Regulatory Issues Controlling Carbon Capture and Storage

by

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Abstract

Climate change is increasingly being recognized by governments, industry, the scientific community, and the public as an issue that must be dealt with. Parties are pursuing various strategies to reduce CO_2 emissions. Renewable energy, energy efficiency, cleaner fuels, terrestrial CO_2 sequestration, and geologic CO_2 capture and storage (CCS) are the major efforts underway.

This thesis examines some major regulatory and political issues that may affect geologic sequestration projects in the future. CCS is a technology system that captures CO_2 from a point source (e.g. power plant or industrial facility), pressurizes it into liquid form, transports it, and finally injects it underground into a porous geology for long-term storage. Technical and economic issues of capture, transportation, and injection of CO_2 have been relatively well studied over the past decade. The impacts of how current environmental regulation and political action to curb climate change will affect CCS have not been thoroughly explored.

This thesis investigates the Environmental Protection Agency's Underground Injection Control Program and several types of protected and restricted land use areas to evaluate where it would be difficult or impossible to site a CCS project. I also explore state-level action on climate change and categorize them based on their attractiveness for CCS projects.

I suggest a methodology for incorporating this regulatory information into a geographic information system based decision analysis tool, designed to aid decision makers dealing with CCS.

Thesis Supervisor: Howard Herzog
Principal Research Engineer, Laboratory for Energy and Environment

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List of Acronyms

BLM	Bureau of Land Management
CCS	carbon dioxide capture and storage
CO2	carbon dioxide
CWA	Clean Water Act
EOR	enhanced oil recovery
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FLPMA	Federal Land Policy and Management Act
FWQA	Federal Water Quality Administration
GAP	gap analysis program
GHG	greenhouse gas
GIS	geographic information system
IPCC	Intergovermental Panel on Climate Change
lbs	pounds
MWh	megawatt hours
NGO	non-governmental organization
OECD	Organization for Economic Cooperation and Development
PWS	public water supply
ROW	Right of Way
SWDA	Safe Water Drinking Act
UIC	Underground Injection Control
UNFCCC	United Nations Framework Convention on Climate Change
USDW	underground source of drinking water

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Finally, I'd like to thank my Dad. He spurred my scientific curiosity as a kid by always answering my questions, and asking some of his own about science and the world.

CHAPTER 1: INTRODUCTION

Climate Change

The economies of industrialized nations' are critically dependent on fossil fuels. Burning coal, oil, and natural gas release carbon dioxide (CO_2), the primary anthropogenic greenhouse gas. Greenhouse gases trap solar radiation in the earth's atmosphere, significantly warming the planet. CO_2 concentrations have risen from pre-industrial levels of about 280 parts per million (ppm) in the atmosphere to 370 ppm today.

Evidence of Warming

In 1895, Svante Arrhenius, a Swedish physicist, presented a paper to the Stockholm Physical Society titled, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground." Arrhenius predicted that a doubling of CO_2 concentrations will rise the earth's temperatures several degrees (NASA). Arrhenius set off a century of scientific controversy over his conclusions. The consensus in the scientific community today is that some of the warming of the past century has been caused by increasing CO_2 concentrations. It is still uncertain how much impact anthropogenic forces can be attributed to warming. It is also uncertain about the future trends of warming or what effect it might have on civilization.

Since anthropogenic CO_2 emissions began to rise rapidly with the onset of the industrial revolution, the earth's climate has been altered, in part due to human activities. Over the 20^{th} century, global mean surface temperature rose $0.6 \pm 0.2°C$. Temperature increase over the 20^{th} century was the largest in the last millennium, and the 1990s were likely the warmest decade of the last millennium (IPCC 2001).

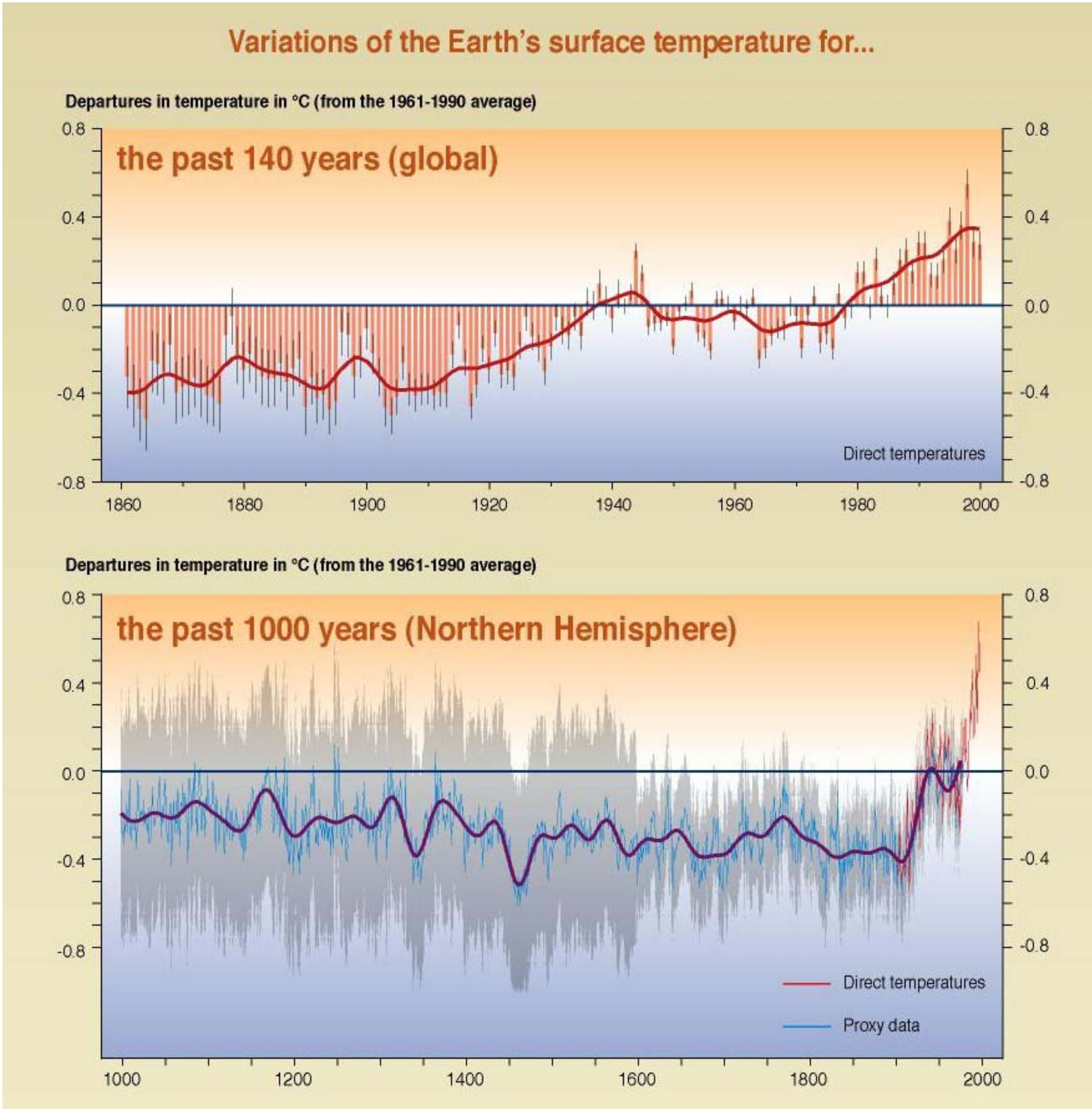

Figure 1. IPCC 2001

Over the 20th century, sea levels rose by 1 to 2 mm annually, artic and glacial ice and permafrost were all reduced substantially, precipitation increased by 5 to 10% in the Northern Hemisphere, heavy precipitation events increased in the Northern Hemisphere, and parts of Asia and Africa experienced more frequent droughts (IPCC 2001). Climate models confirm that humans are having an impact on climate, and natural forcing alone does not explain these events. Consider the following graphs:

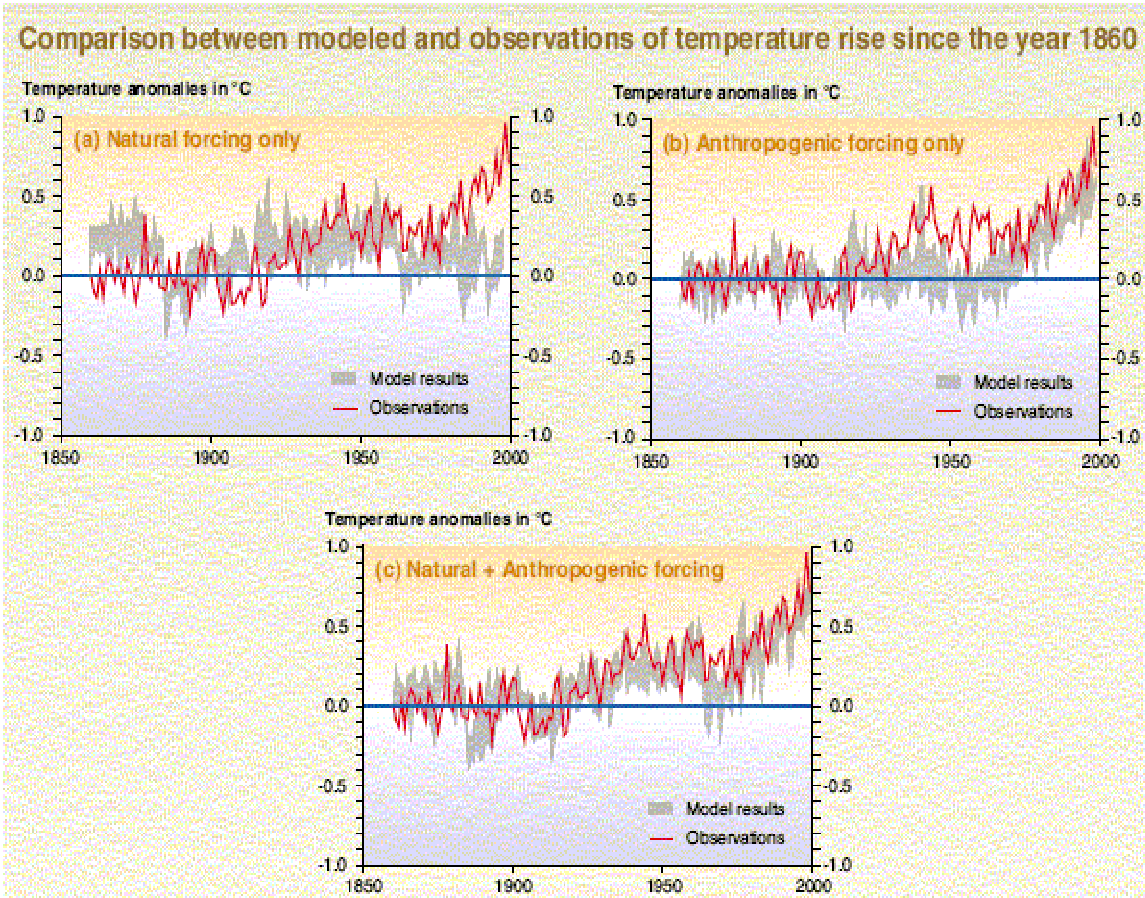

Figure 2. IPCC 2001

Emission Scenarios

The Intergovernmental Panel on Climate Change (IPCC) conducted a scenario exercise to examine potential future emissions concentrations and temperature changes. They project concentrations of 540 to 970 ppm by 2100, resulting in temperature increases of 1.4 to 5.8°C. These scenarios are based on different assumptions of economic structure and growth and assume that no GHG mitigation policies are introduced (IPCC 2001).

Effects of Climate Change

Climate change will have beneficial and negative effects on human health and socio-economic systems. The extreme emissions scenarios, however, are more likely to have strong negative effects and fewer benefits. The threats are particularly acute for poor and vulnerable communities in tropical and subtropical countries (IPCC B, 2001).

Some effects of climate change include:

- Fewer extreme cold days, more extreme hot days;
- Wider geographical range of tropical/subtropical diseases;
- Crop zones shifted towards the poles;
- Possibility for more volatile weather, e.g. increased flooding;
- Sea level rise;
- Potential for the ocean's thermo-haline circulation belt to slow or shut down, causing an abrupt cooling of much of Europe.

Mitigation options

A portfolio of technology options exist that can stabilize atmospheric concentrations of CO_2 emissions at a safe level. Given that countries will continue to pursue strong economic growth policies, they will need to find ways to emit far less CO_2 per unit of GDP. There are several basic paths for doing so.

Energy efficiency can be improved in most sectors of the economy. Efficiency can be improved in the production and manufacture of goods, such as running a new, lean cement plant. The end-use efficiency of goods, such as automobiles and home appliances, can also be improved to yield more benefits while using less energy.

Electricity production can be shifted to lower CO_2 intensive fuels. Switching from coal to natural gas to produce electricity reduces CO_2 emissions by about half. Renewable energy sources such as, wind, solar, geothermal, tidal, and biomass, have no or minimal CO_2 emissions, but are generally more expensive then fossil sources. Nuclear energy is an option for large scale energy production today, but faces significant challenges about public acceptance.

CO_2 can be absorbed from the atmosphere into biomass and the soil. Planting trees, and preserving existing forests takes CO_2 out of the atmosphere. This CO_2, however, is released when the tree dies. Appropriate land management on farms can also sequester CO_2 in the soil.

CO_2 can be captured from exhaust streams of electricity generators and some industrial facilities and stored in geologic formations or the ocean in a process referred to as carbon dioxide capture and storage (CCS). It is this technology that is the focus of this thesis.

Carbon Dioxide Capture and Storage

This thesis will examine some regulatory issues that might effect future deployment of CCS systems. Within the past five years, CCS has begun to be seen as a feasible option for making major CO_2 reductions. The massive capital investments and momentum of the fossil fuel and electricity sectors make CCS an attractive option to continue to use fossil fuels during the transition to a low-carbon economy. Government support in the US has ramped up quickly, the Department of Energy's research budget from $1 million in 1998 to a proposed budget of $49 million in fiscal year 2005 (Connaughton, 2002; DOE, 2004).

Many of the component technologies of a CCS system are mature and commercially available. CO_2 capture technology has been used utilized to remove impurities in natural gas for 60 years. Also, some electricity generators and industrial plants capture CO_2 to use in the food-processing and chemical industries (Anderson 2003). Thousands of miles of CO_2 pipelines are in operation to bring the gas from natural deposits to fatigued oil fields for enhanced oil recovery. Oil producers, industrial and chemical plants, and wastewater managers all inject large volumes of fluids underground to dispose of liquid wastes.

Current estimates put costs of capturing and storing CO_2 at $200 to $250 per ton of carbon stored. Learning by doing and technology improvements have the potential to bring this cost down substantially (Anderson 2003).

Thesis Objectives

This thesis will explore where environmental and health regulations in place today could affect project developers and other decision makers planning CCS projects. I will attempt to draw attention to areas where projects could not be undertaken, and where they might be feasible, but would have to fight time consuming and expensive siting and regulatory battles. Pipeline right-of-ways, injection sites, and storage reservoir locations will be considered against existing regulation.

In particular this thesis will explore:

- The EPA's Underground Injection Control program's regulations that control underground injection of fluids. In addition, I'll layout several options for how CCS might be included in the UIC program.
- Protected area's within the United States where laying pipeline or siting an injection well would be difficult or prohibited. These areas include national parks, national forests, federally owned lands, marine protected areas, land where endangered species inhabit, and densely populated cities.
- State and regional initiatives to decrease CO_2 emissions, as an indicator of the importance a state places on climate change mitigation.
- A methodology for incorporating the types of regulatory and political data listed above into a geographic information system decision-analysis tool.

Motivation

Substantial research has been conducted on technical and economic aspects of CCS. Thus far little attention has been paid to regulatory issues. Regulatory issues will impact CCS project development. Well and pipeline construction requirements, restrictions on project siting, monitoring of injected CO_2, and other factors will all impact a project's financial viability.

This thesis takes a preliminary look at regulatory issues that government planners and project developers are likely to face when deciding where to implement a CCS project.

CHAPTER 2: INCORPORATING REGULATORY AND POLITICAL DATA INTO A GIS DECISION ANALYSIS TOOL

Geographic Information System Overview

A geographic information system (GIS) is a software system that displays and analyzes geographically-referenced data. GIS was initially developed in the 1950s and 60s with government funding (Mark 1997). The Canada Geographic Information System was developed in 1963 to analyze Canada's national land inventory. The following year, Harvard Lab for Computer Graphics was established; where the software foundation for today's GIS technology was developed. The US Census Bureau built the "Dual Independent Map Encoding" in 1967 which powered the 1970's census use of geocoding. Following these technological accomplishments, several commercial GIS firms were founded; most notably Environmental Systems Research Institute (ESRI) and Intergraph (Mark 1997).

Today GIS applications are used by a large and growing number of industries. ESRI is the dominant GIS software company with 35% of global market share (Wire 2001). ESRI's ARC INFO, ARC View, and ARC IMS are the defacto standard platforms for most in the industry. A simplified model of a GIS system is seen in the graphic below:

Figure 3. Simplified GIS Model, MIT Lab for Energy and Environment

Spatial Data

At the heart of all GIS applications is spatial data. Each data point in a GIS can have many attributes associated with it – but all have some form of geographic information. The spatial information is typically represented in relation to a co-ordinate grid (i.e. degrees longitude and latitude). For example, a point can represent a single power plant. The data point would contain the plant's latitude and longitude as well as its vintage, generation capacity, emissions, and other relevant information. A line in a GIS could represent the boundaries of a state park. The line could contain information about the park.

Data Types and Sources

There are two types of data that are used in a GIS: vector and raster. Vector data is represented as lines and points to identify objects. Vector data is typically used when representing things that are not homogenous, or can be represented as discrete objects, such as rivers, city boundaries, or power plant locations.

Raster data divides a dataset into a regular grid of cells. Each grid contains one homogenous set of information per cell. For example, if a region of terrain were to be classified as flat, graded, steep, or very steep – each grid would have one value associated with it. This data type is coarser then vector. Raster data is often derived from aerial and satellite photography.

There are many sources for finding GIS data. In the US, the United States Geological Survey (USGS) has GOS datasets on the natural resources of the country. The US Census Bureau has the most comprehensive set of demographic information in the world. These datasets are available free over the internet.

Private firms sell a wide range of specialty GIS data. Datasets on oil, natural gas, and mineral deposits are widely available because they are of such high value to extraction companies. Marketing data is becoming more widely available as businesses begin to realize the power of employing GIS in corporate planning.

Layers

Information in a GIS is represented and stored in *layers*. A layer contains one type of data. Multiple layers can be laid over each other to perform analysis and see relationships. The layer structure allows for flexibility and the ability to re-use information in other applications. Layers can be swapped in and out of an application quickly and easily. It is also a convenient method for storing geographic information.

Lets consider a simplified model of an electric utility using GIS to plan upgrades to their network. The GIS operator would obtain the necessary data layers from data warehouses. One layer would have information on existing power plants. The plant layer would describe who owns them, their generating capacity and other details. A second layer would contain data on existing transmission and distribution power lines. These lines would be represented by a vector line with information describing its voltage, capacity, and other relevant information. A third layer would represent population density in city block sized grids, stored in raster format, that would have electricity demand associated with it.

Analysis

GIS is much more then map-making software. Relationships between spatial data can be manipulated and analyzed in many powerful ways. Common applications include logistics, routing, population shifts, business planning, ecological studies, and much more. A simple example of GIS analysis is seen in the map below. In this map, brine aquifers were sorted by depth, and represented as seen here:

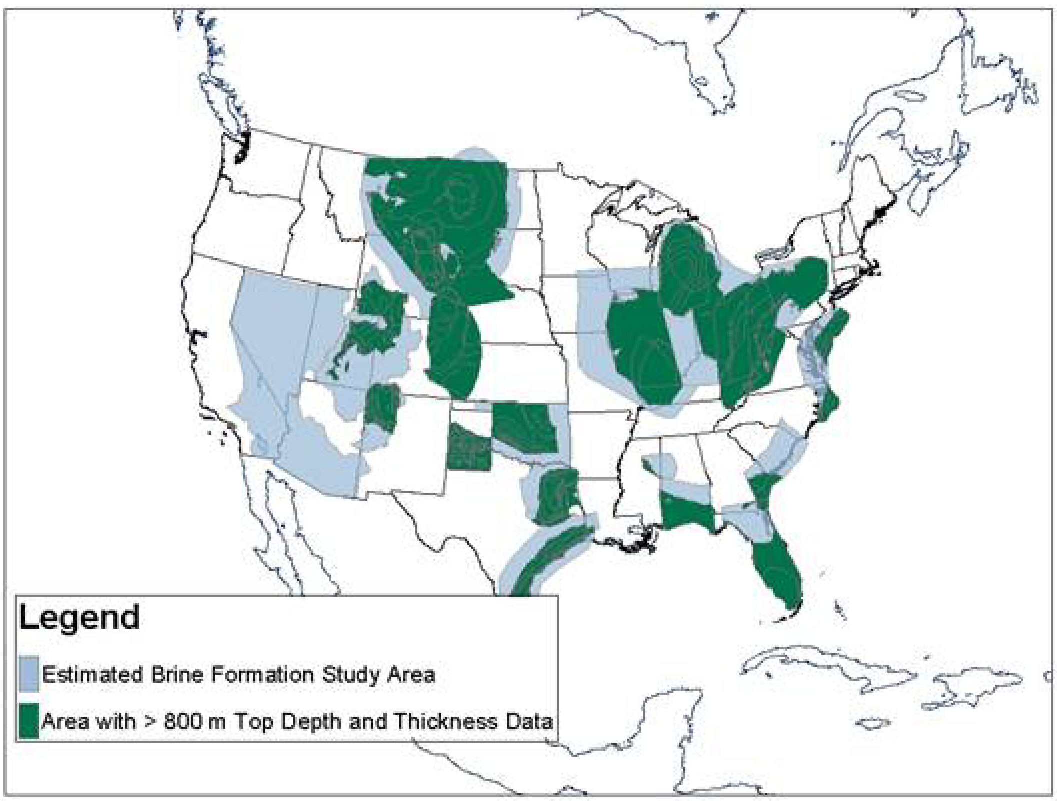

Figure 4. Brine Aquifers Represented in a GIS, Hovorka, 2003

To take another simplified hypothetical example, if a nationally franchised coffee shop wanted to open a new store in Boston, they could use GIS analysis tools to select the best locations. The GIS could provide a short list of properties for an agent to investigate.

In our coffee shop example, the company would collect relevant data layers for Boston. They would include existing coffee shops and restaurants, population density, available properties and their prices, zoning regulations, a property's proximity to a subway stop, and other factors that influence siting the shop.

An algorithm would be developed that evaluated various characteristics of a property and ranked each. For example, the closer the property to a subway stop, the higher its rank in that category. Other factors such as number of competitors, average income, and traffic patterns would all be rated. Someone in the company experienced in what makes for a good location would help weight the importance of these different factors in the algorithm. The GIS would calculate the highest ranking properties.

GIS offers the benefit of complex, multi-layer analysis that can recognize patterns and relationships that would be difficult or impossible for humans. GIS also works very fast compared to humans.

MIT Carbon Dioxide Capture and Storage GIS Decision Analysis Tool

Researchers at MIT's Carbon Sequestration Initiative are developing a GIS decision analysis tool to help decision makers identify early opportunities for carbon dioxide capture and storage (CCS) projects. The system will be accessible over the internet using ESRI's ArcIMS technology.

The first version of the system will enable users to select a CO_2 source such as a power plant or ammonia plant and match it to the best sites for geologic storage. The system will also evaluate the least cost pathways to lay the CO_2 pipeline between the source and sink.

Future versions of the tool will include the ability to calculate marginal CO_2 abatement curves for a region of the country. It will also be able to analyze multiple sinks and sources in a region. The system will eventually be upgraded to utilize a systems dynamics approach, which will analyze CO_2 stocks and flows within a network.

Data

The MIT GIS incorporates data on sources of CO_2, potential sinks, the grade of the terrain, and relevant regulations. The primary CO_2 sources in the database are for power plants, natural gas processing facilities, ammonia plants, cement plants and several other industrial facilities. The data on power plants comes from the US Energy Information Agency's E-Grid database. The other facilities come from a database prepared for the International Energy Agency's Greenhouse Gas Program by the consulting firm Ecofys (Ecofys, 2002).

Potential sinks include brine aquifers (i.e. aquifers with salty, undrinkable water), depleted oil and gas fields, and unminable coal seams. These datasets come from various US Federal agencies and academic databases.

Data on the grade of the terrain was obtained from the US Geological Survey (USGS). Regulatory information was gathered from primarily from the USGS and the Pew Center on Global Climate Change (USGS, Pew, 2004).

Cost layers

When a decision maker is considering implementing a CCS project, cost will be the biggest driver. Any CCS project undertaken today is likely to be a demonstration project with subsidies from the government. In the future, laws requiring a limit on CO_2 emissions will prompt firms to find the lowest cost emissions reduction options.

Our GIS tool evaluates the viability of a source/sink combination based on a representation of costs to capture, transport, and inject the CO_2.

A geographical area under consideration for a project is broken up into grids. Each grid has a total cost associated with it. The GIS uses a route optimization function to calculate the lowest cost path between any particular CO_2 source and the nearest sink. The cost of the entire path is summed. The same CO_2 source is compared with all nearby sinks within a set distance. The source-sink pair that has the lowest total cost path is identified as the best potential source/sink match. The financial cost of implementing the project can then be estimated.

Several techno-economic parameters are used to create the cost layers. The main three cost considerations are listed below:

- Capture cost of the CO_2, this is based on the type and engineering characteristics of the facility;
- Transport costs, based on the length and width of the pipeline and slope of terrain (i.e. its more costly to lay pipe on a steep surface). In addition, river, railroad, and highway crossings all increase the cost.
- Injection costs, based on the measure of injectivity (how hard it is to pump the liquid underground).

Regulatory and Political Data in the MIT GIS

Regulatory and political factors will have an effect on CCS projects. These considerations are sometimes referred to as “soft” data because they are difficult to include in a quantitative project analysis. In this thesis, I try to establish a methodology for including regulatory and political factors into our GIS. In this thesis I examine how regulatory and political data can be represented in our GIS tool. These data types will be treated as part of the cost layer. This data can reduce, increase or have no impact on a grids cost.

There are numerous examples of how regulatory and political factors will influence CCS projects. A representative sample is listed below:

- States with pro-active environmental policies may give incentives to projects that offset CO_2.
- States with particularly strict laws or not familiar with regulating underground injection might raise project costs substantially.
- State agencies with a low capacity for regulating health, safety and environment issues could lengthen and complicate the permitting process for project developers – substantially increasing costs.
- Restricted wilderness areas, national parks, projected marine areas, land surrounding species on the endangered list, and certain protected critical habitats (e.g. certain wetlands) are off-limit to project development.

This thesis will not recommend specific values that should be attributed to regulatory and social data in the cost layer. Determining values could be a next step in developing the GIS system.

Current System

Some of these regulatory data sets will be incorporated in the analysis algorithm used in the current implementation of the GIS analysis tool. For example, we know that project developers can not lay a pipeline or drill an injection well in an area designated as a wilderness area. These areas will be assigned a cost of infinity and thus will not be considered viable for an injection area. When the system calculates pipeline routes, it will have to route around these protected areas. The following sections will more fully develop these concepts for each dataset.

Other information that has less clear implications for projects will not be incorporated into the cost-layer algorithms for this version. The information will still be included in the GIS. It will be available to inform decision makers and allow them to draw their own conclusions.

CHAPTER 3: THE UNDERGROUND INJECTION CONTROL PROGRAM

Groundwater overview

The U.S. has grown more dependent on groundwater for domestic and agricultural use over the 20th century. By the 1970's, almost 90% of the U.S. population relied on groundwater (Apps 2004).

Injection well history

Underground injection of wastewater began in the 1930s by the oil and gas industry. Today several types of wastewater are injected underground including brine water from oil production, municipal waste (i.e. lightly treated sewage), and non-hazardous and hazardous liquid industrial wastes.

Oil Fields

When oil is extracted a large quantity of brine water comes up with it. Prior to the 1930s producers disposed of the brine on the surface in ditches to evaporate. It was discovered that this contaminated shallow aquifers and caused health problems (Brasier 1996). Producers began to reinject the brines into depleted reservoirs.

Enhanced oil recovery, the practice of injecting fluids into fatigued oil fields to enhance production, probably began in the 1930s (EPA unknown). The U.S. oil and gas industry operate approximately 167,000 injection wells injecting over 2 billion gallons daily (EPA unknown).

Industrial Waste

The first reported injection of industrial waste was by Dow Chemical in 1939 (Harlow 1939). The growth of industrial waste injection wells has been rapid since the end of WWII. In 1950 there were about five waste injection wells. This number rose to about 333 by 1974 (Wilson) and 473 today (EPA 2001). The volume of waste injected is about 9 billion gallons annually (Apps 2004).

History of UIC Regulation

Regulation of underground injection began when the Kansas State Corporation Commission began to regulate oilfield brine injection in 1934. In 1961 the Texas Railroad Commission was the first to regulate other types of injected waste under the Texas' Injection Well Act. Ohio, Michigan, West Virginia, New York, and Colorado began to regulate underground injection during the late 1960s. Missouri and North Carolina banned underground waste disposal outright in the early 1970s (Walker 1976).

Questions about the safety of underground injection began to arise in the late 1960s. In April 1968 an injection well operated by Hammermill Paper Company in Pennsylvania ruptured and released pulping liquor onto the ground and into Lake Erie. Its suspected, but never confirmed, that a noxious liquid found five miles away at Presque Isle State Park originated from the Hammermill leak. Well failures also occurred in Beaumont and Odessa Texas that resulted in drinking water contamination (Tsang 2001). In the 1960s an injection facility at the Rocky Mountain Arsenal is suspected to have caused a series of earthquakes; one measured 5.5 on the Richter scale (Wilson 2003).

Federal regulators responded to these problems through a policy statement by the Federal Water Quality Administration (FWQA) in October 1970 that "opposed the disposal or storage of wastes by subsurface injection without strict controls and a clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters or otherwise damage the environment" (Herbert 1996). FWQA's policy stated that subsurface waste injection was to be used as a temporary measure until better alternatives were developed. The FWQA was merged into the newly formed EPA in December 1970.

The EPA first tried to regulate underground injection in 1973 under the 1972 Clean Water Act (CWA). EPA ran into legal problems trying to regulate injection in EXXON vs. EPA in 1973. The CWA protects the "navigable waters of the US", which prevented EPA from regulating underground injection under CWA (Wilson 2003).

Congress extended EPA's authority to regulate underground injection in 1974 by passing the Safe Water Drinking Act (SWDA) that "authorizes the EPA to establish federal standards applicable [to public water systems] for protection from all harmful contaminants, … and establish a joint Federal-State system for assuring compliance with these standards and for protecting underground sources of drinking waters". Part C of the SWDA established the Underground Injection Control (UIC) program. EPA promulgated the rules for the UIC program in 1980.

UIC Program Overview

The UIC program regulates injection of wastes into the subsurface to protect current and potential sources of drinking water. EPA defines an underground source of drinking water (USDW) as an aquifer that supplies a public water system (PWS) or contains enough water to supply a PWS; currently supplies drinking water for human consumption or contains water with less than 10,000 milligrams/liter of total dissolved solids (40 CFR 144.3).

The UIC divides underground injection into five major classes. The nature of the waste and its disposal location determine what class an injection project will fall under.

Table 1. UIC Well Overview

Class I wells are technologically sophisticated and inject hazardous and non-hazardous wastes below the lowermost underground source of drinking water (USDW). Injection occurs into deep, isolated rock formations that are separated from the lowermost USDW by layers of impermeable clay and rock.

Class II wells are oil and gas production brine disposal and other related wells. Operators of these wells inject fluids associated with oil and natural gas production. Most of the injected fluid is brine that is produced when oil and gas are extracted from the earth (about 10 barrels of brine for every barrel of oil). Enhanced oil recovery projects also fall under Class II.

Class III wells are wells that inject super-heated steam, water, or other fluids into formations in order to extract minerals. The injected fluids are then pumped to the surface and the minerals in solution are extracted. Generally, the fluid is treated and re-injected into the same formation.

Class IV wells inject hazardous or radioactive wastes into or above underground sources of drinking water. These wells are banned under the UIC program because they directly threaten public health

Class V wells are injection wells that are not included in the other classes. Generally, they are shallow and depend upon gravity to drain or "inject" liquid waste into the ground above or into underground sources of drinking water. Experimental UIC projects are also given Class V status.

Adapted from EPA UIC Program http://www.epa.gov/safewater/uic/classes.html

Primacy

States can apply to the EPA to run their own UIC programs, if they meet basic proficiency criteria. Currently 34 states run their own program, 6 share responsibility with the EPA, and 10 are administered directly by the regional EPA office (Wilson 2003). States may apply more stringent rules for their own UIC programs. States with primacy write their own regulations concerning whether underground injection will be allowed, what types of activities will be allowed, the permitting process, and other aspects of the UIC program.

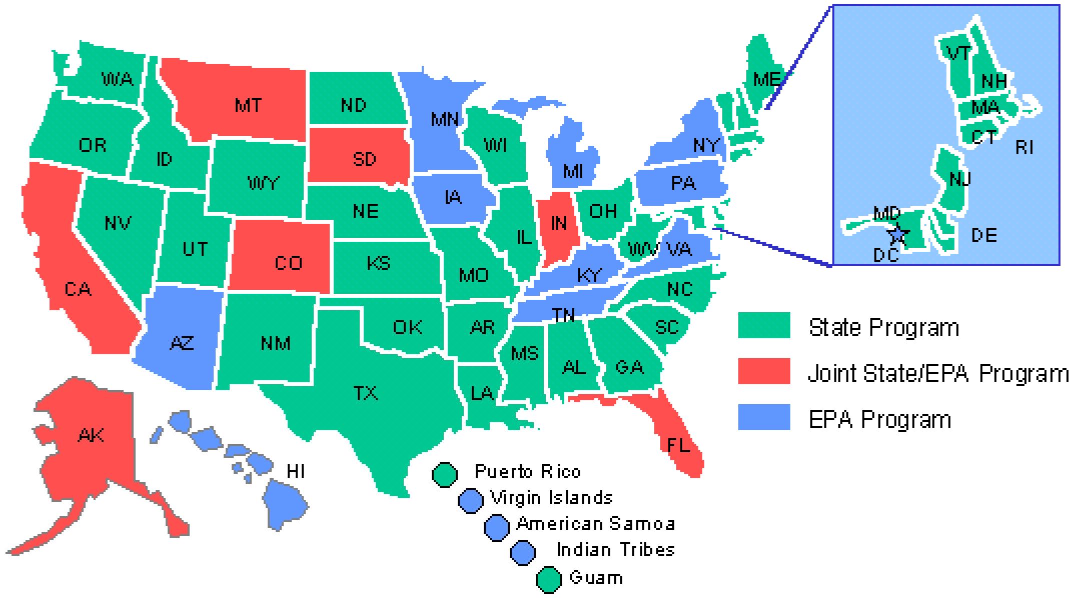

Figure 5. Map of States with UIC Primacy, EPA

Class I Wells

Class I wells inject either industrial or municipal waste beneath the lowermost USDW. Industrial waste is classified as either hazardous or non-hazardous based on the characteristics of the wastewater. Currently, there are 473 Class I wells in the U.S., 123 hazardous and 350 non-hazardous or municipal (EPA 2001). Typical well depths range from 1,700 to 12,000 feet (EPA 2001). Texas, Louisiana, Florida, and Kansas are the top four states with the most Class I wells.

Class I wells are the most stringently regulated well class. Siting a Class I hazardous well can cost $2 million, involving 11,000 hours of technical work (EPA 2001). Typically, class I wells are regulated by state departments of environment or natural resources (Wilson 2003). Figure 6 shows the distribution of Class I wells in the US.

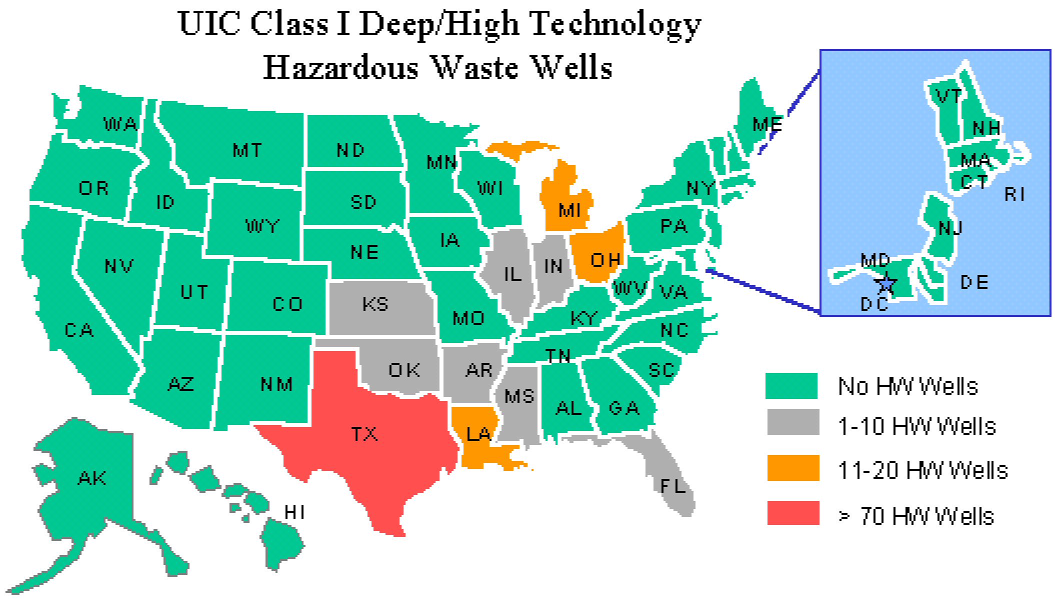

Figure 6. EPA

Class I Municipal Wells

The only state that has Class I municipal wells is Florida. They inject lightly treated sewage into porous underground formations. These wells may be the most analogous to injected CO_2 because the sewage is less dense then surrounding fluids and has an upwards bouncy driven flow. CO_2 is even less dense then sewage at these depths and will have an even stronger tendency to rise.

Geologic requirements for Siting

Class I wells must be sited so that they inject wastes into geologic formations able to safely contain their waste. Extensive testing is required to ensure that the injection zone is large enough and has acceptable porosity and permeability to accommodate the waste. The injection zone must be overlain by at least one layer of relatively impermeable rock to prevent the wastes from moving upwards (EPA 2001).

Class I wells require project developers to submit detailed geologic and hydrologic data. They must show that the geologic formation is homogeneous, does not contain faults and is separated from drinking water supplies by thick layers of strata. This is to prevent leakage into drinking water supplies. Class I wells are sited so if any one component of the system fails, the fluid remains in the intended subsurface layer (EPA 2001).

The project manager must also prove that there are no abandoned, unplugged wells around the injection site in a zone called the area of review (AoR). The AoR for non-hazardous wells is a minimum one quarter mile radius from the well and a minimum of two miles for hazardous wells. States often increase the AoR to improve safety. In Texas the AoR is 2.5 miles, 2 miles in Louisiana, and 1 mile in Florida and Kansas (EPA 2001). These four states contain 70% of the nations Class I wells.

Additional Geologic Siting Requirements for Class I Hazardous Wells

Class I hazardous wells must file for a no-migration petition. The developer must demonstrate that the injected waste will not leave the injection zone for 10, 000 years. A petition is a massive complex technical analysis detailing construction, the waste, geology, and hydrology. Sophisticated computer modeling of the underlying hydro-geologic data is required for a permit.

Well Construction

The Class I wells must adhere to strict construction requirements that improve their safety performance. Wells are required to have an inner and outer casing that prevents the hole from caving in. It also stops the wastes from migrating to ground water in case of well failure. All materials must be corrosion resistant.

Operation requirements

Class I well operators must continuously monitor injection pressure, flow rate, and volume. Class I hazardous wells must have alarms and automatic shutoff switches if acceptable pressures are exceeded (EPA 2001). They are also required to monitor USDWs that are within the wells AoR. Mechanical integrity tests of the wells are required every five years for non-hazardous wells, and every year for hazardous wells.

Class II Wells

Class II wells are oil and gas production, brine disposal, and other related wells. Operators of these wells inject fluids associated with oil and natural gas production. Most of the injected fluid is brine that is produced when oil and gas are extracted from the earth (about 10 barrels of brine for every barrel of oil). Many Class II wells are enhanced oil recovery projects. Two billion barrels of brine are injected daily in Class II wells (EPA unknown).

Class II wells must follow the same construction requirements as Class I non-hazardous wells. Class II wells typically have less stringent permitting requirements than Class I wells, making them less expensive. Figure 7 shows the distribution of Class II wells in the US.

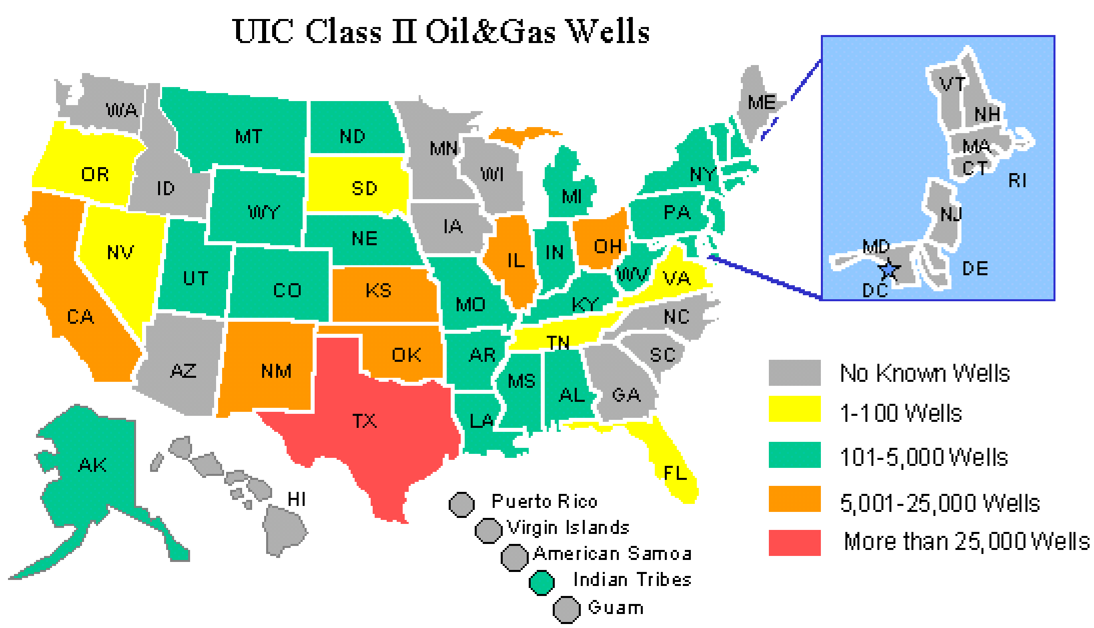

Figure 7. EPA

Class V Wells

Class V wells are injection wells that are not included in the other classes. Generally, they are shallow and depend upon gravity to drain or "inject" liquid waste into the ground above or into underground sources of drinking water. Some Class V wells inject below and directly into USDWs. To classify as a Class V well, the injected material can not be a hazardous waste as defined under the Resource Conservation and Recovery Act. Experimental UIC projects are often given Class V status.

The EPA estimates that there are 686,000 Class V wells in the US. There are 23 categories of Class V wells. The two largest categories are: storm water drain wells (approximately 248,000) and large septic systems (approximately 353,000) (EPA 1999).

Regulations on Class V wells vary widely state-by-state. The regulatory schemes used to control Class V wells include, but are not limited to the following (EPA 1999):

- General authority to protect USDWs with discretionary authority;
- Permit by rule, meaning that an entire category of wells is permitted assuming they comply with technical specifications
- An identical or general permit, meaning that a permit is issued for each well within a category;
- Authority to issue site-specific permits, make inspections, and take enforcement action if necessary.

An overview of all the categories of Class V wells is found in Appendix C. It includes the number of wells documented, characteristics of the well category, and state specific regulations for that well category.

Discussion

The discussion in this chapter will explore three points:

- How to incorporate regulatory information about the UIC program in a geographic information system.

- How CO_2 projects could be classified under the UIC program.
- Issues surrounding CO_2 injection beyond the scope of the UIC program.

Regulatory Data for the GIS

State's regulatory capacity

Data on the UIC program is incorporated into our GIS system based on an approximation of a state's capacity to run their UIC program. States are categorized as having low, medium, or high capacity. States were categorized by combining the number of Class I and II wells in each state. States with no wells are ranked as low, those with a minimal number are ranked medium, and the states with the most wells are ranked high. States with a high ranking will show up as slightly more attractive project sites and those with low ranking will show up as slightly less attractive.

Primacy

Primacy states are more likely to have a higher capacity for dealing with UIC projects. Non-primacy states have to deal with EPA regional offices for their UIC permit, which adds additional bureaucracy and increases permitting time. This suggests that primacy states would be preferred for CCS projects. However, due to the potential for stricter regulations state-by-state, primacy states are not necessarily preferable for CCS. Also, the capacity of state regulatory offices will vary state-by-state.

Given these circumstances, a state's having primacy or not having primacy is weighted neutral in our GIS system. Future work could examine the stringency of state UIC regulations and the capacity of their regulatory agency. This data could then be incorporated into the GIS system.

What Class for CO_2?

Today, it's unclear how CO_2 injection for long-term storage will be regulated. It's safe to assume that CO_2 injection will fall under the regulatory authority of the UIC program. It seems likely that states that have been granted primacy will be delegated responsibility for running their own UIC CCS program.

Regulators at EPA are currently considering what UIC regulatory regime is appropriate for CCS. They held a stakeholder meeting in February 2004 to get input from researchers and regulators from EPA, DOE, and state agencies.

State-level regulators are also working on the issue independently through the Interstate Oil and Gas Compact Commission. They have been working on this issue since 2002 and feel that the states should be responsible for designing and implementing UIC regulations for CCS.

There are several paths UIC regulations could go for CCS. One potential path is to delegate responsibility to the states. States could choose to regulate CO_2 storage as they see fit. Projects could be regulated based on the nature of the project. Enhanced oil recovery (EOR) projects could be regulated under Class II rules, and through the agency responsible for Class II regulations. CO_2 injected into deep brine aquifers could be regulated as a Class I well, and by the appropriate state agency.

Different state agencies are often responsible for regulating Class I and Class II wells. Class I is often controlled by a states environmental, or national resource office, while Class II are controlled by a state's hydrocarbon agency. This approach works well because the agencies involved will be most familiar with the type of injection activity.

Another possibility is that federal regulators can decide that CCS projects will be regulated as either Class I or Class V, and introduce a new category with rules specific to CCS.

A final and unlikely option is to create a sixth class specifically for CO_2 storage. This could contain within it several categories based on what type of project is being considered (e.g. EOR, storage in brine aquifers, storage in unminable coal beds). This option has not been discussed by regulators or academics working on the issue, and is only speculation on the author's part.

Granger Morgan of Carnegie Melon University believes that today's UIC regulations which are based on design standards (detailing well-construction, geologic siting, etc) will not be adequate for CCS. Dr. Morgan feels that CO_2 injection and storage will be sufficiently different than today's operations to warrant a new regulatory approach. He feels that UIC rules should be performance-based (e.g. mandating an acceptable leakage rate). This should allow project developers more flexibility and ensure the environmental goals are met (Morgan, personal communication).

Class I

John Apps from the University of Berkeley has argued that CO_2 storage should be regulated similar to Class I hazardous wells. This argument is prefaced on Class I hazardous requirements that the geologic formation will not leak the injectate for 10,000 years. CO_2 must also be kept contained for long time periods. He also cites that CO_2 is less dense then its surrounding environment, and thus will always try to migrate upwards (Apps 2004).

In a paper by Tsang and Benson, also from Berkeley, they say that Class I wells are the most relevant to CO_2 storage. Their argument is that CO_2 will likely be stored at depths greater than 800 meters, where it reaches supercritical state and is easier to store. Most drinking water aquifers are shallower then 800 meters. Class I wells regulate injection below USDWs. They do not feel that the strict "no-migration" requirements of Class I hazardous projects are required. Low levels of CO_2 entering USDWs are not likely to be a problem (Tsang 2001).

Class V

The Texas Bureau of Economic Geology is conducting an experiment to store CO_2 in a saline aquifer. They received a Class V permit from Texas regulators. A Class II permit was ruled out because their experiment did not deal with liquid hydrocarbons. Regulators felt a Class I permit was not necessary because of the relatively small volume injected, the benign nature of CO_2, and the states large experience with EOR projects.

How CCS is Different: CO_2 Accounting

At some point in the future, CO_2 and other greenhouse gases will be regulated in the US. Investors will be able to receive credit for CO_2 they store underground that would otherwise have ended up in the atmosphere. These credits will have some monetary value. When offset CO_2 has a value, detailed accounting rules will be required.

Rules for accounting for, monitoring, and verifying CO_2 offsets will be required by the congressional act that authorizes a cap or tax on CO_2. These rules will be needed for companies to meet their obligations for CO_2 reductions or to participate in a market based cap-and-trade system. The Environmental Protection Agency (EPA) is currently tasked with keeping the nation's CO_2 inventory. The EPA will be probably also be required to promulgate accounting rules.

Although monitoring and verification of CO_2 won't be the responsibility of the UIC program, a nationally consistent set of CO_2 reporting and monitoring standards will facilitate CO_2 accounting when it happens.

EPA officials working to write the UIC rules for CCS should collaborate with their colleagues responsible for the CO_2 inventory. Monitoring and accounting rules could be written into the UIC program that would make it relatively simple to include CCS projects later when CO_2 is regulated.

How CCS is Different: Risk of Surface Leaks

The mandate of the UIC program is to protect current and potential sources of underground drinking water. It doesn't deal with the risks of the waste migrating upwards and releasing onto the surface. The closest example of this is Florida's Aquifer Storage and Recovery sites where they inject treated municipal waste into underground limestone aquifers. Some waste has been found to have migrated into shallow drinking water aquifers. None has yet migrated to the surface.

A discharge of CO_2 to the surface would have two types of risks associated with it. The first is a global risk. That is, the purpose for storing the CO_2 was to keep it out of the atmosphere to reduce climate change. This released CO_2 would then contribute towards climate change by trapping additional radiation in the atmosphere. This issue should be included in the discussion of CO_2 accounting rules discussed above.

Then there's in-situ risk. At the surface CO_2 is denser then air. In low laying areas, CO_2 can accumulate in a pool. The Office of Health and Safety set the maximum average CO_2 exposure to be 0.5% for an 8-hour workday. Short-term exposure at levels of 1 to 5% can cause physiological effects, you lose conscience at concentrations above 10%, and can die above 30% (Forbes, 2002).

Because of CO_2's buoyancy at depths of 800 meters and deeper, UIC regulations for CCS could choose to consider the global and in-situ risks. EPA officials writing UIC rules for CCS should also collaborate with environmental officials dealing with exposure risks at the surface in designing UIC regulations.

It is unclear if CCS project developers will have to demonstrate that CO_2 won't pose a surface risk to the agency responsible for the UIC program, the state health and environment agency, or both.

CHAPTER 4: PROTECTED AREAS

Overview

Not all land in the United States is equal. A combination of ownership and regulation dictates what a parcel of land can be used for. In most communities the local government sets zoning regulations that determine if an area is zoned for commercial or residential development.

Regulations are in place at the local, state, and federal levels that restrict or prohibit development on protected parcels of land. These regulations vary in how stringent they are. In some areas, they require project developers to meet minimum standards on safety and environment before receiving permits needed to start construction. Other regulations prohibit any development activity in protected areas.

These regulations exist to serve several policy goals. Some are written to protect the environment by preserving critical eco-systems and protecting species endangered by extinction. Other regulations protect land in order to provide outdoor recreation, manage forest and grasslands sustainably, and set aside unspoiled wilderness areas to be appreciated by generations to come.

In this chapter, I discuss how land-use policies that constrain or forbid development projects are likely to effect carbon dioxide capture and storage projects in the future. I will also explore how this information can be incorporated into our GIS decision analysis tool as described in Chapter 2.

In the following section I will describe in further detail how the GAP dataset can be used to analyze land management policies in a GIS. In addition, I'll talk in more detail about certain of the regulations in the GAP database. It's important to understand the forces behind our decisions to preserve land. Its also important to understand how these preservation policies are operating today. For example, the US Forestry Service is supposed to foster sustainable dual-use land purposes. In practice, bloated bureaucratic procedures and other factors make projects in national forests long difficult affairs.

Background of the Conservation Movement

America has a rich history of environmental conservation. In the early 19th century, America was still searching for ways to define herself. America needed to create an identity separate from Europe.

At the time, most Americans lived on the east coast. Niagara Falls was the most impressive natural phenomenon in the area. As early as 1834 the falls were being overrun by merchants, tour-guides, and makeshift restaurants. People debated the need to protect this national treasure vs. the American spirit of freedom of action (Runte 1997).

Origins of the National Parks

The concept of establishing a system of national parks is attributed to George Catlin. He traveled to the Dakotas in 1832 and was awestruck by the beauty of what he saw in both the landscape and Native American culture. He wrote that this might be preserved "by some great protecting policy of government... in a magnificent park.... A nation's park, containing man and beast, in all the wild and freshness of their nature's beauty!" (Mackintosh 1999)

In 1864 Congress donated Yosemite to the state of California. It was given in order to be protected as a State Park. In 1872 Congress set aside the Yellowstone area for preservation. It was located in the Wyoming and Montana territories, so it remained under the control of the US Interior Service. Yellowstone marked the first national park in the United States (Mackintosh 1999).

Conservation at the Turn of the 20th Century

President Theodore Roosevelt placed a high emphasis on environmental conservation. During his presidency from 1901 to 1909 he added five National Parks, four Big Game

Refuges, fifty-one National Bird Reservations, and the National Forest Service. He believed in sustainable use of our nation's natural wealth, and appointed Gifford Pinchot to head the Forest Service (Filler 1995).

Figure 8. Muir and Roosevelt at Yosemite, Wikipedia

By 1916 the Department of the Interior was administering 14 national parks and 21 national monuments. They had no institutional framework in place, and no clear guidance from Congress on how to manage them.

Two factions of environmental preservation groups had very different ideas on how our protected land should be handled. One faction was led by John Muir. Muir felt that nature should be preserved in its natural state. The second faction was led by Pinchot. Pinchot, like Roosevelt, advocated for “wise use” policies that would allow for limited commercial and recreational activities on preserved land.

This schism came to a head over the issue of whether or not to dam Yosemite's Hetch Hetchy Valley for a reservoir to serve San Francisco. Muir fought the idea while Pinchot lobbied for it. Pinchot won the battle and Congress permitted the dam in 1913. The outrage that resulted from the dam helped Steven Mather to successfully lobby President Wilson and the Congress to create the National Park Service within the Interior Department (Mackintosh 1999). The map below shows where the National Parks are today.

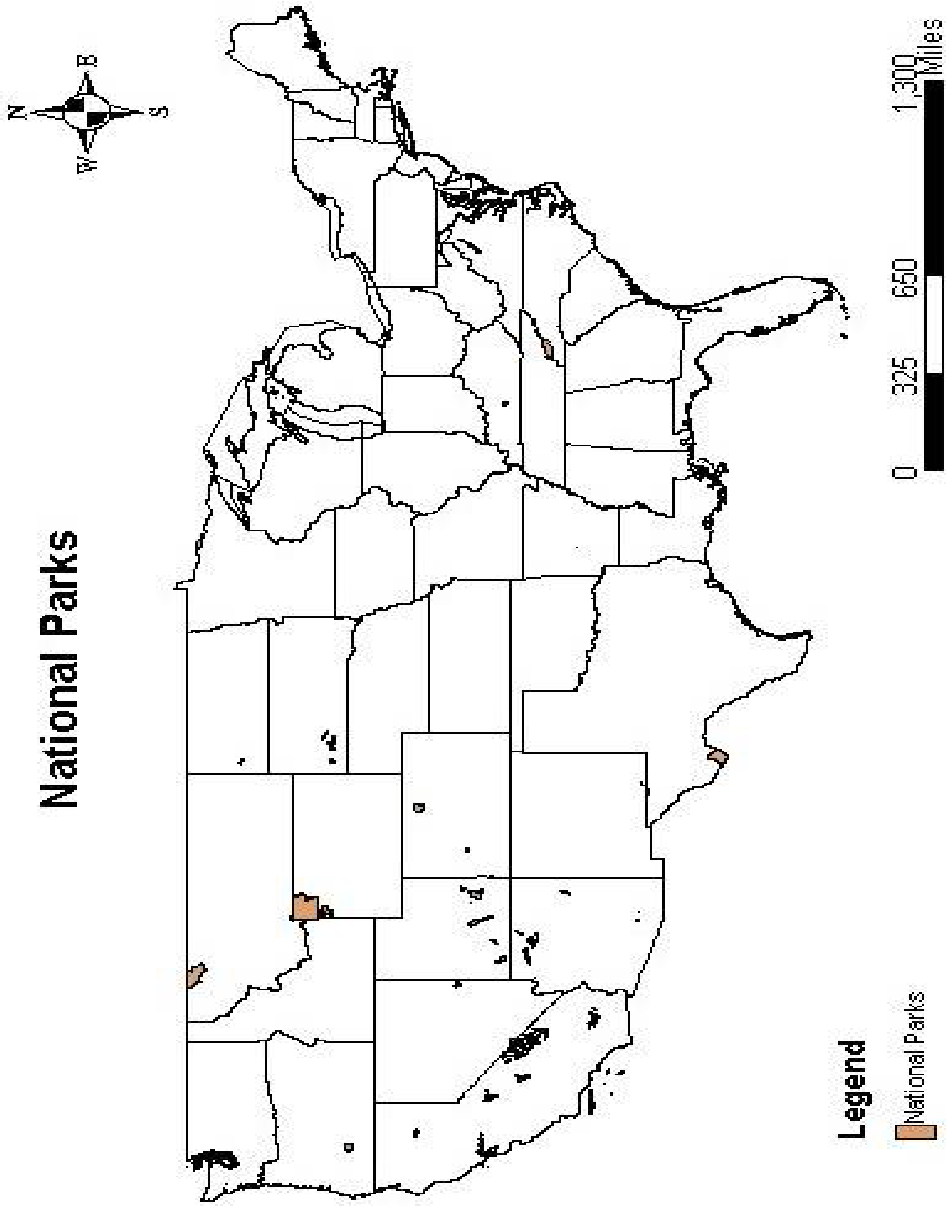

Figure 9. National Parks, USGS

This chapter will discuss the following:

- National Parks
- GAP Analysis
- Bureau of Land Management lands
- Endangered Species Act
- National Wildlife Refuge Program
- Roadless Area Conservation
- Pipeline Right of Ways

Land Use Today: GAP Codes

The United States Geological Survey uses a method called GAP Analysis to help preserve endangered species and threatened habitats. Gap analysis is a tool for environmental planners to proactively protect biodiversity. It seeks to identify gaps between land areas that are rich in biodiversity and areas that are managed for conservation (Crist 2000).

GAP analysis was developed throughout the 1980s by J. Michael Scott as a way to plan for conserving bird's habitats in Hawaii. He later brought this technique to the University of Idaho Cooperative Fish and Wildlife Research Unit. The US Fish and Wildlife service ran a pilot project using Scott's methods. Today there are GAP projects in all 50 states and more than 500 local, state, federal, and private organizations participate.

There are three basic steps to performing a GAP analysis (Crist 2000)

- *Step 1:* map vegetation to the alliance level. Alliances are natural assemblages of plant species. This helps characterize the physical and chemical factors that shape an area's environment.

- *Step 2:* map the predicted distributions of all terrestrial vertebra.

- *Step 3:* delineate land stewardship at one of four levels.

The GAP system is useful to planning a CCS system in two ways.

First it can show where species on the endangered list are "predicted" to be. The data is represented in 90 meter square grids. The data is presented as a binary code (1: species predicted to be there and 0: species not predicted to be there) (Brannon 2004). GAP isn't set up to pick out endangered species yet, but if a database of endangered species were cross referenced with a GAP database, a layer of endangered species could be produced. One problem with this idea could be if the species are represented differently between the two databases.

Second, the delineation of land stewardship will show where project development could not occur for CCS projects. Land management status is classified as being Status I, II, III, or IV.

Definition of GAP codes

The management status (land stewardship) categories are defined as (Crist 2000):

- **Status 1**: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

- **Status 2**: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.

- **Status 3**: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.

- **Status 4**: There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout."

Table 2. GAP Land Management Description

GAP Land Management Description (Crist 2000)	GAP Status
Federal Lands[1]	1,2, or 3
Bureau of Land Management (BLM)	1,2, or 3
Area of Critical Environmental Concern (ACEC)	1 or 2
Globally Important Bird Area	1,2, or 3
National Conservation Area	1,2, or 3
National Monument	1,2, or 3
National Natural or Historic Landmark	1,2, or 3
National Outstanding Natural Area	1,2, or 3
National Recreation Area	2 or 3
National Scenic-Research Area	1,2, or 3
Research Natural Area (RNA)	1
Significant Cave and Cave System	1,2, or 3
Wild, Scenic, and Recreation River	1,2, or 3
Wilderness Area	1 or 2
Wilderness Study Area (WSA)	2 or 3
World Heritage and Biosphere Site	1,2, or 3
Bureau of Reclamation (BOR)[1]	1,2, or 3

National Recreation Area	2 or 3
Wildlife/Recreation Management Area	1,2, or 3
Fish and Wildlife Service (FWS)	1,2, or 3
National Wildlife Refuge (NWR)	1,2, or 3
Waterfowl Production Area	1,2, or 3
Wilderness	1,2, or 3
Conservation easement	1,2, or 3
Forest Service (USFS)	1,2, or 3
Archaelogical Area	1,2, or 3
Botanical Reserve	1 or 2
Geological Area	1,2, or 3
Municipal Watershed	2
National Game Refuge	1,2, or 3
National Monument	1,2, or 3
National Primitive Area	1,2, or 3
National Recreation Area (NRA)	2 or 3
National Scenic-Research Area	1,2, or 3
Research Natural Area (RNA)	1
Wild and Scenic River	1 or 2
Wilderness Area	1 or 2
Wilderness Study Area	2 or 3
Department of Defense (DoD)[1] and Department of Energy (DOE)	**1,2, or 3**
Ecological Reserve	1,2, or 3
National Wildlife Refuge Overlay	1,2, or 3
Special Resources Area/Research Natural Area	1,2, or 3
Army Corps of Engineers[3]	?
Department of Energy (DOE)	?
National Park Service (NPS)[1,2]	1,2, or 3
International Historic Site	1,2, or 3
National Battlefield	1,2, or 3
National Battlefield Park	1,2, or 3
National Battlefield Site	1,2, or 3
National Historical Park	1,2, or 3
National Historic Site	1,2, or 3
National Lakeshore	1,2, or 3
National Memorial	1,2, or 3
National Military Park	1,2, or 3
National Monument	1 or 2
National Park	1 or 2
National Preserve	1,2, or 3
National Recreation Area	2 or 3
National Reserve	1,2, or 3
National River and Wild and Scenic Riverway	1,2, or 3
National Seashore	1,2, or 3
Wilderness Area	1 or 2

Natural Resources Conservation Service	any
Conservation Easement[3]	?
Conservation Reserve Program Land (optional)[3]	?
Wetland Reserve Program Land[3]	?
Wildlife Habitat Incentive Program Land[3]	?
Bureau of Indian Affairs (BIA)	any
Wildlife Reserve[3]	?
National Oceanic and Atmospheric Administration (NOAA)[3]	?
National Estuarine Research Reserve[3]	?
Native American Lands	any
State Lands	any
State Parks & Recreation Areas	any
State School Lands	any
State Wildlife Reserves	1,2, or 3
Regional Government Lands	any
Local Government Lands	any
City Parks	any
County Parks	any
Non-Governmental Organization Lands (NGO)	1,2, or 3
Audubon Society Preserves	1 or 2
Local Land Trust Preserve/Easement[1]	1,2, or 3
The Nature Conservancy (TNC)	1,2, or 3
TNC Easement	1,2, or 3
TNC Preserve	1,2, or 3
Private Land	any
Private Conservation Easement/Conservation Deed Restriction	1,2, or 3
Private Institution-Managed for Biodiversity	1,2, or 3
Private Unrestricted for Development/No Known Restrictions	4

1. Status rank given is for land units with substantial natural land cover. Land units with substantial human alterations should be downgraded, and primarily developed land units of all categories should be the lowest status allowed for that category.
2. National Parks are status 1 unless they are dominated by visitor facilities or other developments.
3. There was insufficient information to provide a status range as of this writing.
4. Management of water sources is addressed in the aquatic component of GAP.

Discussion of GAP codes

Status 1 and Status 2 lands are not able to be used for CCS projects. These are strictly protected lands, which are preserved for their natural and spiritual values. In certain cases the lands administrator or an act of congress can make expections and allow projects to occur in these areas.

A buffer area – where no CCS project could be implemented – of ten to fifty miles surrounding Status I and II sites may be required. This is only speculation on the author's part. No buffer area is required by any regulation today. People are likely to worry about CO_2 escaping to the surface and polluting these protected lands. This buffer may or may not be mandated by the government. Project developers should keep in mind public opinion when planning for CCS projects. Injecting CO_2 too near a protected area may spark protest.

Status 3 lands might be available for CCS projects. If they are allowed, developing then will impose higher project costs from the permitting, and environmental impact statements that will be required. Activities currently permitted on Status 3 lands such as mining and forestry activities impose environmental change on a fixed area of a protected region. Direct implementation of CCS project (i.e. drilling and well construction) will have a similar limited impact. However, the potential for CO_2 leaks into other zones of the protected area could cause problems.

Status 4 lands will be the most attractive areas for CCS projects.

GAP datasets also contain some information on land ownership. They catalog who actually owns the land in some cases, particularly government land. State-level GAP analysis projects often include a broader set of information that could be used in our CCS GIS.

For example, the Louisiana GAP project has assembled a set of GIS layers of interest to CCS project developers, which includes (Center):

- aquifers,
- geology
- hydrology
- pipelines
- primary, secondary, tertiary roads
- railroads

- soil types
- land management status
- land stewardship status

Bureau of Land Management

The Bureau of Land Management (BLM) is a division of the Department of the Interior. It is responsible for managing 264 million acres of public lands. Lands under BLM management are primarily in the 12 Western states and Alaska (BLM 2004).

BLM manages its land with a "multiple use" strategy. It operates under the mandate of a wide array of legislation. The most comprehensive and relevant piece of legislation is the Federal Land Policy and Management Act (FLPMA) of 1976.

The FLPMA sets the policy of the United States that: "....the public lands be retained in Federal ownership, unless as a result of the land use planning procedure provided in this Act, it is determined that disposal of a particular parcel will serve the national interest..." Through FLPMA, Congress legislated that public lands should be publicly owned and managed for "multiple use," defined as: "...the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs for the American people... (BLM 2004)"

There are different categories of BLM lands. Some are specifically designated for forestry, oil and gas extraction, mining, and residential land to be sold. Other lands have more flexible uses and project developers can apply with the local BLM officials for the necessary permits.

BLM is authorized under the FLPMA to issue right of ways for several explicit classes of projects and "other facilities or systems which are in the public interest. (BLM 2004)" CCS projects are likely to be considered projects in the public interest.

BLM lands may make good locations for CCS injection sites and pipeline routes. These lands are largely uninhabited, and are intended to host some industrial activity. There are also established procedures for applying for land use permits, and preparing the environmental impact statements. In addition, there are oil production projects on BLM lands. CO_2 could potentially be used for EOR at these sites. This would generate a revenue stream for the CCS project. The map below shows the extent of land managed by the BLM. Not all are candidates for CCS projects as some BLM lands are protected.

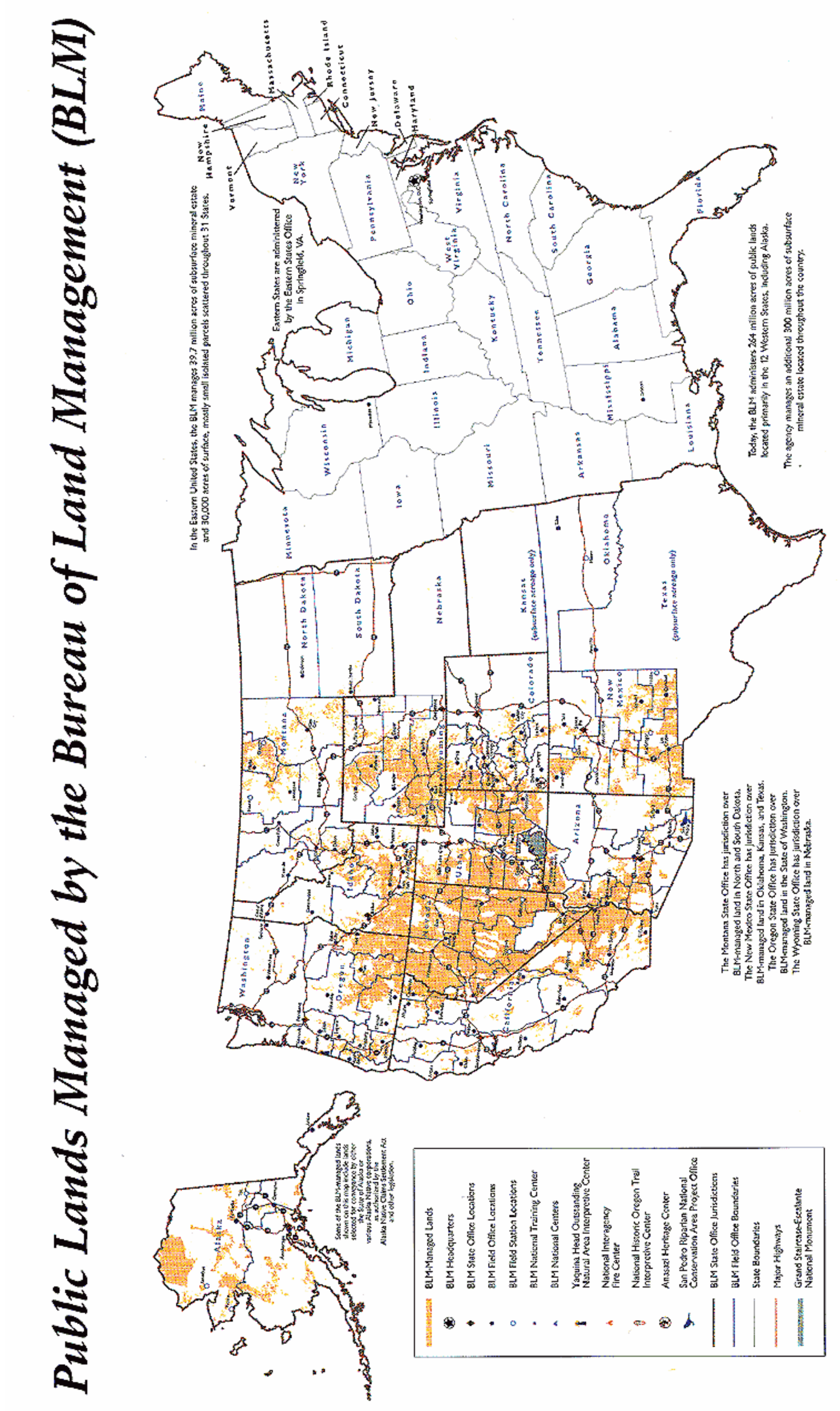

Figure 10. BLM Lands, USGS

Roadless Area Conservation

One of the last acts of the Clinton administration was to issue the Roadless Area Conservation Rule in 2001 (Federal Register 2001). The rule protects 58.5 million acres of US Forest service land from forestry and road building. The protected area represents 30% of the Forest service's land.

The Bush administration has weakened this rule by exempting the Alaska's Tongass Rainforest from the Roadless Rule (USDA 2003). The administration is also pressing to let state governors decide if land covered by the rule in their state should stand. The map below shows the land covered by the Roadless Rules as they stand today.

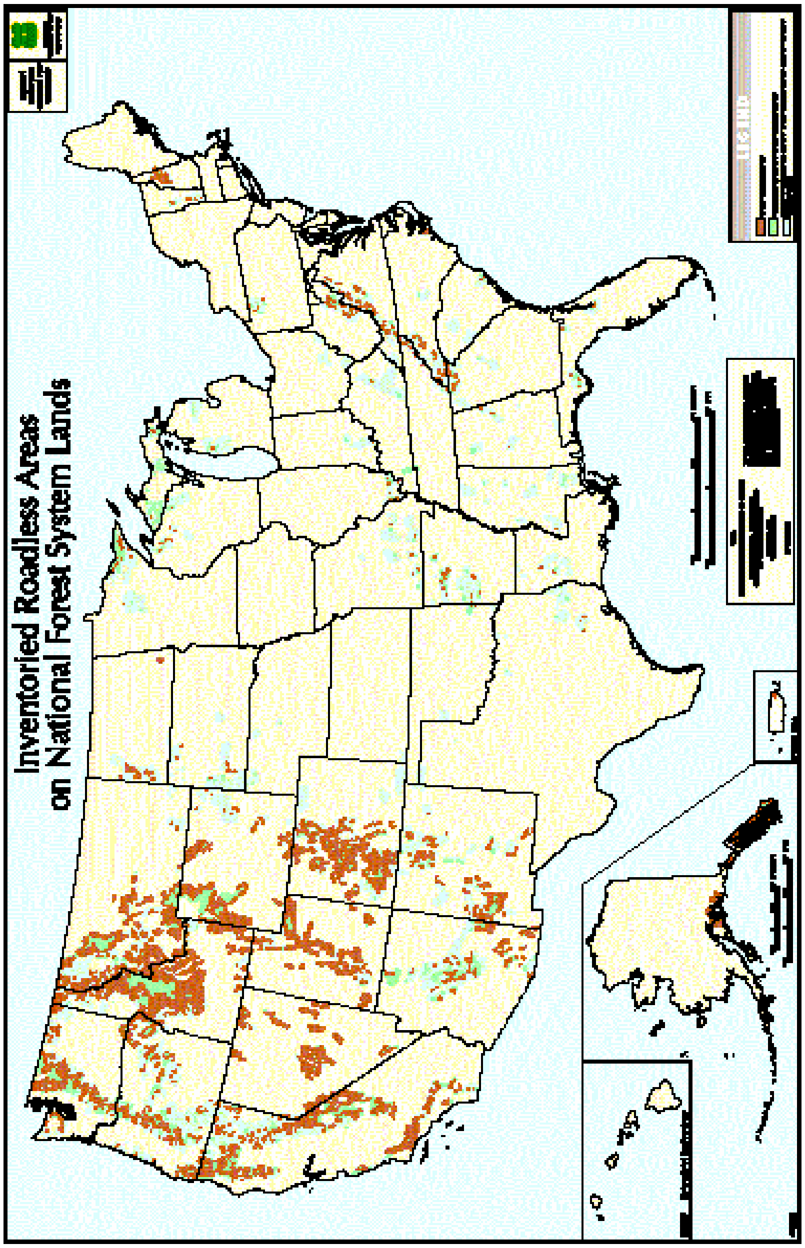

Figure 11. Roadless Areas, via US Forest Service

National Wildlife Refuge Program

The National Wildlife Refuge Program protects habitats that benefit wildlife and provide outdoor recreation areas. They are managed by the U.S. Fish and Wildlife service. President Roosevelt created the first wildlife refuge at Florida's Pelican Island in 1903 (NWRP 2002).

Since, the network has grown to include 535 wildlife refuges and over 3,000 bird nesting areas. More than 700 species of birds, 220 species of mammals, 250 reptile and amphibian species, and more than 200 species of fish live in these refuges. They also hold over 250 threatened or endangered plants and animals (NWRP 2002).

Development in these refuges is prohibited. The only activities permitted in national wildlife refuges are: hunting, fishing, wildlife observation and photography, and environmental education and interpretation.

National Wildlife Refuge areas are represented in the GAP database discussed in Chapter Two. They are assigned a Category I code, which precludes them from development activities.

The map below shows the extent of a number of different types of protected areas in the US today.

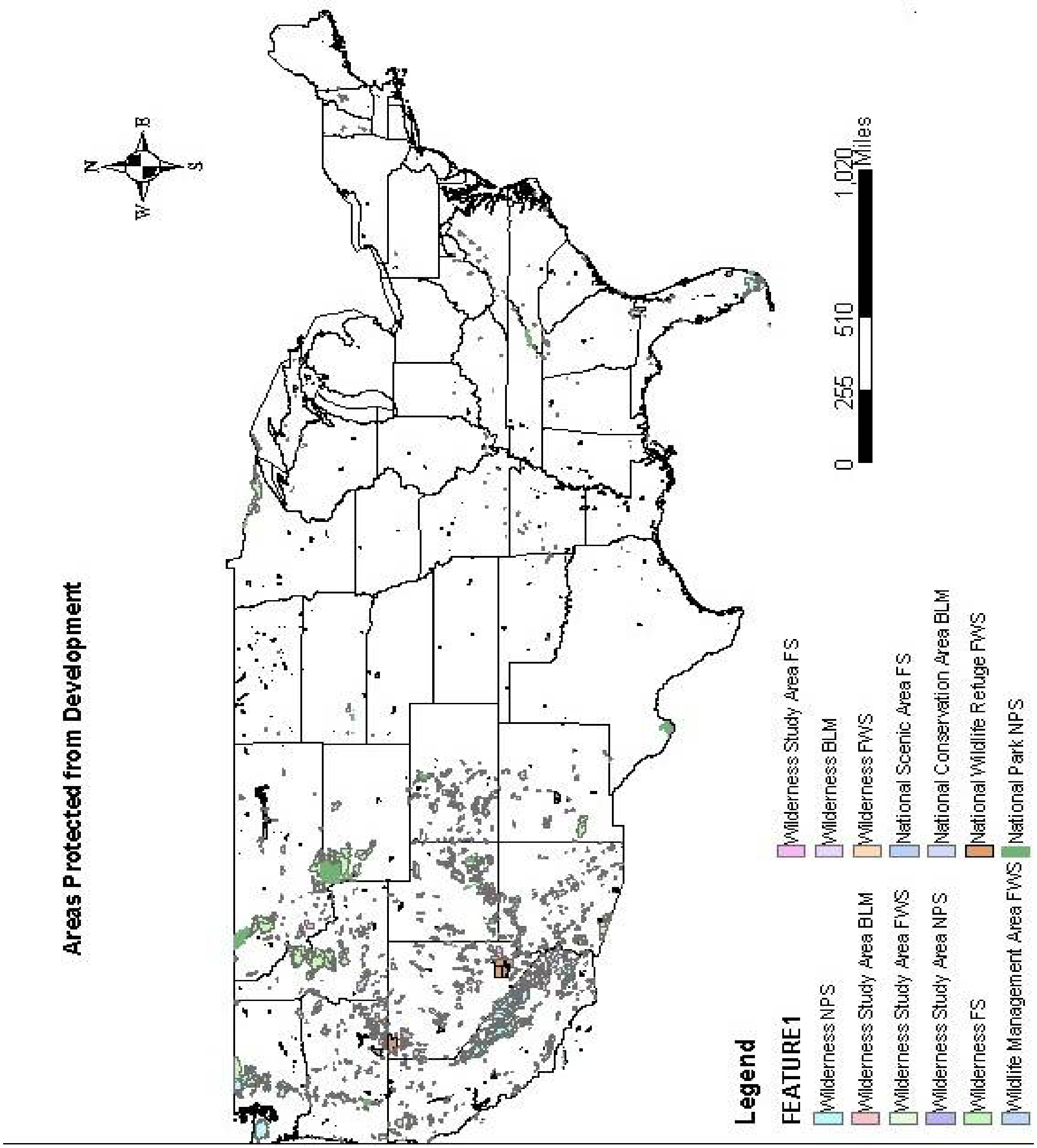

Figure 12. Protected Areas, USGS

Endangered Species Act

Congress passed the Endangered Species Act in 1973. The Act set up a program to protect threatened and endangered species and the habitats where they live. The Department of the Interior maintains the list and the US Fish and Wildlife Service administers the program. There are currently 632 plant and animals on the endangered list and 190 on the threatened list (FWS 2002).

Under the Act, it's illegal to "take" any species on the list. The Act says that a take is "harass harm hurt hunt shoot wound kill trap capture or collect or attempt to engage in any such conduct". Harm can mean significant habitat modification or degradation (FWS 2002).

There have been some high profile cases where developers were blocked from implementing multi-million dollar projects because of the presence of an animal on the endangered species list. The West Coast Spotted Owl was added to the list in 1990. Since, large tracts of timberland in Oregon and Washington have been off limits to logging because it is the natural habitat of the owl. Loggers lost jobs, and the local economy suffered.

It would be difficult to implement a CCS project on land that is the natural habitat of an animal or plant on the endangered species list.

The map below from the Fish and Wildlife Service shows the number of endangered species found in each state.

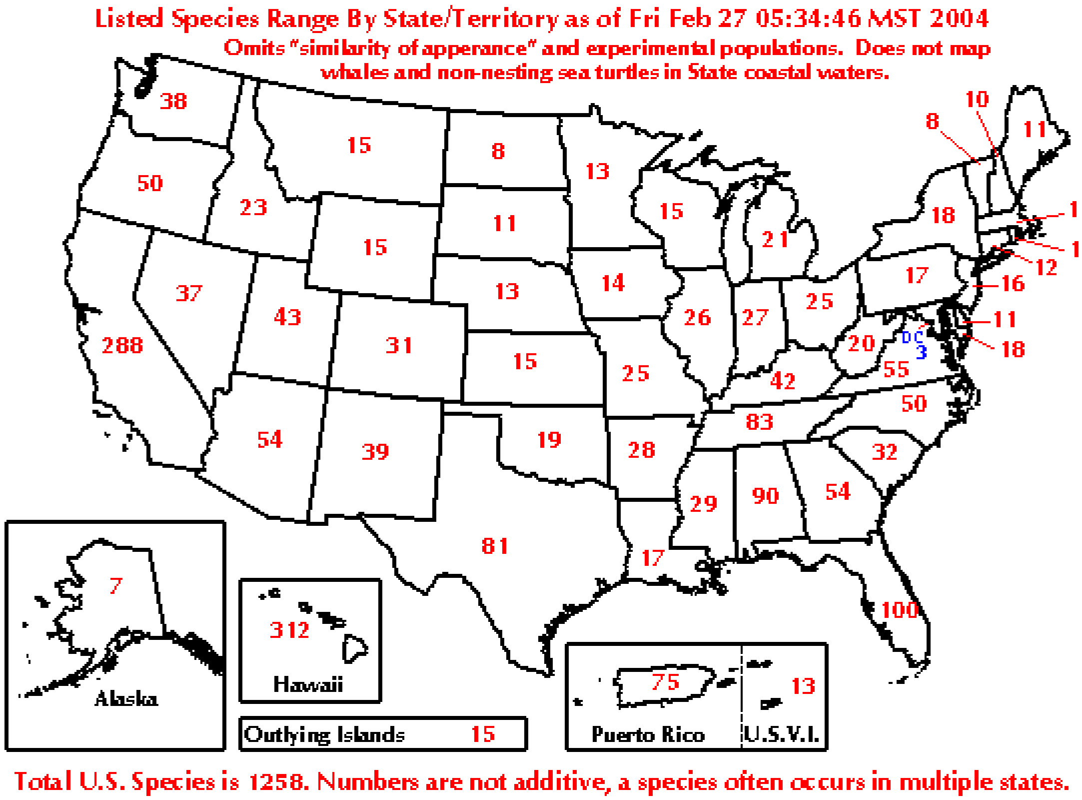

Figure 13. Map Endangered Species by State, (FWS 2004)

Pipeline Right of Ways

Some CO_2 sources for power plants will be located directly on top of appropriate geological sinks. In these cases, a well can be drilled straight down and the CO_2 injected. In most cases, however, a pipeline will have to be constructed to transport the CO_2 from the source to an appropriate sink.

Large quantities of natural gas and oil are piped around the United States every day. A lesser amount of CO_2 is also piped, primarily for EOR. There is nothing new or innovative about CO_2 pipelines for CCS.

The regulatory issue involving pipelines is establishing a right of way (ROW). An ROW is a swath of land over (pipelines are usually buried) and around the pipeline. The property owner grants some legal rights to the pipeline company. These rights allow the company to "operate, test, inspect, repair, maintain, replace, and protect one or more pipelines on property owned by others. (Office of Pipeline Safety unknown)" These rights typically extend 25 feet on both sides of the pipe.

Pipeline companies propose the route they wish the pipe to follow to the Federal Energy Regulatory Commission (FERC). As part of the permitting process the company must study other possible routes that would have less impact on the environment. They must also consider routes along existing ROWs, for pipelines as well as ROWs for transmission lines, roads, and railroads (FERC 2003).

Companies must first try to negotiate with landowners to pay them for signing an easement – which allows the use of their land. If FERC has approved the pipeline's route and the landowner refuses, the easement can be acquired under the powers of eminent domain (FERC 2003).

Pipelines on Federal Land

Pipelines can be constructed on some federally-owned land. The Bureau of Land Management is authorized under the FLPMA to issue ROWs for electricity transmission and distribution lines, communication towers, highways, railroads, pipelines (except oil and gas pipelines) and other facilities or systems which are in the public interest. Oil and gas pipelines are authorized under the Mineral Leasing Act, and are controlled by a different set of regulations (BLM 2004). CO_2 pipelines fall under the jurisdiction of the FLPMA.

Federal land in the Western US is typically found in large uninterrupted tracts. This makes the project developer's job easier then if he has to negotiate separately with hundreds of land owners. This can offer substantial cost savings. Guidelines for obtaining a pipeline ROW on Federal is found in Appendix B.

Pipelines in National Parks

Regulations vary from National Park to National Park by the type of activities permitted in that park. Even within a single park, the regulations sometimes differ. In some regions of some National Parks, permits for pipeline ROWs are granted.

For example, the Great Smoky Mountains National Park has a natural gas pipeline running through it. There is a "scenic corridor" in the park where the pipeline could not be run (Park Service 2001). Both the BLM and National Park Service require environmental impact statements for pipelines run on the land they manage.

Chapter 5: State and Local Action on Climate Change

Overview

Some states are now pursuing climate change mitigation strategies while others are not. These proactive states may make more attractive sites for CCS projects for two reasons. First they may offer financial incentives for CO_2 offsets. Second these states will have a higher capacity to handle projects that reduce greenhouse gas (GHG) emissions. I discuss how a state's level of attention to climate change – and by proxy its attractiveness to future CCS developers – can be represented in our GIS decision analysis tool.

Addressing Climate Change at the National and International Levels

During the 1990s attention to climate change was mostly focused on actions at the international and national levels. The United Nations Framework Convention on Climate Change (UNFCCC) and the Conference of the Parties that resulted from them were the international forums for climate change mitigation. Representatives of national governments attend these forums to discuss and negotiate an international plan of action to reduce GHG emissions.

Rational for International Cooperation

Working on climate change in an international forum is the best way to tackle the issue for three reasons:

- First, it is truly a global problem. GHG emissions from one nation disperse throughout the atmosphere and will cause warming in other nations. A global strategy is in the best interest of all nations and may help avoid future conflict.

- Second, reducing GHG emissions will cost money and make the products and services of a country more expensive. If all the industrialized countries take action in concert, no one nation will become substantially uncompetitive with another. This would make it easier for any nation to take action.

- Third, the lowest cost opportunities for reducing GHG emissions are not evenly distributed among nations. A country's economic structure, fuel mix, and level of development determines their marginal GHG abatement costs. The least cost GHG reduction strategy is to let countries trade amongst each other for GHG allowances.

U.S. Government Action

The United States entered the UNFCCC in 1992 which set the stage for a future binding agreement on CO_2 reductions. The United States signed the Kyoto protocol in 1997 but it was never ratified by Congress. The Kyoto Protocol requires most OECD countries to cut emissions by 5.2% below 1990 levels by 2008 to 2012, but has no binding commitments for developing countries.

On July 25, 1997 the Senate voted 95 to 0 to support the Byrd-Hagel Resolution (SRes 98), which says that the US will not ratify Kyoto because it does not include developing countries, and would impose undue economic burden on the US economy.

On March 13th, 2001 President Bush announced the US's withdrawal from the Kyoto protocol in a letter to Senator Chuck Hegel. The following year, the Bush administration announced their strategy to deal with climate change. The Bush strategy focuses on research and development initiatives for new technologies to reduce emissions. The Bush plan includes a voluntary domestic GHG intensity target. The critical element of the plan is that its voluntary. It creates no economic incentive to reduce GHG emissions, but rather relies on the "push" of new technologies from research and development and the impacts of specific initiatives.

Climate change related legislation has been introduced with increasing frequency in Congress over the past decade. The following list shows the number of bills introduced to Congress related to climate change (Pew 2004):

- 105th Congress (1997-1998) – 7 bills
- 106th Congress (1999-2000) – 25 bills
- 107th Congress (2001-2002) – 80 bills
- 108th Congress (2003-2004) – 70 bills (in 2003 only)

Attempts have been made in the 107th and 108th Congress to enact legislation in the Energy Policy Act to cap GHG emissions. Congress voted on but did not enact legislation that would cap GHG emissions in the 2003 Energy Policy Act. The Energy Bill in the 107th Congress was never reconciled between the House and Senate versions. The Energy Bill in the 108th Congress passed the House but did not have the votes to avoid a filibuster in the Senate. The bill never made it to the President's desk for signature (Pew 2004).

The most important piece of climate change legislation introduced thus far has been the Climate Stewardship Act of 2003 (S.139). This act was sponsored by Senator Lieberman (D-Connecticut) and Senator McCain (R-Arizona). The version of the bill voted on in October 2003 (S.Amdt.2028) would have capped GHG emissions from 2010 at the 2000 emissions level. The bill proposed capping GHGs from electricity generation, transportation, industrial, and commercial sectors. It proposed a cap-and-trade system, allowing companies to fully trade emissions allowances to meet their commitment. The measure was defeated 43 to 55 in the Senate (Pew 2004).

The States Respond

There is a history of a state pioneering environmental regulation. These regulations are sometimes adopted by other states and by federal regulators.

California has been the strongest state leader in new environmental legislation. In the 1970s California set stringent emissions control standards for their automobile fleet.

California's standards were adopted by other states, and later by the federal government (Vogel 1997). This phenomenon has been coined the "California effect", and reflects how states can have a positive upward harmonization of environmental standards. Automobile manufacturers complied with California's regulations because it is such a large market, they can not afford to ignore it. After automobile manufacturers had designed cars to meet California's standards, it wasn't hard for them to roll out a cleaner fleet for the rest of the country.

After witnessing the Byrd-Hagel resolution, US withdrawal from Kyoto, and the non-aggressive Bush administration climate plan, the states understood that they would have to take action independently to address climate change. Some states have begun to do so.

States are addressing the issue in several ways. Some are enacting legislation specifically to address climate change. Others are addressing broader goals, such as reducing air pollution and diversifying their electricity supply. These activities have positive ancillary benefits which include GHG reductions. All of the following efforts underway by certain states that will reduce GHG emissions:

- cap GHG emissions;
- improve energy efficiency;
- increase the use of renewable energy;
- sequester CO_2 in the trees and soil;
- encourage CO_2 capture and storage projects;
- require companies to report emissions;
- create an inventory of GHG emissions;
- and reduce emissions from the transportation sector.

MIT GIS and Categorizing State Action on Climate Change

In this thesis, I assume that some states will be more proactive on addressing climate change then others. I define proactive states as those who are doing or will do one or more of the following: enact CO_2 caps, offer incentives for CO_2 reductions, write climate change action plans, or promote specific CO_2 reduction programs. These actions will encourage firms to implement projects that offset GHG emissions, including CCS projects. Other actions which reduce GHG emissions such as support for energy efficiency or renewable energy are not considered because they don't specifically target climate change.

Besides providing financial incentives, these proactive programs will create other benefits that better prepares a state for GHG offset projects in the future. State regulatory bodies will have staff and established procedures for dealing with them. Montana's Climate Change Action Plan explicitly states that through the act of developing the plan "Montana will be better equipped to evaluate and influence proposals on climate change…" (Quality 1999).

Proactive states may require large companies to create internal GHG inventories. Companies in these states may also create a position or entire department responsible for their climate change responsibilities. British Petroleum and Nike are examples of firms today that inventory GHGs and have staff dedicated to the companies' climate change commitments. Ancillary services related to climate change mitigation, such as specialized consulting firms and GHG trading services will be established in the state. The state's citizens will be more aware, and possibly more accepting of the need to take action on climate change.

Given these benefits of proactive states, I assume that they will be better-suited to hosting a CCS project. The main advantage of developing a CCS project in these states will be the financial incentive they offer for GHG offset projects. This advantage will be diminished when federal CO_2 cap or incentives are enacted. It's likely that such measures will be enacted at the federal level within the following decade or two. States might still have more strict CO_2 caps or higher incentives, after federal action is taken.

State Action Plans on Climate Change

The Environmental Protection Agency works with states to develop action plans on climate change. As of 2003, 27 states and Puerto Rico have voluntarily completed plans. The action plans help states identify policies to reduce GHG emissions through a mix of public and private programs. The fact that a state has a plan does not obligate it to take any action on climate change. An example of a state action plan is found in Appendix A, it's the executive summary for Montana's plan. The map below shows states that have completed action plans.

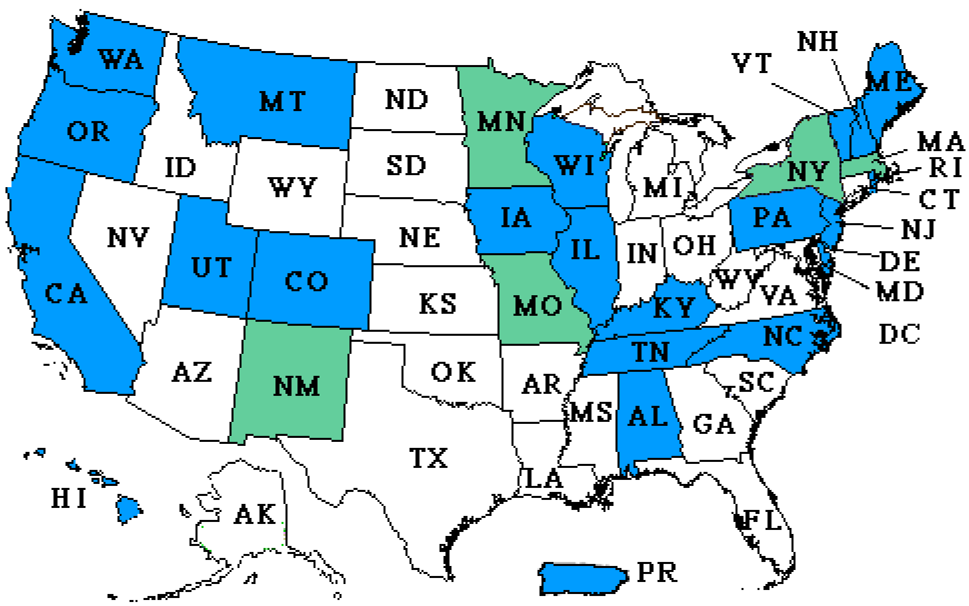

Figure 14. States with Climate Action Plans (EPA, 2004)

Blue states – Have an action plan

Green states – Planning an action plan

White States – No action plan

Explaining the Categories

I've categorized states by how proactive they are in addressing climate change. States have been ranked as:

- Category I, states with legislation in place that controls GHG emissions specifically;
- Category II, states in the process of planning controls on GHG emissions;
- Category III, states that have an action plan for greenhouse gas mitigation;
- Category IV, states that do not have, and are not actively planning to control GHG emissions nor do they have a greenhouse gas action plan. Nearly all states, however, run environmental or energy initiatives that reduce pollution and GHGs, however, this Category metric is specifically focused on states targeting GHG emissions.

Table 3. State Categories on Climate Change Action

Categorizing states by how "proactive" they are on climate change

Category I	Category II	Category III
New Jersey	Connecticut	Montana
Massachusetts	New York	Utah
New Hampshire	Vermont	Colorado
Oregon	Rhode Island	New Mexico
Maine	Delaware	Minnesota
California		Iowa
West Virginia		Missouri
Ohio		Wisconsin
Washington		Alabama
		Kentucky
		Tennessee
		North Carolina
		Pennsylvania

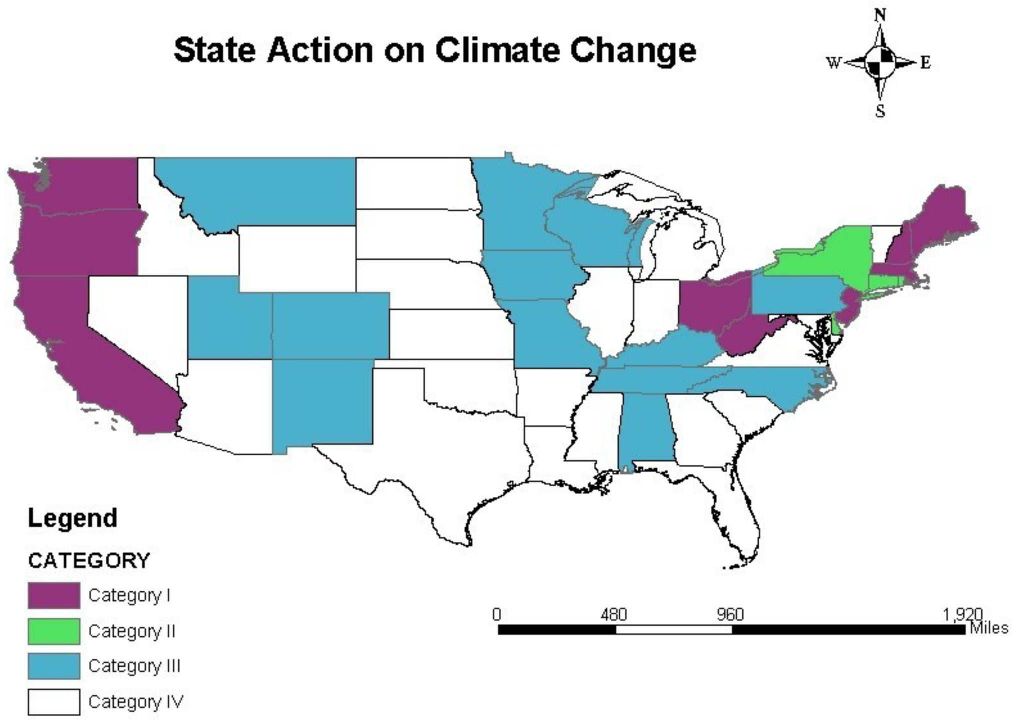

Figure 15. Map of State Action on Climate Change

Other criteria could be used, but not considered in this thesis for simplicity. For example, states with GHG inventories or states that require large companies account for and report emissions could be another useful metric. I don't claim to have captured all State policies on climate change, this list should not be considered exhaustive.

Incorporating the Information into the Current GIS

The current version of our GIS tool will have information for CCS decision makers on what category a state falls in. In addition, it will give a brief description of their policies. This will inform them of the receptiveness to GHG mitigation projects, and the possibility for getting paid for the CO_2 they will sequester. For example, CO_2 offsets in Oregon receive about $2 per metric ton of CO_2. This is due to a law in Oregon capping CO_2 from power plants, as I discus below.

Incorporating the Information into Future Versions

Future versions of the system may incorporate these categories into the algorithm used to evaluate a site for implementing a CCS project. States in Category I would slightly reduce the "cost surface", as referred to in the GIS chapter of this thesis, for the entire state. The lower cost makes the state a more attractive prospect for CCS projects. Category II states would improve a state's attractiveness, but less so. A Category III state would be neutral. A Category IV state would have a slightly higher cost surface, reducing its attractiveness.

The Pew Center on Global Climate Change issues an excellent annual report detailing individual states' actions on climate change (Pew 2004). The section below draws heavily on the Pew Center's report to describe the state's policies in Category I and II. Category III states are all extracted from the EPA map of states with climate action plans found above.

States in Category I

New Jersey has committed itself to reducing GHG emissions to 3.5% below 1990 levels by 2005. New Jersey emitted 136 million tons in 1990 and was on track to emit 151 million tons if action was not taken. Their plan includes: instructing state agencies to work directly with businesses, instituting a renewable energy portfolio standard, setting specific targets in other sectors, and requiring large firms to report GHG emissions.

Massachusetts decided in May 2001 to cap CO_2 emissions from her six biggest emitting electricity generators. The goal is to reduce CO_2 emissions from these plants from 2000 lbs CO_2/MWh to 1800 lbs CO_2/MWh by 2006 or 2008. Plants unable to meet these requirements can purchase emission reduction credits to meet their obligations.

New Hampshire passed legislation in May 2002 to reduce power plant emissions to 1990 levels by 2006.

Oregon passed legislation in 1997 that requires new power plants to offset 17% of their CO_2 emissions by purchasing credit from a non-governmental organization (NGO) the Climate Trust. The Climate Trust runs CO_2 emissions reductions programs, and sells the utilities the offset credits. So far, the reductions have cost about $2 per metric ton of CO_2. Climate Trust has implemented 11 projects offsetting about 2.5 million metric tons of CO_2. Their total portfolio investment has been $5 million (Climate Trust 2004)

Maine is a signatory to a regional Climate Change Action Plan, a group comprising all the governors of the New England States along with the Eastern Canadian Premiers. At their annual conference in August 2001, the Governors approved a plan to reduce regional GHG emissions to 1990 levels by 2010 and 10% below 1990 levels by 2020, and eventually reduce emissions to a safe level. Maine was the first to codify this plan into law in June 2003 with the bill [ME HP 622] that will: create a state climate plan consistent with the regional plan, inventory and reduce CO_2 emissions from state-funded programs and facilities, and spur partnerships with NGOs and businesses to reduce emissions (Maine 2003).

West Virginia and **Ohio** are both supporting the FutureGen project, a joint Department of Energy and industry effort to build a $1 billon demonstration project for an integrated coal gasification combined cycle power plant with CCS.

California enacted legislation in 2002 requiring the California Air Resources Board to establish GHG emission standards for passenger cars and light trucks. The standards will achieve "the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles taking into account environmental, social, technological, and economic factors". These regulations will apply to cars from 2009. Other states are carefully watching the development of these regulations, and some are considering adopting them. At least Massachusetts and Connecticut are considering using California's rules.

Washington enacted legislation on March 09, 2004 that regulated CO_2 from power plants. The legislation is similar to Oregon's plan (EEA 2004).

States in Category II

In 2003, the Governor of **New York** sent a letter to the Governors of 10 states in the North East asking them to participate in a regional CO_2 cap-and-trade initiative for power plants. **Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, Delaware**, and **New Jersey** all expressed interest and are now working together to design the program. The program, the Regional Greenhouse Gas Initiative aims to complete the project's design by 2005.

Maryland and **Pennsylvania** are participating as observers to the Regional Greenhouse Gas Initiative.

Conclusions

While technical and economic concerns will be paramount to decision makers implementing CCS projects, regulatory and political factors will influence their decisions. This thesis examined some of these regulatory and political factors. The key findings in this thesis are:

- **Regulatory** – the primary regulatory issue that will affect CCS projects is the Underground Injection Control program. UIC regulations will need to be modified to meet the particular issues posed by CO_2 storage. CCS may be regulated under some form of Class I or V well regulation.
- **Land Use** – a number of land-use regulations will need to be considered when planning CCS projects including: Environmentally-sensitive and culturally-important land is protected as National Parks, Wildlife preserves, Roadless Areas, and other protected classifications. The federal government owns large tracts of land, much of which is under the control of the Bureau of Land Management. Various regulations control BLM lands, and a variety of development activities are permitted. Pipeline right-of-ways need to be secured before construction. Using existing right-of-ways will facilitate this. The USGS offers datasets with information on many of these issues.
- **State Action on Climate Change** – some states are taking proactive action on climate change today. These states may be attractive locations for CCS projects. Proactive states may offer incentives for CO_2 offset projects or have a higher capacity for dealing with them.

This regulatory information can be incorporated into a GIS decision analysis tool. The MIT system today uses this regulatory information to inform decision makers. Future versions could quantify this information and include it in the analysis algorithms. It can improve the accuracy of the GIS decision analysis tool.

Research in the future could examine some of the regulations and land-use policies discussed in this thesis in more detail. Future work could include:

- An analysis of state-specific UIC regulations to determine the exact rules for each state;
- A quantitative methodology for incorporating the concepts of this thesis so they can be used in a GIS algorithm.

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Appendix A. Montana Greenhouse Gas Action Plan: Executive Summary (Quality 1999)

MONTANA GREENHOUSE GAS PROJECT:
Building a Foundation for an Action Plan
EXECUTIVE SUMMARY
(December 1999)
DRAFT
Montana Department of Environmental Quality
1520 E. Sixth Avenue
Helena, MT 59620
406-444-6697
grnhouse@state.mt.us

2
EXECUTIVE SUMMARY
"Greenhouse gases" influence the climate by slowing the loss of heat back into space. Most scientists now believe that human activities emit enough greenhouse gases to noticeably alter the climate. Carbon dioxide from fossil fuel use is the primary, but not the only, greenhouse gas added by humans. The current scientific recognition that climate change is a serious possibility is not matched by a public or political acceptance of the need for comprehensive action, or even necessarily by an understanding of what the options are.

The Montana Department of Environmental Quality (DEQ) undertook this project to provide the information those individuals, businesses and government will need before acting to reduce greenhouse gas emissions.

For the most part, the project report analyzes issues that many Montanans already are concerned about for reasons separate from that of reducing greenhouse gases. For instance, helping homeowners reduce their energy bills or changing government regulations that favor urban sprawl, both of which can lead to lower greenhouse gas emissions, already have some support.

It is likely that Montanans will be doing something in the coming years to reduce greenhouse gas emissions. The much publicized doubts about climate science and Congressional opposition to international treaties on greenhouse gases should not obscure the fact that businesses at home and abroad, as well as other governments, already are moving to address global climate change. Montana should be prepared to respond to national and international initiatives. Twenty-four other states have completed or are working on their own greenhouse gas action plans. By having this report, Montana will be better equipped to evaluate and influence proposals on climate change.

The Montana Greenhouse Gas Project is only a first step. Montana will not have an official plan without informed public debate. Now, most members of the public and most policy makers have only a vague notion of what preventing climate change might mean to them and what actions they should take. The project report presents detailed analyses of specific issues, which should focus the public debate. With that focus, Montanans should be better able to choose what they must do to reduce greenhouse gas emissions.

Realistically, taking actions based on the analyses presented here would reduce, not eliminate, the threat of climate change. But debate over alternatives must start somewhere, or else there never will be legislative action, business plans, or widespread personal commitments to reduce greenhouse gas emissions.

The evidence for human-induced climate change is accumulating but is complicated and largely statistical in nature. The most widely reported evidence comes from computerized models, which, while still evolving, are increasingly accurate. The improvement during the last decade of models forecasting El Niño/La Niña events, simpler but still complex climatic events, indicates the progress being made. Closer to home, research done at the University of Montana indicates spring is arriving earlier in northern latitudes, which could seriously affect forests and other natural ecosystems.

Non-statistical, easily visible evidence, such as the receding of glaciers in Glacier Park, clearly shows that climate change of some kind is occurring; more sophisticated analyses suggest greenhouse gases from human activities may be the cause.

In spite of uncertainties, a scientific consensus is emerging. Scientists agree that the atmospheric concentrations of greenhouse gases such as carbon dioxide, methane, nitrous oxide and perfluorocarbons are increasing. The concentration of carbon dioxide alone has increased 30 percent since 1850. There is general agreement that the global climate appears to be changing. Most scientists accept a link between the two changes. In 1995, the Intergovernmental Panel on Climate Change (IPCC), a group of scientists from around the world, stated, "For the first time the balance of evidence suggests there is a discernible human influence on the earth's climate, or to put it another way, the changing climate over the last 100 years cannot be explained by natural variability alone."

Research since then has done more to strengthen this conclusion than to weaken it. Many people and businesses, as well as certain foreign governments, remain unpersuaded. Their concerns could be dismissed as similar to the now-discredited objections raised against early suggestions that the ozone layer was being destroyed.

However, a more positive reply to climate change skeptics is that given in May 1997, by John Browne, the chief executive officer of British Petroleum (now BP Amoco): The time to consider the policy dimensions of climate change is not when the link between greenhouse gases and climate change is conclusively proven, but when the possibility cannot be discounted and is taken seriously by the society of which we are part. We in BP have reached that point. The science is increasingly persuasive. The likelihood of a national initiative is growing. Montanans should be concerned with practical questions about the economic and social consequences of programs chosen to reduce greenhouse gas emissions. Montanans ought to be prepared to participate constructively in the national debate.

Reducing greenhouse gas emissions is both simple and complex. It's simple in that what must be done is easily summarized:

- use fossil fuel more efficiently,
- use alternatives to fossil fuel, and
- generate fewer waste products in industrial and agricultural processes.

However, the on-going efforts by individuals, businesses and governments to accomplish these ends, albeit for reasons other than controlling greenhouse gas emissions, shows just how complex the task will be. The answers may require rethinking and replacing existing methods and technology. We must find the ways and the will to do more than we have done in the past.

Yet, the sheer magnitude of the idea of climate change, and the seriousness of the possible consequences can cause people and politicians to shy away from direct actions. Emissions in Montana, as in other states, can be divided into those associated with industrial processes (such as aluminum production, oil refining, electricity generation)and those associated with more dispersed uses (such as residential heating, commercial lighting, driving cars). DEQ already has prepared an inventory of greenhouse gas emissions in Montana. While, as one might expect, the big industrial facilities are major emitters, other smaller sources have significant cumulative emissions.

For instance, the transportation sector accounts for one-fifth of all inventoried emissions in Montana. Even our everyday activities are major emitters. Common activities, such as heating houses, lighting commercial buildings, and driving back and forth in town, collectively account for 15-20 percent of emissions.

Greenhouse gas emissions are intertwined with almost every aspect of society. Actions that reduce greenhouse gas emissions also generally reduce emissions of pollutants that are dangerous to health. The U.S. Environmental Protection Agency (EPA) estimates that 85 percent of greenhouse gas emissions nationally come from sources that already are directly regulated under the Clean Air Act. DEQ hopes to encourage practices that speak both to immediate environmental problems and to long-term climate change.

The report covers a wide range of areas. DEQ believes that action in any of these areas would have benefits that extend beyond greenhouse gas issues. DEQ concentrated on market-based alternatives, ones that don't prohibit greenhouse gas emissions, but which do make behavior that reduces greenhouse gas emissions more economically attractive.

Some of the more significant areas covered include:

- Highway expenses currently paid through property taxes could be shifted to fuel taxes to give drivers a better idea of the true cost of driving. The change would mean no net increase in taxes, but would reduce the driving that drivers themselves think has the least value.
- The state could search for alternatives to those government requirements that hinder the development of compact, mixed-use and pedestrian friendly urban areas. State and local road design standards, model zoning codes and septic tank requirements are just some examples of regulations and practices that presently can encourage driving and discourage alternatives.
- The restructuring of the electric utility industry could be extended by including the way transmission line use is priced and by decontrolling customer metering and billing. These changes will make the actual cost of electricity more visible, and therefore show how energy efficiency investments are more attractive.
- A carbon tax would make less carbon-intensive activities more attractive and could be used to reduce the net tax burden on most Montanans. However, it is a complicated and contentious issue that would require study before adoption could be considered.

The project report discusses numerous other issues related to greenhouse gas emissions.

It also discusses ideas that have been suggested at the national level, but which are not appropriate in Montana. The project report does not call for a net increase in taxes. It does show that raising some taxes while lowering others would reduce subsidies—and thereby reduce interest in—activities that emit greenhouse gases and other pollutants.

Those losing their subsides may question raising the issue while those seeing their taxes lowered may support the discussion. Overall, reducing subsidies could improve the efficiency of the Montana economy while improving the environment.

The project report does not set a specific legislative agenda. DEQ believes more discussion is necessary before such an agenda can be set. Many of the possible actions may eventually be taken because they make sense in their own right, and not for reasons having to do with climate change. At this point, the only action unique to climate change that DEQ proposes to take is to help protect Montanans who voluntarily act to reduce greenhouse gas emissions. This action could take the form of implementing a state registry of voluntary actions, as New Hampshire already has done, to ensure those actions will be recognized whenever national requirements for reductions are established. Beyond that, DEQ will encourage

Montanans to develop an understanding and a consensus on actions to reduce greenhouse gas emissions. The project report is to be used as a background and reference document. Certain sections, especially those dealing with the greenhouse gas science and policy, have extensive footnotes and Internet links. They are designed to aid those seeking more detailed information on a particular topic. These references also show the significant and systematic efforts that have been made on the science of climate change.

While disagreements remain, both on the science and on the proper response, there is an extensive body of literature and thoughtful analysis of the problem. Links are indicated in the text by an underline. Appendix 1 contains a list of all the links, for those who are reading a hard copy of the report. Unless otherwise noted, all links are to sites that are not part of DEQ; DEQ has no control over their content or availability.

APPENDIX B. OBTAINING A RIGHT OF WAY ON PUBLIC LANDS

Bureau of Land Management Right-Of-Way Program (BLM unknown)

Each year, thousands of individuals and companies apply to the Bureau of Land Management (BLM) to obtain a right-of-way (ROW) on public lands. A ROW grant is an authorization to use a specific piece of public land for a certain project, such as roads, pipelines, transmission lines, and communication sites. The grant authorizes rights and privileges for a specific use of the land for a specific period of time. Generally, a BLM ROW is granted for a term commensurate with the life of the project. Typically, grants are issued with 30-year terms, and most can be renewed.

The BLM places a high priority on working with applicants on proposed ROW to provide for the protection of resource values and to process the application expeditiously. This brochure is designed to acquaint you with this process. A more complete explanation of the BLM ROW program is found in Title 43 of the Code of Federal Regulations, Parts 2800 and 2880. Copies of these regulations are available at all BLM offices. The BLM has also initiated efforts to streamline the application processing procedures (see Instruction Memorandum No. 96-27 and Instruction Memorandum No. 97-18)

Careful advance planning with BLM personnel who will be handling your application is the key to success. If they know about your plans early, they can work with you to tailor your project to avoid many problems and costly delays later on in the process.

If you are not familiar with local BLM jurisdictions, the best place to start is by contacting a BLM State Office listed in the back of this brochure. Each State Office oversees a number of Districts, which in turn oversee Resource Areas. Depending on your project, you may be working primarily with personnel at a BLM District Office or, more likely, at a BLM Area Office.

WHEN YOU DO--AND WHEN YOU DON'T--NEED A R/W

As a general rule, you do need a ROW whenever you wish to build a project on the public lands. Some examples of land uses which require a ROW grant include: transmission lines, communication sites, roads, highways, trails, telephone lines, canals, flumes, pipelines, reservoirs, etc.

You don't need a ROW for so-called "casual use." What kinds of activities are considered "casual use"? Examples include driving vehicles over existing roads, sampling, surveying, marking routes, collecting data to prepare an application for a ROW, and performing certain activities that do not cause any appreciable disturbance or damage to the public lands, resources or improvements.

Depending on the specifics of your proposed activity, uses on the public lands can be either casual use or a use requiring a grant. It's a good idea to contact the BLM and discuss your plans before assuming your use is casual. The BLM can then make a judgment on the requirements in your particular case.

STEPS IN APPLYING FOR A ROW

1. Contact the BLM office with management responsibility for the land where the ROW is needed.

2. Arrange a preapplication meeting with the Field Office Manager or appropriate staff member. Jointly review the application requirements and form to determine what information is needed,.

If you call ahead to set up the meeting, it can often be arranged and held at the site of your proposed use.

3. When you have all the information, bring or mail the application, along with the nonrefundable application processing fee, to the appropriate BLM office.

PREAPPLICATION MEETING

The preapplication meeting provides the opportunity for you to fully discuss and describe your proposal in detail and provides an opportunity for BLM to fully explain processing requirements. The preapplication meeting will also cover fees, safety, work schedules, and other items. This meeting has the potential for saving both you and the BLM time and expense. For example, in FLPMA, Congress directed that ROW in common shall be required, to the extent practical, in order to minimize adverse environmental impacts and the proliferation of separate ROW. This is accomplished through a system of designated ROW corridors and co-locating communication uses on existing towers and within multi occupancy buildings when feasible. During the preapplication meeting, the staff may examine the proposed ROW to see if it would fit in an existing corridor or in an existing communication facility.

The BLM wants to make the application process as easy as possible. Accordingly, the application form requests a minimum amount of information. (A copy of the application follows the itemized instructions for filling out the application) Even so, incomplete information is often the reason application periods are unnecessarily prolonged.

To avoid problems, you should review the form prior to your preapplication meeting and, if possible, fill it out before or during the preapplication meeting with the BLM. Be sure to bring any information that may be useful during this session. For example, Item 8 requests a map of the project area. You may already have a survey or other adequate map that will satisfy this requirement and provide additional information in processing your application.

COMPLETING THE APPLICATION FORM

Directions for completing the application are included on the form; however, the following supplemental instructions may also assist you. Incomplete information is often the reason application periods are unnecessarily delayed.

Item 6--This applies only to oil and gas pipelines, applicants must be citizens of the United States. Citizenship is required of all partners in a partnership. Aliens may own or control stock in corporations if the laws of their countries do not deny similar privileges to citizens of the United States.

Item 7--Requires addressing all the details of what you need and how you plan to accomplish it. Be as specific as possible in describing the project, its location, and dimensions. Include the legal description of the affected public land. Attach separate sheets as necessary, since the space in this block is limited. You may wish to follow the Plan of Development (POD) outline (following the application form) to complete this section. This outline should help you thoroughly describe your project and its associated impacts. You should also describe and apply for a Temporary Use Permit for any extra construction width you may need.

Item 8--Attach a map (BLM intermediate scale map, 1:100,000; U.S. Geological Survey quadrangle; aerial photo; or equivalent) showing the approximate location of the proposed ROW and facilities on public land and existing improvements adjacent to the proposal. Only improvements that may directly affect the proposal need to be shown on the map. Include the township, range, section, and a north arrow.

Item 9--It is not mandatory to submit documentation of other approvals at the time of application. However, the authorized officer may require other agency approvals prior to processing.

Item 10--The "initial cost reimbursement payment" is discussed in the Costs and fees section. You will be notified by formal decision letter of the fee category determination for your application.

Item 12--If you have no doubts about your capacity to complete the project, write in "[I am/We are] technically and financially capable of completing the project described in this application." The BLM Authorized Officer may require that you post a performance bond or that you hire a registered engineer, depending upon the scope and complexity of your project.

Item 13-18--It is generally not necessary to complete these items. However, if you have made studies that concern these questions, the information should be submitted to accelerate the processing of the application.

Item 19--It is mandatory to provide information related to the use or transportation of any hazardous materials. Simply writing in "N/A' in this block is not satisfactory.

Supplemental--The supplemental page is to be completed only when the application is for an oil and gas pipeline. In such cases, fill in only I(g) and either I(e) or III(c). If this information has been previously submitted with another BLM ROW application or grant, provide office and file identification numbers.

Signature block--If someone is acting as your authorized agent and you want them to sign the application or grant on your behalf, a resolution to that effect must be filed with application.

To sum up, the application form is considered complete when information has been provided for the following items:

Required - Items 1, 3, 4, 5, 7, 8, 10, 12, signature, and date.

Required if applicable - Items 2, 6, 11, 19, and supplemental page.

Optional - Item 9, 13, 14, 15, 16, 17, and 18.

A base application consists of a completed application form (Standard Form 299), map, and the nonrefundable cost reimbursement processing payment.

COSTS

There are three different charges involved for a ROW grant:

Processing Fees associated with your application- The first charge will reimburse the United States in advance for the expected administrative and other costs incurred in processing the application. Processing fees must be paid when the written application is submitted. The BLM will use the information presented during the preapplication meeting to estimate the application processing fee. The BLM will first designate the project as either major or minor. Fees for minor category projects are charged according to a schedule available at BLM offices. Costs for major category projects depend on whether the project is one authorized under FLPMA or under the Mineral Leasing Act. Major category projects applied for under the authority of FLPMA require the payment of *reasonable* processing costs for ROW. The *actual* processing costs will be required for ROW applied for under the authority of the Mineral Leasing Act.
Monitoring fee -- The second charge is a one-time nonrefundable fee to reimburse the United States for the cost of monitoring compliance with the terms and conditions of the ROW grant, including requirements for protection and rehabilitation of the lands involved. The BLM will monitor your construction, operation, and maintenance of the ROW and, when the time comes, the shutdown of your activities and the termination of the ROW grant. The amount of this fee is also determined according to a schedule available at BLM offices. Again, if the estimated monitoring costs exceed a certain amount, the applicant will be required to reimburse the United States for the actual monitoring costs.
Rental -- The third charge is the annual rental. It is payable before the grant is issued and is based on the fair market rental value for the rights authorized. The rental for *linear and communication site*s on public

lands is usually established via two separate administrative schedule (see Linear Schedule or Communication Uses Schedule). These schedules, which are based roughly on land values in the project area, are adjusted annually by an economic index. In some cases, the rental is established by an appraisal.
No application, monitoring, or rental is required for:
State or local agencies or instrumentalities thereof (except municipal utilities and cooperatives whose principal source of revenue is customer charges) where the land will be used for governmental proposes and the land resources will continue to serve the pubic interest.
Road use agreements or reciprocal road agreements.
Federal agencies.
Other exemptions, waivers, or reductions in the application and/or rental may apply and can be explained by BLM officials during the preapplication meeting.
REMEMBER TO PLAN AHEAD
You should arrange for your preapplication meeting well in advance of when you would like to start work on the project. Processing time for an average grant is 60 to 90 days. However, grants for complex projects can take much longer. Try to contact the BLM as soon as possible. The Area Manager and staff are ready to provide information, advice, and assistance to help you prepare an application.
You must use a STANDARD FORM 299 (22KB PDF - mail or fax form to the appropriate office) to file an application.
TEMPORARY USE PERMIT (TUP)
Keep in mind that all activities associated with the construction, operation and termination of you ROW must be within the specified limits of the authorization. Item 7 on the ROW application is where you would identify your need for the use of additional land during the construction phase of your project. This additional land maybe necessary for construction, stock piling of excess materials, equipment parking, etc. If additional land is required during construction, you will need to apply for a TUP. This TUP can be granted for up to 3 years; granting a term of this length generally allows the holder of the ROW adequate time to any stipulated requirements for restoration of disturbed land. TUP needs should be discussed during the preapplication meeting.
You can apply for a TUP at the same time as you apply for a ROW by describing its dimensions, locations, and term needed in item 7 of the standard ROW application (SF-299), or by describing it in your Plan of Development. You may also apply for a TUP after your ROW has been granted; in this case, you would use a separate SF-299 form, and would pay additional processing/monitoring fees for BLM to process the TUP. This might require a separate environmental clearance and take additional processing time. The Bottom line: if there is a possibility that you may need extra construction width or space, it is best to identify this in your ROW application.
ROW PLAN OF DEVELOPMENT (outline)
1. Description of the Facility (e.g., road, pipeline, utility line, etc.)
What is to be built?
What will it be used for?
Why is it necessary to use public lands?
When do you propose to construct? Specify duration and timing if known.
How long is the authorization needed?
II. Design Criteria
The degree of design must be compatible with the proposed use and anticipated environmental impacts.
All disturbances must be within the boundary of the ROW.
A. Road Specifications
Length and width of ROW
Width of road surface
Maximum grade of road
Minimum/maximum clearing width
Cut/fill slope ratios
Type and location of drainage structures
Cattle guards, fences, gates
Proposed surfacing (gravel) type and quantities
Dust abatement
Centerline survey plat
Design drawings including:

Plan and Profile sheets
Typical roadway cross-sections
Culvert installation details
Grade dip detail (water bars, rolling dips, etc.)
Cattle guard, fence and gate details
Construction specifications
Materials specifications
B. Pipeline Specifications
Length and width of ROW
Diameter of pipe and type of material
Depth of pipeline
Size if trench
Construction access requirements during and after construction
Construction equipment requirements
Survey plat
Site specific engineering surveys for critical areas
Cathodic protection site, valve stations, compressor stations
C. Power Line Specifications
Length and width of ROW
Size, number and type of conductors
Height and size of tower/poles
Vegetation clearance requirements
Raptor proof design
Construction access and equipment requirements
Transformers, substations, anchor locations, pulling sites
Marker ball installations
D. Communication Site Specifications
(pertain to non-linear sites)
Site dimensions
Size of all structures (building, towers, guys)
Site design plan
Utility requirements (power, phone)
Access requirements during and after construction
Technical data report including specifications of equipment, frequency of transmissions
FCC license
Compatibility with other users
III. CONSTRUCTION OF THE ROW FACILITY. Most surface disturbing activities associated with ROW occur during this phase of the project. The following components have been found to be common to most ROW construction projects. These items, where relevant, should be carefully described in the plan of development.
A. Flagging and Staking the ROW.
Stake centerline and/or the exterior limits of the ROW
Construction staking, cut and fill areas, clearing limits
B. Clearing and Grading of the ROW.
State how much topsoil will be saved, show where it will be stockpiled and how it will be spread
Describe disposal of all woody vegetation (trees, stumps and brush) cut on the ROW
C. Earthwork
Engineering and quality control
Excavation and placement of embankment
Borrow material sources
Removal of structures and obstructions
Disposal of unsuitable excavated materials (e.g. oversize rock, weak soils, etc.)
Soil erosion and water pollution control measures
D. Structure Installation
Describe how improvements will be constructed ie., constructed on site, prefabricated and delivered to site, concrete cast-in-place, precast concrete, etc.

E. Stabilization, Rehabilitation and Revegetation
1. Soil replacement and stabilization. (Explain how soil will be stabilized in the project area).
Recontouring all disturbed areas to restore original contours
Placement of waterbars and/or other erosion control structures
2. Seeding Specifications
Seed mixture (certified seed required)
Rate, method, schedule for seed application
Application of mulch (straw, burlap, hydromulch) and locations
Application of fertilizer (type, location, rates)
Criteria for determining success of revegetation
IV. OPERATION AND MAINTENANCE OF THE FACILITY
Describe what maintenance is required and anticipated level of use
When will scheduled maintenance be performed
Snow removal
Pesticide Use Proposal-application to BLM describing plans for controlling noxious weeds
V. TERMINATION AND ABANDONMENT
Removal of facilities
Reclamation of disturbed areas
Written plan required
VI. MISC. INFORMATION NEEDS
A. Waste Disposal
Trash, construction debris
Solid waste disposal
Hazardous waste
B. Traffic Control Plan
Barricades
Construction signs
Flagpersons
C. Safety Plan for employees, contractors, general public
D. Fire Prevention Plan
E. Spill Prevention and Contingency Plan
Preventive measures
Notification of proper authorities
Incident Response/Containment measures
Testing and Cleanup measures
F. Temporary Use Permit (TUP)
List needs for additional space outside ROW
Proposed use
Dimensions
Specify duration of TUP (include time to rehabilitation site)
PROCESSING A ROW APPLICATION
Once you have filed an application, the BLM will review it to make sure all necessary information has been included. The application is then evaluated to determine the probable impact of the activity on the social, economic, and physical environments. The BLM will also check to see if the proposed ROW is consistant with the existing land use plan, and will check to see what valid existing rights currently exist on the lands in question.
A ROW application may be denied for any one of the following reasons:
--The proposal is inconsistent with the purpose for which the public lands are managed.
--The proposal would not be in the public interest.
--The applicant is not qualified.
--The proposal is inconsistent with Federal, State, or local laws.
--The applicant is not technically or financially capable of accomplishing the project.
--Serious environmental consequences that cannot be mitigated would result.
A preapplication meeting will reduce the possibility of the application being denied.
APPEAL RIGHTS

If the application is denied, the official written notice will give the reasons for the denial and information on how to file an appeal, should you so desire.

LIABILITY

The holder of a right-of-way grant is responsible for damage or injuries to the United States Government in connection with the holder's use of the ROW.

The holder indemnifies or insures the United States Government harmless for third party liability, damages, or claims arising from the holder's use and occupancy of the ROW.

APPLICANT CONTRIBUTIONS TO PROCESSING

ROW applications are generally processed in the order received, but a thorough, complete application will invariably be put ahead of a deficient, problem-riddled application. ROW applications often compete against other land use applications and other priority workloads. For this reason, applicants may have to wait for extended periods of time for the BLM specialist to complete required inventories. Other points to consider are weather and season of the year. Processing of an application may come to a standstill waiting for a clearance. For example, if you filed an application late in the fall and the BLM archaeologist already had other workloads committed for that year, the archaeologist may not be able to get to your clearance prior to snowfall and the application may be delayed until the next summer.

One option you may wish to consider is contracting with qualified individuals or firms to perform required inventories when the BLM has other competing workloads. The BLM does accept the work of certain qualified individuals and firms that hold permits to do cultural resources and T&E inventories on the public lands. These firms do the field inventory and write reports for BLM approval. This can often significanty reduce the processing time for you application and may also reduce the processing. These items should be discussed with the BLM at the pre-application meeting.

YOUR ROW RESPONSIBILITIES

Once you have a ROW grant, you can proceed with your plans. However, there are a number of responsibilities you should keep in mind. The following questions and answers help explain these responsibilities.

APPENDIX C. SUMMARY OF THE 23 CATEGORIES OF CLASS V UIC REGULATIONS

Overview of Class V Wells Included in This Report (continued)

Well Type	Inventory		Number of States Potentially with Wells	Injectate Constituents > MCLs or HALs	Contamination Potential	State Regulations in States With the Most Wells
	Documented	Estimated				
Subsidence Control Wells	28	158	5	Injectate data not available; reasonable to assume injectate in wells in NY, OR, and LA exceeds MCLs for some parameters.	Cannot be assessed due to lack of access to details on well design, construction, and operation. No contamination incidents reported.	Permit by rule: LA, OR Individual permit: NY Ban new wells: WI

Overview of Class V Wells Included in This Report (continued)

Well Type	Inventory		Number of States Potentially with Wells	Injectate Constituents > MCLs or HALs	Contamination Potential	State Regulations in States With the Most Wells
	Documented	Estimated				
Mine Backfill Wells	5,060	>7,890	22	Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Lead, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Zinc, Aluminum, Copper, Iron, Manganese, TDS, Sulfate, and pH	Contamination potential depends on site-specific conditions and practices. No contamination incidents reported that are directly attributable to Class V mine backfill wells.	Permit by rule: ID, KS, TX, IL, and ND (sometimes general or individual permits are required) General permit: WY Individual or area permit: WV, OH, IN, PA
Aquaculture Waste Disposal Wells	56	<106	6	Nitrate, Turbidity, and Chloride	Potential exists for operators to dispose of liquid wastes (e.g. waste or spent aquaculture chemicals) via aquaculture injection wells. Contamination potential depends on case-specific factors. No contamination incidents reported.	Permit by rule: ID (for wells <18 feet deep), NY Individual permit: HI, MD, ID (for wells • 18 feet deep) General permit: WY
Solution Mining Wells	2,694	2,694	2	Sulfate, Molybdenum, Radium, Selenium, Arsenic, Lead, Uranium, TDS, Chloride, Manganese, Aluminum, Iron, and Zinc	Not likely to receive accidental spills or illicit discharges. No contamination incidents reported that are directly attributable to Class V wells.	Individual permit: AZ, NM

Overview of Class V Wells Included in This Report (continued)

Well Type	Inventory		Number of States Potentially with Wells	Injectate Constituents >MCLs or HALs	Contamination Potential	State Regulations in States With the Most Wells
	Documented	Estimated				
In-Situ Fossil Fuel Recovery Wells	0	0	0	Ammonium nitrate	Most recovery operations, in the last 20 years, seem to have caused some ground water contamination (number of cases unknown). Problems are due to recovery operations not necessarily injection. Injection wells, deemed unlikely to receive accidental spills or illicit discharges.	Individual permit: WY, CO
Special Drainage Wells	1,944	>3,750	15	Coliform, Turbidity, Nitrogen-total ammonia, Arsenic, Cadmium, Cyanide, Lead, Molybdenum, Nickel, Nitrate, Radium 226, Iron, Manganese, TDS, and Sulfate	Depends on the well type and site characteristics.	Permit by rule: ID, IN, OH Area permit: FL (single family swimming pools only) Individual permit: AK, FL, OR
Experimental Wells	396	>396	10	Chloride, Sulfides, Uranium	Experimental tracer study wells not likely to be vulnerable to spills and illicit discharges. Experimental ATES systems inject treated water, and are not very vulnerable to spills or illicit discharges. One contamination incident reported.	Permit by rule: CO, TX, ID (for wells <18 ft. deep) Individual permit: SC, NV, WA, and ID (for wells >18 ft. deep)

Overview of Class V Wells Included in This Report (continued)

Well Type	Inventory		Number of States Potentially with Wells	Injectate Constituents >MCLs or HALs	Contamination Potential	State Regulations in States With the Most Wells
	Documented	Estimated				
Aquifer Remediation Wells	10,222	10,756	39	Sometimes inject reagents at concentrations above MCLs, though no data to show levels	Not likely to be vulnerable because injectate quality controlled by the conditions of the operations being conducted. Some concern for unapproved or unsupervised voluntary cleanups. One contamination incident reported.	Permit by rule: TX Individual permit: KS, OH, SC
Geothermal Electric Power Wells	234	234	4	Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Copper, Fluoride, Lead, Mercury, Strontium, Sulfate, Zinc, TDS, Manganese, pH, Iron, and Chloride	Generally not vulnerable to receiving accidental spills or illicit discharges, in some cases due to Best Management Practices (BMPs). No contamination incidents reported.	Individual permit: CA, HI, NV, UT
Geothermal Direct Heat Wells	31	48	10	Arsenic, Boron, Sulfate, Fluoride, Chloride, Iron, Manganese, and TDS	Unlikely to receive accidental spills or illicit discharges. No contamination incidents reported.	Permit by rule: ID (<18 ft deep) Individual permit: CA, NM, NV, UT, OR, ID (≥18 ft deep)

Overview of Class V Wells Included in This Report (continued)

Well Type	Inventory		Number of States Potentially with Wells	Injectate Constituents > MCLs or HALs	Contamination Potential	State Regulations in States With the Most Wells
	Documented	Estimated				
Heat Pump/Air Condition Return Flow Wells	27,918	>32,801 (but likely <35,000)	40	Lead, Copper, Chloride, and TDS	Low contamination potential because the wells are part of enclosed systems and are generally maintained on private property. Three contamination incidents reported.	Permit by rule: AZ, IL, KS, MI, MN, NE, ND (most wells), NY, OH, PA, SC, TN, TX, VA, WV, WY General permit: WI (for open-loop discharge to shallow subsurface soil absorption field in the unsaturated zone above the uppermost drinking water aquifer) Individual permit: DE, FL, MD (some wells), MO, NV, NC, OR (unless individually exempted), VT, WA Banned: WI (for open-loop discharge directly back into an aquifer)
Salt Water Intrusion Barrier Wells	315	>609 (but likely <700)	5	Typically meets MCLs	Unlikely to receive accidental spills or illicit discharges. No contamination incidents reported.	Permit by rule: CA Individual permit: FL, NY, and WA
Aquifer Recharge & Aquifer Storage and Recovery Wells	1,185	>1,695 (but likely <2,000)	28	A few constituents reported at levels above the MCLs (typically meets MCLs)	Unlikely to receive accidental spills or illicit discharges. No contamination incidents reported.	Permit by rule: CA, CO, ID (<18 feet deep), OK, TX Individual permit: FL, ID (≥18 feet deep), NV, OR, SC, WA
Noncontact Cooling Water Wells	<5,775	>7,780	32	Injectate expected to meet MCLs/HALs because contains no additives/not chemically altered	Low probability of pipe leaks that could result in accidental releases. No contamination incidents reported.	Permit by rule: TN, WV, OH, IA, MT, CA Individual permit: AK, WA (existing), AL, NY Ban: WA (new)