AWSA TIER-2 – NMSU PROPOSAL

Abstract: We propose a watershed restoration project that will potentially increase the water supply and contribute to meeting existing and future water demands in the region. This project will also generate critical knowledge and understanding of the hydrologic response following silvicultural treatments in the arid southwest. Increasing the water supply to meet an ever growing demand will be beneficial and useful for New Mexico stakeholders in the region; increasing knowledge, empirical evidence, and understanding of watershed processes following treatments will be invaluable for state and local managers, as well as policy makers.

Watershed management using silvicultural principles has been identified as an appropriate tool to increase water supply, protect and improve water quality, and generally improve the overall condition of the watershed. Current conifer stem densities in forests and woodlands are outside of the historic range of natural variability resulting in increased evapotranspiration losses and an increased risk for large acreage crown fire. Our proposal calls for a nested watershed approach where silvicultural prescriptions will be designed to reduce stem densities to historic levels in forests and woodlands. Nested watersheds will be instrumented to gather empirical data necessary to track potential changes in the water budget following restoration treatments. Detailed results and analysis will provide accountability and increased knowledge of hydrologic processes in arid mountainous regions.

1. [570] If the proposal would extend the water supply through conservation, or increase the supply through development of new water,

a. Describe the location and verify the ownership of and legal access to lands related to the proposal. [0 to 30 points]

In collaboration with the NM State Land Office (SLO), we have identified the Luera Mountains (NM T6S R10W; 22,290 acres) in Catron County as an ideal location for our watershed restoration project. Except for sections 31 and 33, the entire township cited is administered by the SLO. Legal access has been granted to NMSU, a beneficiary of the Trust, for collaborative project implementation (see letter of support from the SLO). The Luera Mountains range between 7,150–9,482 feet in elevation and are characterized by pinyon juniper woodlands and ponderosa pine and mixed conifer forests.

b. Identify the source of the water to be put to use. [0 to10 points]

The source of water to be put to use in our proposal is water that will be saved as a result of decreased evapotranspiration (ET) losses due to restoration treatments that reduce tree densities in forest and woodlands.

c. Describe and quantify whether and how the proposal would extend the water supply through conservation, or increase the supply through development of new water in the Southwest Planning Region. [4 points for each 10 AF up to 500 points]

Our proposal has the potential to extend the water supply through conservation efforts, specifically, the reduction in ET losses through watershed restoration (thinning). Evapotranspiration losses can negatively affect the water balance of a watershed. This phenomenon is particularly acute when dense forests and woodlands (fig 1a) are able to intercept, evaporate, and transpire large amounts of water. Forest management practices, such as thinning, are an effective tool for reducing ET losses and redistributing water flows within the system (fig 1b). Redistributed water can result in increased streamflow, soil moisture, and groundwater level all of which can promote an increased understory herbaceous response, which leads to increased infiltration and reduced erosion.

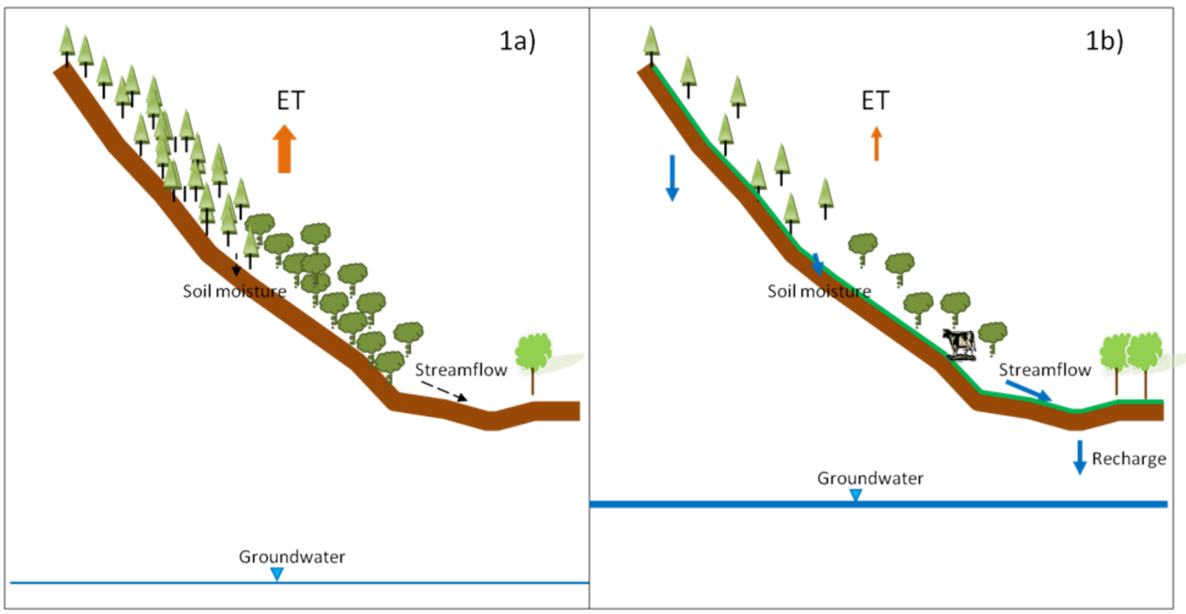

Figure 1. Conceptual model of different water budget components within the continuum of upper, lower , and riparian landscapes showing current, untreated, conditions (1a), and water flow redistribution following overstory canopy removal through thinning (1b).

Over a 10-year period, we propose to treat 1500 acres of mixed-conifer and ponderosa pine forest, and 500 acres of and pinyon-juniper woodland. Our proposed treatments have the potential to extend the water supply through conservation by reducing ET losses by 2331 ac-ft during the 10-yr duration of the project and by a total of 2968 ac-ft in year 15 (Table 1 and Table 2). It is noteworthy to mention that even though funding sought for this project is only for 10 years, the benefits of overstory reduction in ET savings, and consequently a better distribution of water flows within the watershed, are extended for several years.

Table 1. Calculations of evapotranspiration savings expressed as acre-feet following thinning in mixed-conifer forests.

Year	Acres treated/yr	Number of years following restoration treatment														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	150	59	53	49	43	39	29									
2	150		59	53	49	43	39	29								
3	150			59	53	49	43	39	29							
4	150				59	53	49	43	39	29						
5	150					59	53	49	43	39	29					
6	150						59	53	49	43	39	29				
7	150							59	53	49	43	39	29			
8	150								59	53	49	43	39	29		
9	150									59	53	49	43	39	29	
10	150										59	53	49	43	39	29
	1500	*10-yr project water savings (ac-ft)*									**2129**					
												Total water savings (ac-ft)				**2711**

Table 2. Calculations of evapotranspiration savings expressed as acre-feet following thinning in pinyon-juniper woodlands.

Year	Acres treated/yr	Number of years following restoration treatment														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	50	6	5	5	4	4	3									
2	50		6	5	5	4	4	3								
3	50			6	5	5	4	4	3							
4	50				6	5	5	4	4	3						
5	50					6	5	5	4	4	3					
6	50						6	5	5	4	4	3				
7	50							6	5	5	4	4	3			
8	50								6	5	5	4	4	3		
9	50									6	5	5	4	4	3	
10	50										6	5	5	4	4	3
	500	*10-yr project water savings (ac-ft)*									**202**					
												Total water savings (ac-ft)				**257**

Calculations are based on conservative estimates of actual ET losses for mixed-conifer and ponderosa pine (1.3 ft/yr) (Branson et al., 1981) and for pinyon-juniper (0.74 ft/yr) (Thurow and Hester, 1997) under 50% thinning and estimates of ET net savings (i.e., overstory removal – vegetation recovery & replacement). We expect decreases in ET savings in the years following treatment, which can be attributed to the establishment of understory species like forbs, grasses, and shrubs, and to a degree, tree recovery. For mixed-conifer and ponderosa pine, we theorize a 30% reduction in net ET savings in year 1, followed by a gradual decrease in the following years down to a minimum of 15% in year 6, after which ET savings are considered marginal. For pinyon-juniper, we expect a 15% reduction in net ET savings in year 1, followed by a gradual decrease in the following years down to a minimum of 7.5% in year 6.

Although upper elevation vegetation has a better potential for providing greater levels of streamflow following restoration, lower elevation pinyon-juniper sites have beneficial water redistribution impacts as well. As understory cover increases following treatment, infiltration increases slowing water residence time which promotes increased percolation, sub-surface flow, and potentially streamflow and recharge of the local aquifer.

d. Demonstrate how the proposal would meet AWSA and CUFA requirements. [up to 30 points] (see www.AWSAplanning.com for AWSA and CUFA documents)

The 2004 Arizona Water Settlements Act, Section 212(i) allows payments to be made to projects that meet a water supply demand in the Southwest Water Planning Region of New Mexico. Our proposal is a water supply alternative and therefore the Consumptive Use and Forbearance Agreement would not be invoked. Our proposal has the potential to meet a water supply demand by increasing water yield in upper (ponderosa pine/mixed conifer) and lower (pinyon-juniper) elevation watersheds following restoration treatments. Current and future water demands in the region including public, commercial, and agricultural demands all rely and benefit from water discharged from the Gila watershed. Watershed restoration treatments have been identified as an appropriate tool to increase water supply, protect and improve water quality, and generally improve the overall condition of the watershed. Specifically, current conifer stem densities in forests and woodlands in the Gila Basin are outside of the historic range of natural variability resulting in reduced water yields. Watershed restoration treatments that reduce stem densities potentially reduce evapotranspiration rates resulting in increased watershed water yield. Increased water yield from the Gila Basin will help meet the existing public, commercial, and agricultural water supply demand.

2. [40] Describe the proposal and its technical viability.

a. Include any (or reference publically-available) technical and engineering studies completed and demonstrate how these studies support the proposal. [up to 20 points]

In New Mexico, limited data is available regarding how vegetation management practices affect water supply. Several studies that have been conducted in different parts of the world and in the western U.S. address different vegetation-water interactions, however, limited data that can help quantifying the effects that vegetation management practices have in the water supply of New Mexico is available, particularly in watersheds of the Gila basin. We are proposing a project that will increase water supply through conservation and that will provide critical information regarding the effects of “thinning” on the different water budget components and their associated hydrologic processes in watersheds of the Gila basin. Proper monitoring and documentation of these water supply-vegetation removal interactions will be pursued and will be available to inform stakeholders about the pros and cons of implementing such vegetation management practices in watersheds of New Mexico.

The water budget is a simple way of understanding how much water is available, but also can be a powerful tool for better understanding vegetation-water interactions and inform decision makers. A simplified version of the water budget can be expressed by the following equation:

$$P = ET + Ro + \Delta S + G$$

Where, P is precipitation (snow and rain), ET is evapotranspiration, Ro is runoff, ΔS is change in soil water storage, and G is groundwater recharge. Correct measuring or calculating of the different water budget components is challenging, and if done incorrectly, can lead to poor management decisions.

Multiple studies have focused on monitoring runoff and soil moisture response to different levels of vegetation cover removal (Baker, 1984 and 1986; Brown et al., 1974); other studies have focused on evapotranspiration, runoff, and soil moisture relationships as a way to add information to the water budget (Thurow and Hester, 1997; Wilcox et al., 2006). However, ET calculations are often overlooked by considering an average value for the entire region (Moran et al., 1994) and in many cases the groundwater budget component is not even considered, assuming disconnected stream–aquifer relationships, or leaving the potential for aquifer recharge up for interpretation in the management implications section. As indicated by Wilcox, (2002), additional information regarding landscape-scale processes and ground-surface water interactions in semi-arid landscapes is needed. Under this context we propose a project aimed to provide accurate estimates of the different water budget components that integrates different hydrologic processes at different landscape scales.

Our paired and nested watershed project is designed to be conducted on an upper and lower elevation watershed in the Gila basin. Upper elevation watersheds are characterized by mixed conifer and ponderosa pine, while lower elevation watersheds are characterized by pinyon-juniper. Over a 10-year period, 1500 acres of mixed conifer and ponderosa pine and 500 acres in pinyon juniper will be thinned.

Monitoring the response and accounting for the different water budget components following restoration treatments will be conducted at different spatial and temporal scales. In stage 1 (years 1–4), we will monitor hydrologic process occurring at the small (~ 50 acres) and medium (~ 300 acres) scales (Figure 2). At stage 2 (years 5–10), we will continue to monitor hydrologic processes at the small and medium scales, but we will also derive information to assess potential treatment effects at the larger (> 2000 acre) scale.

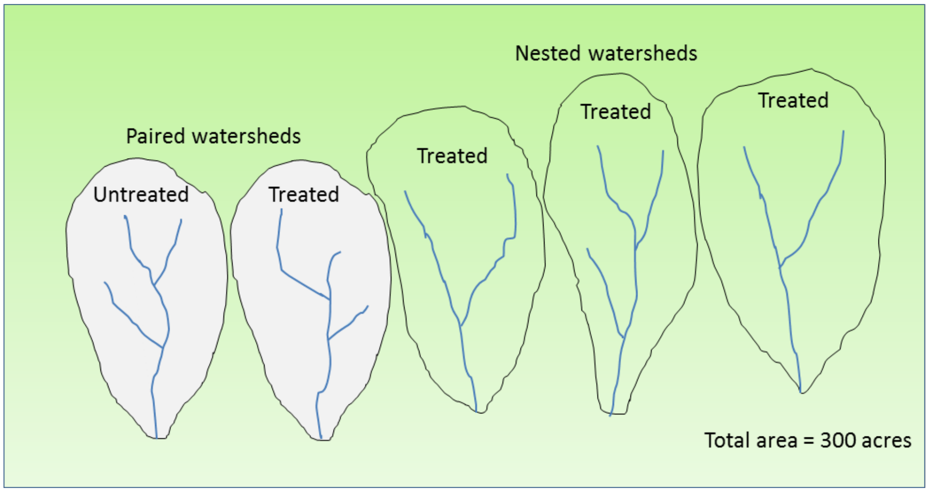

Figure 2. Conceptual diagram of the small (paired) and medium (paired + nested) watershed treatment scales proposed in this project.

In stage 1, we will monitor an area of approximately 300 acres in each landscape. This area encompasses several (5-6) smaller-sized watersheds, with at least one well defined pair of watersheds in each area. Paired and nested watershed studies provide stronger evidence of the influence of watershed management on water yield than time-trend studies because they provide a calibration period and a control watershed (Bosch and Hewlett, 1982). We will use a paired and nested watershed approach that will allow us to evaluate tree density-thinning effects on different water budget components of these two geographical areas. Under this approach, one watershed in each area will be left untreated, and will serve as the control, and the rest of the watersheds will be treated at different years throughout the first 4 years of the project to allow for baseline data to be collected. Using this combined approach will allow us to document pre- and post-treatment effects, but also will let us document management practices (thinning) effects on various water budget components at a larger spatial scale.

For the small scale, each well-defined pair of watersheds will be used to closely look at the pre-treatment and post-treatment and at the treated versus untreated effects in each landscape. These paired-watersheds will be heavily instrumented to monitor precipitation, soil water content, runoff, and different climate variables (i.e. wind speed and direction, precipitation, relative humidity). Also, we will monitor shallow groundwater level fluctuations to determine the effects of the silvicultural treatment on subsurface flow and runoff. In addition, water samples will be collected to determine water quality variations attributed to the treatment.

For the medium-scale, the rest of the watersheds in each 300 acres area also will be instrumented, but not as intensely, to capture the spatial variability of the treatment effects on the water budget. We will focus mainly in the precipitation/runoff ratio and water loss by ET, which will be determined through a combination of ground measurement and remote sensing. Ground measurements will include measurements of precipitation, runoff, sap flow, microclimate and surface fluxes of net radiation, sensible and latent heat, canopy temperature, soil/ground temperature, and soil heat. In addition, we will monitor deep groundwater level fluctuations to determine the thinning-treatment effects on the recharge of the local aquifer.

In stage 2, we will use a combination of remote sensing techniques and hydrology models to expand local results to larger spatial scales (>2000 acres). Satellite sensed data will be used to determine ET. Remotely satellite sensed ET will be verified with ground measurements of the different climate variables being monitored. We will use the Precipitation-Runoff Modeling System (PRMS) (Leavesley, 1983) to simulate hillslope runoff and we will use a systems approach to integrate different hydrologic processes occurring through the continuum of upper-elevation to lower-elevation to riparian landscapes, at the larger spatial scale.

b. Include any (or reference publicly-available) hydrologic, ecologic, or geotechnical studies completed and demonstrate how information included in these studies specifically supports or detracts from the proposal. [up to 20 points]

Watersheds are able to capture, store, and release precipitation occurring within their boundaries. This can be manipulated, to a certain extent, by implementing vegetation management practices. These practices aim to capture and retain precipitation by decreasing evapotranspiration losses, increasing soil moisture and infiltration, and reducing erosion. All these hydrologic processes promote temporary storage and delay subsurface flow.

Forested watersheds are important sources of surface water in major river systems of the southwest including the Gila River Basin (Neary et al., 2003). Several studies conducted on higher elevation forests, suggest that there is a good opportunity to increase water yield by decreasing the density of the forest. For instance, Baker (1986) reported water yield increases up to 2.5 inches, which steadily decreased to 0.7 inches in year 10 following 77% overstory removal in a ponderosa pine watershed in Arizona. Also, on a review of multiple studies related to vegetation changes on water yield and evapotranspiration Bosch and Hewlett (1982) concluded that pine forest types can have an average 40 mm change in water yield for each 10% change in cover. Hibbert (1983) indicated that a good potential for increasing streamflow can be expected in areas where annual precipitation exceeds 18 inches. A report presented by Rich and Gottfried (1976) that summarizes different treatments applied to mixed-conifer at Workman Creek in Arizona show increases in water yield ranging from 13% to 34% following treatment.

Thinning of lower elevation pinyon-juniper woodlands may provide multiple benefits associated with the redistribution of the water budget components within the watershed. For instance, studies conducted by Thurow and Hester (1997) indicate that groundwater recharge will occur following juniper removal. In addition, Allen (2008) indicated that restoration treatment, thinning and application of slash mulch, in P-J woodlands in the Jemez Mountains resulted in increases of herbaceous cover, stabilizing of soils, and supporting of surface fire. Treatment of pinyon-juniper woodlands for increasing water yield is more questionable, in the sense that not that many studies have been able to prove a clear relationship between overstory removal and increases in streamflow.

According to Ffolliot and Stropki (2008) pinyon-juniper woodlands are not considered high water-yielding sources mainly because of the low precipitation and the high evapotranspiration losses associated with these landscapes. In addition, Ffolliot and Stropki (2008) indicated that in areas with precipitation of 18 inches or less infiltration water will not penetrate far enough into the soil as to influence soil water storage. However, a study conducted by Baker (1984) reported annual streamflow increases of up to 157% following pinyon-juniper mortality in an Arizona woodland watershed following herbicide treatment. Also, Wilcox (2002) indicated that there is a good potential for juniper rangelands to increase streamflow or groundwater recharge. This potential is based on high interception rates associated to juniper extensive canopy cover and to shallow soils and permeable material (conducive to subsurface flow) commonly found on juniper dominated woodlands. Also, studies by Deboodt et al. (2008) showed increases in spring flow following treatment. The study conducted by Deboodt et al. (2008) showed late spring flow increases of up to 225%, an increase in the number of days of recorded groundwater, and an increase of late season soil moisture following juniper reduction in a watershed in Oregon with 13 inches of annual precipitation. This 13 inches level of precipitation is similar to what is commonly observed (12-16 inches) in P-J landscapes of New Mexico.

3. [40] Quantify estimated costs.

The primary goal of our 10-year proposal is to increase the water supply by implementing watershed restoration treatments. Our secondary and complementary goal is to document, quantify, and explain this potential chance in the water budget with empirical data. Both ventures require significant expenditure of time and financial resources to be successful. Please see attached budget spreadsheet for greater detail.

a. *Quantify the proposal's estimated costs, including planning, design, and/or construction, and administration or oversight. [up to 10 points]*

Planning, design, administration and oversight costs for our primary goal (i.e., implementation of restoration treatments) will be borne largely via cost sharing between the NM State Land Office and NM State Forestry. For the past two years, State Forestry and the State Land Office (and others) have been collaborating in the Luera Mountains to implement forest and woodland restoration treatments. Currently, both of these agencies are seeking additional restoration treatment dollars for the continuation of this project (e.g., forestry grants, severance tax funds, etc.). If successful funding is secured, NMSU will collaborate with these two agencies to plan, design, and administer the restoration thinning contract.

Planning, design, and administration for our secondary goal (quantification of changes in the water budget) will be borne by NMSU. Supplemental salary dollars are requested for two NMSU principal investigators to meet these needs over a 10-year period ($207,094). The standard NMSU indirect cost recovery rate of 42.4% has been reduced to 15% ($165,942). The balance (27.4%) will be cost shared by NMSU ($303,121).

b. *If applicable, quantify the proposed project's on-going administrative, operational, and maintenance costs. [up to 10 points]*

Ten year on-going operational costs for our primary goal are represented by restoration treatment dollars ($875,000). A contractor will be hired for the forest restoration component of this project. A target of 150 acres/year of mixed conifer and ponderosa pine forest restoration will be pursued during years 1–10 at an average cost of $500/acre ($750,000). A target of 50 acres/year of pinyon-juniper woodland restoration will be pursued during years 1–10 at an average cost of $250/ac (total $125,000). The NM State Land Office will oversee and administer this contract with assistance from NM State Forestry and NMSU.

Ten year operational costs for our secondary goal include expertise in hydrology and ecology for 10 years (with reduced time investment after year 6)($207,094), and in evapotranspiration for 2 years ($17,198). A hydrology technician will dedicate 50% of position time in years 1–6 and 25% of position time in years 7–10 to project activities including field and laboratory work. A GIS technician will dedicate 25% of position time for years 1–6 to project activities focusing on map creation and GIS analysis ($184,368). Four laborers will assist in different activities of the project including field work, laboratory analysis, data analysis, and report preparation. Two laborers will be funded years 1 & 2, and 2 laborers will be funded years 3–6 ($176,000). Fringe benefits for professionals (32%), technicians (32%), and laborers (1%) for 10 years will cost $105,609. Four deep wells at a cost of $10,000 each will be required to track changes to groundwater.

c. *Describe environmental compliance activities, and quantify the costs for environmental mitigation and restoration related to the proposal. [up to 10 points]*

As standard operating procedure, environmental compliance activities on State Lands will be conducted prior to project implementation by resource professionals. These costs will be borne by the State Land Office. Compliance activities include field surveys to assess threatened and endangered species, forage and timber resources, cultural sites, wildlife habitat, soils, and hydrology. The need for environmental mitigation is not anticipated in relation to watershed restoration treatments. However, if mitigation actions are required we have intentionally budgeted the cost of treatment acres on an average per acre basis. This allows for flexibility should unforeseen circumstances arise such as emergency environmental mitigation.

d. *Quantify the AWSA funding sought for the proposal and for the pendency of the proposed activity's or project's duration. [up to 10 points]*

Additional costs not quantified above include travel, equipment and supplies. Travel costs include mileage reimbursement at $0.555/mile and per diem at $123/day. Each year 1–4 will require 15 round trips @ 460 miles from Las Cruces to the project site (6900 miles @ $0.555 = $3830). Each year 5–10 will require 8 round trips @ 460 miles from Las Cruces to the project site (3680 MILES @ $0.555 = $2042). Each year 1–4 will require 3 people to spend 60 nights in Socorro (180 nights @ $123 = $22,140). Each year 5–10 will require 2 people to spend 30 nights in Socorro (60 nights @ $123 = $7380). Total travel and per diem for 10 years = $160,412 [($3830 + 22,140) X 4 years = $103,880; ($2042 + 7380) X 6 years = $56,532].

Funds required for equipment and expendable materials needed for field work and laboratory analysis are detailed below (10-year totals).

- Weather Station (4) @ $7,000 each; for monitoring weather parameters
- Sap flow system (4) @ $5,000 each; for determining tree transpiration
- Flume w/ sensor (10) @ $1,500 each; for measuring runoff
- Data loggers (20) @ $1400 each; for field data collection
- Soil moisture probe (192) @ $250 each; for determining soil water content
- Piezometers w/ senor (7) @ $800 each; for monitoring shallow groundwater level
- Automated rain gauges (14) @ $500 each; for collecting rainfall data
- Infrared temperature sensor (4) @ $2000; for estimating evapotranspiration
- Rainfall simulator (4) @ $ 500 each; for determining rainfall-runoff interactions
- Field laptop (4) @ $1500 each; for field data collection and analysis
- Equipment support ($8000); for powering and connecting data loggers
- Remote sensing images & processing ($15,000); for evapotranspiration calculations
- Software ($3000); for field data acquisition equipment, GIS, modeling, and renewal)
- Office supplies ($5,500); for paper, notebooks, etc.
- Field supplies ($15,500); for clinometer, DBH tape, GPS, tree paint, etc.
- Equipment maintenance ($19,000); for replacement parts, hardware, etc.
- Educational costs ($5,000); for publication expenditures, outreach material, and Extension workshops.

Our 10-year proposal budget is $2,170,223.

4. [40] If proposal impacts, beneficially or adversely, the environment of the Southwest Planning Region, the Gila River, its tributaries or associated riparian corridors, use the best available science to:

a. Describe and quantify how the proposal might impact the project site and environment, particularly state and federally-listed species. [up to 10 points]

Before restoration treatments are implemented on the ground, cultural and biological surveys will be conducted to identify resources and minimize potential impacts to state and federally-listed species, wildlife habitat, soils, and cultural sites. Our proposal may have short term impacts on the treatment site environment, but long term ecological benefits on treated watersheds. Short term impacts may occur at the project site during implementation of restoration treatments. Short term impacts may include soil disturbance due to thinning, and sedimentation following precipitation events. We do not predict any long term negative environmental impacts. Long term ecological effects will occur incrementally as understory and overstory vegetation responds to increased light, nutrients, and water. Long term ecological effects are predicted to be beneficial and will serve the broader goal of restoring ecosystem processes to historic conditions. Examples include enhanced ecosystem services such as production of clean air and water. Wildlife habitat including that occupied by threatened and endangered species will benefit from restoration treatments and restored ecosystem processes.

b. Describe and quantify the proposal's efforts to mitigate possible adverse impacts on the environment, particularly riparian areas and state and federally-listed species in the Gila Basin and at the specific location of the proposal. [up to 10 points]

Short term impacts due to forest thinning operations will be mitigated by implementing 'best management practices' specifically designed to mitigate any negative impacts at the treatment site as well as adjacent riparian areas. Short term impacts could include soil disturbance following thinning, and sedimentation following high intensity precipitation events. Best management practices are the most effective and practical means of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals. The New Mexico State Forestry Division has published an extensive handbook on best management practices which includes explicit implementation details recommend to be used on any forest treatment project including those in riparian areas. The handbook is titled "New Mexico Forest Practices Guidelines" and can be found at the following web site (http://www.emnrd.state.nm.us/fd/). Specific best management practices aimed at reducing impacts to riparian areas include creating buffer zones and streamside management areas where no thinning may occur within 50 feet of the high water mark, no landing zones or roads may be created, and skid trails must be minimized to reduce impacts.

Following best management practices, Cram et al. (2007) reported that light to moderate disturbance following mechanical harvesting operations resulted in insignificant differences in sediment concentration as compared to untreated sites following rainfall simulations (i.e., 0.22 vs. 0.20 g/L). Moreover, it should be noted that using an erosion prediction model the USDA Forest Service (2005) found sedimentation following wildland fire to be 70 times greater as compared to a thinning treatments comparable to our proposal prescription. The model predicted a wildfire on an intermediate slope would yield 9.5 MT/ha of sediment. This was 353 times greater than the highest sediment yield reported by Cram et al (2007) following mechanical treatments. Restoration treatments will reduce the risk for high severity crown fire (Cram 2006).

c. Describe and quantify how the proposal may benefit the environment, particularly riparian areas and state and federally-listed species in the Gila Basin and at the specific location of the proposal. [up to 10 points]

Our proposal has the potential to increase the water supply through conservation efforts. Following restoration treatments our proposal will benefit treated watersheds including riparian areas by restoring ecosystem processes such as fire regimes, hydrologic cycles, understory diversity and production cycles, and wildlife population dynamics. Current fire regimes in particular are outside of their historic range. Low-frequency, high-intensity crown fires have replaced high-frequency, low-intensity fire regimes in southwestern forests. High-intensity crown fires can severely disrupt these forest ecosystems. Following high-intensity crown fires, timber resources are damaged or destroyed; wildlife habitat is altered or destroyed; nutrient stores are depleted; soil hydrology is altered; and duff, litter, and vegetation layers are removed exposing soil to rapid erosion events which in turn overwhelm riparian areas, streams, and rivers. Treated watersheds will be able to capture, store, and release precipitation occurring within their boundaries. By capturing precipitation these watersheds will increase soil moisture and infiltration which in turn promotes temporary storage and delays subsurface flows. By increasing water capacity within the watershed and reducing the threat of crown fire these sites will benefit wildlife habitat.

d. List any environmental statutes, rules, or regulations that may apply to the proposal, and demonstrate how the proposal implementation will comply with such laws, rules or regulations. [up to 10 points]

Our proposal is designed to be conducted entirely on NM State Trust Lands. All significant actions including forest and woodland restoration treatments must be compliant with state laws and regulations. State Land Office resource personnel will consider all existing environmental statues, rules, and regulations that are applicable to state lands at the treatment site including the Commercial Timber Harvesting Requirements (NMAC 19.20.4). Proactive resources surveys will be conducted prior to treatment implementation and are specifically designed to mitigate any potential negative environmental impacts to state lands. This process considers an exhaustive list of potential environmental impacts to water quality, wildlife species and their habitats, soils, vegetation including sensitive species, and even archeological sites. Environmental clearance costs will be borne by the NM State Land Office and NM State Forestry.

5. [70] Describe any economic or cost analysis information and data for the proposal:

a. Quantify estimated economic benefits including environmental, recreation, value of water itself, value of the water to the regional economy, increased economic growth, protection against loss of jobs, agriculture, ranching, local economic sustainability or growth, or other. [up to 10 points]

Although our proposal is designed to produce ecological benefits following restoration treatments, numerous economic benefits are borne out of ecological benefits. For example, it can be argued that ecosystem services that are enhanced following restoration treatments have economic environmental values (although quantifying of these benefits directly into dollars is challenging; i.e., the cost avoided by restoring a watershed vs. building a water treatment facility). Specific ecosystem services that may be enhanced by our proposal that have environmental value include production of clean air and water, fiber and forage, and wildlife habitat.

Similar to ecosystem services, valuing the water itself that our proposal intends to increase is challenging and would be depend on whether or not a water right was possessed (water in NM is based on the rule of prior appropriation). However, in the case of the Luera Mountains, lessees with grazing permits also have water rights for their livestock. As such, improving the ability of the watershed to capture and hold water would promote stability for these permittees and thereby promote increased or sustained ranch value.

Water is a limited resource in the arid southwest and therefore its value will only increase with growth and increased demand. Increasing the water supply through restoration treatments may mitigate or dampen this growing tension. Economic development in the region will be dependent upon increased water supplies and who has the water right to this increase.

Rural employment opportunities will be made available as a result of the watershed thinning contract. The 10-year nature of the project will provide a reoccurring opportunity for income generation as well as skill development. Rural employment opportunities also support local and regional agricultural and ranching families seeking to diversify their incomes.

b. Quantify estimated costs including planning, design, and/or construction, environmental compliance, operation, maintenance, repair, and administrative costs or other. [10]

Please see question 3 for quantified project costs associated with planning, design, environmental compliance, operation, and administration. Maintenance and repair costs for our field equipment over the course of 10 years will be managed by our field technician. Although this is an inevitable component of field work, it is efficient to promote institutional knowledge in the technician position. As such we have budgeted 10 years of salary ($133,903) for a field technician to insure this need is addressed.

c. Identify the source of local contributions and demonstrate the commitment and ability to pay any local cost-share for project proposal, including any applicable exchange costs [1 point for every % of project cost to be borne by local sponsor up to 50 points]

Local contributions for this project include collaborative partnerships with the NM State Land Office and NM State Forestry. Strong letters of support from these two agencies demonstrate their level of commitment. It should be noted, due to policy circumstances, we are not officially claiming the considerable cost share contributions these two institutions are providing to this project in the way of planning, design, and administrative oversight.

Additional local contributors with expertise to contribute to the project include the Water Resources Research Institute and Dr. A. Salim Bawazir from the Civil Engineering Department at NMSU. Dr. Bawazir has expertise in instrumentation used to calculate evapotranspiration. Attached letters of support demonstrate their level of commitment.

The administration at NMSU has agreed to reduce the indirect cost recovery rate from 42.4% to 15%. In addition, an allowance has been made to cost share the balance (27.4% or $303,121). NMSU’s costs share of $303,121 is 14% of the total budget.

6. [120] Describe how the proposal addresses the needs of a particular group or groups or interests on the issues of

a. *Historic uses, traditions, cultures, and customs. [up to 10 points]*

Current watershed conditions characterized by overstocked forests and woodlands are susceptible to crown fire as well as insect and disease epidemics. Following severe disturbance events, historical uses such as livestock grazing, traditions and customs such as hunting, and cultural practices are either precluded from occurring or are minimized due to degraded resource conditions. Watershed restoration treatments reduce the likelihood these natural disturbances events grow to proportions outside of their natural range of variability.

b. *Current and future demands for water in the Southwest Planning Region. [up to 20 points]*

Demands for water in the arid Southwest have been a fact of life for as long people and communities have inhabited the region. In fact, many of the historical demands for water such as public consumption, commercial (industrial, mining, and power), and agriculture will continue to represent the water demands of the future. The intensity of this demand will depend on factors such as population growth and climate variability. Our proposal is cognizant of these multiple water demands and the ever present need for increased water supply. Moreover, our proposal recognizes that the traditions, cultures, and customs of this region are largely dependent on the surrounding natural resources. Sound management of these natural resources is paramount for their survival, and can be best achieved with increased knowledge of ecosystem function. Comprehensive watershed management can lead to enhancement of surface recharge, aquifer storage, and recovery of Gila River flows as outlined in the Southwest New Mexico Regional Water Plan (NMOSE 2011).

c. *Flood control.[up to 20 points]*

Watersheds in forested landscapes are vital for flood and erosion control. Forest watersheds in the southwest that are resistant to flooding as well as fire, drought, insect and disease outbreaks are characterized by relatively low timber stocking rates and vigorous understories. Restoration treatments that reduce stocking densities promote increased herbaceous understories which in turn promotes increased water infiltration, percolation, and soil stability. Restored upland watersheds also support important adjacent riparian areas. Restored riparian areas are able to serve numerous important ecological functions such as filtering sediments and pollutants, slowing the velocity of water during high flow events, maintaining the stability of stream banks and reducing erosion, and providing valuable habitat for wildlife.

d. *Fire protection, prevention, or suppression. [up to 20 points]*

Fire suppression and exclusion policies in western forests have created unique ecological conditions and management challenges as a result of increased conifer densities from pinyon-juniper woodlands to mixed conifer forests. Evidence of impaired watersheds in terms of erosion and sedimentation immediately following extreme wildfire events are evident throughout the West. Natural resource managers are increasingly concerned with minimizing the risk of large-scale crown fires in these systems. Research results suggest fuel reduction followed by frequent prescribed fire is well suited as a management tool to restore and sustain entire watersheds and their ecological functions, particularly in pine-grassland forests. Anywhere the fire has to drop to the surface is an area where trees can survive. As a general rule one can expect an inverse relationship between the degree of fuel reduction and the likelihood of crown fire.

e. *Recreation. [up to 20 points]*

Recreational opportunities in functioning ecosystems are more likely to be accessible and enjoyable as compared unhealthy systems. For example, fishing, hunting, hiking, camping, and off road use on National Forests are generally available to the public (with the appropriate permit in some cases). However, following crown fire National Forest policy dictates that hazard areas and areas of critical environmental concern be closed to the public until conditions are deemed safe or acceptable. This closure significantly restricts public use for recreational opportunities. Our proposal calls for restoration treatments that will ultimately result in watersheds that are resilient to severe wildland fire and therefore less likelihood to be closed to recreational opportunities following fire.

f. *Environmental protection and/or enhancement. [up to 20 points]*

Environmental surveys will be conducted to ensure the proposed site is appropriate for restoration treatments. Resource surveys minimize potential impacts to state and federally-listed species, wildlife habitat, soils, and cultural sites. Pending the findings of the surveys, specific silvicultural prescriptions for forests and woodlands will be developed in close coordination with the State Land Office and Sate Forestry based on sound science. On-site monitoring will be implemented during silvicultural operations to insure implementation plans and goals are being achieved. Environmental enhancements such as the production of clean air and water are expected benefits following restoration treatments.

g. *Any others. [up to 10 points]*

7. [40] List those supporting the application, including federal, state, and local government entities; Indian nations, tribes or pueblos; irrigation or conservation districts; non-profit organizations; and other entities. Provide letters or resolutions of support for the application. [up to 40 points]

Collaborators and supporters of this project include:

- New Mexico State Land Office
- New Mexico State Forestry
- Water Resources Research Institute
- Dr. A. Salim Bawazir, Civil Engineering, NMSU
- Livestock permittees within the Luera Mountains

8. [30] Describe whether the proposal would benefit one or more than one of the counties in the Southwest New Mexico Planning Region – Catron, Grant, Hidalgo, and/or Luna Counties. [10 points/county up to 40 points]

Although our project site is located in Catron County, residents in Grant and Hidalgo County who have depended upon their forests for centuries will also benefit. New Mexico’s forests represent the ecological and economic 'epicenters' upon which much of the state depends for many products and resources including, but not limited to water (both quantity and quality), forest products, forage for livestock, game and non-game wildlife, and, increasingly, recreation. However, the ability of New Mexico's forests to serve many ecological functions and provide the values listed above has been compromised throughout the last century due to dramatic increases in small-diameter woody biomass. Opportunities to restore degraded watersheds will benefit the residents of these western counties ecologically and economically. Specific knowledge of how forest thinning treatments affect water budgets will be of further benefit to landowners and natural resources managers in these counties.

9. [50] Describe whether the proposal would support economic growth or benefit one or more than one of the following interests in the Southwest New Mexico Planning Region – agricultural, ranching, municipal, recreational, or other (specify). [10 points/interest up to 50 points]

Many western forests are currently in degraded ecological condition due to densities of woody material far exceeding their historic range of variability. Concurrently, many small rural communities throughout the West including those in Catron, Grant, and Hidalgo Counties have suffered severe setbacks in their local economies due to a reduction in the procurement of renewable resources from forests. Within the scientific community there is a general recognition that mechanical treatment or removal can improve watershed function, reduce the threat of severe wildland fire behavior, improve watershed conditions, permit re-introduction of prescribed fire, improve understory diversity and productivity, improve timber productivity, and improve foraging habitat for both wild and domestic ungulates. All these improvements benefit agricultural, ranching, recreation, and municipal interests.

Restoration of Southwestern forests and rural economic development is an objective of this proposal. Currently, young people from these communities have few if any economic opportunities to remain in the community. The advent of forest restoration jobs will help create new opportunities for our young adults who usually have to leave the region to find long-term employment. In this proposal, we plan to address this issue by strengthening the restoration infrastructure by treating degraded watersheds with local manpower and knowledge. Rebuilding an appropriately scaled infrastructure is essential for watershed restoration to succeed in rural NM.

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