Appendix 9

GIS Methodology

Following are further descriptions of how Federal lands were placed into the nine categories referred to in Table 2-8 and a detailed description of the GIS methodology used.

Based upon guidance from BLM and USDA-FS offices, Table A9-1 shows the NLA/LUP jurisdictions within the inventory area.

Table A9-1. Jurisdictions Classified as NLA/LUP

Jurisdiction	Comments
Arapaho-Roosevelt NF	Select areas
Ashley NF	Northern unit only
Big Cypress NPS	Select areas
Big Horn NF	
Bitterroot NF	
Bridger-Teton NF	Areas east of of Highway 189
Caribou-Targhee NF	Caribou NF
Corps of Engineers	Black Warrior Basin
Custer NF	
Department of Defense	Selected areas in the Denver Basin
Dillon, MT, BLM Field Office	
Dixie NF	
Fairbanks BLM Field Office	Southern NPRA only
Fish Lake NF	
Flathead NF	
Florida Panther FWS	
Gallatin NF	
Gunnison, CO, BLM Field Office	
Kootenai NF	
Lewis and Clark NF	Western portion only
Lolo NF	
Milwaukee BLM Field Office	All Federal subsurface interests
Nebraska NF	Pine Ridge Ranger District
Routt-Medicine Bow NF	Medicine Bow portion only
Ten Thousand Islands FWS	
Uinta NF	Unmapped western portions only
Wasatch-Cache NF	Western portion only

Table A9-2 shows how agency jurisdictions were used to categorize lands for this inventory.

GIS files were available to define most of the access categories; however, for the NLA/LUP category, they had to be created. In these situations, the administrative boundary (such as a National Forest) was extracted from the surface ownership data and the resultant polygon was then attributed as NLA/LUP. For example in Figure A9-1, the Wasatch-Cache National Forest boundary in the Wyoming Thrust Belt is shown in green. The grey represents the area within the forest that is undergoing land use planning, which is categorized as NLA/LUP.

A9.1 Stipulation Exceptions

Exceptions to stipulations are sometimes granted. For example, a crucial elk winter range timing limitation exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using

Table A9-2. Federal Land Categorization

Federal Land Management		Categorization	Level
Bureau of Land Management	BLM	Subject to stipulations	
Bureau of Reclamation	BOR	Subject to stipulations	
Department of Agriculture*	USDA	No Leasing (Administrative), general category (NLA)*	2
Department of Defense**	DOD	No Leasing (Administrative), general category (NLA)**	2
Federal Split Estate	SPLIT	Subject to stipulations	
Fish and Wildlife Service	FWS	No Leasing (Administrative), general category (NLA)	2
United States Forest Service	UFS	Subject to stipulations	
Miscellaneous Federal Land Managers (DOE, DOJ, DHS, etc.)		On Advisement from Office	
National Park Service	NPS	No Leasing (Statutory/Executive Order), (NLS)	1
Federal Land Use Designations			
Inventoried Roadless Areas	IRA	Subject to stipulations	
National Conservation Areas	NCA	No Leasing (Statutory/Executive Order), (NLS)	1
National Monuments	NM	No Leasing (Statutory/Executive Order), (NLS)	1
National Recreation Areas	NRA	No Leasing (Statutory/Executive Order), (NLS)	1
National Wildlife Refuges	NWR	No Leasing (Statutory/Executive Order), (NLS)	1
Special Designated Areas	SDA	No Leasing (Statutory/Executive Order), (NLS)	1
Wilderness Areas	WILD	No Leasing (Statutory/Executive Order), (NLS)	1
Wilderness Reinventory Areas	WRA	Subject to stipulations	
Incorporated Towns and Cities	ITC	No Leasing (Statutory/Executive Order), (NLS)	1
Wilderness Study Areas	WSA	No Leasing (Statutory/Executive Order), (NLS)	1

* Ft. Keo Agricultural Experimental Station, MT, only

** Except for the Naval Petroleum Reserve, Casper Field Office, which is subject to stipulations

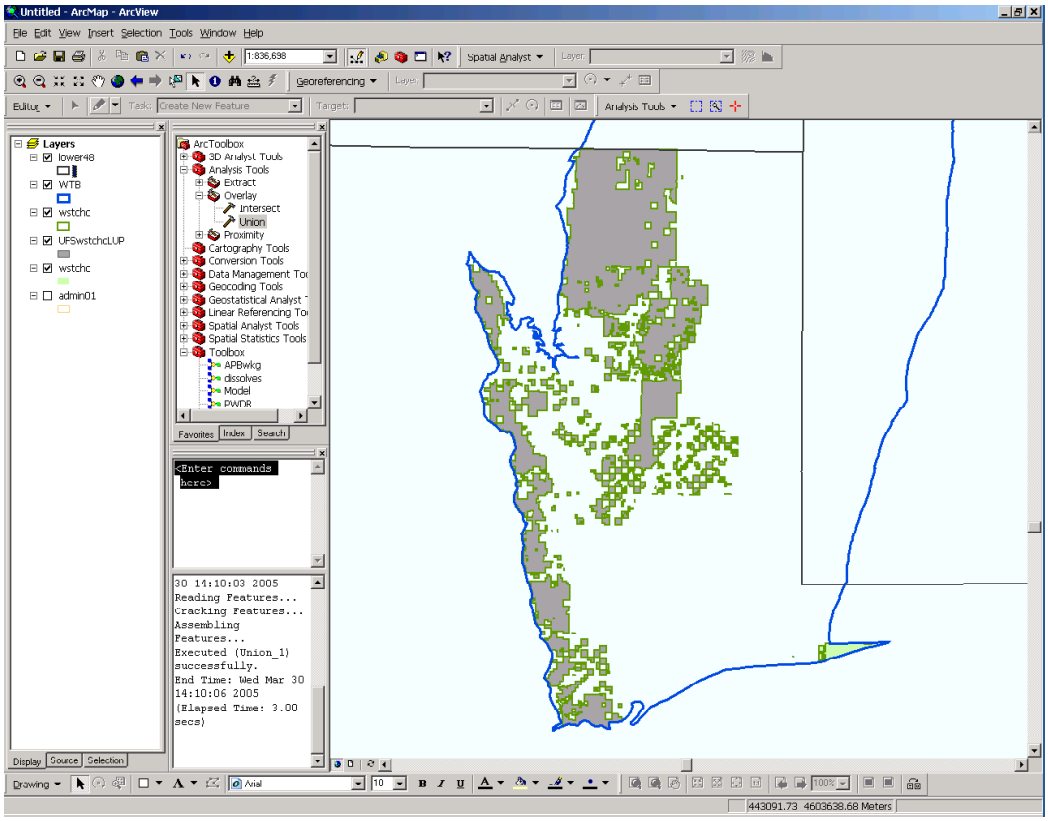

Figure A9-1. Creation of NLA/LUP Polygons

the general areas during a particular year. Because records of exceptions to lease stipulations were not available, BLM and USDA-FS field personnel were asked to determine, based on their experience, which lease stipulations were granted exceptions for drilling and how often. The exception factors thus determined are shown by jurisdiction in Table A9-3.

Lease stipulations, particularly timing limitations, can overlap. Where exception factors overlap, the cumulative effect is calculated by multiplying the overlapping factors (from Table A9-3). This calculation implicitly assumes that exceptions for multiple stipulations would likely not be obtained for a given area. For example, cumulative effects of excepted stipulations for the Wyoming Thrust Belt study area are determined as shown in Table A9-4. The application of these exception factors is described below in Section A9.3.

A9.2 Treatment of NSO Areas

Directional drilling (or "extended reach drilling") is technology that can be employed to reach subsurface targets not located directly underneath the drilling rig. In this inventory resources beyond a certain EDZ are assumed to not be technically recoverable (Figure A9-2). While it is true that directional drilling horizontally out to distances of 5 or 6 miles is possible in production settings such as Alaska, this type of drilling is not the general case in the lower 48 and is impracticable for exploration.

Table A9-3. Stipulation Exception Factors by USDA-FS and BLM Office

Jurisdiction	Study Area	Exception Factors										
		Big Game Winter Range	Indiana Bat	Steep slopes	Raptors	Scenic Landscapes	Designated Non-motor Sites	Calving and Fawning	Visual Resources Management	Designated Historic Sites	Spotted owl, Lynx (T&E)	
Allegheny NF	APB		10%									
Arapaho Roosevelt NF	DEN				10%							
Big Cypress NP	FLP											
Black Hills NF	DEN					60%	40%			25%		
Bridger-Teton NF	WTB	10%		10%				10%				
Buffalo, WY, BLM Field Office	PRB				25%							
Caribou-Targhee NF	WTB	10%										
Carson NF	PDX/SJ	10%										
Casper, WY, BLM Field Office	PRB	25%			25%							
Glenwood Springs, CO, BLM Field Office	UP											
Glenwood Springs, CO, BLM Field Office	GGRB	20%			30%							
Grand Junction, CO, BLM Field Office	UP, PDX/SJ	70%		15%								
Idaho Falls, ID, BLM Field Office	WTB	10%										
Kemmerer, WY, BLM Field Office	WTB	10%			10%							
Kemmerer, WY, BLM Field Office	GGRB	20%			30%							
Lander, WY, BLM Field Office	GGRB	20%			30%							
Little Snake, CO, BLM Field Office	GGRB	20%			30%							
Manti La Sal NF	UP, PDX/SJ			50%				80%				
Medicine Bow-Routt NF Thunder Basin NG	GGRB	20%			30%							
Miles City, MT, BLM Field Office	PRB	50%			50%							
Milwaukee, WI, BLM Field Office	APB		10%									
Missoula, MT, BLM Field Office	MTB	20%		15%	20%							
Moab, UT, BLM Field Office	UP, PDX/SJ	70%										
Monongahela NF	APB		10%									
Nebraska NF	DEN											
Pinedale, WY, BLM Field Office	GGRB	20%			30%							
Pocatello, ID, BLM Field Office	WTB	20%										
Rawlins, WY, BLM Field Office	GGRB	20%			30%							
Rock Springs, WY, BLM Field Office	GGRB	20%			30%							
Royal Gorge, CO, BLM Field Office	DEN			15%					20%		20%	
San Juan, CO, BLM Field Office	PDX/SJ	50%			50%							
Uncompahgre, CO, BLM Field Office	UP	10%			10%							
Uncompahgre, CO, BLM Field Office	PDX/SJ	50%			50%							
White River, CO, BLM Field Office	UP	80%			25%							
White River NF	UP, GGRB							50%				

	Exception Factors												
	Sharp-tailed Grouse and Sage Grouse Display Grounds	Sage Grouse	Birds	Recreation Sites	Riparian/flood Areas	Sedimentation (roads)	Bald Eagle Winter Roost	City of Rifle Watershed	Sensitive Resources	Antelope Fawning	Soils, Watershed	Marshes	Mangrove Forests
			10%										
												5%	5%
		25%											
						10%							
								100%					
		20%											
									30%				
		10%											
		20%											
		20%											
		20%											
		20%											
		10%											
										70%	70%		
	15%			5%	5%								
		20%											
		20%											
		20%											
							50%						
							50%						

Table A9-4. Exception Factors Example for Overlapping Stipulations (WTB Study Area)

Stipulation	Exception Factor (EF)
Big Game	10%
Sage Grouse	10%
Raptors	10%
Big Game and Sage Grouse	1%
Big Game/Raptors	1%
Sage Grouse/Raptors	1%
Big Game, Sage Grouse and Raptors	0.10%

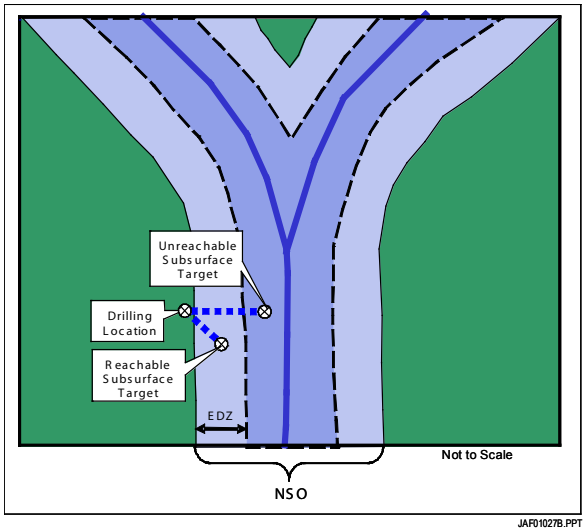

Figure A9-2. Extended Drilling Zone Conceptual Diagram

Directional drilling for exploratory purposes occurs in some areas but is much more limited in scope. As in the case of stipulation exceptions, BLM and USDA-FS field personnel were interviewed to determine the practicable width of the EDZ. The width of the EDZ is partially a function of the depth to the drilling objective—generally the deeper the objective, the larger the EDZ. The EDZ distances supplied by the offices and used in this inventory are shown in Table A9-5.

Table A9-5. Extended Drilling Zones by Jurisdiction

Jurisdiction	Study Area	EDZ (miles)
Alabama NF	BWB	0.25
Albuquerque, NM, BLM Field Office	PDX/SJ	0.25
Allegheny NF	APB	0.13
Arapaho Roosevelt NF	DEN	0.25
Ashley NF	UP, GGRB	0.25
Beaverhead-Deerlodge NF	MTB	0.50
Big Cypress NP	FLP	0.25
Black Hills NF	PRB, DEN	0.25
Bridger-Teton NF	WTB, GGRB	0.50
Buffalo, WY, BLM Field Office	PRB	0.25
Butte, MT, BLM Field Office	MTB	0.25
Caribou-Targhee NF	WTB	0.50
Carson NF	PDX/SJ	0.25
Casper, WY, BLM Field Office	PRB, DEN	0.25
Cedar City, UT, BLM Field Office	PDX/SJ	0.00
Cibola NF	PDX/SJ	0.25
Daniel Boone NF	APB	0.00
Fairbanks, AK, BLM Field Office–AK NPR-A NE	NA	3.00
Fairbanks, AK, BLM Field Office–AK NPR-A NW	NA	1.00
Fairbanks, AK, BLM Field Office–AK NPR-A S	NA	N/A (NLA/ LUP)
Fairbanks, AK, BLM Field Office–ANWR	NA	N/A (NLS)
Farmington, NM, BLM Field Office	PDX/SJ	0.25
Finger Lakes NF	APB	0.25
George Washinton NF	APB	0.25
Glenwood Springs, CO, BLM Field Office	UP, GGRB	0.25
Grand Junction, CO, BLM Field Office	UP, PDX/SJ	0.25
Grand Mesa Uncompahgre/ Gunnison NF	UP	0.25

Table A9-5. Extended Drilling Zones by Jurisdiction (continued)

Jurisdiction	Study Area	EDZ (miles)
Grand Mesa Uncompahgre/ Gunnison NF	PDX/SJ	0.00
Gunnison, CO, BLM Field Office	UP	0.25
Helena NF	MTB	0.25
Idaho Falls, ID, BLM Field Office	WTB	0.50
Jackson, MS, BLM Field Office	FLP, BWB	0.50
Jackson, MS, BLM Field Office	APB	0.00
Jefferson NF	APB	0.25
Kanab, UT, BLM Field Office	PDX/SJ	0.00
Kemmerer, WY, BLM Field Office	WTB	0.50
Kemmerer, WY, BLM Field Office	GGRB	0.25
Lander, WY, BLM Field Office	GGRB	0.25
Lewis and Clark NF	MTB, eastern portions	0.25
Lewistown, MT, BLM Field Office	MTB	0.25
Little Snake, CO, BLM Field Office	UP, GGRB	0.25
Manti La Sal NF	UP	0.50
Manti La Sal NF	PDX/SJ	0.25
Medicine Bow-Routt NF Thunder Basin NG	UP, PRB, GGRB	0.25
Miles City, MT, BLM Field Office	PRB	0.25
Milwaukee, WI, BLM Field Office	APB	N/A (NLA/ LUP)
Mississippi NF	BWB	0.13
Missoula, MT, BLM Field Office	MTB	0.50
Moab, UT, BLM Field Office	UP, PDX/SJ	0.25
Monongahela NF	APB	0.25
Monticello, UT, BLM Field Office	PDX/SJ	0.25
Nebraska, Oglala, Buffalo Gap NF	PRB	0.13
Nebraska, Oglala, Buffalo Gap NF	DEN	0.00
Newcastle, WY, BLM Field Office	PRB	0.00
Newcastle, WY, BLM Field Office	DEN	0.25
Pike-San Isabel NF	DEN	0.25
Pinedale, WY, BLM Field Office	GGRB	0.25
Pinedale, WY, BLM Field Office	WTB	N/A (NLA/ LUP)
Pocatello, ID, BLM Field Office	WTB	0.50
Price, UT, BLM Field Office	UP	0.25
Price, UT, BLM Field Office	PDX/SJ	0.00
Rawlins, WY, BLM Field Office	GGRB, DEN	0.25
Richfield, UT, BLM Field Office	UP	0.25
Richfield, UT, BLM Field Office	PDX/SJ	0.00
Rock Springs, WY, BLM Field Office	GGRB	0.25
Royal Gorge, CO, BLM Field Office	DEN	0.25
Salt Lake, UT, BLM Field Office	UP	0.25
Salt Lake, UT, BLM Field Office	WTB	0.50
San Juan, CO, BLM Field Office	SJ portion	0.00
San Juan, CO, BLM Field Office	PDX portion	0.50
Santa Fe NF	PDX/SJ	0.25
South Dakota BLM Field Office	PRB, DEN	0.25
St. George, UT, BLM Field Office	PDX/SJ	0.00
Tennessee Valley Authority	BWB	0.50
Tennessee Valley Authority	APB	0.00
Uinta NF	UP	0.25
Uncompahgre, CO, BLM Field Office	UP	0.25
Uncompahgre, CO, BLM Field Office	PDX/SJ	0.50
Vernal, UT, BLM Field Office	UP	0.00
Wasatch-Cache NF	WTB	0.50
Wayne NF	APB	0.13
White River, CO, BLM Field Office	UP	0.25
White River NF	UP, GGRB	0.25

The effect of the inclusion of the EDZs in the analysis is to remove an area of land from the perimeters of NSO polygons. The width of this area removed via GIS processing is determined by Federal jurisdiction (Table A9-5) as determined by each field office. The area removed then defaults to the resource access category that would otherwise apply in the absence of the NSO stipulation. The net effect is that the underlying resource is no longer considered inaccessible even though the surface above it cannot be occupied by drilling equipment.

Figure A9-3 shows an actual example from the Wyoming Thrust Belt. Areas shown in light blue represent a 1/2-mile extended drilling zone removed from the NSO areas for the resource categorization. Areas shown in blue represent the resource Net NSO. The black area depicts an area of no leasing; as such the EDZ was not applied to these lands as a rig cannot be sited in no lease areas.

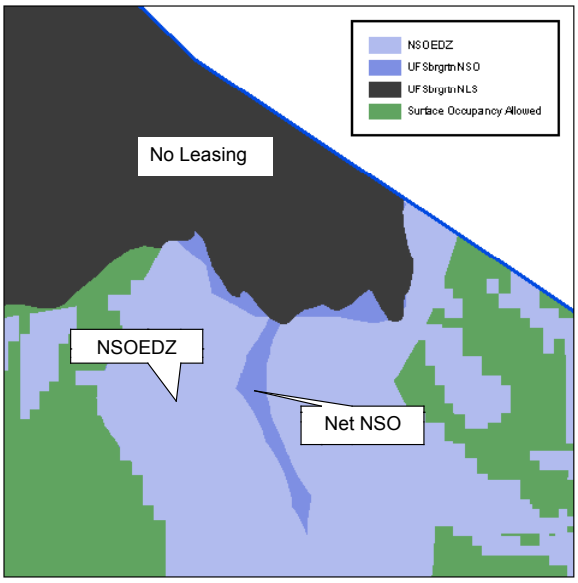

Figure A9-3. Removal of the Extended Drilling Zone from NSO Areas

A9.3 Analytical Modeling of Federal Lands and Resources

The analytical goal of the inventory is to calculate the area of Federal lands (including non-Federal lands overlying federally owned oil and gas estate [split estate]) in each access category in the hierarchy and the volume of oil and gas resources underlying the Federal lands in each access category, while at the same time accounting for stipulation exceptions and the accessibility of the EDZ.

One of the primary objectives for the development of the categorization is to achieve geographic independence for a given parcel of land subject to overlapping stipulations (hence, the use of the categorization hierarchy where that parcel of land would be subject to only one category). The following discussion illustrates the application of the land access categorization for an area of multiple stipulations from the Kemmerer, WY, BLM FO in the Wyoming Thrust Belt, where sage grouse leks and nesting habitat and big game winter range define an access category. These types of stipulations are among the most common found in the study areas.

Figure A9-4 shows a selected point where the stipulations overlap and the resultant categorization is “Timing Limitation Stipulations >6 to <9”. A query at that point brings up a dialog box which lists the stipulations in effect. Table A9-6 contains the corresponding stipulation data extracted from a corresponding master stipulations list.

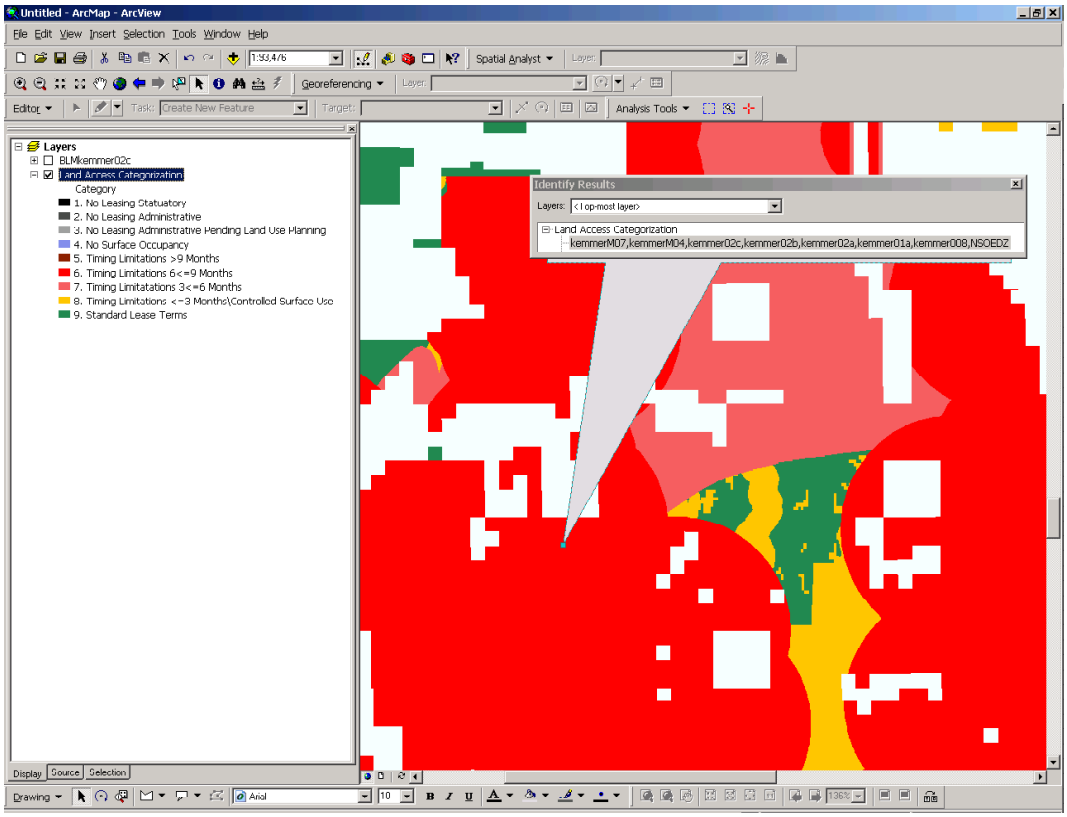

Figure A9-4. Display of Overlapping Timing Limitations (WTB Study Area)

Table A9-6. Sample Master Stipulations List for a Selected Area

Agency	STIPID	Description	LUP Source	Category	TLS months	Exception Factor	EDZ (mi)	Study Area	
								WTB	GGRB
BLM	kemmer008	Green River formation paleontologic survey	p. 11	CSU				X	X
BLM	kemmer01a	Slopes >25%	p. 55	CSU				X	X
BLM	kemmerM04	Sage and sharp-tailed grouse strutting grounds	WY SO	CSU				X	X
BLM	kemmerM07	Big game winter range	WY SO	CSU				X	X
BLM	kemmer02c	Wildlife habit protection—grouse leks and other important habitat	p. 55	NSO			WTB - 0.5, GGRB - 0.25	X	X
BLM	kemmer02a	Big game winter range	p. 55	TLS	_AB0123	10%		X	X
BLM	kemmer02b	Sage and sharp-tailed grouse nesting habitat	p. 55	TLS	123456	10%		X	X

Figure A9-5 shows the land categorization as determined by the stipulations listed in the relevant land use plan. Note that the core nesting habitat of the sage grouse (shown in blue), is designated a "no surface occupancy" area. The remaining area is under various timing limitations (colored in shades of red), controlled surface use (gold) or standard lease terms (green).

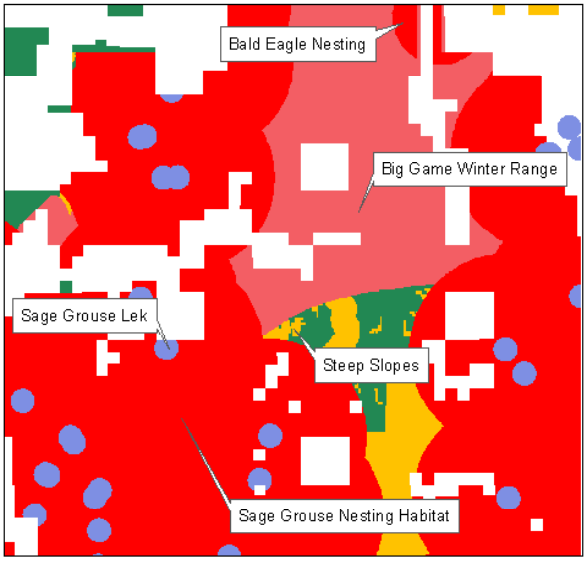

Figure A9-5. Display of Federal Land Access Categorization (WTB Study Area)

Note that in the inventory, with regard to NSO areas, lands and resources are treated differently due to the application of EDZs. Figure A9-6 shows the effect where the EDZ is applied to NSO areas to determine the resource categorization. Note that the application of the EDZ in this example renders the resources under the sage grouse nest area accessible. While the acreage figures for each access category faithfully reflect the management prescriptions contained in the land use plans, the oil and gas volumes are calculated using this adjustment. The net result is that more oil and gas resources are accessible than would be assumed if NSO stipulations were taken at face value.

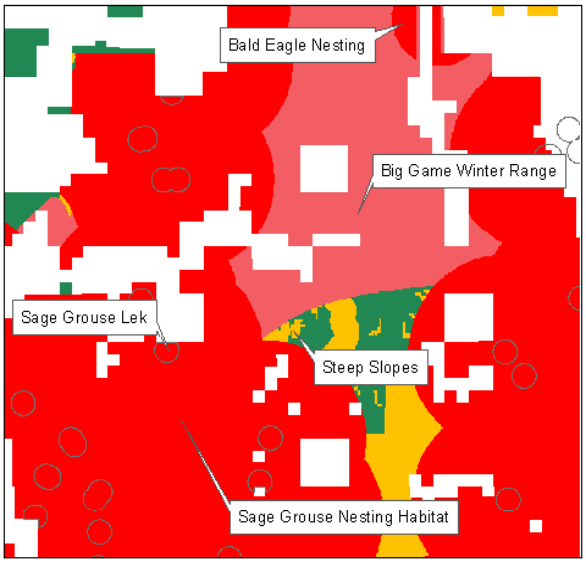

Figure A9-6. Display of Resource Access Categorization with Extended Drilling Zone Applied (WTB Study Area)

In addition, to account for stipulation exceptions, the GIS model determined the effects due to the presence or absence of the stipulations by selectively removing excepted stipulations in the computer. This is illustrated by Figure A9-7, which shows an example for the Wyoming Thrust Belt where the sage grouse nesting habitat stipulation has been removed. Note that in the case of an excepted stipulation, the analysis defaults to the underlying stipulation or standard lease terms, as appropriate.

For example, if sage grouse nesting stipulations are excepted 10 percent of the time (as shown on Table A9-6), then, for an area represented by the sage grouse polygon (where sage grouse stipulations do not overlap other excepted stipulations), 90 percent of the resources is categorized according to the stipulation and 10 percent is categorized according to the underlying stipulation category next in the hierarchy. This calculation is performed accordingly for all of the exception factors within a

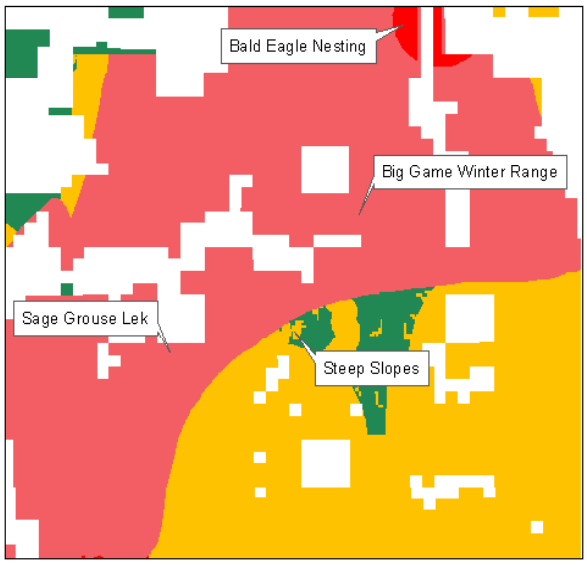

Figure A9-7. Display of Federal Land Access Categorization with Extended Drilling Zone Removed and with Sage Grouse Nesting Habitat Stipulation Excepted (WTB Study Area)

given office jurisdiction (see Table A9-3) or where combinations of these exceptions exist (see Table A9-4).

Access categorization of the Federal lands and resources was determined in aggregate based upon discrete examination of individual GIS polygons using the following equation:

$$FLorRs = \sum((1\text{-}EF) * FLorRs_{(EDZ)} + (EF * FLorRs_{(EDZ\ w/\ Excepted)}))$$

where: FlorRs = Federal Lands or Resources
EF = Exception Factor
(e.g., see Table A9-4)
$FLorRs_{(EDZ)}$ = FLorRs determined using the Extended Drilling Zone
$FLorRs_{(EDZ\ w/\ Excepted)}$ = FLorRs determined using the EDZ plus removal of stipulations for which exceptions are granted

This equation accounts for the occurrence of the extended drilling zone and stipulation exceptions. For excepted stipulations the model defaults to the underlying stipulation category in the hierarchy.

This process results in the generation of numerous individual GIS polygons for each study area. These data are then summed and reported by access category and Federal management agency. For oil and gas resources, categorization is provided by specific resource type (see folder "Detailed Spreadsheets" on accompanying DVD).

A9.4 Quality Control of Modeling Results

A rigorous quality control (QC) check was instituted for the Phase II model. During processing a typical study area will generate more than one million discrete GIS polygons, each with unique characteristics in terms of land status, oil and gas resources, stipulations and exception factors. Complex study areas generate two to three million polygons each. As such, imprecision in GIS mapping data that are insignificant for individual polygons can be amplified in the aggregate. Such imprecision is a direct function of the quality of the data received from the various sources contributing to the inventory.

For all study areas, the quality of the model output is high. For QC purposes, input oil and gas resource volumes and land areas were compared to outputs. A comparison of the study areas revealed percentage differences ranging from zero to 1.32 percent, with most well below 0.5 percent. For a limited number of offices (e.g., Monongahela NF, Vernal, UT, BLM FO, and Allegheny NF) corrections were made to bring errors down to within two percent of

input values. Corrections entailed removal of topological errors occurring in the GIS source data.

The model's land output data differs by 0.26 percent from the input data on an aggregate basis. For oil and gas resources, model output data differs by 0.34 percent from the input data on an aggregate basis.

The QC logs for the study area lands areas and resources are presented on spreadsheets on the accompanying DVD.