The following section supplements the analysis found in Chapter Three, Section 3.2 - Soils of the Draft EIS on page 3.34, "Impacts Related to Oil and Gas Development".

DIRECT AND INDIRECT IMPACTS

Impacts to soils from the development of the shale gas on all unleased federal lands within the GSGP area could occur at the project level, primarily from the construction of well pads and roads. The types of impacts to soils would be the same as those generally described in the Draft EIS but would be the result of an approximate four-fold increase in ground-disturbance. Gas facility development would result in ground cover (vegetation and litter) removal, exposing of mineral soil and potentially soil compaction, soil erosion, and soil displacement. The potential for mass movement of soils and the establishment and spread of invasive plants would also be greater than described in the Draft EIS, given the increased ground disturbance resulting from GSGP development.

The greatest risk for adverse impacts to soils relative to oil and gas development within the GSGP area is on lands identified as being prone to mass movement, lands identified as being highly erosive, and lands with slopes greater than 40%. There are 1,121 acres of lands identified as being highly erosive or prone to mass movement within the GSGP area. Verification of whether those lands are truly highly erosive or prone to mass movement will occur from field analysis at the project level. Lands with slopes greater than 40% were identified using digital elevation models. There are 58,869 acres with slopes greater than 40% within the GSGP area. The Draft LMP contains design criteria and stipulations (including for highly erosive soils, soils prone to mass movement, and steep slopes over 40%) to avoid or minimize soil erosion and other adverse impacts to SJPL (i.e. they are protected with an NSO stipulation).

The haplustalf and haplustept soil types (Animas/Dolores Soil Survey) associated with the ponderosa pine forests (107,500 acres), mountain shrublands (69,600 acres), and pinyon-juniper woodlands (43,800 acres) occupy the majority of the GSGP area lands with slopes less than 40%. These soil types have low to moderate erosion potential but would be the most impacted because the majority of development will occur in these areas.

Oil and gas development on all currently unleased SJPL within the GSGP area could also adversely impact the biological soil crusts that are associated with the semi-desert shrublands, semi-desert grasslands, sagebrush shrublands, and pinyon-juniper woodlands of the GSGP area. Those impacts, which increase each time a vehicle passes over the same crust, include crushing, breaking apart, uprooting, burying, and killing the crusts (Johansen and Rushforth 1985, Belnap 2002). Oil and gas development on these lands could also cause contaminants to be released into the environment, which could adversely affect soils and soil productivity.

The high amounts of Nitrogen emissions that could result from development of the GSGP (as indicated in the air quality model results) could pose concerns for soils. Studies have shown that the deposition of nitrogen (N) from N emissions could increase N levels in soils resulting in a decrease of native plant species and an increase in invasive plant species which could increase fire risk (Allen et al. 2009, Brooks M. L. 2003, and Floyd-Hanna et al. 2004). Furthermore, monitoring on SJPL shows that N loading is increasing in lakes and across the SJPL landscape. In particular, monitoring at Molas Pass shows that since the 1990s there has been a significant increasing trend in NO_3 concentrations in precipitation. Water chemistry

monitoring of pure water lakes in the Weminuche Wilderness over the last decade indicates that those lakes are becoming seasonally saturated with nitrogen (Musselman and Slausen 2002).

Project designs (that avoid unsuitable lands) and the implementation of design criteria and stipulations in the Draft LMP (including ones for highly erosive soils, soils prone to mass movement, steep slopes over 40%, riparian/wetland ecosystems, biological soil crusts, and gypsum soils), as well as targeted NSO stipulations, would protect unique soils and soil features and ecosystems, and minimize adverse impacts to soils.

Alternative Comparison: Impacts to soils in the GSGP area are a function of the amount of ground-disturbance that may occur under each of the Draft LMP alternatives. Alternative A would have the highest potential to impact soils within the GSGP (2,111 acres developed), followed by Alternatives D (2,085 acres), B (2,060 acres) and C (2,035 acres). The No Lease Alternative would have no ground-disturbing impacts and no direct or indirect impacts to soils within the GSGP area.

CUMULATIVE IMPACTS

The Paradox Basin delineates the area considered for cumulative impacts to soils in this analysis (this includes the GSGP area, as well as the broader area of conventional gas development in Montezuma, Dolores and San Miguel counties). Past management activities on federal, private and state lands within this area have caused direct ground-disturbing impacts to soils similar to those described above. In addition to the potential impacts on unleased lands described above, projections for future development on BLM and USFS mineral estate lands already leased could result in an additional 1,786 acres of disturbance (1,166 acres from future gas shale development, and approximately 620 acres from conventional gas development). Direct ground-disturbing impacts to soils from oil and gas development on already leased lands within the GSGP area (about 35% of the GSGP area) could occur and would be the same as those described above. Mitigations for lands currently held under lease would be similar to the mitigations described for unleased lands and would be specified during project level NEPA analysis using COA based on the Draft LMP, Part Three (see Design Criteria for a list of these mitigation measures).

Overall, the cumulative impacts to soils resulting from ground-disturbance associated with all past, current, and foreseeable future management activities on leased and unleased federal and nonfederal lands could occur on a large scale within the Paradox Basin, and some of those impacts could persist for up to 30 years.