Climate Change Vulnerability Assessment EXECUTIVE SUMMARY

USDA Forest Service – Southwestern Region – Rocky Mountain Research Station

Introduction and background: Land managers need to assess ongoing and potential effects of climate change, and coordinate a response for ecosystems, species, and human communities. RMRS, TNC, ILAP, and others have developed assessments, tools, and methods for evaluating vulnerability for key ecological components. The climate change vulnerability assessment (CCVA) project complements much of this work with the development of an ecosystem-based assessment of adequate spatial and thematic detail to support local decisions. CCVA also satisfies some agency Climate Change Score Card requirements. CCVA has resulted in an all-lands vulnerability assessment for major upland ecosystems of the Southwest (Arizona and New Mexico). Based on the anticipated effects by climate change on site potential, individual plant communities are assessed and scored as limited, moderate, high, and very high, according to the degree by which climate envelopes are exceeded with future climate projections.

The CCVA represents the second stage of a coordinated effort with the Albuquerque Lab of RMRS to address climate change in the region. The first stage was a literature review and synthesis of previous climate change assessments, with an emphasis on the Southwest. CCVA was originally envisioned in 2010 and has since evolved over a sequence of steps including the formulation of a project team, vetting to the Regional Climate Change Coordinator and Regional Office staff, and presentation as a research proposal to an academic committee at UNM. Eventually the project was accepted for funding as a Regional Leadership Team Commitment, and also awarded WWETAC funding through RMRS. In late 2011 a one-day scoping session was convened with peers and scientists to further validate the project. A spatial analyst detail position was created to facilitate most of the considerable operations phase. RSAC, UNM, and the RMRS Moscow Lab have also provided essential in-kind support.



Process overview: The Climate Change Vulnerability Assessment (CCVA) takes an ecosystems approach to predicting vulnerability resulting from projected climate change. This assessment provides a measure of vulnerability for each reporting area, and for each major upland ecosystem within the reporting area, to anticipated climate change. Vulnerability is reported for all 6th-code watersheds of Arizona and New Mexico, and for other reporting areas as requested (e.g., National Forests).

In order to adequately predict vulnerability, the landscape is first stratified into recognizable contemporary ecosystems, or Ecological Response Units (ERUs) that repeat across the landscape. Then, base level polygons (segments) were generated for the entire analysis area by the Remote Sensing Application Center (RSAC). Each landscape segment represents similar site potential at the scale of individual plant communities, and was attributed with biophysical variables, contemporary climate variables, and projected future climate variables. Climate envelopes were then developed for each ERU using contemporary climate data, according to the most discriminating climate variables. Finally, each segment was assigned a vulnerability score based on the projected departure in future climate from the current climate envelope of the given ERU. Departure scores are then averaged together across the report unit, and by each major ERU within the reporting unit.

Ecosystem framework: To best evaluate climate impacts on plant communities, it is first necessary to stratify the landscape into recognizable and repeating ecosystem units. For this analysis, ecosystems are represented by Ecological Response Units (ERUs) that represent common site potential and natural disturbance regimes. In this framework, individual plant communities are an expression of site potential (abiotic factors), climate, and disturbance regime. While most abiotic components of a given ecosystem are relatively static, changes in climate have the potential to drive system vulnerability and potentially shift ecosystems on the landscape. The primary underpinning for this stratification of Forest System lands is the Terrestrial Ecosystem Unit Inventory (TEUI)(USDA Forest Service 1986). Individual TEUI map units were cross-walked into appropriate ERUs. Non-Forest System Lands were assigned ERUs based on mapping conducted by the Integrated Lands Assessment Project (ILAP 2011), Natural Heritage New Mexico, and the University of Arizona. Finally, Riparian ERUs were assigned using the r3 Regional Riparian Mapping Project (RMAP) data (Triepke et al. 2012). A total of 31 ERUs, and approximately 16 subclasses, have been identified for uplands of the (Table 3).

Climate models & downscaling: Downscaled climate data for both contemporary and future projections were obtained from the RMRS Moscow Lab (available online). Data obtained include downscaled data from multiple Global Circulation Models and Emission Scenarios that are fitted to thin plate splines to create contiguous climate surfaces for the Southwestern Region. The reader is referred to Rehfeldt (2006) and Rehfeldt et al. (2012) for detailed discussion of spline models and their application to contemporary and projected climate data. For this analysis, overall vulnerability was scored using data derived from the CGCM3 GCM for the 2090 projection using the A1B emission scenario.

Vulnerability reporting: This assessment categorizes climate change vulnerability based on individual plant communities and the projected difference between contemporary climate envelopes and projected climate conditions. Four categories of vulnerability are reported, and category boundaries are defined by departure from climate envelope mean and envelope edge. Climate envelopes were developed independently for each discriminating variable, and are considered to be +/- 2 standard deviations of the sample mean.

Variable	Variable Description:	Standardized Coefficients – Weighted Average	Explanatory Proportion
D100ind	Julian date the sum of degree-days >5 degrees C reaches 100 (re-indexed to energy setting)	1.193	26%
DD5ind	Degree-days >5 degrees C (re-indexed to energy setting)	1.169	25%
SMRMSTIND	Summer moisture index (degree-days >5 degrees C accumulating within the frost-free period divided by growing season precipitation)	1.015	22%
WAHLIND	Wahlberg index (mean annual temperature divided by mean annual precipitation)	0.658	14%
MTWMind	Mean temperature in the warmest month (re-indexed to energy setting)	0.638	14%

Table 1. CCVA Climate Variables:

Climate variables were selected based on their discriminatory power in discerning ERUs and their potential applicability to vulnerability assessment. In total, five variables were selected, and are described in Table 1. Additionally, temperature derived variables were reindexed for each segment based on a common energy setting value.

Variables were scored individually and all positive values (i.e. those values outside their envelopes) were weighted by standardized coefficients and then summed. Negative values are considered "0" so as to not compensate for other departed values. The result is a single vulnerability score for each CCVA segment which is, in turn, placed into one of four vulnerability categories (Limited Vulnerability, Moderate Vulnerability, High Vulnerability, or Very High Vulnerability) described in Table 2.

1	
Category	Note:
Limited Vulnerability:	These values are within 2 standard deviations of the envelope mean and are considered within their climate envelopes.
Moderate Vulnerability:	This represents values equivalent to all variables being 2<3 standard deviations from the envelope mean.
High Vulnerability:	This represents values equivalent to all variables being 3<4 standard deviations from the envelope mean.
Very High Vulnerability:	This represents values equivalent to all variables being >4 standard deviations from the envelope mean.

Table 2. Vulnerability Categories

Uncertainty reporting: Future climate projections based on different Global Circulation Models (GCMs) provide somewhat different values. As a result, there can be some uncertainty associated with a given vulnerability call for some ERUs in some areas. To address this concern, the CCVA provides a measure of uncertainty, which represents the degree of disagreement between different GCMs, within a given emission scenario. Three GCMs were used to assess uncertainty (CGCM3_A2, HADCM3_A2, & GFDLCM21_A2). Uncertainty is reported using a simple agreement process and categories. This process was run at the individual segment scale, and then aggregated up to watersheds as proportional values. The level of agreement is given by the following rule set:

- If all three GCMs produce the same vulnerability category then uncertainty is "Low"
- Otherwise if two of the GCMs produce the same vulnerability category, then uncertainty is "Moderate"
- When all three GCMs differ on vulnerability then uncertainty is "High"

Ecological Response Unit	ERU Subclass	ERU Code	System Type
		SFF	forest
Spruce-Fir Forest	Spruce-Fir - Lower	SFM	forest
	Spruce-Fir - Upper	SFP	forest
Bristlecone Pine		BP	forest
Mixed Conifer w/ Aspen		MCW	forest
Mixed Conifer – Frequent Fire		MCD	forest
		PPF	forest
Ponderosa Pine Forest	Ponderosa Pine/Bunchgrass	PPG	forest
	Ponderosa Pine/Gambel Oak	PPO	forest
Ponderosa Pine – Evergreen Oak		PPE	forest
PJ Sagebrush		PJS	woodland
PJ Evergreen Shrub		PJC	woodland
		PJO	woodland
PJ Woodland	PJ Woodland – Cold	PJOc	woodland
	PJ Woodland – Mild	PJOm	woodland
		PJG	woodland
BI Grass	PJ Grass – Cold Temp	PJGc	woodland
PJ Glass	PJ Grass – High-Sun Precip, Mild	PJGmHS	woodland
	PJ Grass – Low-Sun Precip, Mild	PJGmLS	woodland
			woodland
	Juniper Grass – Cold	JUGc	woodland
Juniper Grass	Juniper Grass – High-Sun Precip, Mild	JUGmHS	woodland
	Juniper Grass – Low-Sun Precip, Mild	JUGmLS	woodland
Madrean Encinal Woodland		MEW	woodland
Madrean Pine-Oak Woodland	MPO	woodland	
Montane / Subalpine Grassland	MSG	grassland	
Colorado Plateau / Great Basin Grassland	CPGB	grassland	
	High-Sun Precip	SDGhs	grassland
	Low-Sun Precip	SDGIs	grassland
	Piedmont Grassland	PFG	grassland
Semi-Desert Grassland	Foothill Grassland	FHG	grassland
	Semi-Desert Lowland Grassland (AKA Chihuahuan Semi-Desert Grassland)	SDLG	grassland
	Sandy Plains Grassland (AKA Chihuahuan Sandy Plains Grassland)	SPG	grassland
Alpine and Tundra		ALP	shrubland / mixed
Mountain Mahogany Mixed Shrubland		MMS	shrubland
Gambel Oak Shrubland		GAMB	shrubland
Sagebrush Shrubland		SAGE	shrubland
Interior Chaparral		IC	shrubland
Sand Sheet Shrubland		SSHR	shrubland
Intermountain Salt Scrub		ISS	shrubland
Sonora-Mojave Mixed Salt Desert Scrub		SDS	shrubland
Chihuahuan Salt Desert Scrub		CSDS	shrubland
Chihuahuan Desert Scrub		CDS	shrubland
Mojave-Sonoran Desert Scrub		MSDS	shrubland
Sandsage		SAND	shrubland
Shinnery Oak (Black Kettle NG)		SHIN	Great Plains
Mixed-Grass Prairie		MGP	Great Plains
Shortgrass Prairie		SGP	Great Plains

Table 3. Ecological Response Units for major upland ecosystems of the Southwest.

Next steps:

- Validation In the coming year CCVA results will be compared against the occurrence of uncharacteristic disturbance (stand replacement fire, bark beetles) since 1990, when human emissions-forced climate change became pronounced, to test the hypothetical relationship between vulnerability and uncharacteristic disturbance.
- Science reference In the coming months Jack and Max will publish a science reference that can be cited, and included with the standard set of CCVA deliverables. The reference will partially fulfill requirements of Jack's graduate program.
- Future ERU distribution As time allows analysis will be conducted to project the future distribution of ERUs (year 2090), including with no-analog plant communities.

REFERENCES

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Climate Change Vulnerability Assessment Carson National Forest – December 2014

The Climate Change Vulnerability Assessment (CCVA) reflects an ecosystems approach to ecosystem vulnerability resulting from projected climate change. This summary provides tabular summaries of the assessment for each major upland Ecological Response Unit (ERU) of the Carson NF. An overview of the project is provided in the accompanying CCVA executive summary (USDA Forest Service 2013).

Figure 1. Patterns of climate change vulnerability on the Carson NF and surrounding lands of north central New Mexico according to the CCVA. The Carson NF is represented by lands within the dark green borders, subdivided by local scale analysis units used in Forest Plan revision.



USDA Forest Service. 2013. Climate change vulnerability assessment – Executive summary. Southwestern Region and Rocky Mountain Research Station briefing paper, on file. Regional Office, Albuquerque NM. 4 pp.

Ecological Response Units of the Carson National Forest

A total of eight major Ecological Response Units (ERUs) were identified for the Carson NF, with two additional minor ERUs. All of these ERUs occur on non-USFS lands in the greater context area of the Carson. Table 1 lists the ERUs of the Carson NF and their relative contribution to the reporting area.

Ecological Response Unit	ERU Code	Percent of Carson NF	Acres	Rank
Alpine	ALP	0.6%	9,996	Minor
Bristlecone Pine	BP	0.3%	4,585	Minor
Montane / Subalpine Grassland	MSG	7.9%	125,351	Major
Spruce-Fir Forest	SFF	18.3%	289,929	Major
Mixed Conifer w/ Aspen	MCW	8.3%	130,959	Major
Mixed Conifer – Frequent Fire	MCD	11.5%	182,847	Major
Ponderosa Pine Forest	PPF	19.7%	312,900	Major
PJ Sagebrush	PJS	13.7%	217,326	Major
PJ Woodland (persistent)	PJO	11.2%	178,196	Major
Sage	SAGE	3.7%	59,144	Major

Table 1. Ecological Response Units of the Carson NF.

Reporting Units

This assessment provides three scales of reporting for vulnerability:

- Plan Unit Scale Includes all land within the administrative boundary of the Carson NF
- Local scale (geographic areas) Includes all lands within the administrative boundaries of the Carson local scale units.
- Subwatershed (6th-code HUCs) Includes all lands within 6th-code watersheds that intersect the Carson NF

Summary of Tabular Reporting

Reporting at each of the three scales provides useful insights for interpretation of climate change vulnerability results for the reporting area. In the tables to follow, vulnerability and uncertainty are reported for each scale and for all ecosystems collectively. In all cases the reporting reflects an all-lands summary, regardless of ownership. For the Plan unit and local scales, reporting is also broken out by ERU. The CCVA results for the subwatershed scale are shown as one vulnerability category for each watershed, representing a composite scoring of vulnerability for all lands.

Vulnerability at the Plan Unit Scale

All Ecosystems

		Uncertainty Category			
Forest	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	10%	24%	0%	35%
	Moderate Vulnerability	1%	29%	14%	44%
Carson NF	High Vulnerability	6%	10%	0%	16%
	Very High Vulnerability	5%	0%	0%	5%
Grand Total		22%	63%	14%	

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	17%	43%	0%	61%
	Moderate Vulnerability	0%	29%	8%	37%
IVICD	High Vulnerability	0%	2%	0%	2%
	Very High Vulnerability	0%	0%	0%	0%
I	MCD Total	17%	75%	8%	
	Low Vulnerability	5%	43%	0%	48%
NACIA/	Moderate Vulnerability	0%	36%	12%	48%
IVICVV	High Vulnerability	1%	3%	0%	4%
	Very High Vulnerability	0%	0%	0%	0%
1	VICW Total	6%	82%	13%	
	Low Vulnerability	31%	55%	0%	86%
MSC	Moderate Vulnerability	0%	12%	1%	13%
IVISO	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MSG Total	32%	67%	1%	
	Low Vulnerability	19%	25%	0%	45%
DIO	Moderate Vulnerability	0%	34%	21%	54%
PJU	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
PJO Total		19%	60%	21%	

		Unc	Uncertainty Category		
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	0%	1%	0%	2%
DIC	Moderate Vulnerability	0%	23%	16%	39%
P12	High Vulnerability	16%	21%	0%	38%
	Very High Vulnerability	22%	0%	0%	22%
	PJS Total	39%	45%	16%	
	Low Vulnerability	4%	21%	0%	25%
DDE	Moderate Vulnerability	0%	28%	20%	48%
PPF	High Vulnerability	3%	19%	0%	22%
	Very High Vulnerability	4%	0%	0%	4%
	PPF Total	12%	67%	21%	
	Low Vulnerability	51%	35%	0%	86%
SACE	Moderate Vulnerability	13%	0%	0%	14%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
9	SAGE Total	65%	35%	0%	
	Low Vulnerability	0%	12%	0%	12%
SEE	Moderate Vulnerability	0%	45%	15%	60%
Эгг	High Vulnerability	15%	10%	0%	25%
	Very High Vulnerability	2%	0%	0%	2%
	SFF Total	18%	67%	15%	

Vulnerability at the Local Scale

Camino Real

All Ecosystems

		Uncertainty Category			
Local Unit	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	5%	19%	0%	24%
Camina Paal	Moderate Vulnerability	0%	41%	14%	54%
Camino Real	High Vulnerability	9%	9%	0%	18%
	Very High Vulnerability	4%	0%	0%	4%
Gran	d Total	17%	69%	14%	

_		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	10%	34%	0%	44%
	Moderate Vulnerability	0%	42%	9%	51%
INICD	High Vulnerability	0%	5%	0%	5%
	Very High Vulnerability	0%	0%	0%	0%
1	MCD Total	10%	80%	9%	
	Low Vulnerability	2%	34%	0%	37%
	Moderate Vulnerability	0%	46%	13%	58%
IVICVV	High Vulnerability	1%	4%	0%	5%
	Very High Vulnerability	1%	0%	0%	1%
Γ	/ICW Total	4%	83%	13%	
	Low Vulnerability	37%	29%	0%	66%
MSG	Moderate Vulnerability	0%	17%	9%	26%
IVI3G	High Vulnerability	0%	8%	0%	8%
	Very High Vulnerability	0%	0%	0%	0%
I	MSG Total	37%	54%	9%	
	Low Vulnerability	26%	52%	0%	78%
DIO	Moderate Vulnerability	0%	20%	0%	20%
FJU	High Vulnerability	0%	2%	0%	2%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	26%	74%	0%	

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	1%	2%	0%	3%
DIC	Moderate Vulnerability	0%	45%	24%	69%
P12	High Vulnerability	14%	12%	0%	26%
	Very High Vulnerability	2%	0%	0%	2%
	PJS Total	17%	59%	24%	
	Low Vulnerability	2%	8%	0%	10%
DDE	Moderate Vulnerability	0%	43%	25%	68%
PPF	High Vulnerability	2%	19%	0%	21%
	Very High Vulnerability	1%	0%	0%	1%
	PPF Total	4%	71%	25%	
	Low Vulnerability	84%	16%	0%	99%
SACE	Moderate Vulnerability	0%	0%	0%	1%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
9	SAGE Total	84%	16%	0%	
	Low Vulnerability	1%	10%	0%	11%
CEE	Moderate Vulnerability	0%	41%	12%	54%
555	High Vulnerability	21%	10%	0%	31%
	Very High Vulnerability	4%	0%	0%	4%
	SFF Total	26%	62%	12%	

Cruces Basin

All Ecosystems

		Uncertainty Category			
Local Unit	Vulnerability Category	Low	Mod	High	Total
Cruces Basin	Low Vulnerability	22%	44%	0%	67%
	Moderate Vulnerability	0%	21%	5%	26%
	High Vulnerability	3%	3%	0%	6%
	Very High Vulnerability	1%	0%	0%	1%
Grand Total		26%	69%	5%	

_		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	32%	60%	0%	92%
MCD	Moderate Vulnerability	0%	7%	0%	8%
IVICD	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MCD Total	32%	68%	0%	
	Low Vulnerability	17%	70%	2%	90%
NACIA/	Moderate Vulnerability	0%	10%	0%	10%
IVICVV	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MCW Total	17%	80%	2%	
	Low Vulnerability	34%	59%	0%	93%
NICO	Moderate Vulnerability	0%	6%	0%	7%
MSG	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MSG Total	34%	66%	0%	
	Low Vulnerability	31%	69%	0%	100%
	Moderate Vulnerability	0%	0%	0%	0%
PJO	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	31%	69%	0%	
	Low Vulnerability	24%	69%	1%	94%
005	Moderate Vulnerability	0%	5%	1%	6%
PPF	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	PPF Total	24%	74%	2%	
	Low Vulnerability	100%	0%	0%	100%
CACE.	Moderate Vulnerability	0%	0%	0%	0%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
SAGE Total		100%	0%	0%	
	Low Vulnerability	0%	6%	0%	6%
6 5 5	Moderate Vulnerability	0%	55%	16%	71%
SFF	High Vulnerability	11%	10%	0%	22%
	Very High Vulnerability	2%	0%	0%	2%
	SFF Total	13%	72%	16%	

Jicarilla

All Ecosystems

		Un	certainty Cate	gory	
Local Unit	Vulnerability Category	Low	Mod	High	Total
li e e ville	Low Vulnerability	5%	0%	0%	6%
	Moderate Vulnerability	5%	33%	18%	56%
JICalilla	High Vulnerability	5%	26%	0%	31%
	Very High Vulnerability	8%	0%	0%	8%
Grand Total		23%	59%	18%	

		Und			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	0%	0%	0%	0%
DIO	Moderate Vulnerability	1%	62%	36%	99%
PJO	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	1%	63%	36%	
	Low Vulnerability	0%	0%	0%	0%
DIS	Moderate Vulnerability	0%	1%	0%	2%
F12	High Vulnerability	25%	64%	0%	89%
	Very High Vulnerability	9%	0%	0%	9%
	PJS Total	35%	65%	0%	
	Low Vulnerability	0%	0%	0%	0%
DDE	Moderate Vulnerability	0%	10%	4%	14%
FFF	High Vulnerability	11%	57%	0%	68%
	Very High Vulnerability	18%	0%	0%	18%
	PPF Total	29%	67%	4%	
	Low Vulnerability	51%	3%	0%	54%
SACE	Moderate Vulnerability	46%	0%	0%	46%
JAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	SAGE Total	97%	3%	0%	

	Uncertainty Category			jory	
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	0%	0%	0%
Эгг	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	100%	0%	0%	100%
SFF Total		100%	0%	0%	

Red River

All Ecosystems

		Un	certainty Cate	gory	
Local Unit	Vulnerability Category	Low	Mod	High	Total
De d Diver	Low Vulnerability	5%	32%	0%	37%
	Moderate Vulnerability	0%	31%	16%	47%
Red River	High Vulnerability	5%	6%	0%	12%
	Very High Vulnerability	4%	0%	0%	4%
Grand Total		14%	69%	17%	

		Unc	ertainty Categ	iory	
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	10%	52%	1%	63%
MCD	Moderate Vulnerability	0%	26%	12%	37%
IVICD	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
MCD Total		10%	77%	13%	
	Low Vulnerability	4%	49%	1%	53%
	Moderate Vulnerability	0%	27%	14%	41%
IVICVV	High Vulnerability	1%	4%	0%	5%
	Very High Vulnerability	1%	0%	0%	1%
ſ	MCW Total	5%	80%	15%	
	Low Vulnerability	33%	67%	0%	100%
MSG	Moderate Vulnerability	0%	0%	0%	0%
IVISO	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MSG Total	33%	67%	0%	

		Unc	ertainty Categ	iory	
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	10%	72%	1%	83%
DIO.	Moderate Vulnerability	0%	11%	6%	17%
PJO	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	10%	83%	8%	
	Low Vulnerability	0%	1%	0%	1%
DIS	Moderate Vulnerability	0%	32%	53%	85%
FJ3	High Vulnerability	1%	13%	0%	14%
	Very High Vulnerability	0%	0%	0%	0%
	PJS Total	1%	46%	53%	
	Low Vulnerability	2%	29%	0%	31%
DDE	Moderate Vulnerability	0%	19%	21%	40%
FFF	High Vulnerability	4%	19%	0%	23%
	Very High Vulnerability	6%	0%	0%	6%
	PPF Total	12%	67%	21%	
	Low Vulnerability	74%	26%	0%	100%
SACE	Moderate Vulnerability	0%	0%	0%	0%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	SAGE Total	74%	26%	0%	
	Low Vulnerability	1%	19%	0%	20%
SEE	Moderate Vulnerability	0%	44%	17%	61%
Эгг	High Vulnerability	10%	8%	0%	18%
	Very High Vulnerability	1%	0%	0%	1%
	SFF Total	12%	71%	17%	

Rio Chama

All Ecosystems

		Un	certainty Cate	gory	
Local Unit	Vulnerability Category	Low	Mod	High	Total
Die Chame	Low Vulnerability	20%	25%	0%	45%
	Moderate Vulnerability	0%	24%	12%	36%
RIO CIIdilid	High Vulnerability	3%	8%	0%	11%
	Very High Vulnerability	8%	0%	0%	8%
Grand Total		31%	57%	12%	

		Unc	Uncertainty Category		
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	29%	54%	0%	83%
	Moderate Vulnerability	0%	16%	1%	17%
IVICD	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MCD Total	29%	70%	1%	
	Low Vulnerability	20%	44%	0%	64%
	Moderate Vulnerability	0%	33%	2%	36%
IVICVV	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MCW Total	20%	78%	2%	
	Low Vulnerability	34%	65%	0%	98%
MCC	Moderate Vulnerability	0%	1%	0%	2%
MSG	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MSG Total	34%	66%	0%	
	Low Vulnerability	52%	38%	0%	89%
DIO	Moderate Vulnerability	0%	7%	3%	10%
PJO	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	52%	46%	3%	
	Low Vulnerability	0%	1%	0%	1%
DIC	Moderate Vulnerability	0%	25%	13%	38%
PJ2	High Vulnerability	11%	18%	0%	29%
	Very High Vulnerability	31%	0%	0%	31%
	PJS Total	42%	44%	13%	
	Low Vulnerability	11%	31%	0%	42%
DDE	Moderate Vulnerability	0%	35%	21%	56%
PPF	High Vulnerability	0%	2%	0%	2%
	Very High Vulnerability	0%	0%	0%	0%
PPF Total		11%	68%	21%	
	Low Vulnerability	90%	5%	0%	95%
SACE	Moderate Vulnerability	4%	1%	0%	5%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
SAGE Total		94%	6%	0%	

	Uncertainty Cat			iory	
ERU	Vulnerability Category	Low	Mod	High	Total
CEE	Low Vulnerability	0%	2%	0%	2%
	Moderate Vulnerability	0%	54%	24%	79%
Эгг	High Vulnerability	8%	11%	0%	19%
	Very High Vulnerability	1%	0%	0%	1%
SFF Total		8%	67%	24%	

Rio Grande

All Ecosystems

		Un	certainty Cate	gory	
Local Unit	Vulnerability Category	Low	Mod	High	Total
Die Grande	Low Vulnerability	12%	16%	0%	28%
	Moderate Vulnerability	0%	11%	11%	23%
RIO GLAHUE	High Vulnerability	15%	16%	0%	31%
	Very High Vulnerability	18%	0%	0%	18%
Grand Total		45%	44%	11%	

		Unc	Uncertainty Category		
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	0%	1%	0%	1%
	Moderate Vulnerability	0%	26%	33%	59%
INICD	High Vulnerability	2%	38%	0%	39%
	Very High Vulnerability	0%	0%	0%	0%
l	MCD Total	2%	65%	33%	
	Low Vulnerability	0%	0%	0%	0%
NACIA/	Moderate Vulnerability	0%	27%	19%	46%
IVICVV	High Vulnerability	10%	32%	0%	42%
	Very High Vulnerability	11%	0%	0%	11%
٦	VICW Total	21%	60%	19%	
	Low Vulnerability	0%	0%	0%	0%
MEC	Moderate Vulnerability	0%	0%	0%	0%
IVISG	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	100%	0%	0%	100%
	MSG Total	100%	0%	0%	

		Und	Uncertainty Category		
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	6%	41%	1%	48%
DIO.	Moderate Vulnerability	0%	23%	28%	51%
PJO	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	6%	66%	29%	
	Low Vulnerability	0%	0%	0%	0%
DIC	Moderate Vulnerability	0%	11%	9%	20%
612	High Vulnerability	25%	25%	0%	50%
	Very High Vulnerability	30%	0%	0%	30%
	PJS Total	55%	36%	9%	
	Low Vulnerability	0%	2%	0%	2%
DDE	Moderate Vulnerability	0%	28%	46%	74%
PPF	High Vulnerability	3%	22%	0%	25%
	Very High Vulnerability	0%	0%	0%	0%
	PPF Total	3%	51%	46%	
	Low Vulnerability	50%	49%	0%	99%
SACE	Moderate Vulnerability	1%	1%	0%	1%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
9	SAGE Total	50%	50%	0%	
	Low Vulnerability	0%	0%	0%	0%
SEE	Moderate Vulnerability	0%	79%	0%	79%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	21%	0%	0%	21%
	SFF Total	21%	79%	0%	

Valle Vidal

All Ecosystems

		Uncertainty Category			
Local Unit	Vulnerability Category	Low	Mod	High	Total
Valle Vidal	Low Vulnerability	2%	35%	0%	38%
	Moderate Vulnerability	0%	36%	14%	50%
	High Vulnerability	5%	4%	0%	9%
	Very High Vulnerability	3%	0%	0%	3%
Grand Total		10%	75%	15%	

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	6%	58%	1%	65%
	Moderate Vulnerability	0%	17%	17%	35%
IVICD	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MCD Total	6%	76%	18%	
	Low Vulnerability	3%	61%	1%	65%
NACIA/	Moderate Vulnerability	0%	25%	9%	34%
IVICVV	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	0%	0%	0%	0%
1	MCW Total	4%	86%	10%	
	Low Vulnerability	5%	78%	0%	83%
MCC	Moderate Vulnerability	0%	17%	0%	17%
IVISG	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	MSG Total	5%	95%	0%	
	Low Vulnerability	13%	82%	3%	98%
OLA	Moderate Vulnerability	0%	2%	0%	2%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	PJO Total	13%	84%	3%	
	Low Vulnerability	0%	0%	0%	0%
DIC	Moderate Vulnerability	0%	0%	100%	100%
612	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
	PJS Total	0%	0%	100%	
	Low Vulnerability	1%	34%	1%	35%
DDE	Moderate Vulnerability	0%	45%	20%	65%
PPF	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
PPF Total		1%	79%	20%	
	Low Vulnerability	0%	15%	0%	15%
CEE	Moderate Vulnerability	0%	47%	18%	65%
SFF	High Vulnerability	11%	9%	0%	20%
	Very High Vulnerability	0%	0%	0%	0%
SFF Total		11%	71%	18%	

Vallecitos

All Ecosystems

		Uncertainty Category			
Local Unit	Vulnerability Category	Low	Mod	High	Total
Vallecitos	Low Vulnerability	10%	25%	0%	35%
	Moderate Vulnerability	0%	32%	20%	52%
	High Vulnerability	4%	8%	0%	12%
	Very High Vulnerability	1%	0%	0%	1%
Grand Total		15%	65%	20%	

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	19%	38%	0%	57%
	Moderate Vulnerability	0%	32%	10%	42%
IVICD	High Vulnerability	0%	2%	0%	2%
	Very High Vulnerability	0%	0%	0%	0%
	MCD Total	19%	71%	10%	
	Low Vulnerability	6%	36%	0%	42%
NACIA/	Moderate Vulnerability	0%	45%	13%	58%
IVICVV	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
MCW Total		6%	82%	13%	
MSG	Low Vulnerability	32%	27%	0%	59%
	Moderate Vulnerability	0%	35%	4%	39%
	High Vulnerability	0%	1%	0%	1%
	Very High Vulnerability	1%	0%	0%	1%
MSG Total		33%	63%	4%	
PJO	Low Vulnerability	10%	29%	0%	40%
	Moderate Vulnerability	0%	33%	27%	60%
	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
PJO Total		10%	62%	27%	

		Uncertainty Category			
ERU	Vulnerability Category	Low	Mod	High	Total
	Low Vulnerability	0%	8%	0%	8%
DIC	Moderate Vulnerability	0%	30%	27%	57%
P12	High Vulnerability	9%	21%	0%	30%
	Very High Vulnerability	5%	0%	0%	5%
	PJS Total	15%	59%	27%	
	Low Vulnerability	3%	23%	0%	26%
DDE	Moderate Vulnerability	0%	30%	30%	61%
PPF	High Vulnerability	2%	10%	0%	12%
	Very High Vulnerability	2%	0%	0%	2%
PPF Total		6%	63%	30%	
CACE	Low Vulnerability	100%	0%	0%	100%
	Moderate Vulnerability	0%	0%	0%	0%
SAGE	High Vulnerability	0%	0%	0%	0%
	Very High Vulnerability	0%	0%	0%	0%
SAGE Total		100%	0%	0%	
SFF	Low Vulnerability	0%	0%	0%	0%
	Moderate Vulnerability	0%	36%	5%	42%
	High Vulnerability	31%	23%	0%	53%
	Very High Vulnerability	5%	0%	0%	5%
SFF Total		35%	59%	5%	

Vulnerability at the Subwatershed Scale – All Ecosystems

The following table gives composite vulnerability scores for each 6th-level watershed that intersects the Carson NF. As with the previous tables, these results represent all lands regardless of ownership.

6th-Lovel HUC	HUCName	Composite Vulnerability
oth-Level Hoc	noc Nume	Category
110800010302	Leandro Creek	Moderate Vulnerability
110800010403	Headwaters Van Bremmer Creek	Low Vulnerability
110800020101	Headwaters Moreno Creek	Moderate Vulnerability
110800020102	Outlet Moreno Creek	Moderate Vulnerability
110800020103	Headwaters Cieneguilla Creek	Moderate Vulnerability
110800020105	Eagle Nest Lake	Moderate Vulnerability
110800020201	Greenwood Canyon	Moderate Vulnerability
110800020202	Middle Ponil Creek	Moderate Vulnerability
110800020203	Headwaters North Ponil Creek	Moderate Vulnerability
110800020205	Outlet North Ponil Creek	Moderate Vulnerability
110800020207	Headwaters Cerrososo Creek	Moderate Vulnerability
110800040101	Upper Coyote Creek	Moderate Vulnerability

		Composite Vulnerability
6th-Level HUC	HUC Name	Category
110800040301	Luna Creek	Moderate Vulnerability
110800040302	Quemado Canyon-Mora River	Moderate Vulnerability
110800040303	Vigil Creek-Mora River	Moderate Vulnerability
110800040304	Rio La Casa	Low Vulnerability
110800040305	Rio La Casa-Mora River	Moderate Vulnerability
130100021103	Cove Lake Reservoir	Moderate Vulnerability
130100021104	Punche Arroyo	Moderate Vulnerability
130100050202	Beaver Creek	Moderate Vulnerability
130100050203	Toltec Creek-Rio de Los Pinos	Moderate Vulnerability
130100050204	City of Ortiz-Rio de Los Pinos	Moderate Vulnerability
130100050301	Canada Tio Grande-Rio San Antonio	Moderate Vulnerability
130100050302	Canada de Los Ranchos-Rio San Antonio	Moderate Vulnerability
130100050303	San Antonio Cemetery-Rio San Antonio	Moderate Vulnerability
130100050404	Bighorn Creek	Low Vulnerability
130201010102	Comanche Creek	Moderate Vulnerability
130201010103	Comanche Creek-Costillo Creek	Moderate Vulnerability
130201010104	Latir Creek-Costillo Creek	Moderate Vulnerability
130201010202	130201010202	Moderate Vulnerability
130201010205	Urraca Canyon	Moderate Vulnerability
130201010206	Latir Creek	Moderate Vulnerability
130201010301	Upper Red River	Moderate Vulnerability
130201010302	Cabresto Creek	Moderate Vulnerability
130201010303	Middle Red River	Moderate Vulnerability
130201010304	Lower Red River	Moderate Vulnerability
130201010401	Arroyo Punche	Moderate Vulnerability
130201010405	Red River-Rio Grande	Moderate Vulnerability
130201010501	Rito de la Olla	Moderate Vulnerability
130201010502	Headwaters Rio Grande de Rancho	Moderate Vulnerability
130201010503	Rio Chiquito	Moderate Vulnerability
130201010504	Outlet Rio Grande del Rancho	Moderate Vulnerability
130201010601	Headwaters Rio Fernando del Taos	Moderate Vulnerability
130201010602	La Junta Creek-Rio Pueblo de Taos	Moderate Vulnerability
130201010603	Rita del Gato	Very High Vulnerability
130201010604	Outlet Rio Fernando del Taos	Moderate Vulnerability
130201010605	Rio Fernando del Taos-Rio Pueblo del Taos	Moderate Vulnerability
130201010606	Arroyo Seco-Rio Pueblo de Taos	Moderate Vulnerability
130201010607	Arroyo del Alameda-Rio Pueblo de Taos	Moderate Vulnerability
130201010701	Headwaters Arroyo Hondo	Moderate Vulnerability
130201010702	Outlet Arroyo Hondo	Moderate Vulnerability
130201010703	Arroyo Hondo-Rio Grande	Moderate Vulnerability
130201010706	Cerros de Taos Ranch	Moderate Vulnerability
130201010707	Mauby Hot Springs-Rio Grande	Moderate Vulnerability
130201010708	Town of Carson	Moderate Vulnerability
130201010801	Lamy Canyon-Arroyo Aguaje de la Petaca	Moderate Vulnerability
130201010802	Martinez Canyon-Arroyo Aguaje de la Petaca	Moderate Vulnerability
130201010803	Canon de Tio Gordito-Arroyo Aguaje de la Petaca	Moderate Vulnerability
130201010804	Indian Lake	Moderate Vulnerability

		Composite Vulnerability
6th-Level HUC	HUC Name	Category
130201010805	Carson Reservoir-Arroyo Aguaje de la Petaca	Moderate Vulnerability
130201010806	Soctt Arroyo-Arroy Aguaje de la Petaca	High Vulnerability
130201010901	La Junta Creek	Moderate Vulnerability
130201010902	La Junta Canyon-Rio Pueblo	Moderate Vulnerability
130201010903	Osha Canyon-Rio Pueblo	Moderate Vulnerability
130201010904	Headwaters Rio Santa Barbara	High Vulnerability
130201010905	Outlet Rio Santa Barbara	Moderate Vulnerability
130201010906	Rio Santa Barbara-Rio Pueblo	Moderate Vulnerability
130201010907	Canada del Oso Sarco	Moderate Vulnerability
130201010908	Canada del Oso Sarco-Embudo Creek	Moderate Vulnerability
130201010909	Arroyo la Mina-Embudo Creek	High Vulnerability
130201011003	Rio Quemado	Moderate Vulnerability
130201011004	Santa Cruz Reservoir-Santa Cruz River	High Vulnerability
130201011101	Canada Comanche	Moderate Vulnerability
130201011102	Canada Comanche-Rio Grande	Moderate Vulnerability
130201011103	Rio Truchas	Moderate Vulnerability
130201011104	Rio Truchas-Rio Grande	Moderate Vulnerability
130201011105	Arroyo del Palacio-Rio Grande	Moderate Vulnerability
130201020101	East Fork Brazos	Moderate Vulnerability
130201020102	West Fork Brazos	Moderate Vulnerability
130201020103	Gavilan Creek	Moderate Vulnerability
130201020104	Gavilan Creek-Rio Brazos	Moderate Vulnerability
130201020203	Wolf Creek	Moderate Vulnerability
130201020501	Cedar Grove Cemetery-Arroyo Blanco	Moderate Vulnerability
130201020502	Headwaters Rio Cebolla	Moderate Vulnerability
130201020503	Outlet Rio Cebolla	Moderate Vulnerability
130201020701	Upper Rio Nutrias	Moderate Vulnerability
130201020708	Huckbay Canyon-Rio Chama	Moderate Vulnerability
130201020901	Montoya Canyon-Canjilon Creek	Moderate Vulnerability
130201020902	Lopez Canyon-Canjilon Creek	Moderate Vulnerability
130201020903	Martinez Canyon	Moderate Vulnerability
130201020904	Martinez Canyon-Canjilon Creek	Moderate Vulnerability
130201020905	Arroyo del Yeso-Arroyo Seco	Moderate Vulnerability
130201021002	Ojito Canyon-Abiquiu Reservoir	Moderate Vulnerability
130201021003	Rio Puerco-Abiquiu Reservoir	Moderate Vulnerability
130201021006	Canones Creek-Abiquiu Reservoir	Moderate Vulnerability
130201021101	Arroyo Seco	Moderate Vulnerability
130201021102	Headwaters El Rito	Moderate Vulnerability
130201021103	Outlet El Rito	High Vulnerability
130201021201	Arroyo del Cobre	High Vulnerability
130201021203	Arroyo del Cobre-Rio Chama	High Vulnerability
130201021204	Madera Canon	Moderate Vulnerability
130201021205	El Rito-Rio Chama	High Vulnerability
130201021301	Canada Biscara-Rio Tusas	Moderate Vulnerability
130201021302	Canada del Aqua-Rio Tusas	Moderate Vulnerability
130201021303	Canada de Los Comanches	Moderate Vulnerability
130201021304	Canada de los Comanches-Rio Tusas	Moderate Vulnerability

6th-Level HUC	HUC Name	Composite Vulnerability
130201021205	Rio Vallecitos-Rio Tusas	High Vulnerability
120201021303	larosa Crook Pio Vallositos	Moderate Vulperability
130201021401	Jalosa Creek-Rio Vallecitos	Moderate Vulnerability
130201021402		Moderate vulnerability
130201021403	Canada de Agua-Rio Vallecitos	Moderate Vulnerability
130201021404	Rio Tusas-Rio Vallecitos	Moderate Vulnerability
130201021501	Canada de Los Comanches	High Vulnerability
130201021502	Upper Rio Ojo Caliente	High Vulnerability
130201021503	Canada Las Lemitas	Very High Vulnerability
130201021504	Middle Rio Ojo Caliente	Very High Vulnerability
130201021506	Lower Rio Ojo Caliente	Very High Vulnerability
140801010801	Carracas Canyon	Moderate Vulnerability
140801010803	San Juan River-Navajo Reservoir	Moderate Vulnerability
140801010901	Headwaters Canon Bancos	Moderate Vulnerability
140801010902	Cabresto Canyon	Moderate Vulnerability
140801010903	Outlet Canon Bancos	Moderate Vulnerability
140801011003	Vaqueros Canyon	Moderate Vulnerability
140801011004	Vaqueros Canyon-La Jara Creek	High Vulnerability
140801011005	La Fragua Canyon	Moderate Vulnerability
140801011006	La Jara Canyon	Moderate Vulnerability
140801011602	Canon Bancos-Navajo Reservoir	Moderate Vulnerability
140801011603	La Jara Canyon-Navajo Reservoir	Moderate Vulnerability
140801011701	Upper Goberndador Canyon	Moderate Vulnerability
140801030303	Wild Horse Canyon-Tapicito Creek	High Vulnerability
140801030403	Ciruelas Canyon-Arroyo Companero	High Vulnerability
140801030404	Munoz Creek	High Vulnerability
140801030405	Martinez Canyon-Carrizo Canyon	Moderate Vulnerability