diameter at breast height** (DBH) in inches (in) for reporting purposes. The changes in DBH values were reported for plots with at least one tree remaining in the plot (n=114). In the sample plots, **DBH changed, on average, by +1.63 in**, with conifers averaging +1.8 in change and deciduous forests -0.73 in change. The decrease was due to the overall reduction in number of trees remaining in the plot. The overall change in size represents a **31% increase in DBH**.

In general, an increase in DBH represents lower probability of tree mortality following a fire.

Table 16. Average change in indicator values for forest fuel management plots by forest type.

Forest Type	Coniferous	Deciduous	Mixed	All Plots
Number of Plots	*104*	*4*	*15*	*123*
Percent Change (whole number)				
Number of Trees in Plot	-68%	-39%	-56%	-66%
Canopy Cover	-51%	-19%	-40%	-48%
Litter Depth	24%	0%	27%	23%
Dead/Declining Evergreens	-78%	-100%	-77%	-78%
Dead/Declining Hardwoods	-96%	-100%	-86%	-93%
Live Evergreens	-78%	-20%	-65%	-62%
Live Hardwoods	-79%	-35%	-26%	-59%
LLB[1]	-7%	80%	50%	13%
DBH[2]	32%	-24%	33%	31%

[1] Change scores for lowest live branch (LLB) were reported only for plots with five or more trees following work as average was measured and calculated for the same five trees. The number of plots are as follows: coniferous (n=47), deciduous (n=2), and mixed (n=6), for a total of 55 plots reported for LLB.

[2] Change scores for diameter at breast height (DBH) were reported only for plots with one or more trees following work. The number of plots are as follows: coniferous (n=96), deciduous (n=4), and mixed (n=14), for a total of 114 plots reported for DBH.

Statistical Significance

To determine if changes in the indicators were statistically significant, values using all plots were compared using the Wilcoxon Signed Rank test. Results presented represent sampled data. Due to the diversity of project objectives, habitats, and species, comparisons of changes by forest type, species, or which treatment is most effective are beyond the scope of this study.

For all plots, the **changes in indicator values were statistically significant ($p<0.01$) for all but 1 indicator** (lowest live branch) (Table 17).

Table 17. Statistical significance of change in forest fuel indicators and corresponding effect sizes.

Forest Fuel Reduction Indicator	n	Average Before	Average After	Percent Change	p-value[3]	Effect Size[4]
Total Trees in Plot (#)	123	15.79	5.38	-66%	<0.01	-0.59
Canopy Cover (%)	123	45.52	23.90	-48%	<0.01	-0.56
Litter Depth (in)	123	2.50	3.08	23%	<0.01	-0.18
Dead/Declining Evergreens (#)	123	3.24	0.70	-78%	<0.01	-0.47
Dead/Declining Hardwoods (#)	123	0.33	0.02	-93%	<0.01	-0.20
Live Evergreens (#)	123	10.39	3.92	-62%	<0.01	-0.50
Live Hardwoods (#)	123	1.82	0.74	-59%	<0.01	-0.23
Lowest Live Branch (ft)	55	9.17	10.36	13%	0.77	--
Diameter at Breast Height (in)	114	5.33	6.96	31%	<0.01	-0.39

A **66% reduction in total trees** in plot exhibited the greatest effect size (-0.59), followed by a corresponding **46% reduction in canopy cover** (-0.56).

Increases in DBH and decreases in dead or declining evergreens were also statistically significant, with moderate effect sizes.

Slight increases in litter depth, decreases in dead or declining hardwoods, decreases in live hardwoods, while all statistically significant, exhibited small effect sizes.

[3] Statistical significance was calculated using the related-samples Wilcoxon Signed Rank Test, with a significance level (p-value) of 0.05. The p-value helps determine the statistical significance of the results. It is a measure of the likelihood of concluding that there is a statistically significant finding when one does not exist. For example, a p-value of less than or equal to 0.05 means that there is a 5% chance of concluding there is a significant difference when one does not exist. A value of less than or equal to 0.05 is commonly used as a threshold for determining statistical significance.

[4] Measures of effect size are standardized measures (between -1.0 and 1.0) that assess the magnitude of this difference. Effect size is often used to determine whether a statistically significant difference is meaningful in practice with effect sizes further from zero, either positive or negative, suggesting greater practical importance. For this statistical test, the criteria for interpreting the absolute value of the r value (or the effect size) are: Small ≥ .10, Medium ≥ .30, Large ≥ .50.

The greatest percent changes occurred in the **number of dead and declining evergreen and hardwood trees**, which were **reduced by 79% and 93%,** respectively.

While **all but one indicator exhibited statistically significant changes** between pre- and post-work assessments, the reduction in the **number of trees** and corresponding reductions in **canopy cover** exhibited the **greatest effect sizes.**

Reducing the number of trees (thereby increasing spacing between trees) and opening tree canopies can **reduce opportunities for fire** to reach and spread in the canopy.

Crews also estimated the amount of biomass removed from the sample plots. **Nearly 30,000 ft^3 of materials were removed**, with almost 28,000 ft^3 coming from the 104 plots in coniferous forests (Table 18).

Table 18. Estimated amount of biomass removed from sample plots by forest type

Forest Type	n	Biomass removed (ft3)
Coniferous	104	27,933.21
Deciduous	4	1,143.00
Mixed	15	746.00
Grand Total	**123**	**29,822.21**

Conclusions

In general, changes seen at the plot level line up with expectations (e.g., reductions in invasive species percent cover, decreases in the number of trees, increases in DBH and LLB) and document the statistically significant changes and contributions corps make to invasive species and forest fuel management.

Across **sample plots**, coverage of the 64 targeted invasive species was reduced by 65%, a statistically significant level, contributing to the goal of reducing invasive species impact on ecosystem health. Additionally, the majority of plots were treated prior to the maturation of invasive species seeds, which suggests increased treatment efficacy by reducing opportunities for seeds to disperse and establish in the soil seed bank. Invasive culling methods led to the removal of the equivalent of 335 semi-trailers worth of biomass, clearing out unwanted plants with the potential to make room for native and desired species.

Corps work also contributed to the reduction of forest fuels as evidenced by changes in indicator values. Trimming and thinning were performed by corps in 87% of reported plots. In general, to mitigate fire risk and severity, the goal is to see:

- Canopy cover decrease
    - In the sample, plots, canopy cover decreased by 48%, contributing to reductions in crown fire potential and severity.
- Litter depth decrease
    - While litter depth increased slightly, by an average of 0.58 in, the change is due to debris remaining on the ground following thinning and trimming activities and should be considered within the context of all other changes in indicators examining reductions in surface and ladder fuels as well as potential benefits from some level of ground fuels.
- Lowest live branch increase
    - Crown base height as measured through lowest live branch increased by an average 1.2 ft, contributing to reductions in the potential for ground fires to move into the canopy.
- Diameter at breast height increase
    - Within the sample plots, DBH increased an average of 1.63 in, contributing to the reduction of potential for tree mortality following a fire.

Removal of dead or declining evergreens and hardwoods should be considered an important result, despite the small "Effect Size" reported in the statistical analysis. Removing 93 percent of dead hardwood trees and 78 percent of dead evergreens eliminates the fire danger posed by those fuels in fire-prone habitats.

This evaluation provides evidence of positive impacts to habitats by Conservation Corps field crews in relation to invasive species management and forest fuels reduction. The protocols introduced in this study are meant to support corps in ongoing evaluation efforts and are recommended for future application. Lessons learned in protocol development and implementation include determining that the *lowest live branch* indicator should potentially be removed from future evaluations due to the difficulty of reliability, particularly due to diversity of tree species and approaches to forest fuel management. While protocols developed were designed to accommodate multiple habitat conditions, the results of this evaluation may also have limited generalizability beyond programs using similar approaches to habitat improvement as those programs evaluated.

Appendices

Appendix 1 – References

Agee, J.K., & Skinner, C.N. (2005). Basic principles of forest fuel reduction treatments. Forest Ecology and Management, 211, 83-96. Retrieved from https://www.fs.fed.us/psw/publications/skinner/psw_2005_skinner(agee)001.pdf

Anderson, H.E. (1982). Aids to determining fuel models for estimating fire behavior. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Report INT-122. Retrieved from http://www.fs.fed.us/rm/pubs_int/int_gtr122.pdf

Brown, J.K. (1974). Handbook for inventorying downed woody material. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. Report INT-16. Retrieved from http://www.fs.fed.us/rm/pubs_int/int_gtr016.pdf

Brown, J.K., Marsden, M.A., Ryan, K.C., Reinhardt, E.D. (1985). Predicting duff and woody fuel consumed by prescribed fire in the Northern Rocky Mountains. Ogden, UT: U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station. Report nr INT-337. Retrieved from http://www.treesearch.fs.fed.us/pubs/32531.html

California Invasive Plant Council. (2012). Preventing the spread of invasive plants. http://www.cal-ipc.org/ip/prevention/PreventionBMPs_LandManager.pdf

D'Antonio, C.D., & Meyerson, L.A. (2002). Exotic plant species as problems and solutions in ecological restoration: A synthesis. Restoration Ecology, 10(4), 703-713.

Davies, K.W., & Sheley, R.L. (2007). A conceptual framework for preventing the spatial dispersal of invasive plants. Weed Science, 55(2), 178-184.

Herrick, J.E., Van Zee, J.W., Havstad, K.M., Burkett, L.M., & Whitford, W.G. (2005). Monitoring manual for grassland, shrubland and savanna ecosystems: Vol. I & II. Las Cruces, NM: USDA-ARS Journada Experimental Range. Retrieved from https://www.ntc.blm.gov/krc/viewresource.php?courseID=281

Jennings, S. B., Brown, N. D., & Sheil, D. (1999). Assessing forest canopies and understory illumination: Canopy closure canopy cover and other measures. Forestry, 72(1), 59-73. http://www.grsgis.com/downloads/publications/densitometer/Reference_Publications/jennings sb_etal_1999.pdf

Larjavaara, M., Pennanen, J., & Tuomi, T. J. (2005). Lightning that ignites forest fires in Finland. Agricultural and Forest Meteorology, 132(3), 171–180. http://dx.doi.org/10.1016/j.agrformet.2005.07.005

MacDougall, A., & Turkington, R. (2005). Are invasive species the drivers of passengers of change in degraded ecosystems? Ecology, 86(1), 42-55.

Mäkelä, A., Mäkelä, J., Haapalainen, J., & Porjo, N. (2016). The verification of lightning location accuracy in Finland deduced from lightning strikes to trees. Atmospheric Research, 172–173, 1–7. http://doi.org/10.1016/j.atmosres.2015.12.009

McAlpine, L., & Porder, S. (2009). Evaluation of large-scale invasive plant species herbicide control program in the Berkshire Taconic Plateau, Massachusetts, USA. Conservation Evidence, 6, 117-123.

Moot, A., Savage, M., Abrams, J., Derr, T., Krasilovsky, E., & Schumann, M. (2010). Multiparty monitoring and assessment of collaborative forest restoration projects: Short guide for grant recipients. Ecological Restoration Institute and New Mexico Forest and Watershed Restoration Institute.

Nott, P., Desante, D.F., & Michel, N. (2003). Habitat Structure Assessment (HSA) Protocol: Describing vertical and horizontal spatial habitat patterns at MAPS stations. The Institute for Bird

Populations. http://www.birdpop.org/docs/misc/MAPS-Materials-Complete-HSA-Manual-Through-Appendix-3.pdf
Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics, 52(3), 273-288.
Powell, D. C. (2012). How to Measure a Big Tree. USDA Forest Service. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794771.pdf
Prichard, S.K., Sandberg, D.V., Ottmar, R.D., Eberhardt, E., Andreu, A., Eagle, P., & Swedin, K. (2013). Fuel Characteristic Classification System Version 3.0: Technical Documentation. Gen. Tech. Rep. PNW- GTR-887. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Retrieved from http://www.fs.fed.us/pnw/pubs/pnw_gtr887.pdf
Pyšek, P., Jarošík, V., Hulme, P.E., Pergl, J., Hejda, M., Schaffner, U., & Vilà, M. (2012). A global assessment of invasive plant impacts on resident species, communities and ecosystems: The interaction of impact measures, invading species' traits and environment. Global Change Biology, 18(5), 1725-1737. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2011.02636.x/full
Schneider, R. G. (2006). Forest Ecosystem Study Unit for the Georgia Envirothon. USDA Forest Service. http://www.gvata.org/curriculum/getfile.ashx?ID=3096
Scott, J. H., & Reinhardt, E. D. (2001). Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. USDA Forest Service. Retrieved from http://www.nifv.nl/upload/149861_668_1236083371581-USDA_rmrs_rp29.pdf
Stephens, S.L., McIver, J.D., Boerner, R.E., Fettig, C.J., Fontaine, J.B., Hartsough, B.R., Kennedy, P.L., & Schwilk, D.W. (2012). The effects of forest fuel-reduction treatments in the United States. BioScience, 62(1), 549-560. Retrieved from https://academic.oup.com/bioscience/article/62/6/549/249143/The-Effects-of-Forest-Fuel-Reduction-Treatments-in.
Stephens, S.L., & Moghaddas, J.J. (2005). Experimental fuel treatment impacts on forest structure, potential fire behavior, and predicted tree mortality in a California mixed conifer forest. Forest Ecology and Management, 215(1), 21-36.
United States Forest Service. (2003). Multiparty monitoring and assessment guidelines for community based forest restoration in Southwestern Ponderosa pine forests. Albuquerque, NM: United States Department of Agriculture, Forest Service, Southwestern Region. Retrieved from https://www.fs.usda.gov/detail/r3/workingtogether/grants/?cid=fsbdev3_022173
United States Forest Service. (2009). Invasive species management strategy. FY 2009-2013. United States Department of Agriculture, Forest Service, Intermountain Region. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5182307.pdf
Wright, C. S., Balog, C. S., & Kelly, J. W. (2009). Estimating Volume, Biomass, and Potential Emissions of Hand-Piled Fuels. USDA Forest Service. http://www.fs.fed.us/pnw/pubs/pnw_gtr805.pdf

Appendix 2 – Invasive species indicator category definitions and sources

Indicator	Measure	Description	Reference
Bare ground/Rock Cover	Percentage of plot occupied by bare ground or rock	Category selection (e.g., NA, NLE, 1-10%, 11-25%, 26-50%, 51-75%, 76-90, 91-100%) of the plot comprised of bare ground or rock Objective: Categorize plot composition	Nott, Desante, & Michel (2003)
Biomass removed [Post mechanical removal only]	Volume of material removed from the plot	Estimated volume (in cubic feet) of biomass removed based on visual assessments of the height, width, and length of material placed in piles (one- species per pile) Objective: Quantify the amount of material removed from the plot	Brown (1974); Wright, Balog, & Kelly (2009)
Invasive Species Cover	Percentage of plot occupied by the target invasive species	Category selection (e.g., NA, NLE, 1-10%, 11-25%, 26-50%, 51-75%, 76-90, 91-100%) of the approximate percent of the plot occupied by the target invasive plant species (at any life stage) Objective: Reduction in percent cover in plot	McAlpine & Porder (2009); MacDougall & Turkington (2005)
Seed Maturation at time of removal	Nominal assessment of seed maturity (Refer to USDA: https://plants.usda.gov/java/noxiousDriver)	Category selection (Yes/No/Unsure) of whether the seeds of the target invasive species had reached maturity prior to the parent plant's removal from the plot. Objective: Removal of parent plants prior to seed maturity	California Invasive Plant Council (2012)
Total Vegetation Cover	Percentage of total vegetation cover in plot (invasive and non-invasive, on ground)	Category selection (e.g., NA, NLE, 1-10%, 11-25%, 26-50%, 51-75%, 76-90, 91-100%) of the total vegetation (native and non-native) in the plot Objective: Categorize plot composition	Herrick et al. (2005)

Appendix 3 – Forest fuel reduction indicator category definitions and sources

Indicator	Measurement	Description	Reference
Canopy cover	Percent	Proportion of an area covered by the vertical projection of tree crowns Objective: Decrease canopy cover	Jennings et al. (1999)
Dead or declining trees	Count	Risk of forest fire due to natural cause or lightning strike Objective: Decrease count	Mäkelä et al. (2016); Larjavaara et al. (2005)
Dominant forest type	Category	Coniferous; Deciduous; Mixed; Tropical Objective: Categorize plot composition	Schneider (2006)
Litter depth	Inches	Depth of litter/vegetation on the ground Objective: Quantify the amount of ground and surface fuels	Wright et al. (2009); Stephens & Moghaddas (2005)
Lowest live branch (LLB) height	Feet	Lowest height above the ground at which there is sufficient canopy fuel (live crown base) to propagate fire vertically through the canopy Objective: Increase lowest branch height	Scott & Reinhardt (2001)
Tree circumference (Circumference at Breast Height, or CBH)	Inches	Size of trees within the plot as described by CBH. Objective: Increase average CBH	Powell (2005)

Appendix 4 – Number of projects by objective

Objective Number[1]	Number of Projects
2	48
5	35
1	9
1,2	8
3	6
6	5
2,5	4
1,2,3,6	4
1,2,5	4
2,6	3
4	3
1,2,3	3
1,2,5,6	2
1,2,6	2
2,4	1
2,5,6	1
3,5	1
5,6	1
1,2,3,4	1
1,2,3,5	1
1,2,4	1
1,3,4	1
Grand Total	**144**

[1] Objective **1**: Encouraging or improving habitat for plant species; Objective **2**: Discouraging or removing plant species; Objective **3**: Encouraging or improving habitat for animal species; Objective **4**: Discouraging or removing animal species; Objective **5**: Reducing forest fuels; Objective **6**: Restoring or creating habitat

Appendix 5 – Plant species for which habitat was improved or the species was encouraged

Plant Species*	Number
Aki'aki	1
Aspen	4
Beach Vitex	1
Box Elder	2
Boxwood	1
Buckwheat	1
Caper Bush	1
Ceylon Leadwort	1
Chokecherry	3
Clover	1
Clustered Field Sedge	2
Cottonwood	8
Coyote Willow	2
Diamond Head Schiedea	1
Dogwood	2
Ferns	1
Five Needle Pine	1
Flowering Species	1
Fremont Cottonwood	2
Golden Currant	6
Grasses	1
Hala	1
Hawai‘i Desert-thorn	1
Hawaiian Rose	1
Ilima	1
Ko‘oloa‘ula	1
Koolau Range 'ohe	1
Kou	1
lama	1
Latherleaf	1
Limber Pine	1
Liverworths	1
Lodgepole Pine	2
Loulu	1
Ma'o	1
Mosses	1
Mountain Mahogany	1
Naio	1

Plant Species*	Number
Narrow Leaf Cottonwood	1
Native Species	9
Naupaka	1
Nebraska Sedge	2
Oakleaf Sumac	3
Ohai	1
Ohi'a Lehua	1
Oʻahu Sedge	1
Oʻahu Soapberry	1
Papala Kepau	1
Peach Leaf Willow	1
Plum	1
Pohuehue	1
Ponderosa Pine	1
Splitleaf Cyanea	1
Sumac	1
Tanglehead	1
Understory Rejuvenation	1
Water Birch	1
Whitebark Pine	1
Willow	2
Willow Stakes	2
Wood's Rose	3
Woodrose	1
Wooly Sedge	2
Yellow 'ilima	1
Total	**103**

*Species listed are the common names and spellings reported.

Appendix 6 – Other activities performed to encourage or improve habitat for plant species

Activities*
Brushing to encourage more new growth for deer. 26.7 acres
Chainsaw ponds to thin forest density
Constructing fireline for future burn
Cutting/piling Ponderosa, Lodgepole pine and Silver Conifer- 1 acre treated
Fuels reduction and discouraging beetle-kill
Remove Scotch thistle, Houndstongue, and toad flax with hand tools - 95%
Removed .7 miles of beetle-kill Lodge Pole Pine with a width of about 75 ft
Removing weeds in the wire enclosure the plants where inside of, and watering Seeding
Spraying herbicide on noxious weeds - 50%
Trimming and thinning Conifer species.
Water plants - 50%, removing invasive weeds - 50% Watered habitat plots - 50%, low stumped Russian Olive trees and applied herbicide to the stumps - 50%

*Activities listed are provided verbatim from submitted data.

Appendix 7 – Plant species discouraged or targeted for removal from a habitat

Plant Species*	Number of Projects
Aspen	1
Australian Tree Fern	1
Autumn Eleagnus	3
Beetle-kill Lodgepole Pine	4
Bladder Campion	1
Buckthorn	1
Buddaeia	1
Buffel Grass	1
Bull Thistle	4
Bullrush	1
Bush Honeysuckle	1
California Grass	1
Canada Thistle	11
Cardaria Draba	1
Chicory	1
Christmas Berry	2
Comada Thistle	1
Common Tansy	3
Cotton Thistle	1
Dalmation Toadflax	1
Diffuse Knapweed	1
Douglas Fir	4
Eastern Red Cedar	1
Fures	1
Garlic Mustard	1
Glossy Privet	1
Grape Vine	1
Guinea Grass	1
Hawkweed Complex	1
Himalayan Ginger	1
Honeysuckle	1
Houndstongue	13
Japanese Barberry	1
Japanese Hops	1
Johnson Grass	1
Juniper	4
Kiawe	1
Knapweed	2

Plant Species*	Number of Projects
Lambsquaters	1
Lead Tree	1
Leafy Spurge	3
Lodgepole Pine	9
Mahonia	3
Meadow Hawkweed	1
Mullen	1
Musk Thistle	4
Myrtle Spurge	1
Oleander	1
Orange Hawkweed	2
Oriental Bittersweet	1
Oxeye Daisy	3
Perrennial Pepperweed	2
Phragmites	1
Pigwee	1
Pines	1
Pinon Pine	1
Poison Hemlock	3
Poison Ivy	1
Ponderosa Pine	3
Prickly lettuce	1
Privet	5
Queen Anne's Lace	1
Rush Skeletonweed	2
Russian Olive	10
Russian Spotted Knapweed	1
Sage Brush	1
Salt Cedar	2
Scotch Thistle	6
Siberian Elm	1
Silver Conifer	2
Spotted Knapweed	12
St. Johnswort	3
Strawberry Guava	3
Sub-alpine Fir	1
Sulfur Cinquefoil	1
Tamarisk	5
Thorny Eleagnus	2
Toad Flax	2
Trifoliate Orange	2
Water Lettuce	1

Plant Species*	Number of Projects
Wedelia	1
Wild Parsnip	1
Wisteria	1
Wooly Mullein	2
Yellow Star Thistle	2
Yellow Toadflax	2
Total	**195**

*Species listed are the common names and spellings provided by corps.

Appendix 8 – Methods employed to discourage or remove plant species from a habitat

Manual/Mechanical Methods	Number of Projects	Number of Acres
Digging	1	4.00
Hand Pulling	9	195.55
Hand Pulling + Digging	4	1,709.50
Hand Pulling + Hand/chain saw	8	1,080.55
Hand Pulling + Mowing	1	89.00
Hand Pulling + Mowing + Hand/chain saw	1	0.50
Hand Pulling + Mowing + Trimming + Digging	1	1.60
Hand Pulling + Other	2	3.00
Hand Pulling + Trimming	1	3.00
Hand Pulling + Trimming + Digging + Hand/chain saw	1	200.00
Hand Pulling + Trimming + Hand/chain saw	5	16.17
Hand/chain saw	21	884.53
Harvesting	1	
Mowing + Digging + Hand/chain saw	1	4.00
Other	6	234.08
Trimming	1	600.00
Trimming + Hand/chain saw	1	410.00
Grand Total	**65**	**5,435.49**

Chemical Methods	Number of Projects	Number of Acres
Cut stem/stump	15	29.14
Cut stem/stump + Basal bark	2	1.70
Cut stem/stump + Other	1	
Foliar herbicide	25	1,713.30
Foliar herbicide + Cut stem/stump	2	8.00
Foliar herbicide + Cut stem/stump + Basal bark	1	
Other	1	
Grand Total	**149**	**1,752.14**

Other Methods*	Number of Projects
Construction of fireline for future burn. Removed snags and limbs 30 ft on either side of road.	1
Crew will return to site to apply Escort XP (metsulfuron to Houndstongue rosettes in October.	1
Cut down beetle killed lodgepole pine	1
Piled cut brush and burning	1
Grand Total	**4**

*Methods employed are provided verbatim from data submitted.

Appendix 9 – Chemicals employed to discourage or remove plants from habitat

Chemical(s) Applied*	Number of Projects
2,4-D, MSM 60	1
Aminea, Dimethyimine and 2,4 dichlorphenoxyacitic acid	1
Aquaneat	2
Element 4 Triclopyr	1
Element 4, Aquaneat	1
Escort, Garlon, Round Up	1
Escort, Milestone	4
Garlan - Oleander, Milestone - Wedelia	1
Garlon 3a	1
Garlon 4	1
Garlon, Milestone	2
Glyphosate	1
Glyphosate 25% solution	2
Milestone (aminopyralid)	5
Milestone (aminopyralid), Polaris (imazypyr)	1
Milestone, 2,4-D (toadflax)	1
Milestone, Amine 2,4-D	1
Milestone, Garlon 4	2
Milestone, Perspective, Polaris, Plateau, RazorPro	1
Milestone, Telar XP	2
Open Sight	1
Perspective	1
Rodeo	1
Rodeo 25% solution	2
Round-up, Reward, Garlon, MSO	1
Transline, Milestone, Polaris	1
Triclopyr	1
Triclopyr, Glypohsate	2
Grand Total	**42**

*Chemicals applied are provided verbatim from data submitted.

Appendix 10 – Animal species for which habitat was improved or species encouraged

Animal Species*	Number of Projects
All Native Species	3
Antelope	1
Birds	1
Blackfooted Albatross	1
Cattle	1
Coot	1
Deer	2
Elk	3
Greater Sage Grouse	1
Hawaiian Moorhen	2
Insects	1
Kamehameha Butterfly	1
Laysan Albatross	1
Migratory Waterfowl	1
Mule Deer	1
Native Amphibians	1
Native Bird Species	1
Native Birds	1
Native Fish	1
Native Mammals	1
Native Reptiles	1
Nene Goose	1
Pronghorn	3
Pronghorn Antelope	1
Shorebirds	1
Small Mammals	1
Yellow-faced Bee	1
Grand Total	**32**

*Species listed are common names and spellings provided by corps.

Appendix 11 – Other activities performed to encourage or improve habitat for animal species

Other Activities*	Number of Projects
1 acre of cutting/piling Ponderosa, Lodgepole pine and Silver Conifer; promoting better environment for rearing young	1
Barbed wire fencing	1
Plant willow propagules and sedge plugs along drainage canals	1
Removing conifer trees to improve habitat for raising young	1
Removing juniper	1
Rocky Mountain Juniper removal - 25 acres	1
Grand Total	**6**

*Methods employed are provided verbatim from data submitted.

Appendix 12 – Other activities to reduce forest fuels

Other Forest Fuel Reduction Activities	Number of Projects
Approximately 20’ fire break betweentw natives and tam; 5’ buffer in tam around isolated natives	1
Beetle killed lodgepole pine	1
Construction of fireline for future burn. Removed snags and limbs 30 ft on either side of road.	1
Created 200 slash piles to burn	1
Made burn piles and log piles	1
Pulled back of duff and debris from old growth trees; 255 trees completed in 5.27 acres.	1
Thinned Ponderosas	1
Grand Total	**7**

*Other activities are provided verbatim from data submitted

Appendix 13 – Other activities to restore or repair habitat

Other Activities*	Number of Projects	Quantity
Fencing constructed	2	0.13 miles
Fencing removed	1	4.50 miles
Fencing repaired	3	35.70 miles
Fixed slope	1	
General fencing (purpose not indicated)	3	2.40 miles
Habitat piles, log piling	1	
Improved trail	1	
Landscaping	1	0.50 acres
Removal of invasive species	1	
Thinning of conifer trees to create better habitat for raising young ungulates	1	
Trash removal	1	
Understory forage regeneration	1	
Grand Total	**17**	

* Other activities involving fencing repaired, constructed or removed were aggregated if it was the same activity. When only fencing was indicated, it was placed in a general category with a note that the purpose was not identified. All other activities listed are as submitted.

Appendix 14 – Targeted invasive species for all invasive species plots

Common Name*	Scientific Name	Number of Plots
Autumn Elaeagnus	Elaeagnus umbellata	1
Blackberry	Rubus	1
Bladder Campion	Silene vulgaris	1
Buckthorn	Rhamnus cathartica	7
Buffel Grass	Cenchrus ciliaris	2
Bull Thistle	Cirsium vulgare	6
Bull Thistle	Cirsium vulgare	6
Canada Thistle	Cirsium arvense	5758
Cheatgrass	Bromus tectorum	1
Chicory	Cichorium inybus	1
Christmas Berry	Schinus terebinthifolius	2
Common Mullein	Verbascum thapsus	4
Common Mullein	Verbascum thapsus	7
Cow Vetch	Vicia villosa	3
Crown Vetch	Coronilla varia	3
Diffuse Knapweed	Centaurea diffusa	1
Douglas Fir	Pseudotsuga menzeisii	3
Dyer's Woad	Isatis tinctoria	1
European Beachgrass	Ammophila arenaria	3
Garlic Mustard	Alliaria petiolata	4
Grapevine	Vitis	3
Grecian Foxglove	Digitalis lanata	6
Guinea Grass	Megathyrsus maximus	1
Haole Koa	Leucaena leucocephala	3
Honeysuckle	Lonicera morrowii	3
Houndstongue	Cynoglossum officinale	6366
Japanese Barberry	Berberis thunbergii	3
Japanese Hops	Humulus japonicus	3
Knapweed	Centaurea cyanus	3
Leafy Spurge	Euphorbia esula	9
Leafy Spurge	Euphorbia esula	10
Ligustrum	Ligustrum lucidum	9
Mahonia	Mahonia aquifolium	1
Meadow Hawkweed	Hieracium caespitosum	9
Musk Thistle	Carduus nutans	2
Myrtle Spurge	Euphorbia myrsinites	1
Narrowleaf Bittercress	Cardamine impatiens	1
Orange Hawkweed	Hieracium aurantiacum	4
Oriental Bittersweet	Celastrus orbiculatus	3
Oxeye Daisy	Leucanthemum vulgare	5
Oxeye Daisy	Leucanthemum vulgare	7
Plumeless Thistle	Carduus acanthoides	1

Common Name*	Scientific Name	Number of Plots
Poison Ivy	Toxicodendron radicans	3
Prickly Lettuce	Lactuca serriola	1
Privet	Ligustrum sinense	1
Queen Anne's Lace	Daucus carota	3
Rocky Mountain Juniper	Juniperus scopulorum	1
Rush Skeletonweed	Chondrilla juncea	9
Rush Skeletonweed	Chondrilla juncea	10
Russian Olive	Elaeagnus angustifolia	9
Russian Olive	Elaeagnus angustifolia	10
Scotch Thistle	Onopordum acanthium	4
Spotted Knapweed	Centaurea maculosa	23
Spotted Knapweed	Centaurea stoebe / Centaurea maculosa	293457
St. John's Wort	Hypericum perforatum	2
Sticktight	Hackelia virginiana	3
Strawberry Guava	Psidium cattleianum	2
Sulfur Cinquefoil	Potentilla recta	3
Tamarisk	Tamarix gallica	1
Tamarisk	Tamarix ramosissima	3
Tamarisk (spp)	Tamarix spp	3
Tamarisk (spp)	Tamarix spp	4
Tamarisk/Salt Cedar	Tamarix ramosissima	5
Tamirsk	Tamarix chinensis	1
Utah Juniper	Juniperus osteosperma	5
Whiplash Hawkweed	Hieracium flagellare	3
Wild Parsnip	Pastinaca sativa	5
Wisteria	Wisteria sinensis	1
Woolly Mullein	Verbascum thapsus	3
Yellow Star Thistle	Centaurea solstitialis	5
Yellow Toadflax	Linaria vulgares	1
Yellow Toadflax/Common Toadflax	Linaria vulgaris	2
Total Plots		**380**

*Species names, both common and scientific, are as provided by corps. Note: Spotted Knapweed was associated with two scientific names. References to Spotted Knapweed were combined in the main report when using the common name and listed separately here with the scientific names.

Appendix 15 – Targeted invasive species by region*

*Species names, both common and scientific, are as provided by corps. Note: Spotted Knapweed was associated with two scientific names. References to Spotted Knapweed were combined in the main report when using the common name and listed separately here with the scientific names.

Eastern Region: GA, NY, SC, NC (Corps = Conservation Legacy, SCA)

Common Name	Scientific Name	Number of Plots
Autumn Elaeagnus	Elaeagnus umbellata	1
Japanese Barberry	Berberis thunbergii	3
Mahnoia	Mahonia aquifolium	1
Privet	Ligustrum Sinense	1
Total Plots		**6**

Central Region: MN, ND, TX, WI (Corps = CCMI, TXCC, MCC)

Common Name	Scientific Name	Number of Plots
Buckthorn	Rhamnus cathartica	7
Canada Thistle	Cirsium arvense	15
Cheatgrass	Bromus tectorum	1
Cow Vetch	Vicia cracca	3
Crown Vetch	Coronila varia	3
Garlic Mustard	Alliaria petiolate	1
Grapevine	Vitis	3
Grecian Foxglove	Digitalis lanata	6
Honeysuckle	Lonicera morrowii	3
Japanese Hops	Humulus japonicus	3
Leafy Spurge	Euphorbia esula	5
Ligustrum	Ligustrum lucidum	9
Narrowleaf Bittercress	Cardamine impatiens	1
Oriental Bittersweet	Celastrus orbiculatus	3
Poison Ivy	Toxicodendron radicans	3
Queen Anne’s Lace	Daucus carota	3
Russian Olive	Elaeagnus angustifolia	3
Spotted Knapweed	Centaurea maculosa	2
Tamarisk	Tamarix ramosissima	3
Wild Parsnip	Pastinaca sativa	5
Total Plots		**82**

Western Region: AZ, CO, ID, MT, UT, WY (Corps = Conservation Legacy, MCC, UCC)

Common Name	Scientific Name	Number of Plots
Blackberry	Rubus	1
Bladder Campion	Silene vulgaris	1
Bull Thistle	Cirsium vulgare	6
Canada Thistle	Cirsium arvense	4243
Chicory	Cihorium inybus	1
Common Mullein	Verbascum thapsus	11
Diffuse Knapweed	Centaurea diffusa	1
Douglas Fir	Pseudotsuga menziesii	3
Dyer's Woad	Isatis tinctoria	1
Garlic Mustard	Alliaria petiolata	3
Houndstongue	Cynoglossum officinale	5558
Knapweed	Centaurea cyanus	3
Leafy Spurge	Euphorbia esula	5
Meadow Hawkweed	Hieracium caespitosum	9
Musk Thistle	Carduus nutans	2
Myrtle Spurge	Euphorbia myrsinites	1
Orange Hawkweed	Hieracium aurantiacum	4
Oxeye Daisy	Leucanthemum vulgare	12
Plumeless Thistle	Carduus acanthoides	1
Prickly Lettuce	Lactuca serriola	1
Rocky Mountain Juniper	Juniperus scopulorum	1
Rush Skeletonweed	Chondrilla juncea	19
Russian Olive	Elaeagnus angustifolia	13
Scotch Thistle	Onopordum acanthium	4
Spotted Knapweed	Centaurea maculosa	18
Spotted Knapweed	Centaurea stoebe	2631
St. John's Wort	Hypericum perforatum	2
Sticktight	Hackelia virginiana	3
Sulfur Cinquefoil	Potentilla recta	3
Tamarisk	Tamarix chinensis	1
Tamarisk	Tamarix spp	9
Tamarisk/Salt Cedar	Tamrix	2
Utah Juniper	Juniperus osteosperma	5
Whiplash Hawkweed	Hieracium flagellare	3
Wisteria	Wisteria sinensis	1
Woolly Mullein	Verbascum thapsus	3
Yellow Star Thistle	Centaurea solstitialis	5
Yellow Toadflax / Common Toadflax	Linaria vulgaris	3
Total Plots		**265**

Pacific Region: HI, OR, WA (Corps = Kupu, NYC, HOC)

Common Name	Scientific Name	Number of Plots
Buffel Grass	Cenchrus ciliaris	2
Christmas Berry	Schinus terebinthifolius	2
European Beachgrass	Ammophila arenaria	3
Guinea Grass	Megathyrsus maximus	1
Haole Koa	Leucaena leucocephala	3
Houndstongue	Cynoglossum officinale	8
Spotted Knapweed	Centaurea maculosa	6
Strawberry Guava	Psidium cattleianum	2
Total Plots		**27**

Appendix 16 – Secondary treatment approaches for plots targeting two or more invasive species

Treatment(s)	Number of Plots
Chemical control	3
Manual removal	16
Manual removal + Mechanical removal + Chemical control	3
Manual removal + Chemical control	2
Mechanical removal	4
Mechanical removal + Chemical control	7
Grand Total	**35**

Appendix 17 – Species removed from forest fuel reduction plots

Species Targeted*	Number of Plots
Aspen	7
Beetle killed Lodgepole pine	11
Blue Spruce	1
Creeping Juniper	2
Douglas Fir	38
Gambel Oak	2
Glossy Privet	2
Juniper Pine	9
Lodgepole Pine	44
Mesquite	3
Mountain Mahogany	4
Pinyon Pine	8
Ponderosa Pine	40
Red Cedar	3
Scrub Oak	1
Spruce	1
Sub-alpine Fir	5
Grand Total	**181**

*Species names are as provided by corps.