21. Research					
ISSUE 21.1	It is not well understood how GrSG population dynamics and sustainability are impacted by (1) the quality and quantity of GrSG habitat; and (2) human-controlled activities in GrSG habitat.				
OBJECTIVE 21.1.1	*Evaluate the effects of habitat quality and quantity* on (1) GrSG behavior; and (2) the dynamics and sustainability of GrSG populations.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.1.1.1	Evaluate how the amount (i.e., "patch size"), configuration, and composition of GrSG habitat affect (1) sage-grouse behavior (e.g., movement and dispersal); (2) species distribution; (3) productivity; (4) population dynamics; and (5) population sustainability. Map and analyze landscape metrics (e.g., edge density, fragmentation, heterogeneity, fractal dimension), using the most reliable and current GIS data and examine the spatial and temporal correlation with sage-grouse population dynamics. Evaluate the potential for dispersal of individuals into currently unoccupied suitable habitat.	BLM, CDA, CPW, Industry, LWGs, NGOs, NRCS, Other Research Institutions, Private Landowners, SLB, Universities, USFS, USFWS, USGS	Begin by 2010	**See Appendix J: Literature Review**	
21.1.1.2	Develop a spatially-explicit population model that incorporates current estimates (with appropriate estimates of temporal and spatial variation) of demography and movement in order to evaluate the relative effects of changing land-uses on GrSG populations.	CCP SC, CPW, NGOs, Other Research Institutions, Universities	Begin by 2009	Thompson, T.R. 2012. Dispersal ecology of greater sage-grouse in northwestern Colorado; evidence from demographic and genetic data. Ph.D. Dissertation, University of Idaho, Moscow, Idaho, USA.	Research conducted in NW CO management zones 1, 3A, and 5.
21.1.1.3	Evaluate the effect(s) of vegetation "quality" (e.g., vegetation structure, sagebrush canopy height and cover, forb and grass height, diversity, and abundance, nutrition available to GrSG) on sage-grouse productivity, adult survival, and population dynamics.	BLM, CDA, CPW, Industry, LWGs, NRCS, Private Landowners, SLB, Universities, USFS, USFWS, USGS	Begin by 2012		
ISSUE 21.1	It is not well understood how GrSG population dynamics and sustainability are impacted by (1) the quality and quantity of GrSG habitat; and (2) human-controlled activities in GrSG habitat.				
OBJECTIVE 21.1.2	*Evaluate human-controlled impacts* on *GrSG habitat,* and the resulting implications for GrSG populations.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.1.2.1	Examine the effects of different habitat treatments on the quality, quantity, and configuration of GrSG habitat, and the responses of GrSG populations.	BLM, CDA, CPW, LWGs, NRCS, Private Landowners, UCEPC, USFS, USFWS, USGS	Begin by 2015		
21.1.2.2	Evaluate the effects of varying grazing management practices (domestic and wild ungulates) on the quality of GrSG habitat (e.g., grass and forb abundance, diversity, and vegetation structure).	BLM, CPW, CSU Extension, LWGs, NAGP, NRCS, Universities, USFS, WAFWA	Begin by 2015		
21.1.2.3	Evaluate the impacts of infrastructure, energy, and mineral development (including reclamation efforts following development), on the quality, quantity, and configuration of GrSG habitat.	CPW, CCP SC, LWGs, Universities	Begin by 2015		

Reference Number	Conservation Strategy	Responsible Parties	Timeline	Implementation	Effectiveness
21.1.2.4	Evaluate the potential impact of (and techniques for) converting CRP to sagebrush habitat on sage-grouse distribution and population viability.	CPW, LWGs, NRCS, Private Landowners, Universities, UCEPC, USFS	Begin by 2010	**UCEPC** has installed one project in 2012 to benefit wildlife in previously cropped land. Another project underway, will be completed summer 2013.	**CPW** proposed research project (2014) that will evaluate the population and demographic response of Columbian sharp-tailed grouse to CRP habitat improvements.
ISSUE 21.2	It is not well-understood how GrSG behavior and demographics are impacted by human-controlled activities.				
OBJECTIVE 21.2.1	Evaluate the *impact of various human-controlled activities on GrSG behavior* , and the resulting implications for GrSG populations.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.2.1.1	Evaluate the impact of agricultural and residential development on the behavior, distribution, demography, and population dynamics of sage-grouse.	BLM, CPW, Universities	Begin by 2020		
21.2.1.2	Evaluate the effect of powerlines, fences, roads, and other human infrastructure on the behavior, distribution, demography, and population dynamics of sage-grouse.	CPW, Industry, LWGs, Universities	Begin by 2015		
21.2.1.3	Evaluate the impact of energy development on the behavior, distribution, demography, and population dynamics of sage-grouse. Include: (1) how specific factors affecting population parameters are influenced by energy development; and (2) the relative impact of specific aspects of oil and gas development (e.g., intensity, duration, and timing elements in PVA [see pg. 210]). Recognize the need and timeline necessary to integrate research data and results into energy development planning cycles.	USFWS, Industry, CPW, BLM	Begin by 2020	**CPW Research:** See 3.4.3.3	
21.2.1.4	Evaluate the effect of mining development on the behavior, distribution, demography, and population dynamics of sage-grouse.	CPW, Universities	Begin by Dec. 2008		
21.2.1.5	Evaluate the effect of recreational activities (e.g., lek viewing, hiking, camping, off-road vehicles, etc.) on the behavior, distribution, demography, and population dynamics of sage-grouse.	CPW, Other Research Institutions, Universities	Begin by 2020	This research not conducted, but CPW could use existing data to conduct post-hoc analyses with Colowyo Coal Pit.	
ISSUE 21.3	The effectiveness of current measures designed to protect GrSG from the impacts of energy and mineral development is not well understood.				
OBJECTIVE 21.3.1	Determine the effectiveness of the various programs and approaches designed to protect GrSG from the potential adverse impacts of energy and mineral development, and related infrastructure.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.3.1.1	Determine the effectiveness of energy and mining mitigation actions, reclamation, existing stipulations, and BMPs in protecting GrSG habitat and populations.	Universities, CPW	Begin by 2010	**CPW Research:** See 3.3.1.2 and 3.3.4.7	

Reference Number	Conservation Strategy	Responsible Parties	Timeline	Implementation	Effectiveness
21.3.1.2	Determine the effectiveness of stipulations, restrictions, and guidelines designed to protect GrSG populations and habitat from the potential adverse impacts of infrastructure (e.g., powerlines, wind turbines, roads).	USGS, USFWS, USFS, NRCS, LWGs, CPW, CDA, BLM, APHIS	Begin by 2010	**BLM:** Habitat and population monitoring will continue in areas of development. BLM will continue to consider and incorporate new science in recommended restrictions and guidelines for SG in coordination with CPW. CPW has the lead on SG research in CO. **CPW Research:** See 3.3.1.2 above	
ISSUE 21.4	The impacts of predation on GrSG are not well understood.				
OBJECTIVE 21.4.1	Examine the effect(s) of predation on GrSG behavior and population dynamics.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.4.1.1	Determine age-specific mortality (especially for chick and adult females, as per the PVA sensitivity analysis [see pg. 217]) and identify the relative risks from avian and mammalian predation within local GrSG populations.	USGS, USFWS, USFS, LWGs, CPW, CDA, BLM, APHIS	Begin by 2010	Thompson, T.R. 2012. Dispersal ecology of greater sage-grouse in northwestern Colorado; evidence from demographic and genetic data. Ph.D. Dissertation, University of Idaho, Moscow, Idaho, USA.	Too early to assess to inform management. This work provided the first estimate of survival (1st yr of life) for GSG. Cause specific mortality was only assessed for broad grouping of avian vs. mammalian.
21.4.1.2	Implement research to better understand the behavioral and spatial interactions of GrSG predators with prey and other predator species.	USGS, USFWS, Universities, CPW, BLM,APHIS	Begin by 2015		
21.4.1.3	Evaluate the large-scale effects of landscape structure (e.g., composition and configuration of landcover types) and small-scale effects (e.g., perch site availability, vegetation structure, and predator exclosures) on GrSG predator-prey interactions.	USGS, USFWS, Universities, CPW, CDA, BLM, APHIS	Begin by 2015	Thompson, T.R. 2012. Dispersal ecology of greater sage-grouse in northwestern Colorado; evidence from demographic and genetic data. Ph.D. Dissertation, University of Idaho, Moscow, Idaho, USA.	Too early to assess.
21.4.1.4	Evaluate whether predator control aimed at specific predator species is an effective management tool that increases production and recruitment of sage-grouse in local populations.	USGS, USFWS, Universities, CPW, CDA, BLM, APHIS	Begin by 2015		
21.4.1.5	Evaluate the spatial and temporal interactions between different trophic levels (e.g., predators and prey) and between similar trophic levels (e.g., examine the impact of grazing by deer and elk on the quality of sagebrush habitats and its effect on sage-grouse behavior and productivity).	USGS, USFWS, USFS, Universities, NRCS, LWGs, CPW, CDA, BLM, APHIS	Begin by 2015		
ISSUE 21.5	WNV is lethal to GrSG and has been detected in Colorado, but few details are known about its potential impact on GrSG.				
OBJECTIVE 21.5.1	Investigate the potential impacts of WNV on GrSG populations in Colorado.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**

Reference Number	Conservation Strategy	Responsible Parties	Timeline	Implementation	Effectiveness
21.5.1.1	Determine the level of susceptibility to WNV and survival patterns of each GrSG age and sex class. Examine whether sage-grouse can develop immunity to WNV and whether the immune response can be inherited.	CPW, NWRC, Other Research Institutions, Universities	Ongoing	Not conducted and not needed. CPW tested 16 samples in 2007 and only 1 tested positive for WNV. Colorado does not have a problem with WNV.	
21.5.1.2	Examine the spatial interaction of mosquito species that are the main vectors of the virus (e.g., Culex tarsalis and C. pipiens) with seasonal habitat use by GrSG (e.g., evaluate whether sage-grouse are more likely to be exposed to the virus in relatively wetter brood-rearing habitat than in lekking and nesting habitats).	CPW, Other Research Institutions, Universities	Begin by 2010	Not conducted and not needed. CPW tested 16 samples in 2007 and only 1 tested positive for WNV. Colorado does not have a problem with WNV.	
21.5.1.3	Examine the potential impact of WNV on GrSG population dynamics and viability.	CPW, Other Research Institutions, Universities	Ongoing	Not conducted and not needed. CPW tested 16 samples in 2007 and only 1 tested positive for WNV. Colorado does not have a problem with WNV.	
ISSUE 21.6	There is a lack of credible research on the theories of additive and compensatory mortality and sport harvest of GrSG.				
OBJECTIVE 21.6.1	Foster and support the research and the collection of data to gain knowledge about additive and compensatory mortality thresholds and sport harvest in GrSG.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.6.1.1	Initiate experimental field research designed to specifically address the issue of compensatory and additive mortality and GrSG. Collaborate with other western states that hunt GrSG.	CPW	Begin 2009, Continue 5 - 10 years		
ISSUE 21.7	Small isolated populations of greater sage-grouse may have low genetic diversity, which may facilitate inbreeding depression.				
OBJECTIVE 21.7.1	Monitor genetic diversity within the smaller isolated populations of greater sage-grouse in Colorado.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.7.1.1	Continue to develop and refine, if it proves feasible, techniques to obtain DNA from sage-grouse fecal droppings so that genetic testing can be accomplished without capturing birds.	CPW, Universities	Ongoing		
ISSUE 21.8	Current methods for monitoring trends in GrSG populations and for estimating GrSG population size from lek counts make many unsupported assumptions.				
OBJECTIVE 21.8.1	Conduct research to establish reliable and effective methods for monitoring GrSG population trends and estimating population size.				
Reference Number	**Conservation Strategy**	**Responsible Parties**	**Timeline**	**Implementation**	**Effectiveness**
21.8.1.1	Develop and evaluate protocols for the inventory and monitoring of GrSG populations and to evaluate factors that influence the population ecology of GrSG.	CPW, Universities	Begin by 2010		
21.8.1.2	Evaluate whether GrSG lek counts can be calibrated and measurements of accuracy and precision can be assessed using mark-resight or sightability models.	CPW, Universities	Begin by 2010		
21.8.1.3	Evaluate alternative methods for estimating GrSG population abundance (e.g., line transects or DNA fingerprinting using fecal samples).	CPW, Universities	Ongoing		

Reference Number	Conservation Strategy	Responsible Parties	Timeline	Implementation	Effectiveness
21.8.1.4	Determine the causes of mortality in different GrSG age and sex classes and the consequences for population dynamics.	USGS, USFWS, USFS, Universities, NRCS, LWGs, CPW, CDA, BLM, APHIS	Begin by 2015	Thompson, T.R. 2012. Dispersal ecology of greater sage-grouse in northwestern Colorado; evidence from demographic and genetic data. Ph.D. Dissertation, University of Idaho, Moscow, Idaho, USA.	
21.8.1.5	Examine the correlation (and time lag) between the variation in annual GrSG productivity and subsequent lek counts and its impact on the precision of population estimates.	USGS, USFWS, USFS, Universities, NRCS, LWGs, CPW, CDA, BLM	Begin by 2010		
21.8.1.6	Refine the population viability assessment of GrSG based on more accurate and precise estimates of demographic parameters.	USGS, USFWS, USFS, Universities, LWGs, CPW, CDA, BLM	Ongoing	**BLM:** BLM will partner with CPW on any updates to the PVA for GRSG and other research projects as appropriate. This has not been done to date.	