ANIMAS RIVER REMOVAL AND REPLACEMENT OF INVASIVE PHREATOPHYTES

Final Report

Prepared for:
Invasive Phreatophyte Control Program
Attn: Chris Sturm

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Introduction

Mountain Studies Institute (MSI) assembled an accomplished team of conservation partners to advance a comprehensive, interdisciplinary approach to address phreatophytes in the Animas drainage under the Animas River Removal and Replacement of Invasive Phreatophytes (Animas River RIP) project, funded by the Colorado Water Conservation Board (CWCB). The partners included: La Plata County Weed Management Program (LPCWP), Southwest Conservation Corps (SCC), La Plata Open Space Conservancy (LPOSC), and Animas Watershed Partnership (AWP). In addition, the USDA Natural Resources Conservation Service (NRCS)- Durango Office and the Bird Conservancy of the Rockies provided technical assistance. The overall ecological objective of this project was riparian restoration of the Animas River. The benefits of this project include: improved water quality; restored stream channel capacity and reduced flooding hazards; and enhanced wildlife habitat for native species, such as migratory neotropical songbirds and native fish, and T&E species which can occur in the area, including the Southwest Willow Flycatcher, Western Yellow-Billed Cuckoo, and New Mexico Meadow Jumping Mouse. Benefits to the community include education about river health and invasive species ecology, and enhanced recreational access and experiences through improved river health and integrity. Replacement of ornamental invasive phreatophytes with less-water consumptive species and natives will reduce groundwater consumption in the future, resulting in increased available water for all uses. An additional objective was to benefit local agriculture by control of plants that invade pastures, fields and irrigation ditch banks.

The project complimented but did not duplicate the efforts of several partners to educate the community and control phreatophytes. These partners include: the Southern Ute Tribe, La Plata County, City of Durango, and the San Juan Conservation District in New Mexico. Collectively, these partners helped to address gaps and to leverage their past and current efforts by extending eradication efforts onto lands that have not yet been treated, resulting in a regional approach to controlling invasive species. This project also created the first ornamental planting replacement program in the Animas Watershed of Colorado.

Background

The infestation of Russian Olive and associated woody invasives (tamarisk) in the upper Animas river valley may quickly be approaching the Economic Injury Level for farming and ranching land uses. If left untreated, the problem could soon become one economically prohibitive to resolve.

The Animas River RIP project followed Integrated Pest Management in the La Plata County Weed Management and Enforcement Plan and City of Durango Community Forest Plan (Removal of Invasive Species): education, prevention, mechanical treatment, and chemical treatment. The La Plata County Weed Management and Enforcement Plan highlights education and prevention as the number one priority in an integrated weed management approach. Our project included landowner education as a central part of our approach, which entails training in invasive plant identification, monitoring techniques, and the importance of early intervention in follow-up treatments.

Our efforts were based upon the objectives and goals outlined in the *La Plata County Weed Management and Enforcement Plan* (Article II Chapter 58). The *San Juan Woody Invasives Implementation Plan (2008)*

called for the eradication of wild Russian olive and tamarisk trees and strongly emphasized the need for tree replacement program. Additionally, the *Animas Watershed-Based Plan (2011)* identified the loss of native riparian habitat and function as a critical factor in the degradation of Animas River water quality. The plan points out that the assimilative capacity (i.e. the ability of riverside areas to utilize and/or sequester the pollutants in the river) of healthy riparian areas plays an important role in the quality of surface water in the river. Further, the following objectives were listed as critical to the Animas River's health: (1) improve riparian condition, including reducing invasive species, (2) protect and increase stream flows, and (3) utilize conservation easements and habitat programs to create incentives for landowners (Best Management Practices, page 39).

First noted in 2008, in the San Juan Woody Invasives Plan, the largest impediment to Russian olive removal in past efforts has been a lack of public will to remove shade trees and ornamental trees that have value to homeowners. Homeowners have sited the loss of shade and screening as major concerns. Our project sought to address this challenge directly through two strategies (1) mapping and inventory of priority infestation areas and (2) integrated education and outreach campaign using trusted social networks to leverage support for replacement and removal programs. We developed a program of IPM that included invasive species education, prevention of seed dispersal, mechanical and chemical weed control, and education of landowners to self-monitor their properties for future invasion.

As partners, both Southwest Conservation Corps (SCC) and La Plata Open Space Conservancy (LPOSC) shared the lessons learned from previously mentioned efforts on both the Dolores and Animas Rivers with MSI, which added to project success. Corps capacity dedicated to riparian restoration is relatively new and was first piloted by SCC in recent years in Southwestern Colorado.

Methods

Our Scope of Work was divided into five primary tasks: (1) map, inventory, and prioritize areas for removal of Russian olive, tamarisk, and other phreatophytes in the Animas River Basin, (2) develop a comprehensive outreach and education program to recruit private landowners, (3) Remove and replace phreatophytes (Russian olive, tamarisk, and Siberian elm) from (a) riparian infestations and (b) replace ornamental trees, (4) Monitor effectiveness and re-treat as necessary, and (5) Coordinate, administer, and report project outcomes. Each task is addressed below:

TASK 1 – MAP, INVENTORY, AND PRIORITIZE AREAS FOR REMOVAL

We mapped invasive phreatophyte populations along the Animas and Florida river corridors to help prioritize treatment locations. Our removal efforts were focused on the top of the watershed, working south towards the state line. We attempted to accurately map Russian Olive populations along the Animas and Florida river corridors by exploring several mapping methodologies and sources of aerial imagery. Our original intent was to replicate a methodology described by Hamilton and others (2006) utilizing a Geographic Information System (GIS) extension, Feature Analyst, to identify unique spectral signatures on the landscape. Unfortunately, the Feature Analyst extension was unable to effectively distinguish Russian

Olive from other features on the landscape along the Animas River. We discuss our attempt to use Feature Analyst in Appendix A. Our mapping efforts were also limited by the availability of high resolution imagery that depicts the summer leaf-on period. For example, La Plata County had high resolution aerial images photographed in 2015 and 2017, but large portions of the images were flown in the early spring, before Russian Olive had full foliage. We accessed NAIP imagery that does depict summer leaf-on conditions from USGS Earth Explorer and USDA Geospatial Data Gateway, but the resolution of the imagery was too coarse to distinguish individual or small stands of Russian Olive from adjacent vegetation. We also explored proprietary image sources. DigitalGlobe, who provides imagery to Google Earth, had high resolution summer imagery from 2015, but the imagery did not cover our entire area of interest and the cost to purchase the imagery was prohibitively expensive for this application.

Ultimately, we found that the most effective method of mapping Russian Olive along the Animas and Florida river corridors was to manually delineate trees using the mosaic of imagery available within Google Earth. Following this time-consuming task, we used field verification to further refine our mapping effort. Crews visited randomly selected mapped units in the field and documented whether Russian Olive was or was not indeed present. We found that a few tree species, mainly ornamental spruce trees, were occasionally mistaken for Russian Olive during the initial Google Earth mapping effort. Utilizing new search image criteria informed by the field verification results, we revised our manual delineations to be more accurate. As a result of these efforts, we produced a geodatabase containing 873 polygons representing 455 acres of mapped Russian Olive individuals and stands along the Animas and Florida river corridors (See Figure 1). Our intention was to use these maps to prioritize treatment areas by proximity to river, size of infestation, and willingness of landowners. However, landowner willingness became the main driver of the areas treated. GIS shapefiles of Russian olive and phreatophyte populations, and all treated areas, along the Animas and Florida river corridors in La Plata County will be provided to CWCB.

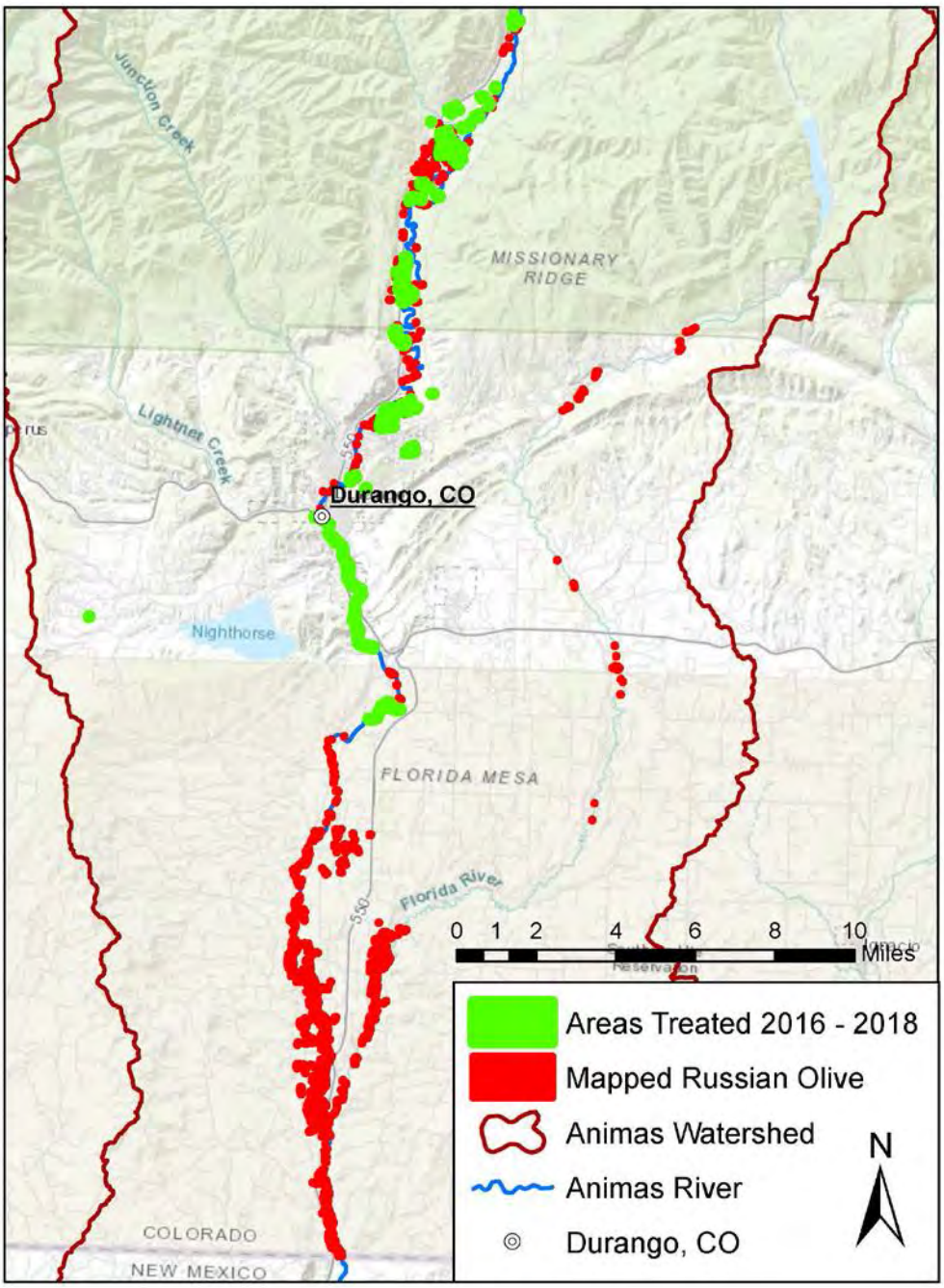

Figure 1: Mapped Russian olive and areas treated under the Animas River RIP project.

TASK 2 – EDUCATE, OUTREACH AND RECRUIT LANDOWNERS

MSI successfully engaged over 60 landowners through participation in the program and had an even broader reach to educate the public about woody invasives beyond those that participated in the program. MSI Community Science Director, Amanda Kuenzi gave power-point presentations to various groups in the La Plata county community (see Table 1), as well as numerous in-person on-site meetings with landowners. Additionally, there were two articles published in the local newspaper, the Durango Herald. Ms. Kuenzi also gave a radio interview which was originally aired through KSJD, but may be aired on radio stations across Colorado, through a collective of stations, in the coming months (Appendix B).

Education efforts were furthered through some of the many programs that MSI conducts. Invasive phreatophyte lessons were incorporated into the 2016, 2017, and 2018 Forests to Faucets teacher workshops, reaching approximately 48 teachers and environmental educators – each of which will impact numerous students each year. Invasive species ecology and the impact of phreatophytes has also been incorporated into programming under the "Experience Mountain Science Program" (xMSP) which targets high-school students within the five-county region. Through this xMSP outreach, MSI staff have educated over 150 students about invasive species ecology.

MSI also built partnerships and educated the staff of the Animas Mosquito Control District (AMCD) and the Durango-based maintenance crew for the Colorado Department of Transportation (CDOT). Staff within both of these groups began using herbicide to eliminate Russian olive in their respective work areas. This greatly increased the scope of our project, as these crews have access to increased areas that are currently infested by Russian olive. These crews also have indefinite funding and will continue to treat Russian olive season after season.

Ms. Kuenzi participated in the 2017 and 2018 annual conferences for Rivers Edge West (formerly the Tamarisk Coalition), presenting a poster of the accomplishments under this grant at the 2018 conference. She also presented the accomplishments to the Southwest Basin Roundtable at the April 2018 meeting.

Table 1: Area groups that hosted presentations about Invasive Phreatophyte Control

Organization	**Approximate Number of Attendees**
Animas Consolidated Ditch Association	80
Durango Lyons Club	8
Durango Kiwanis Club	10
Durango Daybreak Rotary	40
Several local Home Owner's Associations	30
Animas Watershed Partnership (Wetland tour)	15
Animas Valley Grange	8
Escalante Middle School	70
Colorado Native Plant Society – Southwest Chapter	30

TASK 3 – REMOVAL FROM RIPARIAN AREAS AND REPLACEMENT TREE LANDSCAPING

MSI worked with landowners to develop a Weed Management Plan for their individual parcel, as well as working with Homeowners Associations, one school, one church, a mobile home park, and a wedding venue. Assessments were done to determine the best practices for removal and revegetation. In total 56 plans were created with landowners (some were done with the entire Homeowners Association, involving multiple landowners).

Following the Integrated Management Plan, SCC saw crews mechanically removed Russian olive and tamarisk utilizing chain saws. In some cases, the "hack and squirt" or frill-cut method was used. Following the chain saw removal or frill cut, SCC crews treated stump cuts and/or cambium layer with an appropriate herbicide, methylated seed oil, and marker dye. In total, approximately 290 acres were treated.

Disposal of the materials from removal efforts was accomplished in several ways. A portion of the participants were willing to pile burn the waste on site. Another portion asked to have it trucked away to a common burn pile at the Animas River Wetlands property. Some landowners hired out the chipping or rented chipper equipment. The most notable method of slash disposal was through cooperation with the Durango Daybreak Rotary club. Rotarians volunteered their time and personal vehicles to pick up the firewood sized slash from project sites and hauled it to a staging area. This wood is being cured for one year, and will then be split and distributed by the Rotarians to help low income families and seniors to heat their homes. The Rotary club reported that they collected approximately 10 cords of woods, which will be distributed to approximately 20 families in fall of 2018.

During the early spring weeks of 2017 and 2018, willow poles were planted in fringe wetlands on a total of 7 acres. SCC crews uses a "water drill" tool to create holes for willow pole planting. At one property, the "willow mattress" technique was used to place willows horizontally in a wetland.

Landowners were offered reimbursement for 50% of the cost of replacement trees for landscaping, up to $300. Landowners were asked to fill out a form and submit receipts to receive a reimbursement check. Approximately $12,000 was set aside for this purpose to be able to serve a majority of the participants. However, this portion of the program had very low participation. Only 11 landowners turned in a request for reimbursement, and of these, only four requested the full amount of $300. In total, only $2,680 in reimbursement checks were issued.

TASK 4 – MONITOR PROGRAM EFFECTIVENESS, RETREAT AS NECESSARY

SCC crew members mapped treated areas using ARC GIS Collector platform. Pre- and post-treatment photos were taken and the photopoints were marked using GPS.

Several areas that had been treated for Russian olive in previous efforts were monitored and re-treated under this grant. These included 16 parcels with conservation easements, and four areas on City of

Durango property. MSI worked closely with the City of Durango arborist and the La Plata Open Space Conservancy to achieve this.

Landowners were taught about the re-sprouting habits of Russian olive and asked to monitor if these occurred. Each landowner was asked to sign a "landowner agreement" which included monitoring for five years. MSI will follow up with landowners on an annual basis and track results. The hope is that MSI will continue to procure funds for retreatment efforts.

TASK 5 – COORDINATE, ADMINISTER, AND REPORT PROJECT OUTCOMES

MSI successfully coordinated the activities of the grant, administered the CWCB funds and matching funds, and reported on project outcomes. A database of all landowner contributions was maintained. MSI developed a series of forms for landowners to fill out in order to track all matches. Example forms are included in Appendix C. A table of all landowner match and tree replacement costs, as reported, is included in Appendix D.

Results

Our accomplishments are summarized below:

Invasive Phreatophyte Mapping and Removal

- Fall 2016 through Fall 2017: 288 acres of Russian olive and 2.7 acres of tamarisk were removed
- Coordination with over 60 individual landowners, including educational outreach about watershed health and the impacts of invasive species on wildlife
- Multiple presentations to area groups about this program, watershed health, and the impacts of invasive species on wildlife.
- Animas Watershed Partnership spent 60 hours on outreach and ground-truthing for prioritization of Russian olive removal efforts
- MSI's interns have spent 60 hours on digital mapping and ground-truthing for prioritization of Russian olive removal efforts
- MSI staff tested use of the Feature Analyst GIS tool

Planting Riparian Vegetation

- Spring 2017: 10 days of SCC crews and MSI staff, planting native willows. In total, planted approximately 4 acres, including 3 private parcels adjacent to the Animas River.
- Spring 2018: 4 days of SCC crews planting native willows. In total, planted approximately 3 acres, including 1 private parcel adjacent to the Animas River and 1 fringe wetland around a pond on common space for a Homeowner's Association.

Matching efforts from our partners (in-kind match)

- NRCS staff assisted in training our crew in the use of the "stinger" water drill to use for planting willows

- La Plata Open Space Conservancy (LPOSC) assisted our efforts by helping us coordinate with Conservation Easement holders to do wetland enhancement work. Of special note, our SCC crews helped to augment the wetlands on the Conservation Easement for the Animas River Wetlands mitigation bank. This is a progressive project that has been developed in the Animas River Valley for nearly 8 years. LPOSC Stewardship Coordinator, Jamie Johnson spent a day planting willows as well
- LPOSC staff also monitored past Russian olive removal project sites to identify areas in need of retreatment
- Colorado Department of Transportation has spent 75 hours man hours, treating approximately 300 stems of Russian olive
- The Animas Mosquito Control District is assisting by removing Russian olive and treating with herbicide
- City of Durango arborist, Greg Sykes monitored past Russian olive removal project sites to identify areas in need of retreatment
- The Durango Daybreak Rotary members have spent over 40 hours collecting the material produced by the removal efforts. They will use this as firewood for low-income families and seniors that will use it for home heating in 2018. A total of 10 cords of wood was stock piled.

Conclusions and Discussion

MSI exceeded the objectives in terms of phreatophyte removal. We would like to continue to explore options include using alternative methods of remote sensing to determine the extent of the Russian olive and tamarisk populations. MSI staff are currently discussing possible uses of infrared imagery in future remotely sensed mapping efforts. MSI will continue to check in with landowners on an annual basis to assess if treated populations of Russian olive are re-sprouting. Landowners that have conservation easements will be visited annually by the La Plata Open Space Conservancy staff for inspections, and monitoring will be done at that time.

MSI is overall very pleased with the project outcomes. Several partnerships were developed and/or strengthened through this work, including engaging AMCD and CDOT in Russian olive eradication. We expect these efforts to continue indefinitely. Momentum for Russian olive eradication has grown over the course of our outreach efforts and the “word of mouth” network about the program has been continuing. At the project’s end, we have a database of nearly 30 properties and landowners that would like to participate in future efforts to remove Russian olive. MSI is seeking additional funding to continue these efforts, and has been notified that we will be awarded $48,714 under the Colorado Water Plan grant program in the Environmental and Recreation category.

We learned several lessons about managing slash disposal, and the problems therein. We were extremely fortunate to partner with the Durango Daybreak Rotary to put a large amount of the waste material to good use, as firewood for low income families. We were also fortunate to have access to the large burn pile at the Animas River Wetlands to transport additional slash. Without these provisions, several landowners with large amounts of Russian olive would not have participated. Communal burn piles and slash transportation methods will be identified ahead of all future project work.

Actual Expense Budget

Below is the actual budget, including all cash match and in-kind match funding, as compared to the budgeted totals. MSI spent $185,954 of the available $195,000 funds awarded, leaving $9,046 of unused funds. This is partially due to low participation in the landowner reimbursement program for costs of replacement trees.

Table 2: Budgeted vs. actual expenditures

Task	Task - Description	CWCB Funds	Additional CWCB PO	CWCB Funds Actual	Other Funding Cash*								Other Funding In-Kind*			Totals Budgeted	Totals Actual
					State Funds Budgeted	State Funds Actual	Landowner Cost Share Budgeted	Landowner Cost Share Actual	Cost Share Grant Programs Budgeted	Cost Share Grant Programs Actual	Local Partners & Nonprofits Budgeted	Local Partners & Nonprofits Actual	Local Partners & Nonprofits Budgeted	Local Partners & Nonprofits Actual	Landowner In-Kind Match Actual		
1	1- Mapping, Inventory, and Prioritization	$ 24,500		$ 23,256			$ -		$ 6,000		$ 2,000	$ 7,000	$ 10,400	$ 3,358		$ 42,900	**$ 33,614**
2	2- Education and Outreach	$ 20,250		$ 20,118	$ 2,500		$ -		$ 3,000		$ 1,250	$ 16,750	$ 10,235	$ 2,000		$ 37,235	**$ 38,868**
3	3- Removal and Replacement	$ 95,250	$ 27,750	$ 119,731	$ 12,000	$ 37,500	$ 12,500	$ 27,042	$ 37,500	$ 20,464	$ 8,400	$ 16,900	$ 98,760	$ 94,250	$ 35,911	$ 264,410	**$ 351,799**
4	4- Monitoring, Retreatment	$ 20,000		$ 17,784	$ 7,500	$ 15,000	$ 7,500		$ 13,500		$ -		$ 17,493	$ 691	$ 29,628	$ 65,993	**$ 63,103**
5	5- Coordination, Reporting, Admin	$ 5,000	$ 2,250	$ 5,065							$ -		$ 1,800			$ 6,800	**$ 5,065**
	TOTALS	**$ 165,000**	**$ 30,000**	**$ 185,954**	**$ 22,000**	**$ 52,500**	**$ 20,000**	**$ 27,042**	**$ 60,000**	**$ 20,464**	**$ 11,650**	**$ 40,650**	**$ 138,688**	**$ 100,299**	**$ 65,539**	**$ 417,338**	**$ 492,448**

Match Summary	
Total cash	$ 140,656
Total inkind	$ 165,838
Total match	$ 306,494

Table 3: Matching Sources of Funding

Match Sources	
1- Mapping, Inventory, and Prioritization	
Cash	La Plata County aerial imagery ($5000), MSI GIS licensing costs ($2000)
In-Kind	AWP, CPW, MSI interns - ground-truthing and digital mapping ($3,358)
2- Education and Outreach	
Cash	Two scholarships to Tamarisk Coalition annual conferce ($600), WFAC mini-grant for wetland brochures ($1000), Partial Temper of the Times grant for wetland brochures ($6000), MSI labor for invasive species outreach and education through partial grants from Southwest Water Conservation District and City of Durango ($2000), Animas Watershed Partnership ($1000), MSI labor costs for Riparian Workshop ($900), MSI labor for invasive species education through xMSP 2016-2018 ($5000 through various grants), La Plata County brochures ($250)
In-Kind	MSI costs (printing, mileage, volunteer events) ($2000)
3- Removal and Replacement	
Cash	CPW Wetland Block grant ($37,500), Landowner cash contributions ($27,042) , Colorado Tree Coalition Grant ($2000), Fort Lewis College tree replacement costs ($4390), La Plata County herbicide cost-share ($362), NRCS wetland improvement projects ($13,712), La Plata County contributions ($2500), COD ($2400) and CYCA ($12,000) funds committed at start of project for removal efforts
In-Kind	SCC volunteer match ($65,142), Cost savings from SCC ($24,120), Labor and equipment incl: CDOT, AMCD, NPS, LPC, and landowners ($4988)
4- Monitoring, Retreatment	
Cash	CPW Wetland Block grant ($15,000)
In-Kind	LPOSC monitoring ($593) and COD arborist monitoring ($99), landowner monitoring ($29,628 {60 homes * 4 hrs * 5 years * 24.69 vol rate})
5- Coordination, Reporting, Admin	
Cash	None
In-Kind	None

AMCD	Animas Mosiquito Control District
AWP	Animas Watershed Partnership
CDOT	Colorado Department of Transportation
COD	City of Durango
CPW	Colorado Parks and Wildlife
CYCA	Colorado Youth Corps Association
LPC	La Plata County
LPOSC	La Plata Open Space Conservancy
MSI	Mountain Studies Institute
SCC	Southwest Conservation Corps
WFAC	Wetland Focus Area Committee

Appendices

Appendix A:
Report: Feature Analyst Tool for Mapping Russian Olive - Animas and Florida River Watershed

Appendix B:
Examples of Project Outreach

Appendix C:
Examples of Landowner Agreements and Contribution Tracking Forms

Appendix D:
Landowner Match and Tree Replacement Costs

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Animas Watershed Partnership, 2011. Animas Watershed-Based Plan. Report published by Animas Watershed Partnership, Durango CO. Best Management Practices. Page 39.

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Appendix A

Report: Feature Analyst Tool for Mapping Russian Olive - Animas and Florida River Watershed

Feature Analyst Tool for Mapping Russian Olive

Animas and Florida River Watershed

Mountain Studies Institute

Amanda Kuenzi and Scott Roberts

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04/02/2018

Introduction

In order to more accurately calculate the acreage of Russian Olive in the Animas River and Florida River corridor, I attempted to implement Feature Analyst™ tool. Feature Analyst™ is a 3rd party extension for ArcMap that extracts features from imagery for GIS analysis. The tool has shown success in extracting features such as roads, rivers, and some land cover types using the feature's spectral and spatial properties. It "learns" to identifies features through a series of training steps, where the user defines the desired feature by digitizing training polygons around a few of the features. After running a trial extraction on the imagery, the user selects correct, incorrect, and missed features. Once the tool successfully selects the desired features, the user creates a model that can be applied to larger sets of imagery.

In a publication by Hamilton and others (2006) they were able to successfully map Russian Olive using Feature Analyst™ in a short, narrow river corridor. This project also attempted to map Russian Olive (RO) using the Feature Analyst™ tool (FA), but on a much longer and wider river corridor. After many attempts, testing various approaches, the tool unfortunately did not have much success. Those attempts are detailed below along with a short discussion of likely reasons the tool did not succeed.

Examples and Results

We acquired the imagery used in this project from La Plata County. The complete set of imagery covers a large portion of land around the Animas River, Florida River, and Lake Nighthorse. However only a small portion of this imagery was used to test the FA tool. The imagery was acquired at both 3-inch and 1-meter resolution in 3 bands (RGB).

Figure 1: White outline shows the portion of the 3-inch imagery used to train and test the FA tool. Pink dots were placed on known RO trees and later used to identify good training areas.

3-inch Imagery Attempts

Most efforts to train the FA tool were done on the imagery shown in Figure 1. First, the FA tool requires the user to choose an input representation, describing the shape and size of the feature. After trying a variety of shapes and sizes, a "Manhattan" shape and 11x11 pixel pattern width seemed to give the best results on the 3-in imagery. Second, polygons were drawn around known RO trees. And the tool was run, allowing it to extract similar features (Figure 2). Following each run, I selected correct, incorrect, and missed features (Figure 3). Once the tool selected the correct features a model was created. The model, allows the tool to be run on an adjacent region of the imagery and should not require any interaction or training. The results of the model, run on 3-in imagery, is shown in Figure 4. While the training appeared to be successful, the model clearly did not distinguish RO from other vegetation, soil, and roads with similar spectral and spatial properties.

To ensure the issues occurring were not only a result of the season and visibility of the RO trees, attempts were also made on a portion of imagery to the north, where the RO trees were more distinct. The tool was trained using the same process as previously described. The tool appeared to be "learning" and selecting RO trees quicker than previous attempts, but when the model was created and allowed to run on an adjacent portion of the imagery, results were still not satisfactory (Figure 5).

Figure 2 (left): Results of a first run, produced by allowing the tool to select features similar to the original training polygons. Training polygons are shown in blue, yellow features were selected by the tool.

Figure 3 (right): An example of training the tool with correct, incorrect, and missed features. Correctly identified features are shown by green, incorrectly identified features in red, and missed features in blue.

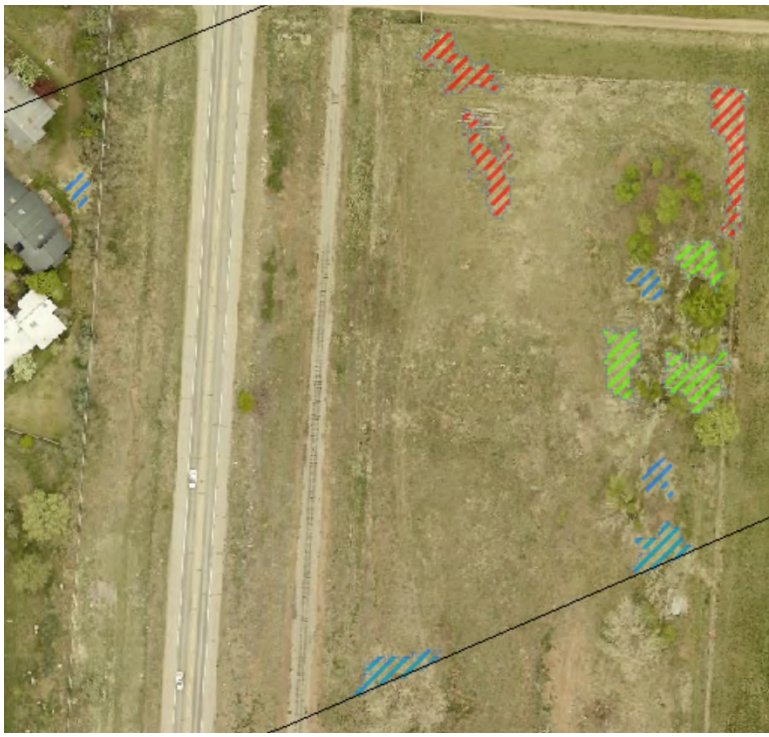

Figure 4 (left): An example of a model run. Black polygons show where the FA tool was trained. White polygons show the results of the model, where the tool picked features on its own. The tool clearly does not select the correct features, patches of soil and roads should not be included. And white arrows point at RO trees that should have been included.

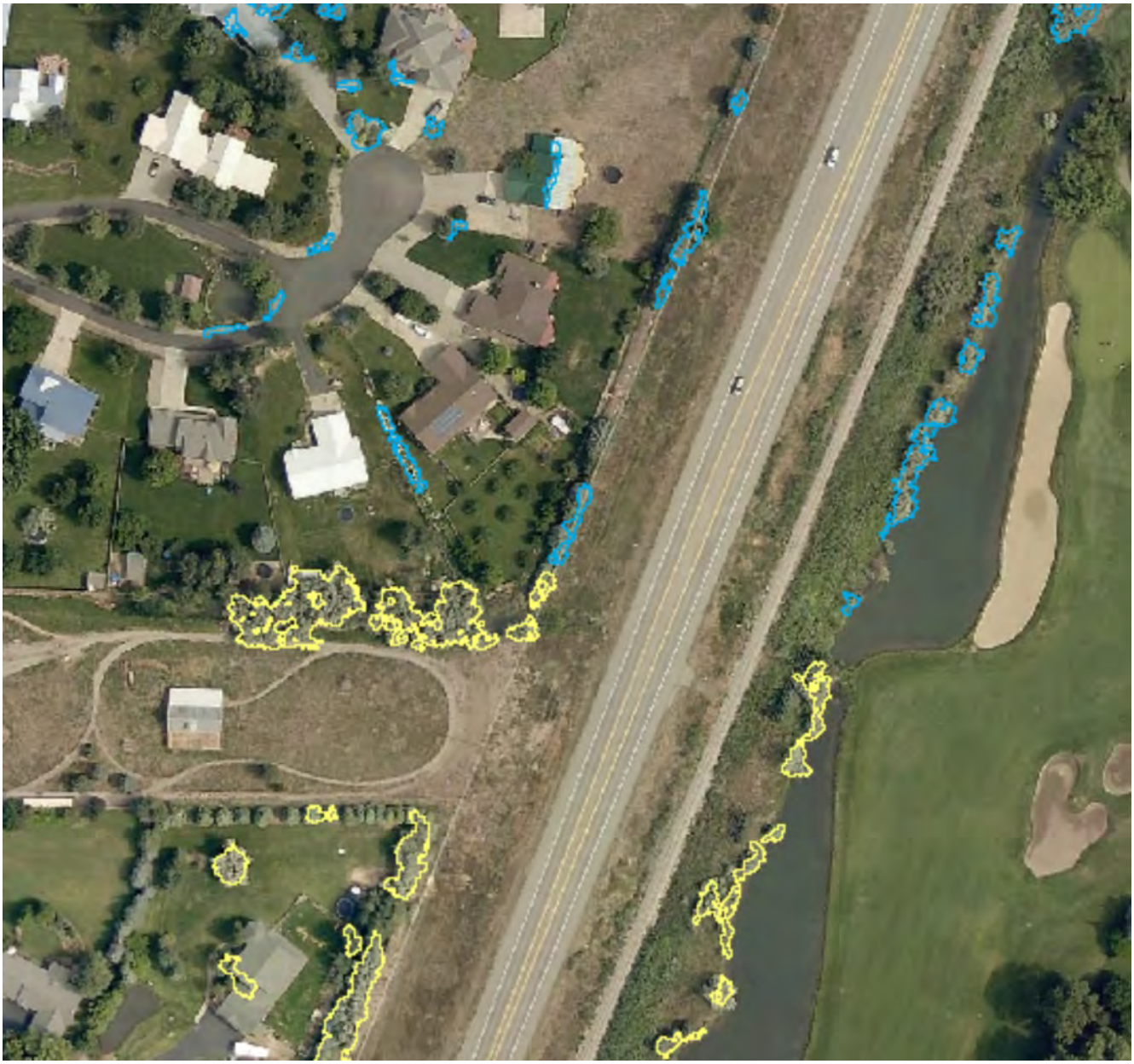

Figure 5: Northern region with more distinct RO trees. Yellow polygons show where the tool was trained, blue polygons show where the model was allowed to select RO on its own. Again, the tool did not properly distinguish RO trees. While it was more successful than previous attempts (Figure 4). It still selects portions of the sidewalk and houses along with the RO.

1-Meter Imagery Attempts

I also tried mapping the RO on 1-meter resolution imagery to test if it could reduce the clutter of incorrectly identified features and to allow images to be processed more quickly. The images were processed and trained using the same procedure as the 3-inch imagery, but with an input representation pixel width of 5x5. The result of the best model is shown in Figure 6. Unfortunately, the model was still not successful and tended to underestimate the size of RO trees.

Multiclass Attempt

As a last resort effort, I also attempted a multiclass approach. Multiclass mapping allows the user to define more than one feature type, but it reduces the amount of interaction/training and tends to generalize features. For this attempt, I defined six classes of features; RO, non-RO vegetation, paved surfaces, dirt surfaces, houses, and water. Each class of features was defined by digitizing polygons around 5-8 examples of the features in the imagery. Each class was then combined into a single shapefile, which was used for analysis. The results of this attempt are show in Figure 7.

Figure 6: 1-meter resolution imagery model. Black polygons, show where the tool was trained. White polygons show the model results. It misses large portions of RO in regions highlighted by the white arrows. Additionally, black arrows point at regions that were incorrectly selected as RO.

Figure 7: Multiclass analysis results. Pink polygons show features that were identified as RO. While it successfully identified most of the RO, it also still selected houses, sidewalks, and other incorrect features.

Figure 8: Extent of imagery used for the multiclass approach in Figure 7. Some urban features and other types of vegetation are very similar in color to the RO trees along the eastern fence line.

Disscussion

Feature Analyst was unable to accurately map Russian Olive within the heterogenous landscape of the Animas River watershed due to limitations of the FA tool and the aerial imagery that was available. The FA tool seems to be designed for mapping more general features, such as forested and non forested regions or paved and non-paved roads. It does not seem to be able to effectively distinguish Russian Olive from other features on the landscape along the Animas River. . The available imagery only had three bands for a natural color image; red, green, and blue. The FA tool may have performed better if the imagery included a Short Wave Infrared (SWIR) band. This band is used to highlight vegetation and may have reduced the selection of houses and sidewalk. Finally, the results were likely not as succesful as Hamilton and others (2006) due to the prevalence of urban features in the Animas River corridor. The tool seemed to work succesfully in regions where RO were fully bloomed, near a source of water, and not adjacent to urban features.

References

Hamilton, R.; Megown, K.; Lachowski, H.; Campbell, R. 2006. Mapping Russian olive: using remote sensing to map an invasive tree. RSAC-0087-RPT1. Salt Lake City, UT: U.S. Department of Agriculture Forest Service, Remote Sensing Application Center. 7 p.

Appendix B

Examples of Project Outreach

THE Durango HERALD

Battle against Russian olive trees waged for second year

Invasive plant chokes out native trees, harms watershed

By Mia Rupani Herald staff writer
Saturday, Oct. 14, 2017 3:34 PM Updated: Sunday, Oct. 15, 2017 10:51 PM

David Pirrone with Durango Daybreak Rotary Club loads firewood from the Russian olive tree removal project that will later be distributed to low-income families and seniors.
Mia Rupani/Durango Herald

Mountain Studies Institute and Southwest Conservation Corps continue to wage war against the Russian olive, an invasive species that chokes out native trees and degrades the quality of the watershed.

Last year, MSI was awarded a $195,000 grant from the Colorado Water Conservation Board and an additional $52,000 from Colorado Parks and Wildlife for a three-year Russian olive-removal project.

Related Story

Removal efforts continued Saturday morning at Animas Valley Elementary and Christ the King

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Organizations Tackle Invasive Tree Species in Animas Basin near Durango

By AUSTIN COPE • 3 HOURS AGO

PROGRAM
KSJD News

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SOUTHWEST CONSERVATION CORPS

Appendix C

Examples of Landowner Agreements and Contribution Tracking Forms

Mountain Studies Institute
SAN JUAN MOUNTAINS, COLORADO

Dear Landowner,

Thank you for participating in the Russian Olive Removal Program! Your participation shows that you care about the future of the Animas River watershed and are doing your part to protect our fragile riparian ecosystems and wetlands!

As a part of this program, we have provided labor by the Southwest Conservation Corps to remove Russian olive and/or tamarisk from your property at NO COST to you! These costs were covered through grant funding by the Colorado Water Conservation Board and Colorado Parks and Wildlife. Our funders would like to hear from you!

Your Cost Share

As part of this program, we ask that each landowner contribute to the success of this program. Your cost share is a very important part of the grant funding we receive and it is imperative that we keep track of it! On the attached form, please let us know what you've contributed in actual costs or time. Please let me know if you have any questions about the form. Eligible contributions include:

Slash disposal

- Did you rent a chipper, trailer, dumpster or other equipment? Please tell us how much you spent on this.
- Did you, your HOA members, staff, or other group help with moving piles of slash or with burning? Please tell us how much time you spent.

Replanting

- Did you purchase trees to replace the Russian olives that we removed? Please tell us how much you spent on this.
- Did you, your HOA members, staff, or other group spend time planting these trees? Please tell us how much time you spent.

Monitoring

Russian olive and tamarisk can resprout several years after treatment. The methods we've employed to remove your trees have been shown to be 90-100% effective. However, we need your help to check to see if your trees start to resprout. Please let us know if you observe any re-sprouting from the base of your trees. We will not be coming back each year to check, so we are relying on you to be our *citizen scientists* and monitor the success of our program!

- We need to know if there are any resprouts for the next 5 years.
- You will be receiving an annual email or letter from us to remind you to check. Please remember to respond!

Post Office Box 426
1315 Snowden St., Suite 305
Silverton, CO 81433

info@mountainstudies.org
www.mountainstudies.org
tel 970.387.5161

Mountain Studies Institute
SAN JUAN MOUNTAINS, COLORADO

Re-treatment

If you find sprouts coming out from the trees that we've treated, please do your part to spray the re-sprouting branches with an herbicide, such as Round Up or Rodeo. A small amount of treatment can help to keep Russian olive from re-establishing in our watershed!

These contributions are important to our funders! We really need your help to document these expenditures so that we can continue to apply for grants and keep these efforts going!

Feel free to fill out the form immediately after your project is completed and email or mail it back to me, along with a signed copy of this letter at:

Mountain Studies Institute
1309 East 3rd Ave
Suite 106
Durango, CO 81301

Or **amanda@mountainstudies.org**

Then if you do more work later on, feel free to send in another copy with that additional information at a later date.

Truly thank you for your participation, and please don't hesitate to contact me if there are any questions!

Thank you for all you do!

Amanda M. Kuenzi
Community Science Director
Mountain Studies Institute

Please sign and return this letter to indicate that you agree to all of the above requests:

Edward Webb
Signature

10/24/17
Date

Edward Webb
Printed Name

Post Office Box 426
1315 Snowden St., Suite 305
Silverton, CO 81433

info@mountainstudies.org
www.mountainstudies.org
tel 970.387.5161

Mountain Studies Institute

SAN JUAN MOUNTAINS COLORADO

Cost-Sharing Document for the Russian Olive Program

Name:

Address:

Financial Contributions:

Slash Disposal (examples: equipment rental, dump fees, paying staff)

Planting (examples: cost of trees, irrigation equipment)

Retreatment (examples: cost of herbicide, hiring people to spray resprouts)

Description of Expense - brief	Dollar amount
Rent Chipper	300.00
Replace trees	3,000.00
TOTAL	3,300.00

Time Contributions:

Slash Disposal (examples: time spent hauling slash, burning piles)

Planting (examples: time spent planting trees, installing irrigation equipment)

Retreatment (examples: monitoring for re-sprouts, spraying herbicide)

* If there are multiple people working, please multiply hours by number of people

Ex: 4 people working for 2 hours = 8 hours spent

Description of Time Spent	Hours Spent
Plant trees	60
TOTAL	60

Mountain Studies Institute

SAN JUAN MOUNTAINS COLORADO

Tree Reimbursement Document for the Russian Olive Program

Name: CHRISTIAN BLACKSHEAR

Address: 5 RIVERBEND CT, DURANGO, CO 81301

Cost of Trees - Must attach copies of receipts!

			Dollar amount
1	BLUE SPRUCE	Amount:	283.19
2		Amount:	
3		Amount:	
4		Amount:	
5		Amount:	
6		Amount:	
7		Amount:	
8		Amount:	
9		Amount:	
10		Amount:	
Please add another sheet if needed			
		TOTAL COST	283.19
Your Refund = TOTAL COST * 0.5 (up to $300)		YOUR REFUND	141.60

Other Financial Contributions:

Slash Disposal (examples: equipment rental, dump fees, paying staff)

Planting (examples: cost of trees, irrigation equipment)

Retreatment (examples: cost of herbicide, hiring people to spray resprouts)

Description of Expense - brief			Dollar amount
1		Amount:	
2		Amount:	
3		Amount:	
4		Amount:	
5		Amount:	
6		Amount:	
7		Amount:	
8		Amount:	
9		Amount:	
10		Amount:	
Please add another sheet if needed			
		TOTAL	

Time Contributions:

Slash Disposal (examples: time spent hauling slash, burning piles)

Planting (examples: time spent planting trees, installing irrigation equipment)
Retreatment (examples: monitoring for re-sprouts, spraying herbicide)
* If there are multiple people working, please multiply hours by number of people
Ex: 4 people working for 2 hours = 8 hours spent

	Description of Time Spent		Hours Spent
1	REMOVING 4 RUSSIAN OLIVES	Hours:	8
2	PURCHASE, TRANSPORT TREE	Hours:	3
3	PLANT NEW TREE	Hours:	6
4		Hours:	
5		Hours:	
6		Hours:	
7		Hours:	
8		Hours:	
9		Hours:	
10		Hours:	
Please add another sheet if needed			
		TOTAL	17

5/1/2018 4:03 PM
Store: 1

Sales Receipt #15895

Durango Nursery and Supply, Inc.

271 Kay Cee Lane
Durango, Colorado 81303
970 259 8800
www.durangonursery.com

Cashier:

Description 1	Qty	Price	Ext Price
Picea pungens glauc	1	$269.96	$269.96 T
BB Evergree 7'		D% 10%Senior	
		Subtotal:	$269.96
State		4.9 % Tax	+ $13.23
		RECEIPT TOTAL:	**$283.19**

Credit Card: $283.19
Visa

Signature: _____

I agree to pay the above amount according to card

Total Sales Discounts: $30.00

Amount: $283.19, Authorization: 09738D, Reference: 1215986331, Card: Visa, Number: 1755.

Thanks for shopping with us!

Returns only accepted with original receipt and materials must be in original condition. Store credit only, no cash returns. No warranty is expressed or implied as to survivability of plant material. Please see our Terms & Conditions of Sale.

15895

Appendix D

Landowner Match and Tree Replacement Costs

Property	Name	Tree Costs	Reimbursment issued	Cash Match	In-Kind Hours	In Kind labor value	Non-labor In-Kind
Waterfall Village	Janet Wolf					$0.00	
Waterfall Village Townhom	Cheryl Rawson					$0.00	
Animosa Sub	Renae Muller	$599.90	$299.95	$125.00	11.00	$285.56	
Animosa Sub	Marilee White					$0.00	
Animosa Sub	Ed Small					$0.00	
Animosa Sub	Charlie Patterson	$568.81	$284.40	$278.00	42.00	$1,090.32	
Animosa Sub	Dan and Bonnie Nicholl			$400.00		$0.00	
Animosa Sub	Sarah and John Vines	$832.42	$300.00		14.00	$363.44	
Animosa Sub	Tom and Jennifer Wickes					$0.00	
Animosa Sub	Steve and Sandi Owen					$0.00	
Animosa Sub	John Harrington					$0.00	
Animas Valley Elementary	Ed Webb			$3,300.00	60.00	$1,557.60	
Swanson	Rebecca Thompson			$0.00	10.00	$259.60	
The Ranch	Sam Foster	$626.91	$300.00	$840.00	25.00	$649.00	
Red Rock Ranch	Jennifer Hawn	$3,150.00	$300.00	$3,550.00	60.00	$1,557.60	
James Ranch	David James	$226.00				$0.00	
Johnson Garden	Stephanie "Taffy" Johnson					$0.00	
Waterfall Ranch	Ed and Patti Zink				305.00	$7,917.80	$12,300.00
Grush	Rick Grush			$700.00	17.00	$441.32	
Patty Kroesen	Patty Kroesen			$280.00		$0.00	
Tony Whittle	Tony Whittle			$600.00	4.00	$103.84	
Paul Sugnet	Paul Sugnet					$0.00	
Stahl-Oliver	Steve Stahl			$2,851.95		$0.00	
Stahl-Oliver	Mark Oliver					$0.00	
Serzen	Betty Serzen					$0.00	
Horizon Properties	Geoffrey Schlittgen					$0.00	
Horizon Properties	Debbie Rowe					$0.00	
Ragland	Chara Ragland					$0.00	
Riverbend Ranch	David Harwood				20.00	$519.20	
Cove Cons. Easement	Randy Rowland			$112.00	36.00	$934.56	
Island Cove Trailer Park	Dan Smith					$0.00	
McGuire	Joe Bob McGuire					$0.00	
Cunningham	Joe Cunningham			$0.00		$0.00	
White	Mark White					$0.00	
Doctor	Uday Doctor					$0.00	
Dearing	Pam and Mike Dearing					$0.00	
Armstrong	Tom Armstrong			$0.00		$0.00	
Dalton Ranch Golf Course	Brandon England			$528.00	48.00	$1,246.08	
Cottonwoods HOA	Ron Smith					$0.00	
Christ the King Lutheran Ch	Beth Stelz			$235.29	12.00	$311.52	
Saltsman	Stephen Saltsman			$13.99	15.00	$389.40	
Riverbend HOA	Kent Ford				25.00	$649.00	
Riverbend HOA	Christian Blackshear	$283.19	$141.60		17.00	$441.32	
Blue Sky Ranch HOA	Diane Giersch	$1,355.84	$283.92	$2,118.73	33.00	$856.68	
Friedman List	Steve List	$179.95	$90.00	$0.00	18.00	$467.28	
Environmental Center Gard	Rachel Landis	$564.09	$282.05	$2,000.00	150.00	$3,894.00	$600.00
Colorado Timberline Acade	Dan Coey					$0.00	
Hoffman	Michael Hoffman	$496.28	$248.14	$100.00	7.50	$194.70	
Patricia Granger	Patricia Granger	$299.98	$149.99	$126.00		$0.00	
Vandenberg	George Vandenberg					$0.00	
Kroeger Ranches	John Neely			$0.00	2.50	$64.90	
Dillon Ranch	John Dillon					$0.00	
Olinger	Keith Olinger					$0.00	
Katz Property	Mark Katz					$0.00	
Rivergate	Nancy Wiley					$0.00	
Durango-Silverton Narrow Gauge Railroad	Evan Buchanan					$0.00	
TOTALS		**$9,183.37**	**$2,680.05**	**$18,158.96**	**932.00**	**$24,194.72**	**$12,900.00**
Percent of trees reimbursed			**29.18%**				