DISSERTATION

CRISES UNWASTED: HOW POLICY ENTREPRENEURS LINKED FOREST BIOMASS TO ENERGY SECURITY IN COLORADO, 1998-2013

Submitted by

Mike Eckhoff

Department of Forest and Rangeland Stewardship

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Doctoral Committee:

Advisor: Kurt Mackes
Co-Advisor: Rick Knight

Charles Davis
Mark Fiege
Marcia Patton-Mallory
Douglas Rideout

ABSTRACT

CRISES UNWASTED: HOW POLICY ENTREPRENEURS LINKED FOREST BIOMASS TO ENERGY SECURITY IN COLORADO, 1998-2013

Colorado's forests are facing threats from wildfires, insect and disease epidemics and human encroachment. At the same time, Coloradans are facing energy security problems from fossil fuel price volatility, unintended consequences from continued fossil fuel dependence, problematic alternative, non-renewable fuel promotions and a struggling renewable energy industry. Subsequently, natural resources managers in Colorado are facing two imposing challenges simultaneously: 1) the need to restore forest health and 2) to manage energy resources sustainably, equitably and with public safety in mind.

Policy entrepreneurs invested in forest energy found ways to link forest health emergencies to energy security crises. This dissertation is a study that explores how that link was forged and what happened in Colorado as result, looking at the actions taken by the four major federal land management agencies (U.S. Forest Service, Bureau of Land Management, National Park Service and the U.S Fish and Wildlife Service). This study also traced briefly how the State of Colorado responded to these crises, too.

First, this study qualitatively surveyed literature in the forest history and policy arenas and energy history and policy arenas to chart how prior events led to current conditions. Media articles were tabulated and coded to quantitatively gauge how salient their respective issues were over time. Using Multiple Streams Theory, policy windows were identified. Second, the Punctuated Equilibrium Theory was applied to the emerging forest energy policy arena during the time frame identified by the policy windows. Finally, interviews and meetings were held with employees at the federal, regional/state and local levels and with members of state government to

determine how the increased saliency of forest and energy issues translated to forest energy policy actions on the ground in Colorado.

This dissertation concludes that federal land management agencies took greater interest and made significant efforts to promote forest energy in Colorado between the years 2000 and 2013. This increased interest resulted in increased funding, regulation and project development and implementation in the state. However, while activity increased, opportunity for additional actions remains. Coloradans would be wise to foster additional public-private initiatives and work to promote forest energy among large groups of proximal forest communities. Inevitably, as fossil fuel supplies decrease and prices increase, Colorado, along with the rest of the country, will in part be forced to return back to its “roots” and Dukert’s notion of “the future behind us.”

ACKNOWLEDGMENTS

Unlike most, if not all, of my peers, my first months at Colorado State University in 2003 were miserable. I was not adapting to graduate school, and I missed North Carolina. I was so despondent by the middle of the semester that I was ready to quit. I said as much to one of my professors in the Department of Political Science, and he suggested I abandon the degree—if only for the weekend—to remember why I chose Colorado. Perhaps I would return rejuvenated.

I drove south. In Colorado Springs, another driver's reckless lane change forced me off Interstate-25 and towards Pike's Peak. Tense, I rationalized that a change in my altitude might change my attitude. After winding up a long, narrow mountain road, unpaved and without guardrails, I stopped at the top of one of Colorado's highest peaks with a clear, uninterrupted view all around me including the Continental Divide. However, in my trance I neglected to look up; I was defecated upon by one of the winged locals. I was figuratively crushed.

Then, as I walked back to my car while trying to clean my shoulder, I noticed that the slope of the path was downward. Almost as if I had just been christened (or more likely looking for any reason not to assume the prodigal son's mantle), I decided that, henceforth, I would think positively. For instance, during my long walk back to the car I decided that matters could not possibly become any worse so all of my future efforts would be viewed as though I were moving downhill. (Also, in retrospect, I left on a Thursday. Friday was the last day to withdraw for the semester. Because I was traveling and lacked the internet access necessary for withdrawing, I forfeited any meaningful choice and was essentially trapped in my academic plan for the semester's remainder.)

Reminiscent of my wandering, I see the parallel in my efforts. Of my many faults, the most vexing is that I focus on the negative. Figures such as "the death of 100% of all mature

lodgepole pine in the next three to five years" or gas price spikes to $4.00 or more per gallon would seem insurmountable and I would have been consumed by the negative coverage. Tireless in their efforts, my graduate committee was vital for ensuring I did not forfeit anything else and helped me to see the opportunities within the bigger picture. I realize I have a knack for missing the forest for the trees. In fact, the basis for this project was an idea from Dr. Mackes. (Someone finally gave him a day off.)

They were not alone. Bob Sturtevant was stalwart in his support and his help with this effort, going so far as to initially serve on my committee and then proofread chapters during his retirement and during his stint with the Peace Corps in Ethiopia. Allison Level with CSU's Morgan Libraries was my guide to resources I did not know existed. I would be lost without her insights, guidance and assistance in and out of the classroom. A number of folks with the Colorado State Forest Service and the Colorado Wood Utilization and Marketing Program helped me along as well, including Tim Reader, Amanda Bucknam, Amanda Morrison, Kristina Hughes, Craig Jones, Matt Schiltz, Tara Costanzo, Damon Vaughn, the CSFS Outreach Division, including Katherine Timm, and Joe Duda, who all helped point me in the right direction (and who probably, given proper hindsight, wish I did not have their personal cell phone numbers).

I met some kindred spirits along the way, including Dan Bihn with Bihn Systems, Inc., the Forest Products Society's CSU Student Chapter and the Society of American Foresters' Alpha Student Chapter. They all seemed to know what to say, especially when I needed so very badly to hear it.

Teaching natural resources history and policy and forest products courses is invaluable. Hundreds of students have been kind enough to let me know where my philosophical shortcomings exist and some even posed the dreaded "So what?" and "Who cares?" questions. I hope I integrated their thoughts and ideas into this manuscript and corresponding lectures. I also hope, in exchange, they learned that managing people is just as critical, if not, more so than managing the natural resources we consume.

I am also tremendously indebted to a myriad of contacts in the forest energy world. To those anonymous respondents from the federal land management agencies' national, state and regional/local levels, I am deeply indebted to their willingness to speak with me openly and honestly. I hope I have captured their thoughts, ideas and experiences accurately. Similarly, for the folks from state and local government and from the forest products industry and environmental community, I am very humbled by their breadth of experience and very appreciative of their willingness to share some of that experience with me.

I am indebted to Dr. Tessler, the staff at Rose Medical Hospital, Dr. Nandi, Dr. Moss, Dr. Larson, Charlotte Popovich, Dr. Snively, the staff at Kaiser Permanente and especially the continued support of Dr. Cohn and my team at Rocky Mountain Cancer Centers. Surviving a bout with *Clostridium difficile* and a subsequent round with Stage 4B Hodgkin's Lymphoma halfway through the research process was the most grueling and difficult challenge I ever faced. I hope they know just how grateful I am for the extension of a lifetime.

Jane Hastings (and Roxie) at Mad About Fitness became my personal trainer, physical rehabilitator, and cheerleader. I'd still be an uncontrolled growth on the couch, unable to perform a push-up or abdominal crunch, much less know what those exercises are, without her help and support. She is the reason I can sit upright at a desk again and was able to type this paper.

When the (wood?) chips were down, my family and friends provided a unique, distant refuge where for a few months, I could recharge and "re-create." I'm indebted to my friends in Lakewood Shorin-Ryu for their support and teaching me the value of courage (and a well timed

punch). Along with my dear friends Erin Belval and Kathie Mattor, my parents and brothers served as sorely overworked and vastly underpaid editors, reviewers and personal focus group.

Finally, I am indebted to a high-elevation avian species that seemingly enjoyed the freedom of not having to mind its bowel control one fateful day in the Springs.

With so many helping, any remaining errors, inconsistencies, exaggerations or unduly complicated and verbose passages where I inadvertently failed to eschew sesquipedalian and erudite diction while attempting to unnecessarily obfuscate the basic yet essential statements of fact (read: lies) belong to me and me alone.

DEDICATION

To the real foresters, who risk more every day than I ever have

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LIST OF KEYWORDS

To conduct the searches of the *Readers' Guide to Periodical Literature*, keywords were first identified by looking for terms encountered during the literature review. Two passes were made through the *Guide* between the years 1973 and 2013, with each pass evaluating both "forestry" articles and "energy" articles for each year using selected keywords. The keywords used for tabulating article counts are listed below.

FORESTRY

- Forest Clearcutting
- Forest Conservation
- Forest Crown Canopy
- Forest Ecology
- Forest Education
- Forest Fires
- Forestry
- Forest Management
- Forest Reproduction
- Forest Soils
- Deforestation
- Wildfires
- Timber/Lumber
- Forest Products Industry
- Healthy Forests Initiative (HFI)
- Healthy Forests Restoration Act (HFRA)
- National Forest Management Act (NFMA)

ENERGY

- Biomass Burning
- Biomass Energy
- Electric Industry
- Electric Lines
- Electric Power
- Electric Power Failure

- Electric Rates
- Electric Utilities
- Wood as Fuel
- Wood Pellets
- Wood Stoves
- Wood Waste as Fuel
- Energy
- Energy Conservation
- Energy Harvesting
- Energy Industry
- Energy Policy
- Energy Subsidies
- Energy Tax Credits
- Renewable Energy
- Renewable Energy Industry
- Renewable Energy Employees
- Gasoline Prices
- Natural Gas Prices
- Coal Prices
- Energy Policy Act (1992 and 2005)
- Electric Power Failure of August 2003
- Energy Independence and Security Act (EISA) of 2007

DEFINITION OF UNITS

Board foot: A board foot (bd ft) is a unit of wood volume one foot long by 12 inches wide by one inch thick or 144 cubic inches. A board foot is roughly equivalent in size to a large kitchen cutting board.

British thermal unit: A British thermal unit (Btu) is the amount of energy needed to heat or cool one pound of water by one degree Fahrenheit. It is equivalent to 1,055 joules in the SI system. It is roughly equivalent to the amount of energy released when one strikes a kitchen match. A fully loaded coal car contains roughly 2.4 billion Btus or enough Btus to meet the annual energy needs of about eight Coloradans. Over 5 million people call Colorado "home."

Cubic foot: A cubic foot (cu ft) is a unit of wood volume equal in size to a cube with one foot in each dimension. On paper, one cubic foot is equal to 12 board feet (bd ft). However, due to saw kerf (saw blade thickness) and machining variability, the conversion factor is more often one cu ft equal to somewhere between 5.7 and 8.3 bd ft.

Energy: Power integrated over time. A 100-watt light bulb left on for 24 hours will have consumed 2.4 kWh of energy (electricity). Energy equals power multiplied by time.

Kilowatt: One thousand watts (kW). Electric utility rates are often billed at a rate of so many cents per kilowatt-hour (kWh).

Megawatt: One million watts (MW). Megawatt measures power output; estimates at the Gypsum forest energy power plant suggest one megawatt of capacity can meet the energy needs of between 800 and 1,000 homes. Power plants are rated in terms of megawatts (MWs). Over half of all coal power plants in the United States are between 100 and 1,000 MWs in capacity; another roughly 42 percent are less than 100 MWs. Most nuclear power plants are rated between 500 and 1,500 MWs. The forest energy power plant in Gypsum, Colorado, is rated at 11.5 MWs

(USDE EIA 2014a; USDE EIA 2014b). To avoid confusion, power plant energy sales are given in terms of megawatt-hours (MWh), i.e. the power plant output rating multiplied by the amount of time power was produced at that rating. Sometimes the quantities are large enough that outputs are in terms of larger units, like gigawatt-hours or terawatt-hours.

Power: The rate at which electrons are transmitted instantaneously. A battery that can provide 250 amps at 12 volts can provide 3,000 watts or 3 kW of power at a moment. (Power equals current multiplied by voltage i.e., amps multiplied by volts.)

Watt: Basic unit of measurement for instantaneous power (W).

CHAPTER 1: WHERE FOREST HEALTH AND ENERGY SECURITY MEET

"And by that destiny to perform an act / Whereof what's past is prologue, what to come / In yours and my discharge."

– Antonio, The Tempest (Shakespeare 1604)

1.1 Introduction

Nothing was particularly ominous about the weather leading up to the Colorado Front Range's 2010 wildfire season. The spring and early summer were wetter and cooler than normal. Rain showers near Boulder, Colorado, frequently produced quarter-inch totals between March and July and several storms between April and June each dropped over an inch (Western Regional Climate Center 2012a). Temperatures were slow to increase in the late spring; the colder weather delayed the anticipated snowmelt (Bunch 2010a; Bunch 2010b). Yet on average, temperatures from January through July were five degrees Fahrenheit lower and precipitation totals were only about four inches higher than expected (Graham et al. 2012, 16-18). Cooler, wetter weather during the Spring is not out of the ordinary for locations like Boulder that are influenced by a continental climate as peak precipitation occurs during April and May and temperatures approximate the annual average (Cohen 1976, 59; Western Regional Climate Center 2012b; Graham et al. 2012, 8).

The weather pattern changed in August. Typical Front Range wildfire seasons are characterized by temperatures exceeding 80° Fahrenheit, relative humidities remaining below 20% and winds speeding more than 20 miles per hour (mph) (Graham et al. 2012, 8). The change for 2010 was more severe as an unusually dry and warm weather pattern settled over the region. While rainfall totals were above normal prior to midsummer, the largest rain event in August was a half-inch burst on the 9th (Western Regional Climate Center 2012a). The National Climatic

Data Center’s Palmer Z Index, which gauges short-term drought and wetness conditions, fell from “moderately moist” in July to “severely dry” by the end of September (Graham et al. 2012, 20). Fire danger levels increased from normal levels in mid-August to record-breaking levels by September. During August and September, the average temperatures for Boulder, Colorado, increased by over six degrees Fahrenheit and average monthly precipitation levels were two inches below normal. In just two months' time, the average temperature increase and average precipitation decrease were almost the exact opposite of the respective averages from the year’s first seven months (Graham et al. 2012, 17-18).

On September 2nd, in the midst of this weather pattern inverse, a volunteer firefighter burned some scrap wood in a fire pit on his Foothills property, about six miles west of Boulder, Colorado, and one mile northeast of Sugarloaf Mountain. After completing his burn, he doused the pit and stirred the drenched ashes with a shovel. He repeated the procedure the next day—a process more intensive and thorough than what one might perform on a campfire—and assumed the embers were extinguished. They were not. A dry cold front moved through the state late on September 5th, creating strong winds. These winds, combined with the previous day’s record high temperatures and low humidity, exacerbated the fire danger. By 10 A.M., wind speeds exceeding 40 mph scattered embers from the charred debris igniting nearby parched grass. By the time the resulting Fourmile Canyon Fire was contained, over 3,500 people were evacuated, 169 structures lost, over 6,000 acres burned and insurance claims exceeded $217 million, making this wildfire the most expensive in state history as of September 2010[1] (Graham et al. 2012; Meltzer 2011; Bounds and Snider 2010).

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[1] The 2012 wildfire season’s costs would dwarf the 2010 season. Please see the Epilogue for a brief overview of the 2012 and 2013 fire seasons’ preliminary impacts in Colorado.

Meanwhile, as Colorado struggles with severe wildfire seasons, the state also faces fossil fuel price spikes due, in part, to growing demands and uncertain supplies stemming from population increases and from global political and economic instability. One approach Colorado has adopted to mitigate the economic impacts to consumers is to focus on extracting its domestic deposits by nurturing a “home-grown” oil and gas[2] industry. The results are impressive. The number of active oil and gas wells has more than doubled since January 2002, from roughly 22,500 active wells to over 51,000 active wells in October 2013. Clusters of derricks and “horsehead” pumpjacks are common along the Interstate-25 corridor north of Denver, in Weld County and in Garfield County. Colorado’s daily oil production has more than doubled since hitting a production low in 1999 and natural gas daily output has more than tripled since 1995 (Colorado Oil and Gas Conservation Commission [COGCC] 2013).

These accomplishments are not consequence-free. Ned and Dollie Prather drove to their cabin on Logan Mountain, northeast of the Town of De Beque, Colorado, on May 30, 2008. After they arrived, Ned poured a glass from the tap and gulped most of it. Immediately, his throat burned, his head and stomach ached and he had trouble breathing. He filled a bottle with tap water, drove to the nearest staffed gas well and asked the workers what he just drank. After smelling the bottle’s contents, the workers said they did not know but offered Ned some bottled water to ease his throat pain. Dollie drove Ned about 90 minutes west to a hospital in Grand Junction, Colorado, where initial tests showed no immediate, permanent damage. Ned waited nearly three weeks for the COGCC to test his water. He learned he consumed a mixture of hydrocarbons commonly used in fracking, a process where large amounts of high-pressured

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[2] "Gas" refers to "natural gas" used in heating, cooking, some power and some transportation applications. "Gasoline" refers to the liquid hydrocarbon fuel used to run internal combustion engines.

water, sand and chemicals are used to crack rock formations to release the gas contained within them. The hydrocarbon concentration in his tap water was 20 times higher than the safety limit for groundwater (Lofholm 2010; Wadholz 2010).

Accounts like the Fourmile Canyon Fire and the Prathers' contaminated drinking water are becoming more frequent. Western and national media frequently feature forest health crises by highlighting catastrophic wildfires and the conditions, such as drought and insect and disease epidemics, that engendered them. In Colorado, evening news broadcasts show trees exploding and homes burning while explaining how bark beetle-killed trees and record triple-digit heat exacerbate the fire danger in the state's unhealthy forests. The morning papers tally damages in terms of numbers of lives lost, millions of acres burned and billions of dollars spent on wildfire suppression and insurance claims. Follow-up stories tally monies spent on post-fire restoration and flood control and also on the revenues lost when federal forested campgrounds are closed because congressionally appropriated mitigation funds are insufficient to ensure public safety.

Energy development stories on national media bring attention to the consequences of exploration while a burgeoning group of YouTube videos show rural homeowners using butane grill lighters to ignite the dissolved carcinogenic hydrocarbons in the well water streaming from their taps. Pressures to expand domestic drilling increase as gasoline price spikes, shown on station marquees, are captured on the evening news broadcasts. Some stories feature analysts or venture capitalists promoting the role alternatives could play in alleviating dependence on non-renewable energy sources. Critiques from fossil fuel developers are just as quick to cast doubts on these Promethean solutions by disseminating evidence of alternative energy technologies' unintended environmental consequences. Furthermore, developing countries' burgeoning economies put additional pressures on scarce resources, including fossil fuels but also on critical or rare-earth materials. These materials are highly sought after by the developed nations as they are crucial for manufacturing alternative, renewable technologies.

Incentives in the forest policy and energy policy arenas further complicate the issues. While billions of federal dollars pay for suppressing wildfires and treating bark beetle-infested forests, some renewable energy tax incentives specifically exclude biomass removed from federal forests, as in the Energy Independence and Security Act of 2007 (EISA). Western states, with disproportionate shares of federally managed forestlands, are discouraged from taking advantage of the same forest management incentives that eastern states may enjoy. Furthermore, federally legislated targets for managing forest fuels reduction projects or for sustainably generating alternative fuels are often controversial and subject to periodic or annual revisions and, subsequently, fights. When federal forests are eligible for incentives, the dollars often cover tree removal but no provisions exist for taxpayers to recoup the cost through manufacturing forest products. Thus, instead of developing a market-based mechanism to pay for the work, the federal government is merely subsidizing businesses to remove the material.

In another instance, the federal Production Tax Credit (PTC) incentivizes electricity generation from renewables like forest biomass. Yet, the incentives are different depending on the form of the biomass consumed (e.g., open-loop vs. closed-loop[3] or dedicated energy crops) and can be less generous for some forms of biomass when compared to other renewables, such as wind and solar. Conversely, as with federal forests in western states, eastern states that lack access to renewables are at a disadvantage as incentives favor those regions that have access to

[3] Closed-loop biomass refers to biomass that is planted and designated for use in a qualified facility to generate energy (electricity in the tax code). Open-loop biomass, where forests are concerned, typically refers to mill residues, pre-commercial thinnings and other hazardous fuels material. The term can also incorporate solid wood wastes (e.g., pallets, construction and demolition debris, etc.). See Bracmort (2012, 8) for more details.

these resources (e.g., corn ethanol in the Midwest, wind in the West, solar in the Southwest, etc.). Finally, the chances for creating parity among all renewable energy sources remains uncertain, especially as the PTC is subject to periodic reauthorizations[4] and each of the various renewable energy lobbies has disproportionate strengths when compared to the amount of energy they contribute to the national energy consumption portfolio.

Incentive inequality is not limited to just the federal government. Some state-level policies are increasingly geared toward incentivizing alternative, renewable energy production. However, most of these policies favor electricity production. Renewable electricity standards (RES) or renewable portfolio standards (RPS) typically require a utility, often an investor-owned utility (IOU), to produce a certain percentage of their electricity using renewables by a specific year. In Colorado, for instance, forest biomass faces some restrictions (e.g., the definition of biomass does not allow for "trees") and other renewables, like solar, have a credit multiplier, which causes solar to appear more attractive for utilities to meet the standard per kilowatt-hour generated.

The results from these misaligned incentives translate into uncertainty and inequality for other sectors. When not left at the mercy of uncertain economic conditions as globalization increases, the U.S. forest products industry is forced to make long-term plans based on short-term, intermittent annual federal budget cycles, most of which over the past decade have relied increasingly on continuing resolutions (CRs) while avoiding the occasional government shutdown. Less affluent environmental non-governmental organizations (ENGOs) may feel ostracized as media accounts from the past decade detailed energy-related political scandals,

[4] The PTC ended on December 31, 2013 as Congress failed to reauthorize it in time. The disparity between the credit received by closed-loop (2.3¢ per kWh) and open-loop biomass (1.1¢ per kWh) remained until the PTC expired.

including one administration’s questionable public loan practices to a donor-related solar energy venture and the “privileged” dealings of its predecessor’s pro-fossil fuel energy task force.

Thus, while the physical and political pressures on forest and energy resources increase with no signs of subsiding, two imposing challenges face natural resource managers: 1) restoring forest health and 2) managing energy resources sustainably, equitably and with public safety in mind. Mangers will need direction from decision-makers. The traditional approach for decision-makers to address these issues is to identify a problem or problems and then to develop, implement and evaluate political solutions—a process akin to using the scientific method to make policy (Nakamura 1987, 144). Some researchers conceptualize this process as linear, consisting of various stages or steps that proponents follow when developing solutions (e.g., Cubbage et al. 1993). Policy solutions may be solitary or part of a solution set generated through iteration. The solution sets tend to be contingent, not only on how problems are defined but also, in some cases, on how and who assigns culpability convincingly (Rochefort and Cobb 1994, 1-31; Stone 2002, 188-209).

In contrast, this dissertation subscribes to Kingdon’s (2003, 122-123, 168-169) notion that the reverse is more accurate. Proponents or policy entrepreneurs develop solutions and then search for problems to which they attach their favored solutions. For the purposes of this paper, the hypothesis is that proponents for FBU in Colorado reframed FBU as a solution to emerging forest health issues and energy crises. FBU became a way to reduce overstocked forest fuel loads and reduce the risk of catastrophic wildfires while providing a cheaper and cleaner energy source and increased economic security for proximal rural communities. Thus, FBU proponents in Colorado attached their preferred FBU solution to the problems of frequent forest fires and simultaneous energy supply problems.

FBU has received little serious attention until the past decade and is becoming more salient. A number of trade publications and articles exist but the majority of this work describes FBU's technical aspects (i.e., moisture contents, British Thermal Unit (BTU) value equivalents, etc.) and quantifies potential amounts. More recent efforts attempt to determine what material is physically and administratively accessible while ecologically sustainable. More specifically, FBU *policy* is largely neglected. The Government Accountability Office (GAO) analyzed the barriers and federal FBU efforts to overcome said barriers (GAO 2005). The federal agencies that were interviewed mentioned steps they were taking but little has been written about FBU *policy* by the GAO since these initial recommendations. Peer-reviewed publications covering FBU policy often select either the forest policy or the energy policy arenas but rarely, if ever, address both policy arenas simultaneously. For instance, Nicholls et al. (2008, 8) analyze FBU policies affecting the Western United States but the policies covered are limited to major federal forest-centered legislation, excluding major corollary federal energy policies. Others (e.g. Benjamin et al. 2009, 129-130; Solomon et al. 2007, 422-424) cover FBU energy policy but exclude forest policy developments. Some efforts have begun integration (e.g., Becker et al. 2011; Guo et al. 2012, 2013; etc.), but studying FBU as it pertains to both forest policy and energy policy, i.e. restoring forest health and using the material to meet energy needs, demands more analytical integration between the forest policy and energy policy arenas.

This project uses a tripartite procedure. First, this paper reviewed media accounts and pertinent literature looking for evidence where forest fires and energy crises captured national attention. It also searched for proponents who skillfully crafted or framed "problems" that favored FBU. Simultaneously, it searched for efforts to place FBU on various public and government agendas. Second, data collected from interviews with key policy arena participants were used to determine and analyze which policy venues were followed and which policy images were adopted to advance FBU. Finally, data from the first two phases was used to construct case histories for four federal land management agencies: the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), the National Park Service (NPS) and the U.S. Fish and Wildlife Service (USFWS). These case histories detailed how federal-level FBU translated into on-the-ground actions and results in Colorado.

1.2 Forest Health in Colorado

Forests are the largest land use category in Colorado (Colorado Governor's Energy Office [GEO] 2009a, 64).[5] They occupy roughly one out of every three acres, passing the total land area used for crops, grazing or urban areas and occupying a space approximately the same size as the state of Maine (U.S. Census Bureau 2010; Colorado State Forest Service [CSFS] 2002, 6). Although trees can be found almost anywhere in the state and at almost any elevation, most forested acres are concentrated along the Front Range, around the Continental Divide and throughout the Western Slope (CSFS 2010a, 7, 15). While forested acres exist on the Great Plains in naturally occurring riparian zones (see Figure 1.1), other forests are synthetic plantings designed to mitigate harsh climatic conditions (e.g., windbreaks, shelterbelts, etc.) for crops, livestock and transportation (CSFS 2012a).

More striking than the sheer forest acreage totals, however, is who manages these acres and to what end(s). First, most forested acres in Colorado are managed by the federal government. Nearly half of all forested lands (46.2%) are managed by the USFS with another

[5] Although forest land is technically the single largest land use category (22 million acres), agricultural lands (28.5 million acres) exceed forested lands as the GEO report separated pasturelands (17 million acres) from crop lands (11.5 million acres).

17.3% managed by the BLM. Other publicly held forests are managed either by additional federal agencies (1.9%) or by state and local governments (3.0%). Tribal forests constitute 1.7% of state forests. About 186,000 private owners control 29.8% of Colorado's forests. This total includes both non-industrial private forestland (NIPF) owners and corporate owners, although the total NIPF acreage is much larger proportionately than total corporate holdings (CSFS 2010a, 14-16; Smith et al. 2009, 155).

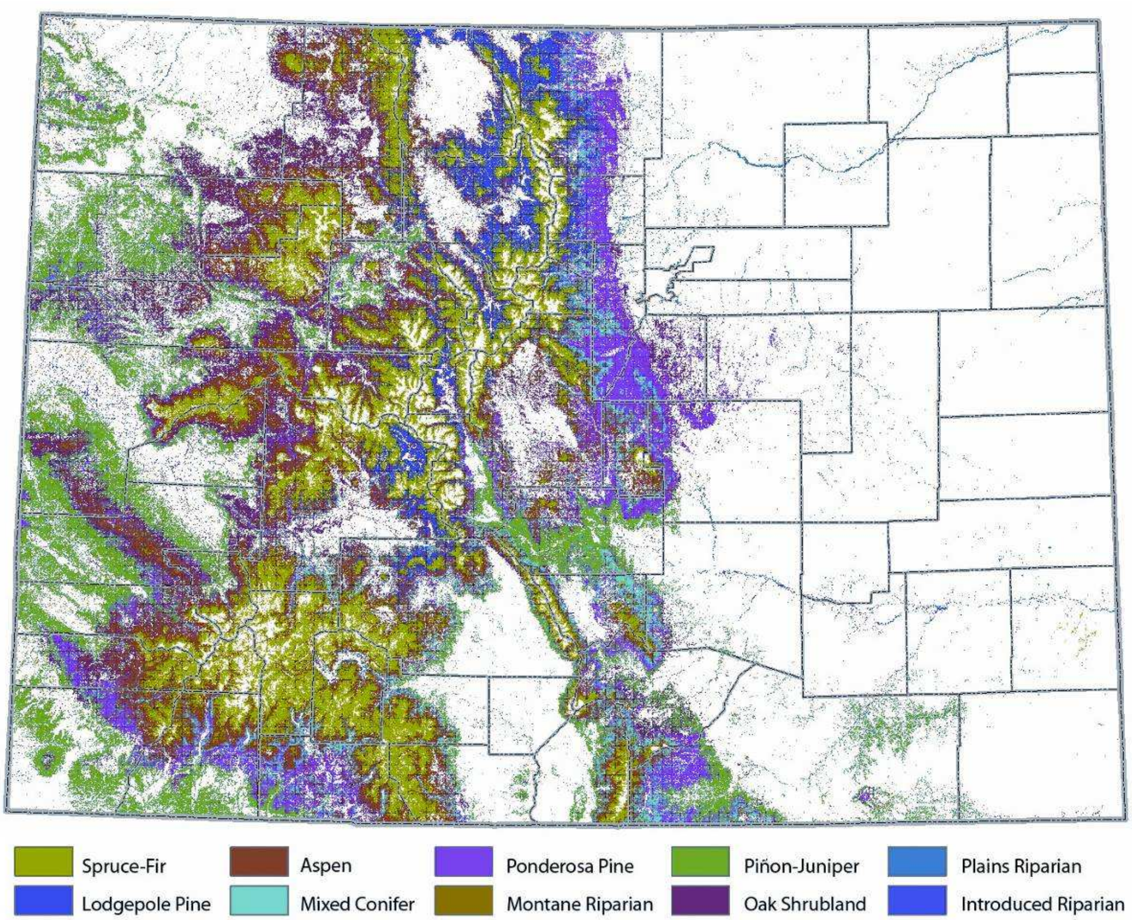

Figure 1.1: Forest Types of Colorado, 2010

Source: Adapted from CSFS (2010a, 7).

Harvesting does not occur on many of these forests, public or private. Colorado sustains an annual net forest growth of about 1.5 billion board feet (BBF) (CSFS 2007, 3). However, Colorado only harvests about 6% of this growth or about 86.5 million board feet (MMBF) of sawtimber each year (Hayes et al. 2012: 22). Thus, the limited timber removals do not significantly reduce the "interest" nor do they touch the "principal," even though both continue to grow unabated (CSFS 2007, 3).

Managing forests for timber and other uses tends to be problematic because portions of federal, state and/or local lands are typically "interlocked or intermingled" (Clawson 1983, 232), with private lands (see Figure 1.2).

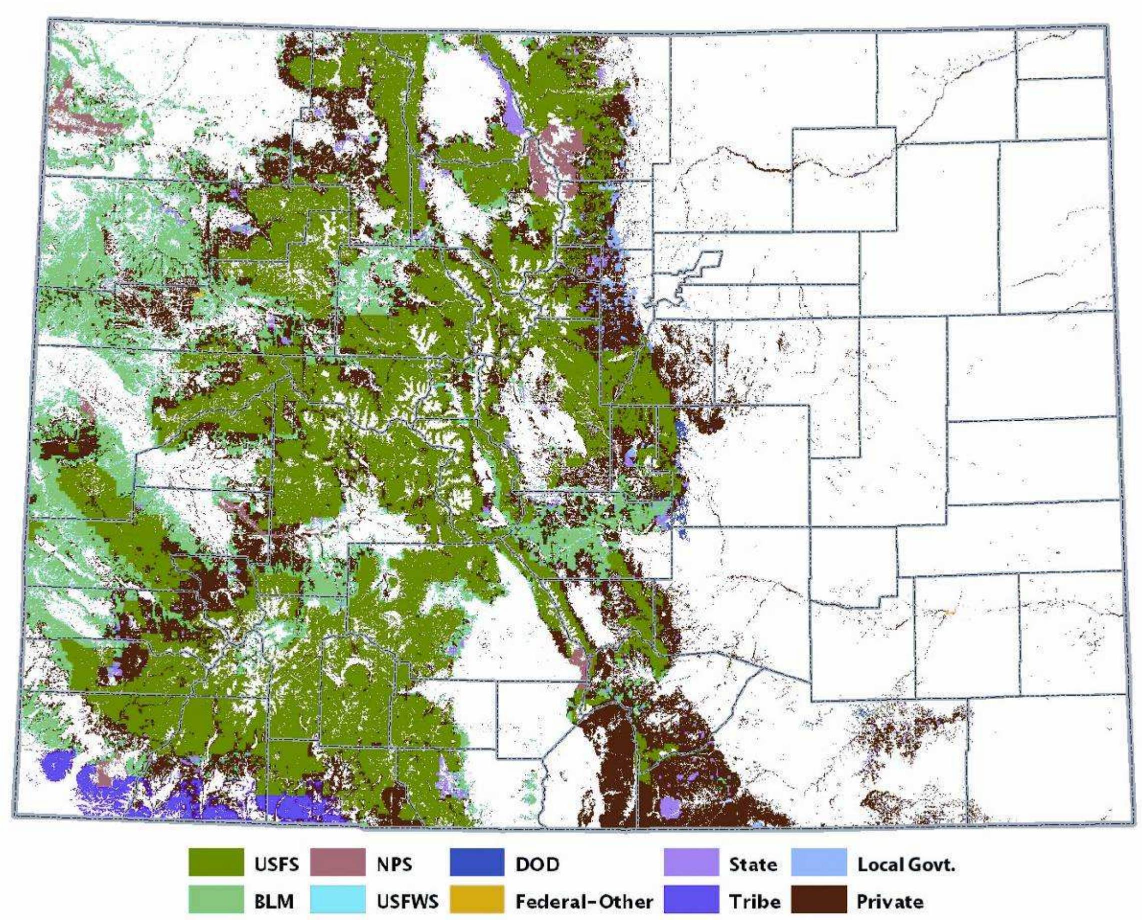

Figure 1.2: Map of Federally-Managed Forests in Colorado, 2010

Source: Adapted from CSFS (2010a, 15).

Complicating forest management further is the nature of the forests themselves. Colorado forests are *disturbance driven*, meaning that indigenous tree species co-evolved with cyclical, natural disturbances such as stand-replacing wildfires, insect epidemics, disease outbreaks, etc. (CSFS 2002, 3). These disturbances rejuvenate forests by ensuring diversity in forest types, age classes and densities across the landscape (CSFS 2007, 12-17). However, wildfire suppression, combined with restricted timber harvests over the past century, has dramatically altered these cycles. Decreasing timber removals combined with large-scale disturbance-suppressing activities cause significant amounts of forest biomass to accrue. FBU proponents, aware of such accruals, would therefore be naturally inclined to frame forest health issues in such a way that would encourage others to see FBU as a solution to them. These issues are summarized below.

1.2.1 Human Encroachment on Forests in Colorado

In the mid-nineteenth century, mining, logging and grazing provided economic incentives for settlement within the forest. However, mining towns were subject to resource-related boom-and-bust cycles creating a transient population, the remnants of which still punctuate the state's landscape. Later, recreation opportunities provided opportunities for people to visit public forests, but still, a sufficient economic basis for more permanent forest settlement was lacking.

The post-World War II economy began to provide such a basis. The need to reintegrate returning soldiers created a demand for housing and employment opportunities. For housing in particular, forest resources (lumber) were slated to expanding suburban environments (e.g. Levittowns, etc.). Timber-dependent communities began to coalesce near national forests lands as the nation began to rely more on national forests for meeting the housing lumber demand. Simultaneously, the increased incomes and leisure time led to increased demand for recreational opportunities; this increased demand led to concessionaires and recreational communities establishing themselves also near national forests.[6]

For Colorado, the economic boom of the 1990s provided the resources that allowed more people to move to Colorado's "Red Zone" (see Figure 1.3), an area characterized as high-risk for catastrophic wildfires.

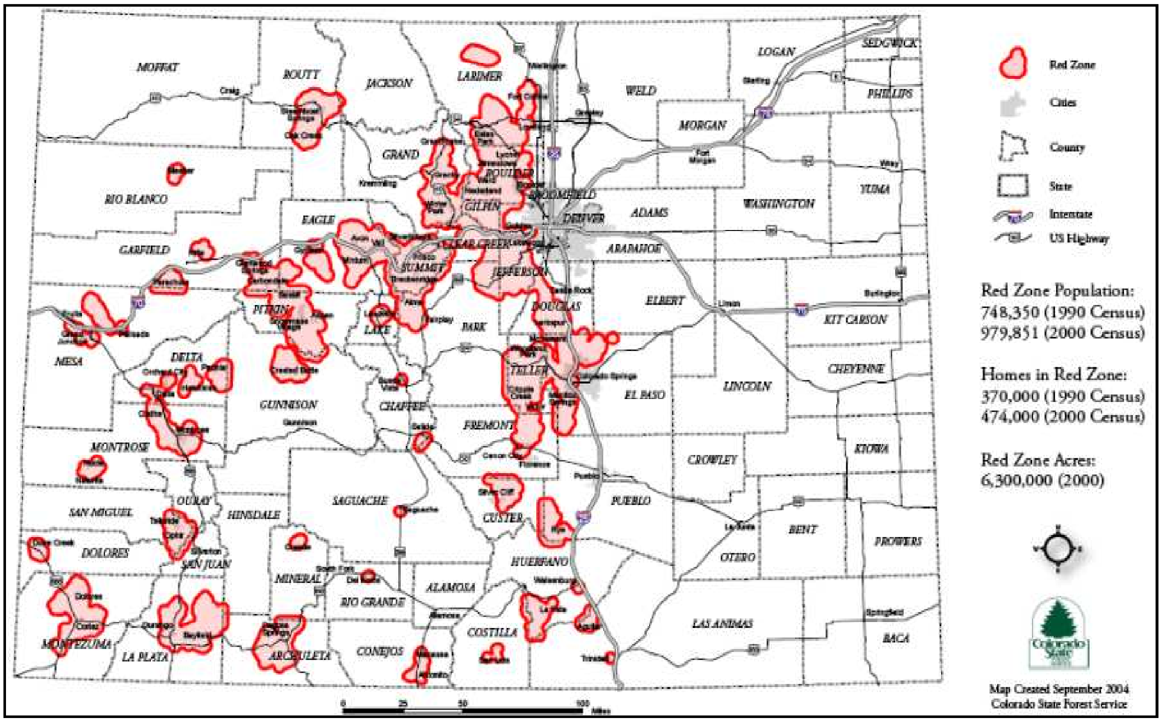

Figure 1.3: Colorado's "Red Zone" Map, 2004

Source: Adapted from CSFS (2004)

This rural growth signaled a demographic shift since more people were now settling than visiting, leading to an increase in forest ecosystem fragmentation. The CSFS (2002, 9) reported that between 1990 and 2000, the number of individuals owning at least one acre of forested land

[6] More on the conflicts between timber and recreation forest users can be found in Chapter 4.

increased from less than 50,000 people to over 200,000 while the number of forested acres under private ownership remained constant.

A more precise gauge for measuring human encroachment may be to examine the growth of the Wildland-Urban Interface (WUI), a land area "where urban development presses against private and public wildlands" (Theobald and Romme 2007, 340). Nationally, the WUI expanded by 52%, with Colorado being one of the top 16 states for WUI growth. In 2000, the Colorado WUI contained over 715,000 acres (CSFS 2008b). Currently, one out of every five people in Colorado, one out of every four homes in Colorado and about 90% of Pitkin, Teller and Summit counties' populations reside in the WUI (Kodas and Hubbard 2012). The WUI is expected to grow by 300% to nearly 2.2 million acres by 2030 as Colorado was one of the anticipated top six states for largest WUI growth over the next 30 years (CSFS 2008b; Theobald and Romme 2007).

The land use patterns in Colorado matches trends in the rest of the Rocky Mountain region. The number of housing units in the WUI increased by 68% from 1990 to 2000 (Schoennagel et al. 2009, 1). The US Fire Administration (2002) reported that 38% of new home construction was adjacent to or intermixed with the WUI in the Western United States. Kusmin (2007) noted that the growth rate in rural or non-metropolitan areas nationwide was three times higher between July 2005 and July 2006 than it was in July 2000, suggesting an increasing migration from metropolitan areas to less-developed rural areas. For Colorado, population growth rates were highest along the Continental Divide and throughout the Western Slope—the same areas where the highest concentrations of Colorado's forests are found (Kusmin 2007). This demographic shift suggests a significant increase in human encroachment and forest ecosystem fragmentation, leading some to identify "land conversion" as the most significant threat to forest ecosystem integrity (25x'25 Coalition 2011: 16).

1.2.2 Forests and Fire in Colorado

In Colorado, Native American tribes used fire to drive or attract forest game; to rejuvenate soils; to communicate; or as a weapon to drive away competing tribes. While fire was also a tool for Euro-American settlers, it quickly became viewed as more of a problem than a benefit. Forest fires could enhance resources and help convert forests to meet human needs (e.g. grazing, open areas for settlement, etc.) but they could just as easily deny access to those materials or even kill. Several large fires reinforced this notion during the mid-to-late-19th century e.g., a “first” deadly fire near Central City, Colorado in 1859, the Peshtigo Fire in Wisconsin in 1871, etc. The need to preserve raw materials, specifically timber, from exploitation and wildfires (whether naturally, intentionally or accidentally set), prompted the creation of the forest reserves in 1891—but not before at least two dozen notable fires had burned along the Colorado Front Range during the prior half-century (Veblen and Donnegan 2005, 53-54, 56, 113-114, 142-144; Steinberg 2002, 65-67; Noel 2012).

The impacts from these forest “protection” efforts vary. At the lower life zones in Colorado (below ~7,500 ft), and to a limited extent in the upper montane life zone (below ~9,000 ft), wildfire suppression had its most significant impact, although one should note that the effects of wildfire suppression are not the only impacts worth considering (Veblen and Donnegan 2005, 65; Kaufmann, Veblen and Romme 2006, 4-6). As fires were suppressed, smaller, weaker trees and dense underbrush that would normally have perished, survived, causing forest fuel loads to accrue (Veblen and Donnegan 2005, 65, 120-121). The open, park-like stand conditions gave way to dense, young stands of Ponderosa pine (*Pinus ponderosae*) trees in the lower montane. Trees in these denser stands are prone to stress due to competition for resources (soil, water, sunlight, etc.). This stress increases tree susceptibility to insect epidemics, such as the mountain pine beetle, and parasites, such as dwarf mistletoe (*Arceuthobium* spp.) (Veblen and Donnegan 2005, 120).

With upper montane lodgepole pine (*Pinus contorta*) forests, fire suppression impacted stand conditions but not with the same efficacy as with lower montane stands. Euro-American miners increased the rate of logging and fires in the late 19th-century in Colorado. Large areas were cleared in a short period of time. As the mines closed, trees regenerated and over time created swaths of even-aged stands. With few large-scale disturbances occurring during the past century, few younger-aged stands developed. The resulting forest stands are homogenous and near the end of their 100-to-150 year life-cycle. However, they are still within the forests' historic range of variability, and the current forest health impairments may not be as abnormal (Veblen and Donnegan 2005, 123-124).

Over the long run, fire suppression at higher elevations may not initially translate into a direct exacerbation of the wildfire threat but acts more like an accessory that creates conditions conducive to large insect and pathogen outbreaks that, in turn, aid widespread, high-severity wildfires. At lower elevations, fire suppression efforts constituted a vicious negative feedback loop resulting in conflagrations that, during the past decade, burned longer and hotter and caused more damage (Pyne 2001a, 75, 150-151; Pyne 2001b, 278-279; Arno and Allison-Bunnell 2002, 16-22). This feedback loop appeared to reach an interim apex[7] in Colorado in 2002 when the state experienced its worst wildfire season on record (Front Range Fuels Treatment Partnership 2006). For instance, one of the year's low elevation fires, the Hayman Fire, burned nearly 138,000 acres and cost more than $200 million ($1,508 per acre) to suppress. This total includes

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[7] Initial costs for the subsequent 2012 and 2013 wildfire seasons are being tallied at the time of writing, but these seasons are expected to be some of the most expensive, destructive and deadliest on record for Colorado. Please see the Epilogue.

costs incurred by industries (e.g. tourism, insurance, etc.), which continued to accrue in 2003 at a rate of approximately $22 million per year or nearly $160 per acre per year (Lynch 2004). The Western Forestry Leadership Coalition (WFLC) (2009) cataloged similar accounts from other fires in 2002.

Costs for largely reactive solutions (e.g., extinguishing established wildfires) are expensive; costs for more proactive approaches, like prescribed burns and mechanical thinning, used to reduce forest fuel loads are lower by comparison but are still high enough to discourage their widespread implementation (Lynch and Mackes 2003). Proactive thinning treatments that used the wood for product for the lower montane acres along the Colorado Front Range can range from $679 to $1,085 or more per acre (Lynch and Mackes 2003). Conservatively assuming an average of $1,000 per acre as a base treatment cost and then multiplying this cost by the footprint of the 2002 Hayman Fire gives a total hypothetical proactive treatment cost of nearly $138 million. Considering the initial $200 million cost figure for a reactive response to the Hayman Fire, which included the death benefit packages for five firefighters and excludes the projected $22 million increase for just the first year after containment, the lower $138 million fixed cost associated with the proactive approach is a bargain by comparison.

1.2.3 Parasitic Insects and Plants in Colorado

In addition to wildfires intensifying, the lack of age class diversity, due in part to fire suppression, enhances the impact of other forest health threats. The mountain pine beetle (*Dendroctonus ponderosae Hopkins*) is the most visible insect agent in terms of area impacted. Whereas forest lands in Colorado cover an area the size of Maine, the area impacted by the mountain pine beetle (MPBs) spans 3.3 million acres (CSFS 2012b, 8), or slightly larger than Connecticut (see Figure 1.4).

While significant in size, the current MPB epidemic is also a time-sensitive matter. Beetle-killed trees may remain on the stump and useful for solid sawn wood products for up to five years and weight losses for trees that have been standing dead for a decade may be as little as 1%.

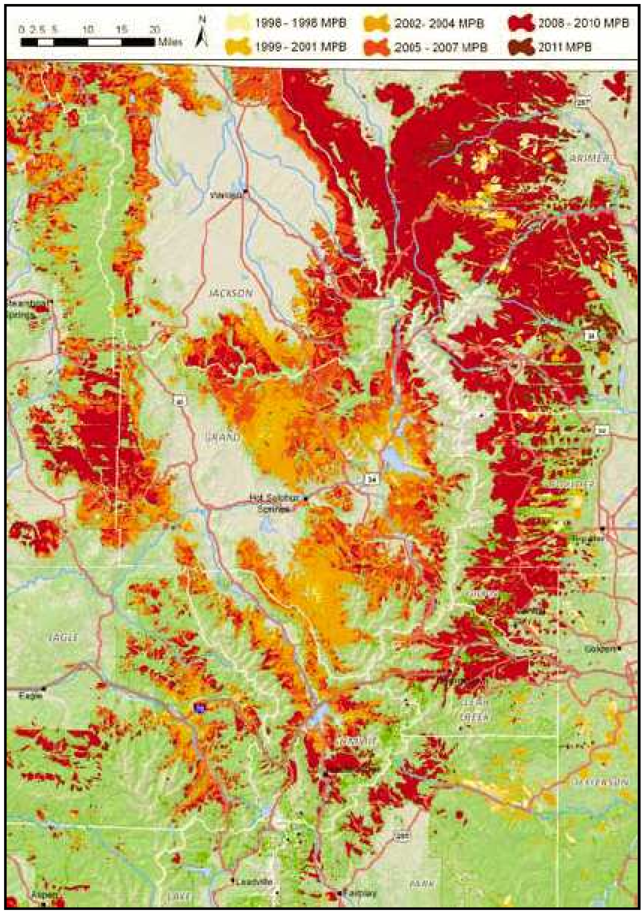

Figure 1.4: The Mountain Pine Beetle Epidemic in North-Central Colorado, 1996-2011

Source: Adapted from CSFS (2012, 7). The red areas are new attacks from 2008-2011 while shades of orange and yellow are attacks from 1996-2007.

Wood pellets and forest energy products may have a longer window of opportunity—perhaps over a decade. However, while standing dead trees may remain economically valuable for some time, some will blow down within two to three years after mortality and 90% of them will be on the ground within 15 years (Lewis and Hartley 2006, 15). Once on the ground, the industry's costs to remove the material from the forest increase as the timber, which usually falls in a jackstraw pattern, requires additional, special handling. Consequently, the amount of accumulating material and the timber loss value total could be substantial. For instance, in Grand County, Colorado, timber value losses are estimated at over $1 billion (Mackes et al. 2010).

Given the limited resources available for forest management, agencies are unable to counteract or mitigate an epidemic of these proportions; thus, planning for the next forest instead may be appropriate (Kaufmann, et al. 2008, 9-10; CSFS 2007, 4-6; CSFS 2008a, 20-27). Plans could focus on diversifying age classes through strategic patch cuts to break up monoculture lodgepole pine stands. In addition, with an estimated 50% of all Colorado lodgepole pine stands and 20% of ponderosa pine stands infested with dwarf mistletoe (a parasitic plant) plans should also incorporate tactics to eliminate infested trees to reduce the likelihood carrier trees could infect saplings in the future (CSFS 2005, 7; CSFS 2007, 18).

1.2.4 Public Safety in Colorado Forests

With more people moving to the forests combined with increasing fire severity from unmanaged stands and years of “catastrophic” (Pankratz 2008) beetle-killed tree mortality rates, the risks to public safety are increasing. For instance, the start to Colorado’s 2012 wildfire season saw over 500 homes destroyed, over 100,000 acres burned and six people lose their lives. Most of these losses were sustained in just two fires: the High Park Fire, which began outside of Fort Collins, and the Waldo Canyon Fire, which started outside of Colorado Springs but quickly found its way into the city, forcing more than 32,000 people (or about one out of every 13 residents) to evacuate (Parker 2012; Udell 2012). An issue for the High Park Fire was the thousands of beetle-killed trees. As it churned westward, the fire entered stands that were 70% beetle-kill, dashing hopes for quick containment (McGhee 2012). While a tree’s fire risk typically declines within two-to-three years after mortality due to the shedding of their needles and fine branches, these forested acres were recently infested. This recent mortality meant the trees still had their highly flammable dead needles on their branches. Even if the High Park Fire had not burned these temporarily highly flammable trees, the intermission between fires might have been short. The beetle-killed trees will eventually blow down. New saplings establish themselves between the jackstraw logs and the fire risk will increase again as the new saplings can carry the fire into fallen trees, making fire suppression more difficult, more hazardous and more expensive (CSFS 2010b, 31).

The increasing human presence in forests heavily hit by insect and disease has increased the risk for injury and fatalities beyond the threat of wildfire. On September 8, 2009, a USFS sawyer and spotter were removing trees in Grand County, Colorado. The sawyer had just begun felling one tree when a second tree, which was beetle-killed, began to fall. Luckily, the spotter saw the moving tree and pulled the sawyer out of harm's way. The beetle-killed tree landed precisely where the sawyer was standing only moments before. The fallen tree had previously been evaluated for defects and none were detected; it was not in contact with the tree the sawyer was working on and winds were below five miles per hour so the saw crew did not detect any obvious hazard. A photo of the scene immediately after the incident is shown in Figure 1.5 (McFall 2010). From the photo, one can see that the tree's base was completely rotten but this defect would not have been visually apparent to the sawyers.

Others have not been as lucky. Kevin Pellini, a logger in Grand County, Colorado, was interviewed by local media in early July 2007 about the need to reduce forest fuel loads, particularly trees threatening residential areas. A little more than a year later on October 24, 2008, Mr. Pellini was piling slash from a beetle-killed lodgepole pine stand he was treating near

Grand Lake, Colorado. The winds intensified while Mr. Pellini was working and knocked down one of the remaining trees. The tree struck Mr. Pellini, killing him. His death is the first beetle-kill-related fatality of the current MPB epidemic (Renoux 2008, Bublitz 2008).

Figure 1.5: Photo of a Near-Miss Involving the USFS in Grand County, Colorado

Source: McFall (2010). Note the orange wedge remaining on the target tree's stump.

Other impacts are indirect but stem from the public safety concern. In 2007, the USFS proactively closed two Colorado campgrounds, each with 300 camping sites. The USFS lacked the funds to remove the dangerous beetle-killed trees making the closure necessary to protect recreationists. The closures cost the agency over $400,000 in revenue. In 2009, 32 campgrounds were closed, with 17 closed for two weeks, 14 closed for the summer and one closed permanently—all due to the MPB epidemic. As the number of rotting and falling beetle-killed trees increases, estimated up to 100,000 stems per day or more in the MPB epidemic's footprint, the impacts and risks to public safety will increase as well (Renoux 2007; Sorensen 2010; Dickinson 2010; Finley 2010).

1.2.5 Climate Change and Colorado Forests

Climate change refers to a phenomenon in which global weather patterns are altered by changes in the Earth's solar radiation budget. Climate change occurs when short wavelength radiation from the Sun enters the Earth's atmosphere. The radiation is then re-emitted from the Earth's surface as long wavelength radiation. Atmospheric greenhouse gases (GHGs) trap this radiation in the form of heat. While GHGs do occur naturally, the levels of anthropogenic GHG contributions to the atmosphere, particularly after the Industrial Revolution, are increasing at a rate faster than the rate at which these gases are removed through natural processes. Many GHGs last only a few years in the atmosphere while others can last thousands of years. Given that synthetic sources of GHGs include electricity production, transportation emissions, heat production and land use changes including deforestation, emission rates are not likely to decrease in the near future (Leggett 2007; Leggett 2009; Malmsheimer et al. 2008, 125-128).

Because climate change stems in part from deforestation and because climate change also impacts forests, it is an important consideration for forest health in Colorado. A significant increase in temperature could have substantial ecological impacts. For instance, warmer temperatures could lead to decreased precipitation in terms of rainfall and/or snowpack. This drop is significant. Due to increasing population, Colorado will see an increased demand for water from its forests but a decreased supply from its altered climate. Forest habitats could migrate "more than 2,000 feet in elevation or 200 miles north" in the Rocky Mountains, which would eliminate the habitat for some plants and animals, extirpating them or removing their range from the United States (Malmsheimer et al. 2008, 130). Warmer temperatures might also help pests, such as MPBs, expand their range, increase the frequency of their attacks and/or increase the duration of their outbreaks (Malmsheimer et al. 2008, 129-130).

Indirect impacts to other forest-dependent concerns might be just as significant. While increases in carbon dioxide may actually increase the amount of forest biomass available, the resulting temperature increase from the GHGs will likely negatively affect skiing and water-based recreation (e.g. stream fishing, lake-based recreation, etc.) or alter leaf chemical composition that negatively affects herbivore health. Warmer weather may help increase the frequency and intensity of wildfires, which may in turn affect human health from emissions, destroy vital habitat for endangered wildlife, clog reservoirs with increased soil erosion and/or reduce recreation receipts—similar to what Colorado experienced during the 2002 wildfire season (Malmsheimer et al. 2008, 129-131).

1.3 Energy Insecurity in Colorado

Colorado consumes tremendous quantities of energy. For 2011, each Coloradan consumed about 289 million British Thermal Units (Btus) (U.S. Department of Energy [USDE] Energy Information Administration [EIA] 2013a). Most (~90%) of the BTUs consumed came from coal, natural gas and oil/petroleum (see Figure 1.6) and each fuel type dominates a market niche. Petroleum/oil is used to meet almost all (97%) of the state's transportation and other liquid fuel needs. Coal-fired power plants generate most (>70%) of the electricity used in the state. Natural gas ("gas" from here on) meets most of Colorado's heating needs (~75%), although some (~25%) of it is used to make electricity and a small fraction is used for transportation. Renewables meet about 5% of Colorado's energy needs; hydropower and wind contribute the most to electricity generation while biomass, both agricultural and forest, contribute the most to heating and liquid fuels production (USDE EIA 2013b; USDE EIA 2013c; USDE EIA 2009).

Unlike forest resources, Colorado uses substantial quantities of its own fossil fuel resources. The state produced over 39 million barrels in 2011, which is part of an increasing trend in production beginning in 1999 (USDE EIA 2013d; COGCC 2012). Despite producing large quantities and exporting nearly $280 million in crude oil products in 2009 (Svaldi 2010), the state overall is a net petroleum importer.

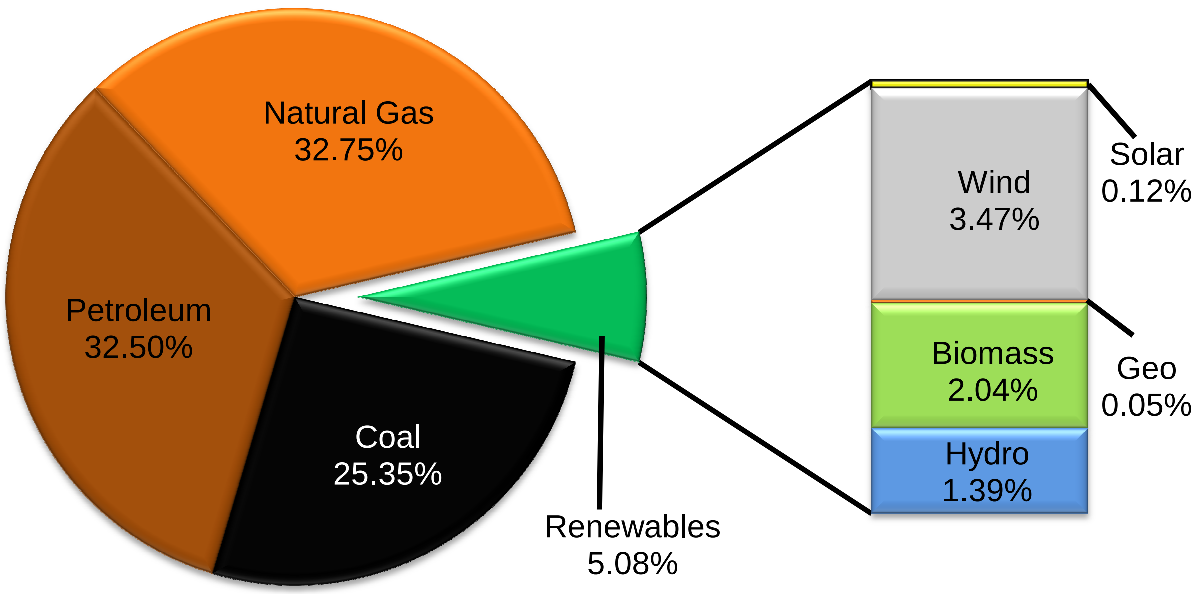

Figure 1.6: Colorado's Energy Consumption by Source, 2011 (Estimate)

Source: USDE EIA (2013b). Note: EIA reports 0.0 trillion Btus for nuclear energy and 59.7 trillion Btus for the net interstate flow of electricity (not shown). Totals may not equal 100% due to rounding.

The state consumes almost three times the amount of petroleum it produces each year and this deficit is met with imports from Texas, Oklahoma and Wyoming (USDE EIA 2013e; USDE EIA 2009). For coal, Colorado is a net exporter, producing around 27 million short tons of coal each year and exporting about 57% to the Eastern United States, Mexico and Europe (Carroll 2012, 1). Colorado uses about 40% of the natural gas it produces (USDE EIA 2009).

Most fossil fuels exist in deposits located in regions or geographic basins that are at lower elevations than most forests. Coal deposits exist under about 30% of the state's surface land. The Western Slope has most of the coal containing the highest amounts of energy per unit (e.g. anthracite and bituminous coal) with high concentrations between Grand Junction and Glenwood Springs, near Craig, and around Durango in the southwest and Walsenburg in south-central Colorado (see Figure 1.7).

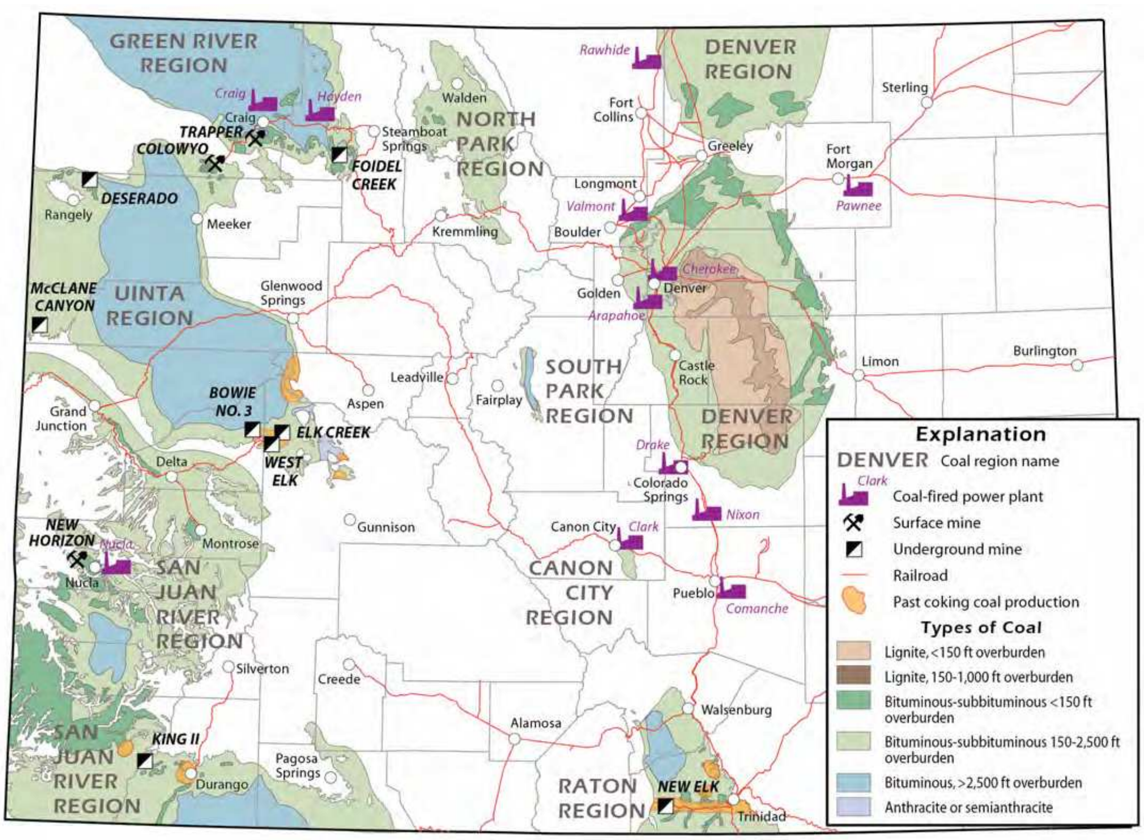

Figure 1.7: Coal Deposits and Power Plants in Colorado, 2011

Source: Carroll (2012).

Almost all of Colorado's coal mines are located in Western Colorado and producers must normally transport product long distances by rail for both domestic consumption and export. Oil and gas deposits are located in eleven distinct geologic basins throughout the state which wrap around the state's mountainous middle (see Figure 1.8).

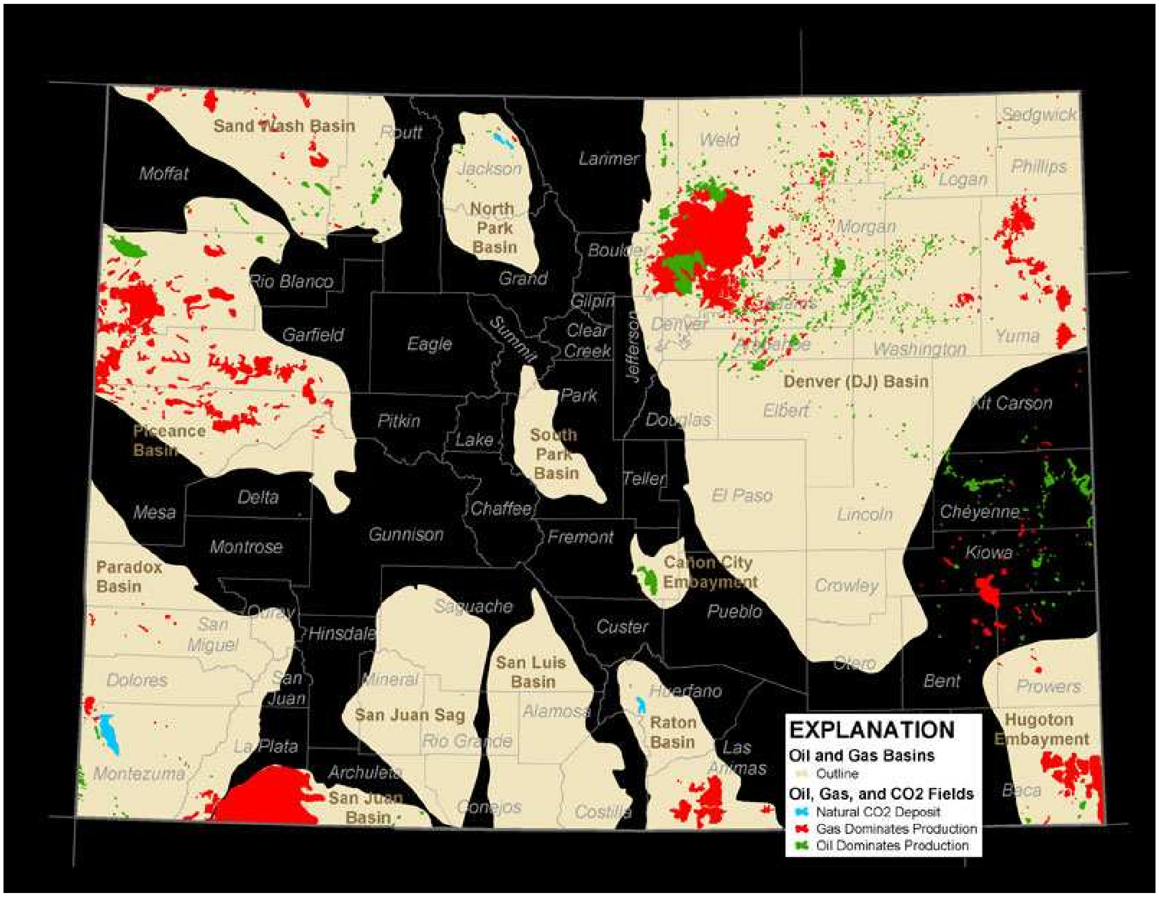

Figure 1.8: Oil and Gas Drill Sites and Basins in Colorado, 2002

Source: Wray et al. (2002).[8]

[8] The referenced map is available online at http://geosurvey.state.co.us/energy/Oil/Pages/OilMap.aspx (accessed July 25, 2012). However, an update by the Colorado Geological Survey and COGCC will not be completed until late 2012. Self-generated maps are available from the COGCC but they cannot distinguish between wells that produce mostly oil versus those that produce mostly gas.

Gas production dominates in these areas and drilling activity continues to increase. According to the COGCC (2013), over 51,500 oil and gas wells were active in Colorado, up from a little over 22,500 wells in January 2002, with 87% of all active wells located in six counties, most of which are located in just Weld and Garfield Counties.

Like coal, oil and gas production has increased as the state's population (demand) increased. Gas production increased from 1.52 billion cubic feet per day in 1995 to an estimated 4.69 billion cubic feet per day in 2012. Petroleum production more than doubled from 52,900 barrels per day in 1999 to 135,300 barrels per day in 2012 (COGCC 2013). With production and prices increasing and with Colorado heavily dependent on liquid fuels, any emerging problem involving these fuels will affect the state's population. Proponents might be inclined to frame such emerging problems in such a way that forest biomass is perceived as a solution, whether in opposition to or congruent with contemporary fossil fuel use and development. For instance, forest biomass could be converted to activated carbon (bio-char) to decontaminate oil and gas well pads. Forest biomass can also be converted into a substitute liquid fuel or used as a substitute heat energy source.

1.3.1 Fossil Fuel Price Fluctuations

One of the more easily recognized problems of the past decade concerns fossil fuels' price volatility. Whether for electrical energy, liquid fuels or thermal energy, prices can shift suddenly, often leaving consumers with little discretionary income and forcing them to choose between necessities ("heating or eating"). For instance, the real price for regular conventional gasoline in the U.S. tripled between December 2001 and June 2008. Prices reached a low in January 2009 only to quickly rise again by April 2011. On the national level, prices mirrored Colorado's own experiences as shown in Figure 1.9 (USDE EIA 2013f; USDE EIA 2013g).

Record high retail prices for residential natural gas remained consistently volatile, ranging in Colorado from a low of $5.27 per thousand cubic feet (MCF) in February 2003 to a record high of $15.96 in August 2008 as shown in Figure 1.10 (USDE EIA 2013h; USDE EIA 2013i).

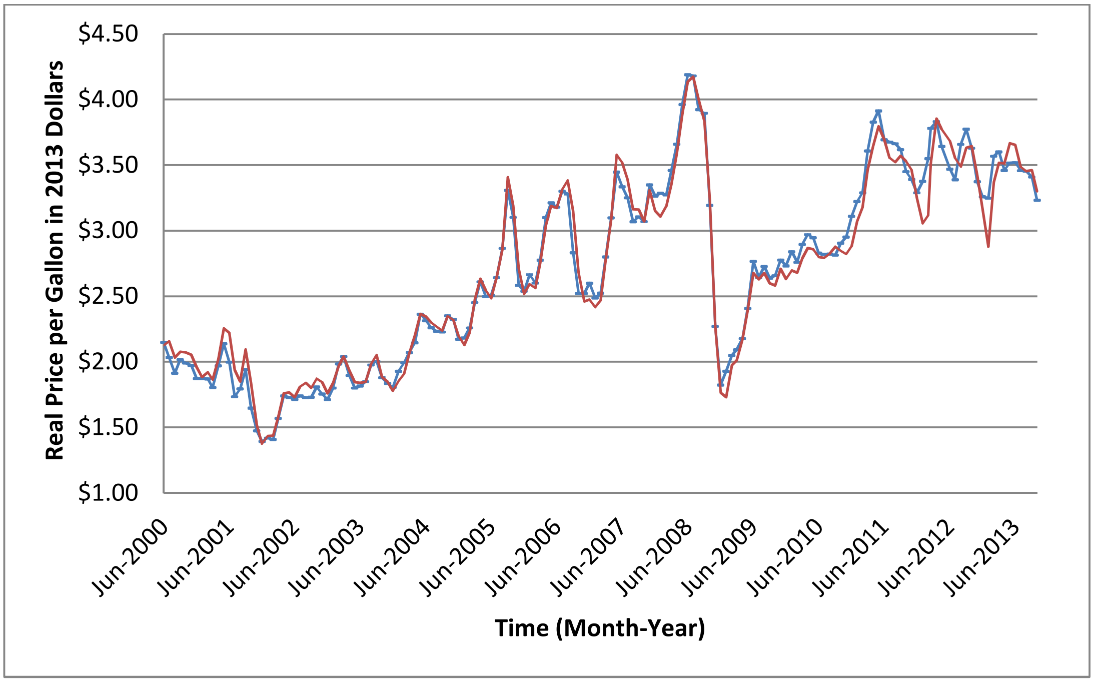

Figure 1.9: Real Retail Price for Regular Gasoline, 2000-2013

Source: USDE EIA (2013f; 2013g). The blue line with tick marks indicates US real retail price; the red line indicates Colorado real retail price. Real prices in 2013 dollars were calculated by the author using the Consumer Price Index.

Energy price spikes are regressive, which are more significant for people in lower socio-economic brackets. According to the Colorado Fiscal Policy Institute, one out of every five families in Colorado lives below the Self-Sufficiency Standard, which is the income level a family of four would require to avoid relying on public or private assistance and could be considered a more inclusive and detailed measure of poverty than the federal poverty line (Pearce 2007, 4). More recently, the National Housing Conference's Center for Housing Policy (Viveiros and Sturtevant 2014, 4) found that 20% of all Colorado families spend at least 50% of their income on housing costs. As fuel prices increase, families living below the Self-Sufficiency Standard and facing high housing costs endure the greater hardship as a proportionately larger percentage of their limited incomes are used for basic necessities than those families maintaining a higher standard of living.

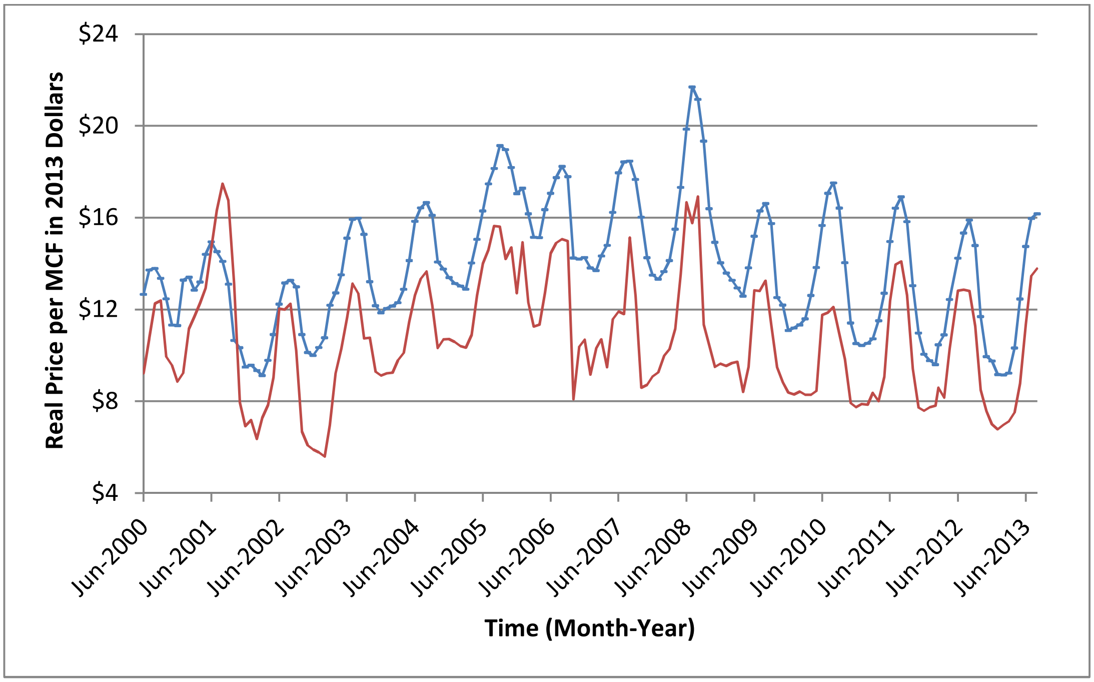

Figure 1.10: Real Residential Price for Natural Gas, 2000-2013

Source: USDE EIA (2013h; 2013i). The blue line with tick marks indicates US real retail price; the red line indicates Colorado real retail price. Real prices in 2013 dollars were calculated by the author using the Consumer Price Index.

1.3.2 Additional Consequences of Continued Fossil Fuel Reliance

While price spikes can influence consumers' behavior, they can also influence producers' behavior. Increases in fossil fuel prices increase incentives for energy producers to expand. However, energy development can be expensive and risky and the results can be unpredictable. Another problem with fossil fuel dependence is that communities developing around energy production are subject to the volatile economic impacts from market, social and environmental changes, positive and negative.

Garfield County, Colorado, is the quintessential example. This Western Slope county experienced a natural gas development boom going into the 2000s, which helped keep unemployment levels below the state's and national average unemployment rates (see Figure 1.11). The period of low unemployment, about two percent less than the state's rate, continued until the gas price drop in 2008 (Garfield County Planning Commission 2010, 10). Still, the county enjoyed prosperity for a time and benefitted substantially from the increased development.

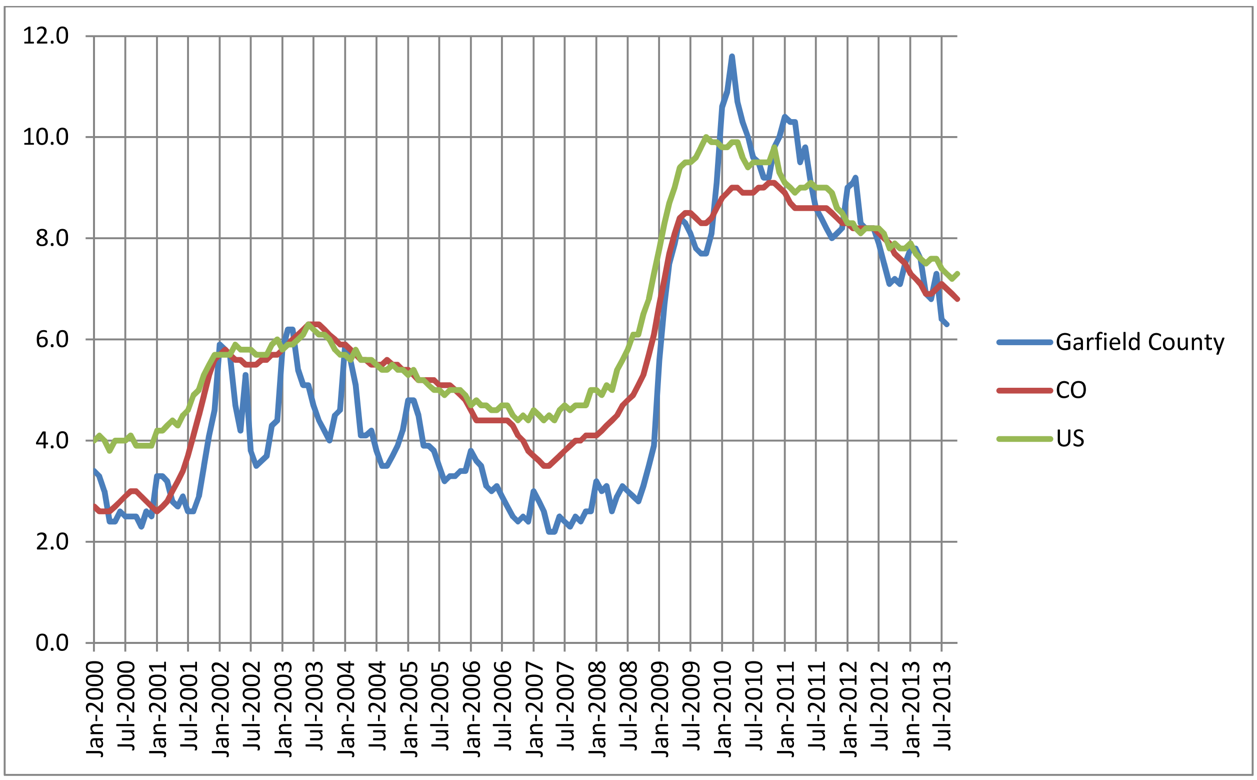

Figure 1.11: Unemployment Rates for Garfield County, Colorado; Colorado; and the United States, 2000-2013

Source: USDL BLS (2013).

Oil and gas property tax revenues constituted about 73% of the total property tax base for Garfield County in 2011 (Garfield County Finance Department 2012, 7). The top 10 taxpaying energy development companies' valuations exceed $1 billion (see Table 1.1).

Table 1.1: Top Ten Largest Oil and Gas Taxpayers in Garfield County, Colorado

Company	2010 Assessed Valuation
Williams Production	$877,643,020
Encana	$366,842,110
Bill Barrett Corporation	$153,967,320
Petroleum Development	$68,926,510
Bargath	$72,829,530
Oxy USA	$57,977,080
Noble Energy	$53,073,370
Enterprise GasProc.	$52,473,310
Chevron	$48,358,220
Antero Resources	$31,414,070

Source: Garfield County Finance Department (2012, 8).

In addition, these companies are philanthropists. For instance, the EnCana, Williams and Shell Oil companies contributed $4.6 million to building a new Colorado Mountain College campus in Rifle, Colorado. Williams and EnCana also split the cost of a new $36,000 electronic sign for the Garfield County Fairgrounds. Housing permits in Rifle, Colorado, jumped by 50% and average housing prices, in the midst of the ongoing national housing crash, increased from $250,000 to $300,000 over the course of one year (Tharp 2009).

This substantial economic growth has come with growing pains. The school system student population, which was historically increasing by 1.5 percent each year, faced a 6% annual increase starting in 2002. The aforementioned dramatic increases in housing prices have priced teachers (and other social service providers) out of home ownership. In 2007, Garfield County Schools lost 54 teachers with many citing housing costs as the reason for leaving. While renting might be an alternative, it is no guarantee of affordable housing. In Battlement Mesa, Colorado, one resident saw her rent increase overnight from $750 to $1,000 per month (Tharp 2009). Population increases are also straining other social services. Garfield County hired 15 new deputies in 2002 to address a 600% jump in assaults and substance abuse incidents. Rio Blanco County faced a more significant crime problem as incidents in the Piceance Basin increased from a mere five cases in 2003 to 1,675 cases in 2007. Increased truck traffic has led governments in Rifle, Colorado, and Garfield County, Colorado, to seek hundreds of millions of dollars for infrastructure improvements that will be needed over the next few years (Tharp 2009).

Reported negative environmental impacts also seem to be increasing. Energy communities' residents have reported feeling sick when exposed to drilling waste, whether those free flowing wastes are absorbed by children playing in creek beds, ingested by residents with their well water or inhaled by employees while working outside. Wildlife in the region is also impacted. In Wyoming, reports have shown that mule deer populations in proximity to the Pinedale Anticline gas field decreased by 46 percent. Another report showed oil and gas drilling development forced pronghorn off their winter range (Tharp 2009).

Certainly environmental impacts are not isolated to the Western Slope. As shown earlier, tremendous amounts of drilling and pumping occur in Weld County, particularly in the southwestern portion of the county. Water wells have been contaminated by a variety of hydrocarbon compounds and are suspected to have come from oil and gas development activities, especially given the high concentrations of pollutants near wells. Seeping chemicals, allegedly from at least one leaking gas well, created water so polluted that it sets off carbon monoxide detectors as it emerges from the tap and can be ignited. In at least one case in Fort Lupton, Colorado, a couple risked having their home explode from well water that is 73 percent dissolved methane (Hemmat 2009a, 2009b, 2010a, 2010b).

Additional impacts are statewide in nature. Successful companies removed one million dollars' worth of product from Colorado wells every 43 minutes in 2009. While revenues are substantial and removed products taxed at the distribution point, for the consumer, the tax exemptions for producers reduce Colorado's effective severance tax rate to the lowest of all top energy-producing states. For instance, wells that produce less than 15 barrels of oil per day or that produce less than 90,000 cubic feet of natural gas are called "stripper" wells; these wells are exempt from severance taxes. Almost all of Colorado's oil wells (>95%) and roughly 75% of natural gas wells are stripper wells; they produce 60% of the state's oil and 20% of the state's natural gas. Because these products are not subject to severance taxes, Colorado forfeits over $62 million annually in lost tax revenue. To place this loss in perspective, one year's worth of recouped severance tax revenue would pay for infrastructure improvements to cover impacts to roads and services from increased drilling activity in Rifle, Colorado, for five years (Minor and Jones 2008, 1-3; Tharp 2009).

1.3.3 Alternative Fossil Fuels

Price increases not only stimulate additional exploration activities but they can also stimulate the search for substitute or alternative energy. For example: when energy price shocks occurred in the 1970s, Presidents Nixon, Ford and Carter enacted measures to promote greater energy independence for the United States. Part of these reform efforts promoted alternative and alternative, renewable energy technology development as substitutes for fossil fuels. One of these technologies was the development of oil from shale (Scamehorn 2002, 163-166, 180-187). Oil shale is an umbrella term referring to any sedimentary rock that contains kerogen, which is a substance that releases petroleum-like liquids and natural gas-like emissions when exposed to high temperatures (~650-900˚F). The material may be heated ("retorted") either after it has been removed from the ground through conventional surface mining techniques or while the material is left in place ("in situ retorting"). Both options have strengths and weaknesses (USDI BLM 2006; USDI BLM 2008; Bartis et al. 2005, 11-23).

Oil shale is significant for the United States because it could provide economic benefits through royalties, increased employment and decreased expenditures on imported fuels. Oil shale also could benefit national security by diversifying the nation's energy portfolio meaning the United States would be less beholden to other oil-producing countries whose policies and interests may run counter to its own (Bartis et al. 2005, 25-33). Colorado stands to benefit more so than other states because the Western Slope contains significant quantities of oil shale. Estimates from the USDE EIA (2009) suggest that as many as one trillion barrels of oil may be recoverable from Western Slope shale; in other words, Colorado oil shale could produce more recoverable oil than the world's current total proven oil reserves.

However, recovering oil shale is difficult. Foremost, shale-derived oil is not a perfect substitute for crude oil. Kerogen is missing the components that make up natural gasoline and the heavier hydrocarbons that industry can process into gasoline. Shale-derived oil is more suitable for other products such as diesel fuel or jet fuel (Andrews 2008, 5). Also, recovering shale-derived oil will necessarily involve substantial land impacts. Extraction for surface retorting will require miners to remove 1.2 to 1.5 tons of shale for every barrel of shale-derived oil. Crushing extracted shale, part of the surface retorting process, will increase the material's volume by 15 percent to 25 percent meaning that processed, spent shale will not all fit when returned to its original space. In situ retorting will disturb less earth but will still require "a decade-long displacement of all other land uses and of preexisting flora and fauna at each development site" (Bartis et al. 2005, 35-37; Andrews 2008, 5).

Oil shale recovery could also lead to higher air emissions for criteria air pollutants (e.g. NO_x, SO_x, VOCs, PM and CO) and also for toxic metals such as arsenic, mercury, cadmium and selenium. Methods exist to control these air emissions but their efficacy and costs in Western Colorado may be difficult to determine as the most recent studies date to the early 1980s. However, even the potential for emissions may be enough to discourage shale development. Carbon dioxide, a GHG, is emitted by the fossil fuels consumed to heat the oil shale and through other steps in the manufacturing process and these emissions in total may be 1.5 to five times higher than those released by conventional petroleum production. These higher emissions are cause for concern as the Energy Independence and Security Act (EISA) of 2007 prohibits the United States government from buying oil that was produced using methods that create more greenhouse gas than standard extraction of regular crude oil using a life-cycle analysis. Thus, federal incentives for oil shale extraction are lacking (Bartis et al. 2005, 38-40; Andrews 2006, 21-23; Andrews 2008, 11-13).

Water quality and quantity could be impacted by oil shale recovery operations. Oil shale operations could leach salts and toxic metals into local watersheds. As with air emissions, methods exist to address potential water contamination issues but the current body of knowledge is insufficient to determine how effective those methods would be over a long period of time.

Also, water quantities will likely be impacted. Producers typically requires between 2.1 and 5.2 barrels of water for every barrel of shale-derived oil produced. Water for this purpose would need to be shifted from the Colorado River Basin. Subsequently, any successful oil shale effort may disrupt water consumption patterns in the Colorado River Basin as mining, processing and reclaiming oil shale all require water (Bartis et al. 2005, 40-42; Andrews 2008, 13-14).

Finally, the economics of oil shale production may hinder efforts. Current state-of-the-art surface mining can operate in surface retorting operations but these operations typically require oil prices in the range of $75 to $90 per barrel to be fiscally feasible. In situ retorting may be more competitive with conventional petroleum processing when prices are roughly $30 per barrel. Shell Oil's experimental Mahogany Research Project in the Piceance Basin claims to be successful on a small scale but larger commercial demonstrations will require additional research, time and funding. Even if the experimental process proves successful, large-scale commercial applications will take decades to develop (Bartis et al. 2005, 22, 44; Shell Energy North America 2007).

Price comparisons with conventional oil are useful not only in gauging economic feasibility but in describing Colorado's experience with oil shale. At least three boom-bust cycles have occurred in the state during and, for a time, after key crises: World War I, World War II and the Energy Crises of the 1970s. In each instance, the perceived petroleum shortage, followed closely by accompanying price spikes, dramatically increased interest in developing oil shale on the Western Slope. However, in all three instances interest deflated soon after the price spikes as the market was flooded with cheap petroleum causing the booms to bust (Scamehorn 2002, 146-147).

The experiences of the most recent boom-bust cycle may be most telling for Colorado. After the initial energy price shocks of the early 1970s, the federal government, as noted above, began a number of programs to promote energy independence, including subsidizing oil shale recovery. A number of large energy companies used these incentive programs to foster oil shale operations in Colorado despite untested recovery technology, a nonexistent labor force and no guarantee of returns (Scamehorn 2002, 180-187; Tharp 2009).

However, the high oil prices that had been sustaining the rush petered out in the early 1980s. By early 1982, oil companies realized their oil shale efforts would not be economically feasible without increased subsidies. On May 2, 1982, known on the Western Slope as “Black Sunday,” Exxon USA withdrew from its oil shale projects quickly. The boom transformed into a bust—literally overnight as about half of the 5,000 residents of Rifle, Colorado, were laid off. The mayor of Rifle reported that his home depreciated by $40,000 in one week. About 10,000 workers lost their jobs over the following weeks. Major Colorado energy companies suddenly found themselves out of work. The emergence of cheap petroleum devastated energy communities in the Western Slope and related industries statewide (Scamehorn 2002, 180-187; Tharp 2009).

1.3.4 Renewed Interest in Intermittent Renewable Energy

In addition to problematic unconventional fossil fuels, price increases combined with potentially devastating social and environmental impacts from continued oil and gas operations encourage the development of alternative and renewable fuels. Alternative, renewable energy projects are typically expensive to implement. System payback periods are calculated by comparing expenditures on the renewable energy system, including fuel, to the status quo i.e., the fossil fuel system currently in place. Thus, increases in fuel prices make previously infeasible alternative and renewable energy technologies, including forest biomass, more attractive as cost-benefit analyses show shorter payback intervals and increased likelihood of a return on investments.

To further encourage renewable energy projects, policy incentives can be created to help with market development and subsidize technological developments. These incentives in effect, can help place renewable energy projects on a more equal footing with their fossil fuel counterparts. Colorado, for example, has promulgated several incentives over the past decade. While most of the attention focuses on solar and wind technologies, some efforts also address other technologies, including biomass, hydroelectric and geothermal.

One of the first incentives passed in 2004. Coloradans voted favorably on Amendment 37, making Colorado the first state to enact a Renewable Portfolio Standard (RPS) through the citizen initiative process. An RPS requires energy producers to either produce or obtain a certain percentage of their electricity from renewable sources. The Colorado RPS ("Renewable Energy Standard") stated that by 2015, 10% of electricity from large, investor-owned utilities (IOUs) would have to be produced by alternative, renewable energy sources, including biomass. Given the progress made by utilities, in 2007 Colorado's General Assembly increased the RPS percentage to 20 by 2020, with additional regulations for rural electric co-operatives and smaller utilities. In March 2010, the General Assembly passed HB 1001 that again increased the required percentage in the RPS. By increasing the percentage of electricity from IOUs from 20 to 30, Colorado enacted one of the most aggressive RPS in the nation.[9] In 2013, the Colorado General Assembly promulgated additional RPS-related requirements for electric cooperatives as well as generation and transmission cooperatives (Colorado General Assembly Senate Bill 252).

[9] Currently, Hawaii has the most aggressive (40%) state RPS requirement. California is second at 33%.

However, the increased attention to renewable energy sources is not evenly balanced. In the initial two RPS bills, the legislation contained a substantial set aside for solar energy. Of the total percentage generated, about 4% of the electricity had to come from solar sources and half of that amount had to come from solar-based electricity that was generated at customers' facilities. In the last iteration, the 4 percent set-aside was stripped in favor of pushing direct generation i.e., encouraging consumers to generate solar power on their own property. Given that the entire second half of the 2010 legislation addresses the certification of photovoltaic system installers, the preferential treatment given to solar energy is again obvious. Also, the RPS uses a series of credit multipliers, which means that one kilowatt-hour (kWh) generated by a specific provider will count as more than one for meeting the requirements of the RPS. For example, a solar electricity project commissioned by a cooperative or municipal utility before July 1, 2015 will earn a 300% credit multiplier, meaning every kWh will count as three. With such inflation, Colorado is not a "True 30" state i.e., Colorado actually produces less than 30% of the power it consumes from renewable energy sources.

The push to promote solar and wind through tax incentives in Colorado is understandable given the state's access to the resources but intermittency becomes a potential pitfall. Solar panels are useless at night and wind does not necessarily blow around the clock. When an RPS begins to call for market penetration rates that exceed 20%, stability problems may occur with the electrical grid. These problems may include but are not limited to: destabilization of the electrical grid through disruptions in the power generation (e.g. clouds over solar panels, wind speeds suddenly decrease, etc.), an increased demand for transmission line construction to carry new generating capacity from remote locations to concentrated consumers, decreased number of favorable sites for generating solar and wind energy and excess electrical power generation that the grid cannot transport. Some of these problems may be ameliorated with so called smart technologies (e.g. smart grids, advanced power storage technologies, etc.) but such approaches are still in their infancies (Enslin 2009; Charles 2009; Hoogwijk et al. 2007; Denholm and Margolis 2007a; Denholm and Margolis 2007b; Chen 2009). With so much attention paid to intermittent resources, forest energy proponents would likely suggest room exists for more reliable alternative electricity-generating methods from sources that are not subject to large-scale power interruptions or that alternatives to electricity-only incentives should be considered.

1.3.5 Afterthoughts on Efficiency

As some policies, such as the RPS, target utility companies' electricity portfolios, laws and regulations often overlook or neglect energy efficiency measures. However, their potential contributions are too significant to ignore. Revisiting oil shale, an oil shale plant that could produce 50,000 barrels per day would cost between $5 billion and $6 billion if using surface reclamation or between $3.5 billion and $4.5 billion if using in situ recovery (Scamehorn 2002, 181). Those same 50,000 barrels would roughly approximate what the United States consumes every three-and-a-half minutes. Instead, if mileage efficiencies for all automobiles in the United States were increased by 2 miles per gallon, the country would conserve 20 times as much fuel and save consumers $100 billion at the pump (Udall and Andrews 2005).

Energy efficiency measures could also apply to fossil fuels and intermittent renewable energy resources. In one instance, researchers compared results from a hypothetical $1 billion investment in electricity production in Montana using coal versus wind. They also compared an identical investment spent on energy efficiency. For coal, an investor would pay for a 500-MW coal plant built over a period of four years, creating 3,900 plant-related jobs paying plant employees slightly more than $50,000 per year. For wind, an investor would pay for two 250-

MW wind farms that could be built within a year, create 265 farm-related jobs and workers would earn around $39,000 per year. With energy efficiency improvements using the same investment to improve residential construction, 8,100 jobs would be created with workers making just slightly less than a wind farm worker (Melcher 2010). While these numbers do not include mining for coal or manufacturing for wind, the stark difference in number of high-paying jobs created during a period of high unemployment suggests that improving energy efficiency might be more effective at stimulating the economy and reducing consumption than favoring one energy production platform exclusively.

1.4 Research Questions

With the increased attention paid simultaneously to forest health and energy issues, policy entrepreneurs have an opportunity to address both sets of issues at the same time. One of these efforts has targeted the use of residual forest material to produce energy. The purpose of this dissertation is to analyze efforts to encourage the four largest federal land management agencies, according to number of acres managed (e.g. the US Forest Service, the Bureau of Land Management, the National Park Service and the US Fish and Wildlife Service), to use forest-based energy in their respective jurisdictions and to detail how those efforts have manifested themselves in Colorado. Research questions addressed in this dissertation include:

- How and why have federal-level forest energy policy incentives emerged?
- How and why are the incentives, approaches and strategies for woody biomass use different among the four federal land management agencies[10] in Colorado?

[10] While the Bureau of Indian Affairs and the Department of Defense could have been included, national security law and Tribal law would need to be considered. Unfortunately, their omission from consideration was necessarily deliberate to keep the project manageable within established constraints.

- Do state/local governments influence agenda-setting for FBU policies? If so, how?
- Do private citizens influence agenda-setting for federal FBU policies? If so, how?

1.5 Plan of the Dissertation

Chapter Two discusses the potential and pitfalls of FBU for energy in Colorado. Chapter Three reviews the pertinent literature on modeling federal land management agencies behavior and identifies a tripartite approach to apply. Chapter Four catalogs major developments in forest policy and how those developments have impacted Colorado. Efforts are made to track the saliency of forest health issues in the state and then tease out the streams and policy images and venues. Chapter Five mimics Chapter Four but shifts the focus to energy policy. Using interviews from policy entrepreneurs identified in Chapters Four and Five, Chapter Six constructs case histories of each of the aforementioned four major federal land management agencies with regards to FBU as a merger of forest policy and energy policy. Chapter Seven summarizes the dissertation's findings, identifies some related policy implications and suggests directions for future forest energy research and improvements for implementation.

1.6 Chapter Summary

Forests are the largest land use class in Colorado and most forests in Colorado are managed by federal public agencies. These forests are undergoing dramatic change largely due to encroaching human settlements, catastrophic wildland fire events, insect and disease outbreaks and global climate change. At the same time, Colorado consumes large quantities of non-renewable energy. As supplies become scarcer, energy prices increase. Price spikes encouraged additional oil and gas drilling in the state, searches for alternative, unconventional fossil fuels and developing and promoting alternative, renewable energy resources.

One way to address both forest health issues and energy issues at the same time is to consider options that include public-private partnerships and decision-making mechanisms for managing forest resources that could also meet energy needs. Forest energy projects can, in part, help reach those objectives, although with some significant potential drawbacks. A number of governmental policies have been promulgated recently to promote forest energy project development in Colorado. This study will analyze how those policies are implemented on the ground and suggest improvements.

CHAPTER 2: FOREST ENERGY IN A NUTSHELL

"As a people, we have the problem of making our forests outlast this generation, our iron outlast this century, and our coal the next; not merely as a matter of convenience or comfort, but as a matter of stern necessity."

– President William Howard Taft in 1908 (U.S. Senate 1911, 5184)

2.1 What is Forest Energy?

Colorado faces threats from unhealthy forests and energy shortages. Continued expansion of communities into dense forest stands, increased wildfire risk due to millions of insect and disease-killed trees, reduced revenues available to public safety agencies and altered climatic conditions threaten forest ecosystems. Meanwhile, fluctuating fossil fuel prices, dwindling fossil fuel stockpiles, discouraging drawbacks from alternative fossil fuels, accruing unintended consequences from renewable energy technologies, and lacking energy efficiency promotions all do little to improve energy security. These issues, combined with the political problems enveloping conventional forest products and energy development, ensure that solutions will not be easily or quickly developed or implemented.

One means of concurrently addressing forest health issues and energy issues is to harvest forest fuels (forest biomass) and use them to produce energy. Defined, *forest (or "woody") biomass* consists of "the trees and woody plants, including limbs, tops, needles, leaves and other woody parts, grown in a forest, woodland or rangeland environment, that are the by-products of restoration and hazardous fuel reduction treatments" and can be used "to produce the full range of wood products, including timber, engineered lumber, paper and pulp, furniture and value-added commodities and bio-energy and/or bio-based products such as plastics, ethanol and diesel" (U.S. Department of Agriculture [USDA] et al. 2003, 2). Forest biomass sources include forest growth, dedicated short-rotation woody crops (SRWC, e.g. willow, hybrid-poplar, etc.), logging and related residues, fuel treatments, land clearings, fuel wood, forest products industry wastes (e.g. mill residues) and urban wood residue, which includes tree, wood and paper waste streams (USDE 2011, 8-9, 16-51; National Association of State Foresters [NASF] 2008, 14; Solomon et al. 2007, 417; Bowyers et al. 2003, 469). Forest energy is produced when forest biomass is converted into energy for human consumption. Forest energy can take one of several forms: heat (thermal energy), electricity (power), liquid fuels or some combination of these three forms (NASF 2008, 4; Zerbe 2006, 8-12). For this dissertation, forest energy projects are defined as facilities that consume forest biomass to produce energy. Note that the forest biomass consumed may or may not come from Colorado's forests.

2.2 Overview: How Forest Energy is Produced

Producing forest energy involves a four-step process to bring material from stump to shelf (see Figure 2.1).

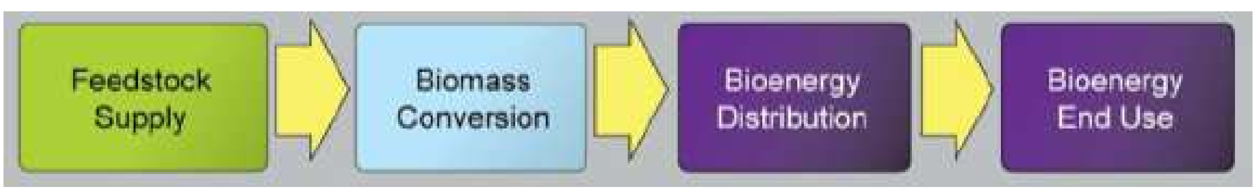

Figure 2.1: Biomass-to-Bioenergy Supply Chain

Source: USDE EERE (2012a, 1-1).

The supply chain figure's simplicity belies how complex forest energy production is and the myriad economic and environmental factors that must be considered. Furthermore, the chart does not show the social inputs, i.e. stakeholders, which include coordinating and collaborating inputs from among "the general public, the scientific/research community, trade and professional associations, environmental organizations, the investment and financial community, existing industries and government policy and regulating organizations" (USDE EERE 2012a, 1-2). Also not shown in the figure is an overriding concern for sustainability. Previously, the federal-level effort to define sustainability involved "the triple bottom line," where the three factors (economic, environmental and social) are visualized as independent and sustainability exists when all factors are properly accounted for and intersect as shown in Figure 2.2. This model is also known as "weak sustainability" (USDA FS 2011, I-2).

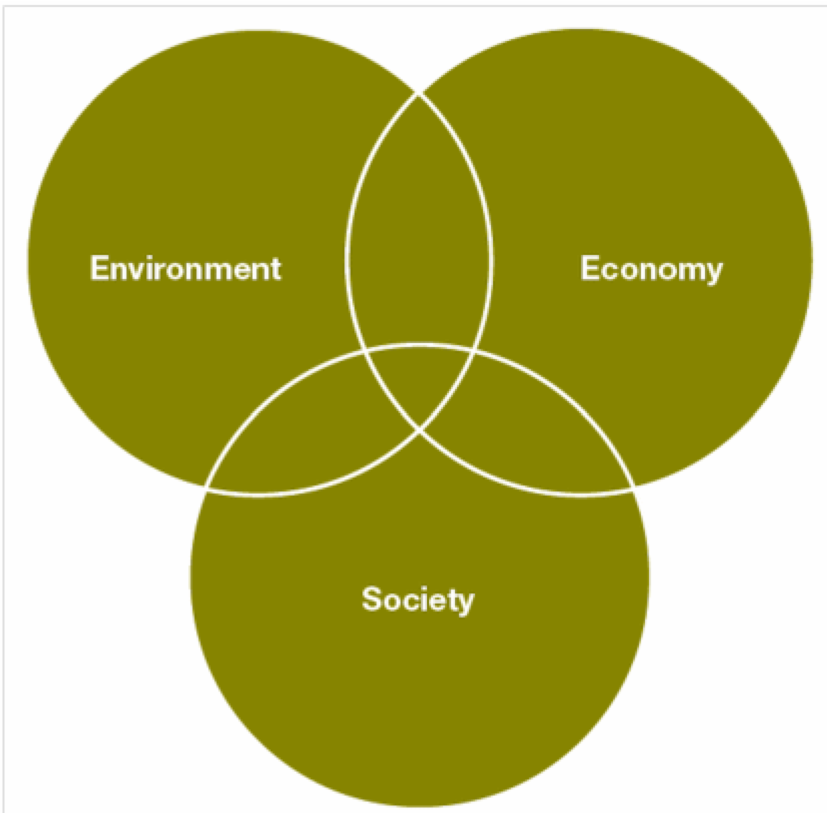

Figure 2.2: Weak Sustainability Model

Source: USDA FS (2011a, I-2).

Following this model and the definition of sustainability outlined by Executive Order 13514, the USDE EERE created a weak sustainability-type model that incorporated additional details about other areas where the factors overlap (see Figure 2.3). A project is sustainable when it is environmentally sound, economically defensible (projects that "pencil out") and socially acceptable. Additional characteristics exist: equitable (economic benefits are distributed equally among society), habitable (society has healthy places to live and work while ecosystem integrity and services are maintained) and feasible (projects that reduce negative environmental impacts and promote economic benefits should be competitive) (USDE EERE 2012a, 2-96 – 2-97).

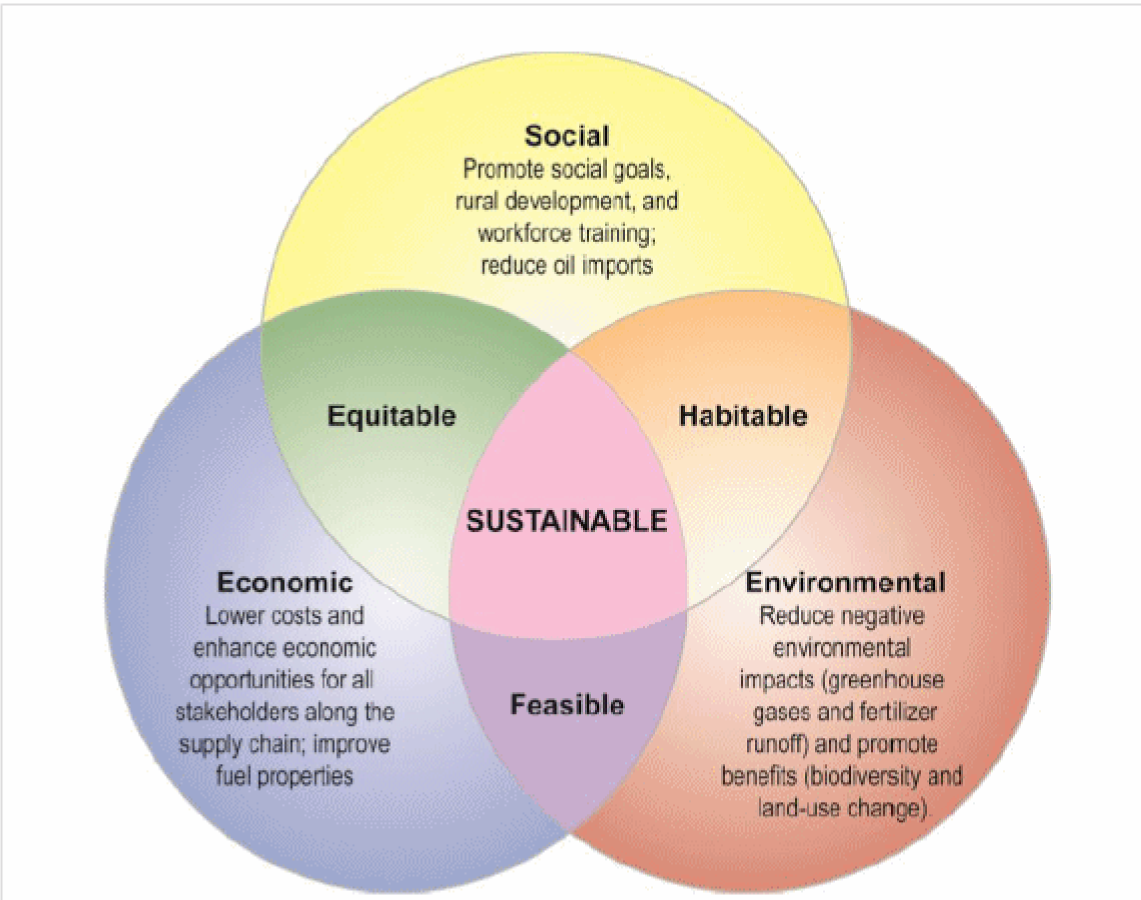

Figure 2.3: USDE EERE Sustainability Model

Source: USDE EERE (2012a, 2-96).

A new approach to sustainability employs a “strong sustainability” model (see Figure 2.4). This model envisions the same three factors as before but they are interdependent instead of independent. The largest factor, the environment, is all-encompassing as it “is the foundation of strong sustainability because the environment provides natural goods and services that cannot be obtained through any other means" (USDA FS 2011, I-2). Society depends on the environment for products and the economy depends on social transactions that involve trading scarce environmentally derived goods.

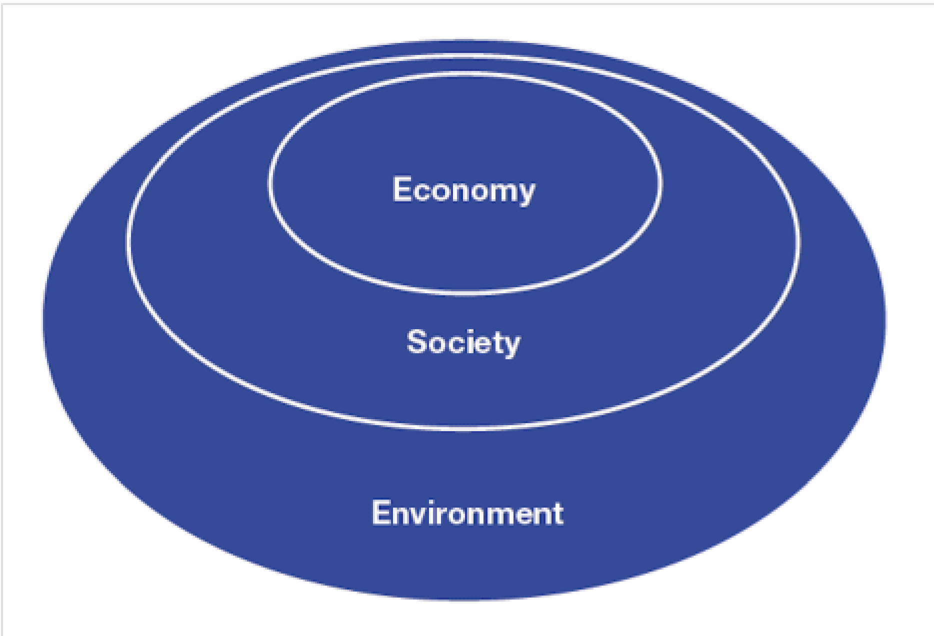

Figure 2.4: Strong Sustainability Model

Source: USDA FS (2011, I-2).

Forest energy projects are no exception. The environment provides the raw material (i.e., trees) for forest energy projects at a given rate. Society harvests these trees and converts them into forest energy using, ideally, the best available technology. Human social interactions determine how and where those forest energy projects may be most efficiently located and operated. However, sustainability means that these exchanges are limited by the rate at which the environment provides the raw materials, often captured in pricing mechanisms.

2.2.1 Feedstock Supply

Following the supply chain figure and the strong sustainability model, the first step in developing a forest energy project is assessing feedstock supply availability and determining how to move that material to a biomass conversion facility for manufacture (see Figure 2.5).

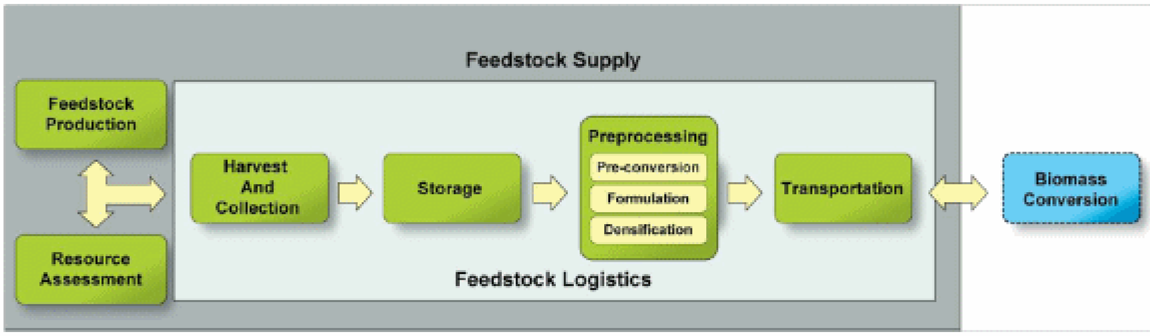

Figure 2.5: Feedstock Supply Diagram

Source: USDE EERE (2012a, 2-9).

Feedstock resource assessments ("supply studies" or "feasibility studies") are critical for determining the amount of biomass that is sustainably available, at what distance from the facility and at what cost per unit. Provided the project is feasible, project designers must then determine how to remove, transport and store the material and if and how the material must be physically converted to a form compatible with the forest biomass conversion factory. The storage stage is particularly vexing for project designers because of the large amounts of water that wood can contain (see Section 2.4.1).

2.2.2 Biomass Conversion

Once forest biomass meeting the necessary specifications is transported from the forest to the facility, then it can be converted into forest energy. Conversion is accomplished through one of two primary process platforms: 1) thermochemical or 2) biochemical (see Figure 2.6). The thermochemical platform uses varying combinations of heat, pressure and oxygen to create fuels, chemicals and power from forest biomass. The biochemical platform converts the forest biomass into sugars, which can then be fermented into liquid fuel and solid co-products.

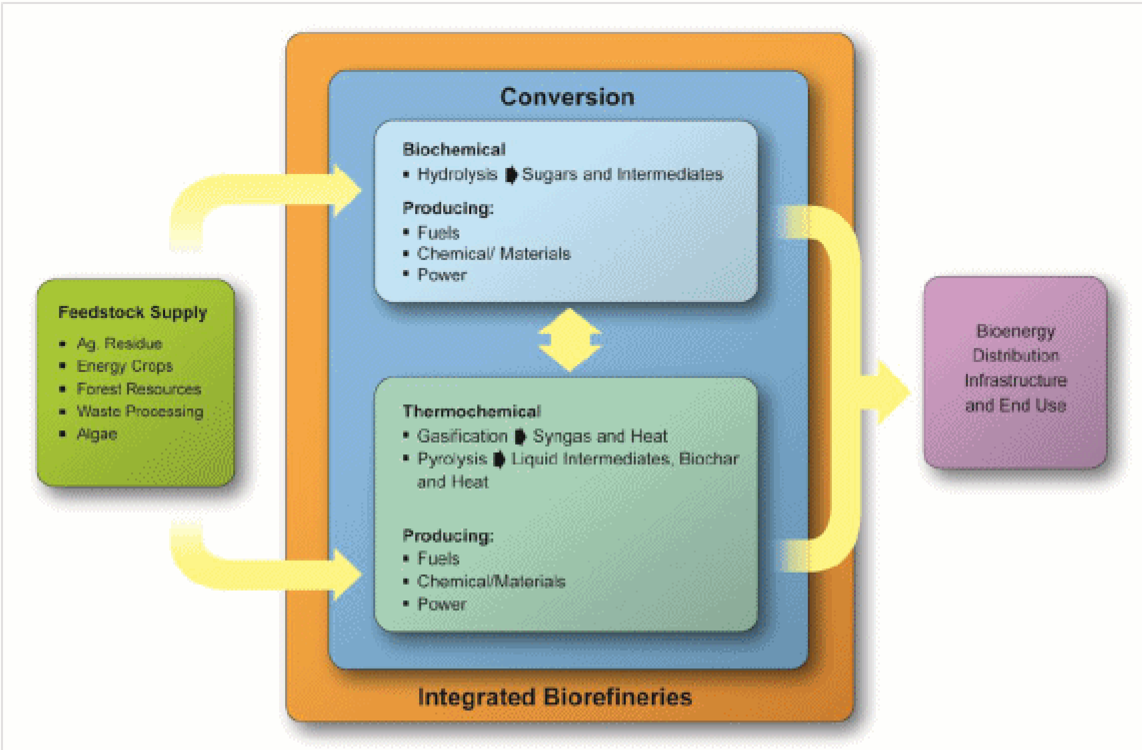

Figure 2.6: Conversion Routes from Biomass to Bioenergy

Source: USDE EERE (2012a, 2-28).

These platforms are distinct in their approach and results but can be complimentary during energy generation since products from one platform can help fuel the other, as in integrated refineries (USDE EERE 2012b, USDE EERE 2012c, USDE EERE 2012d).

2.2.2.1. The Thermochemical Platform

The thermochemical platform includes at least three distinct processes: direct combustion, gasification and pyrolysis. The first thermochemical process, direct combustion, is the oldest and simplest conversion technology. Direct combustion applies heat energy directly to the feedstock to produce carbon dioxide, water and additional heat energy (e.g., campfires)

(Klass 1998, 191-192). However, modern combustion systems have evolved beyond the campfire: a typical large, automated combustion system requires transported forest biomass to conform to a specified fuel form (e.g. wood chips, cordwood, pellets) for immediate use or on-site storage for later use. A conveyor system moves the biomass as needed to a wood boiler or firebox, which is often paired with emission controls, where the feedstock is ignited and combusted. The heat energy generated via direct combustion is then applied to a liquid, usually water or water with a hydrocarbon (glycol) additive, in a holding tank for steam production. The steam is then distributed to a building or campus network via conduits or specialized pipes. Smaller systems are typically furnaces or stoves that may be able to accept a variety of fuel types and then use convection, fans or ducts to move the heated air (USDA Forest Service [FS] Forest Products Laboratory [FPL] 2004, 1; Malmsheimer et al. 2008, 136; Bergman and Zerbe 2008, 2, 6; Zerbe 2006, 7, 9; Kemp and Sibbing 2010, 11). For example, New Earth Green Depot in Lakewood, Colorado, is a distributor of modern wood stoves and wood pellet stoves, which use direct combustion technology.

Direct combustion can assume other forms. Co-firing, for instance, involves burning forest biomass in tandem with another feedstock, typically coal, to produce electrical power. A small portion of the main feedstock, no more than 10% to 15% by weight, is replaced by forest biomass in the combustion mix and then burned to produce steam for operating a turbine (Bergman and Zerbe 2008, 2; Kemp and Sibbing 2010, 12). As an example, the W.N. Clark power plant in Cañon City, Colorado, was permitted under Title V of the Clean Air Act (CAA) to co-fire up to 5% wood by weight with their total coal feedstock prior to its retirement on December 31, 2013 (Prokupets et al. 2003, 204; Business Wire 2014).

Closely related to co-firing is co-generation, which is also known as combined heat and power (CHP). As the name suggests, CHP projects burn forest biomass to produce thermal and electrical energy at the same time. Much like the direct combustion systems, forest biomass is used to heat a liquid and produce steam, but instead of only providing heat, some of the steam is used to operate a turbine to produce electricity. CHP projects are more efficient because one process yields two products while using less fuel than the separate operations would require individually (Bergman and Zerbe 2008, 7; Zerbe 2006, 10). In Colorado, the Town of Nederland purchased a system that was designed to produce both steam heat for the town's community center while at the same time running a microturbine for producing electricity for the building (Colorado Governor's Office of Energy Management and Conservation [OEMC] 2005, 1, 8).

Gasification is a second thermochemical process. Gasification involves converting biomass material to a gaseous state through partial combustion, i.e. oxygen is present in the combustion chamber but, unlike direct combustion, the amount of oxygen is intentionally restricted. Gasification makes either "synthetic gas" (a.k.a. "syngas"), which is mostly carbon monoxide and hydrogen and requires the use of pure oxygen or steam for production, or it makes "producer gas," which does not have the higher concentrations of carbon monoxide and hydrogen because it uses an air mixture. Making producer gas tends to be cheaper than making syngas; however, because both gases have improved combustion qualities compared to biomass solid fuels, energy production efficiencies for gasification tends to be higher than direct combustion. Gasification systems can be used to make heat, electricity, sustain a CHP operation, or even produce liquid fuels (USDA FS FPL 2004, 1; Kimes 2007, 11-12; Bergman and Zerbe 2008, 10; Huber et al. 2006, 4052).

A simple gasification project design is shown in Figure 2.7. Ideally, the delivered biomass feedstock should already match the project's specifications, i.e. typically clean, woody material with low ash and moisture contents. If not, the material may require additional processing and handling and subsequently incur additional expense.

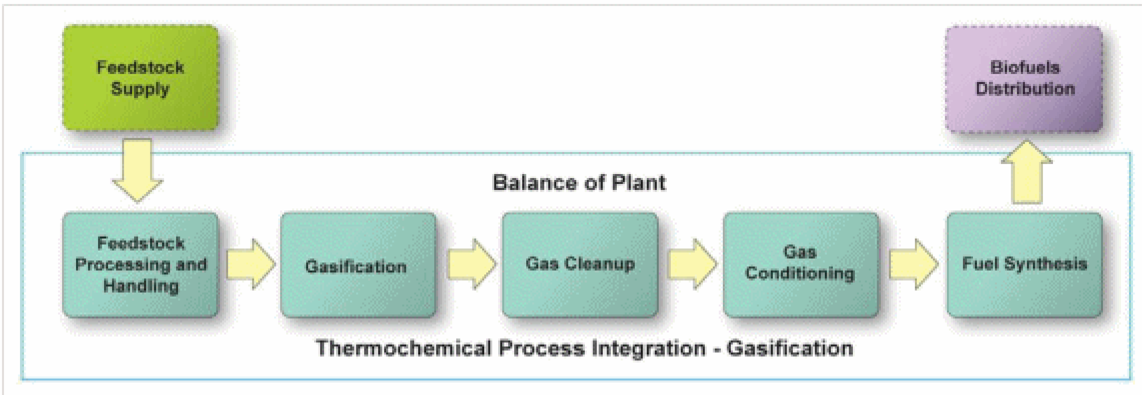

Figure 2.7: Simplified Diagram of a Gasification Production Process

Source: USDE EERE (2012a, 2-42).

Next, the material is subjected to low oxygen and high heat, causing the material to transform into a gaseous product. The gas is then reformed to remove impurities such as tars, ammonia, alkali metals and particulates. Finally, the gas is conditioned by reducing levels of hydrogen sulfide and adjusting the hydrogen-to-carbon ratio of the gas for optimal fuel synthesis (USDE EERE 2012a, 2-42 – 2-43). In June 2012, Renewable Forest Energy and Pagosa Land Company in Pagosa Springs, Colorado, was awarded the Pagosa Area Long-Term Stewardship Contract (LTSC) by the USDA Forest Service (USFS), where the company will remove trees between six and fourteen inches in diameter and then use gasification to make electricity.

Pyrolysis is a third type of thermochemical process. Pyrolysis methods use thermal energy to convert woody material into forest energy in an atmosphere completely devoid of oxygen (see Figure 2.8). Through pyrolysis, manufacturers can produce solids (e.g. charcoal, bio-char), gases (e.g. hydrogen, methane, etc.) and liquids (e.g. bio-oils). The desired end products are important considerations because the type of pyrolysis used determines what products are produced and in what proportions (Johnson et al. 2007, 9; Bridgwater 1994, 6; Huber et al. 2006, 4063).

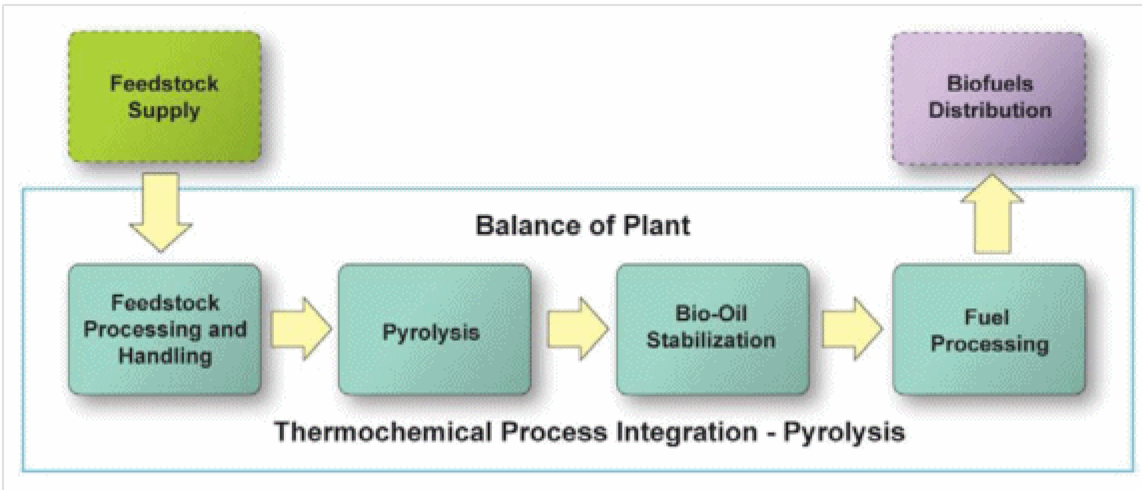

Figure 2.8: Simplified Diagram of a Pyrolysis Production Process

Source: USDE EERE (2012a, 2-44).

Pyrolysis methods are classified by the amount of time the feedstock is exposed to heat. Labels such as “flash,” “fast,” and “slow” or “conventional” are often attached to the pyrolysis label; however, these terms lack standardized definitions so the labels researchers attach to their method could be “arbitrary” (Mohan et al. 2006, 853).The forest biomass’ heat exposure ranges from as little as a fraction of a second to days in high heat, with temperatures ranging between 400-degrees to 1,000-degrees Celsius. Low heating rates, relatively low temperatures and long residence times in the heat maximizes the production of solids (roughly 35% of the final product) while high heating rates, medium temperatures and short residence times maximizes the production of liquids (roughly 75% of the final product) (Bridgwater 1994, 7-8; Bridgwater 2001, 979). High temperatures are indicative of a gasification process, though pyrolysis does produce similar gases that are collected and then combusted to provide heat energy in order to sustain the production process (Ebert 2008; Goyal et al. 2009, 34-36; Mohan et al. 2006, 853-855).

While pyrolysis appears similar to gasification, some key differences between the two processes exist. Faster forms of pyrolysis (e.g. fast, flash, ultra) require a dry feedstock while slower processes are more forgiving. Like syngas in gasification, the bio-oil generated by pyrolysis must be conditioned to make it suitable for use in a petrochemical refinery; water, ash and particulate contents must be filtered and its oxygen content and its acidity must be reduced. Finally, once cleaned and stabilized, the feedstock is suitable for processing into hydrocarbons suitable for renewable fuel applications (USDE EERE 2012a, 2-43 – 2-44; Ringer et al. 2006, 6).

2.2.2.2. The Biochemical Platform

Using forest biomass in thermochemical platform processes to produce heat is much more efficient than converting forest biomass to liquids via the biochemical platform (Zerbe 2006, 13-14). However, the United States' transportation industry currently "relies almost exclusively on refined petroleum products, accounting for over 70% of the oil used" so the biochemical platform provides a useful alternative for crafting liquid fuels suitable for meeting demand while helping to maintain the nation's standard of living (USDE EERE 2012a, 1-5). The biochemical platform, sometimes referred to as the "sugar process" or "sugar platform," converts forest biomass feedstock into liquid fuels through the fermentation of sugars. Using forest biomass, the biochemical process could produce cellulosic ethanol. Cellulosic ethanol is a liquid fuel identical to grain-based (i.e. corn-derived) ethanol except for one major distinction: the feedstock for cellulosic ethanol can be derived from trees, whereas grain-based ethanol is typically derived from agricultural crops or foodstuffs, such as sugar cane (Brazil), sugar beets

(Europe) and corn (United States). Also, one of the byproducts of the biochemical process is lignin, a solid "leftover" that can be burned through thermochemical means to provide heat to fuel the biochemical process or a complimentary thermochemical process.

A simplified illustration of a typical biochemical production process configuration is shown in Figure 2.9. Although the platform faces the same feedstock supply constraints as its thermochemical counterparts, the fermentation processes must also address its own technologically sophisticated challenges. A tree cell's wall is composed of cellulose and hemicellulose surrounded by a lignin sheath. The first step, pretreatment, must separate the lignin from the cell wall while also disrupting the structural integrity of the cellulose crystalline fibers (see Figure 2.10). The liberated five-carbon sugar cellulose is what the platform needs for subsequent fermentation and liquid fuel production.

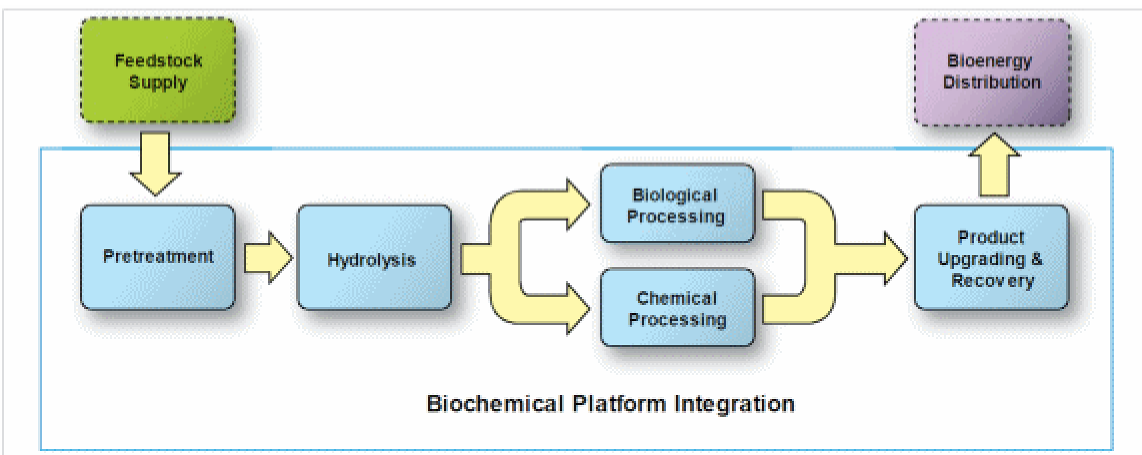

Figure 2.9: Simplified Diagram of a Biochemical Production Process

Source: USDE EERE (2012a, 2-29).

Pretreatment may use hot steam, acids, bases, ammonia or mechanical means to remove the lignin and break down fibers. Because the cell wall structure is resistant to pretreatment, processing costs are high, as much as 17% of the final production cost. After pretreatment, the feedstock undergoes hydrolysis, where enzymes are used to convert the cellulose and hemicellulose into the sugars glucose and xylose, respectively. Using either enzymes or chemicals, the sugars are then fermented into liquid fuel, such as ethanol. Fermentation is difficult because no single enzyme can ferment the mixture of five- and six-carbon sugars.

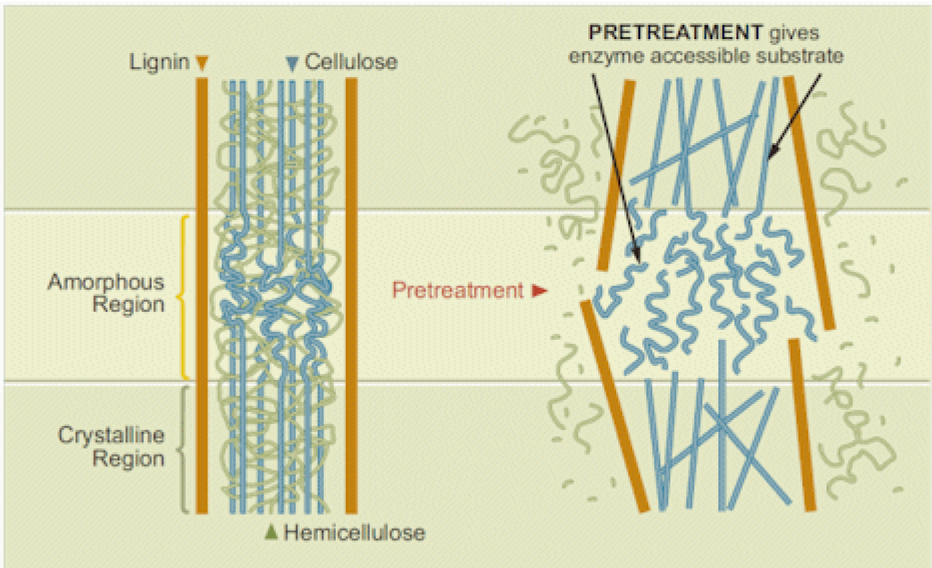

Figure 2.10: Impacts of Pretreatment on a Plant Cell Wall

Source: National Academy of Sciences et al. 2009 (123, as adapted from Mosier et al. 2005, 674).

The resulting fermented liquid product must be refined and residual solids (mostly lignin) are concentrated in a centrifuge for CHP processes, chemically converted into intermediate chemicals, converted into syngas or pyrolysis oil or they are distributed with the liquid fuels for off-site end-uses (EERE 2012a, 2-29 – 2-31; National Academy of Sciences et al. 2009, 121-130; Mosier et al 2005, 673-686; Schnepf 2010, 41-44).

2.2.2.3. The Integrated Biorefinery Concept

One additional platform is the “biorefinery” or “integrated biorefinery” platform. An integrated biorefinery is a conceptualized second-generation refinery that integrates both thermochemical and biochemical platforms at a single installation (see Figure 2.11). Mimicking petrochemical refineries, integration means biorefineries could achieve greater efficiencies and increase the likelihood of commercial success because these new refineries would be capable of producing a larger array of products, including "fuels, chemicals and materials and heat and power" while also remaining flexible enough to accept a variety of biomass feedstocks (Kimes 2007, 9-10; USDE NREL 2009; USDE EERE 2012a, 1-5, 2-57 – 2-61; Dudgeon 2010).

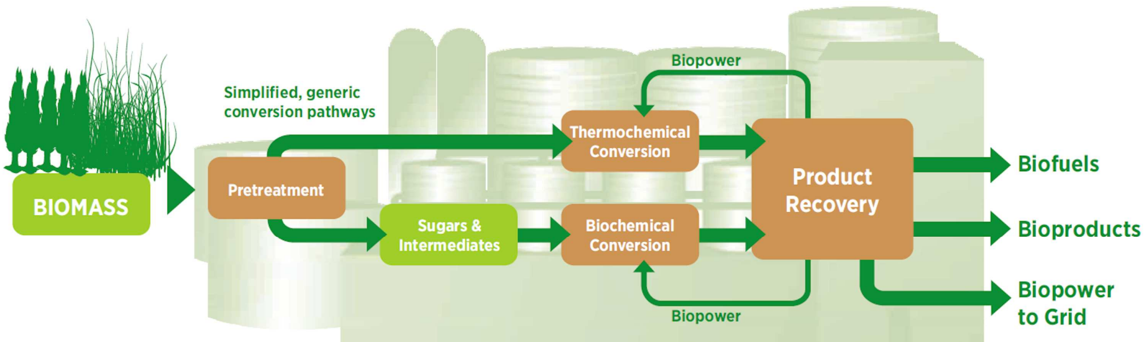

Figure 2.11: Integrated Biorefinery Diagram

Source: USDE EERE (2012e, 2).

2.2.3 Forest Energy Distribution

Once forest energy is produced in a usable form, the third step is distributing that energy to the consumer. Distribution is achieved by truck, rail, barge, pipeline or power transmission line. Trucks are best used for short distances; in the case of ethanol, truck hauling distances are currently limited by economics to about 300 miles.[11] Barges can carry substantial payloads (1.3 million gallons of ethanol vs. 8,000 gallons per truck) but are limited to waterways. Trains are the most economical means for non-power forest energy product distribution but given the

[11] Using data from Jenkins et al. 2008 (see slides 43 and 44), one would spend roughly the same amount of money trucking 8,000 gallons of ethanol from Denver to Grand Junction, Colorado, as shipping the same amount of ethanol by rail from Denver to Las Vegas, Nevada.

predicted increase in ethanol production and infrastructure limitations (e.g., railcar manufacturers are facing a 1.5-year backlog), railway distribution will likely be impeded. A 12-inch pipeline can move up to 4.2 million gallons per day, but the chemical properties of ethanol (e.g., affinity for ambient moisture, corrosive to pipes, etc.) and the lack of currently existing available infrastructure are significant drawbacks. Additional pipelines could be constructed using the right-of-ways developed for petroleum but at costs as high as $1-$2 million per mile (National Academy of Sciences et al. 2009, 227-239).

2.2.4 Forest Energy Consumption

The final step occurs when consumers use the forest energy. None of the applications listed above is theoretical; consumers are currently using forest energy to meet heating, power and liquid fuels demands in addition to converting forest biomass to other petroleum-derived chemical substitutes (USDE EERE 2012a, 1-5 – 1-7). Forest energy consumers range from small-scale residential users (e.g. pellet stoves) to large-scale industrial purchasers (e.g. municipal power plants). However, while the range of consumers is diverse and biomass is the largest energy source of all renewable technologies, the overall contributing percentage to the national energy portfolio is still low (4.1%), although forest biomass constitutes the majority of total biomass-derived energy (roughly 65% or about 2.7% of the national energy portfolio) consumed (USDE 2011, 8).

2.3 Some Advantages of Forest Energy Projects

Given the various possible products that could come from harvested trees, forest energy projects provide a number of advantages for businesses and consumers, forest ecosystems and neighboring environments and for communities and decision-makers. These strengths can be organized based on the significance of forest energy's economic, environmental and ecological and sociopolitical impacts. Economic impacts focus on the availability of resources, such as the capital, labor and raw material, necessary for implementing a forest energy project. Ecological and environmental impacts are those physical considerations that affect land health, including but not limited to impacts to ecosystem integrity. Finally, sociopolitical impacts stem from social values or political developments that may encourage or discourage forest energy project development and implementation. Note that some considerations listed below could fit in more than one category; for brevity's sake, considerations are listed once where their contributions are considered most significant. The following compilation is intended to be illustrative of arguments frequently encountered in the literature and is not comprehensive.

2.3.1 Economic Advantages

Recent estimates suggest that the raw material needed to fuel forest energy projects is abundant. In 2005, the USDA and USDE co-authored a report analyzing the potential for replacing 30% of the United States' petroleum consumption with biofuels manufactured from biomass by 2030. This report, known colloquially as the "Billion Ton Study," found that 1 billion tons of biomass would be needed to complete the "30-by-30" objective and that 1.3 billion tons of biomass, including agricultural and forest residues, were available annually and sustainably. Conservatively, about 368 million dry-tons of that total could be derived from forests (Perlack 2005, 7, 34). Given that the U.S. currently consumes roughly 147 million tons of forest biomass feedstock each year, the U.S. could consume at least 1.5 times more forest biomass than what it already does to generate forest energy without impairing future biomass production (Perlack 2005, 17). The report was updated in 2011 and researchers found that the "30x30" goal was still achievable and that advanced liquid fuel targets set in the Energy Independence and Security Act of 2007 could be met through 2022 (USDE 2011, xviii, xxi).

One approach for removing this available material is through the use of stewardship contracting. Stewardship contracting consists of a number of different management tools used by the USFS and BLM to achieve land management objectives, typically characterized by the agency as trading “goods for services.” In such a contract, not to exceed 10 years in duration, the agency proposes a sale that includes land management objectives (e.g. stream habitat restoration, etc.). The contractor is able to sell material harvested from the sale to pay for the harvesting work while also offsetting the costs incurred by the contractor while achieving the additional management goals. Stewardship contracting allows an agency to achieve its management objectives at a reduced cost while providing economic opportunities for logging contractors. Receipts remaining are retained by the responsible agency for additional projects. The program’s popularity is illustrated by the increase in the number of projects from 38 in 2003 to 172 in 2007 (GAO 2008, 4).

Removed material, whether through stewardship contract or by other means (i.e., service contract), is suitable for forest energy projects in Colorado. Given the state’s colder climate, forest energy projects that generate heat would be advantageous for meeting communal and municipal heating needs (Eckhoff and Mackes 2010). These projects can be highly efficient, ranging from 50% to 80%, depending on the project’s type and scale (see Table 2.1). Some European Advanced Wood Combustion (AWC) systems have efficiencies approaching 90%. Compared to electrical forest energy projects, heating and CHP projects tend to be less expensive to construct, cost less to operate and maintain and use fewer raw materials to produce energy (USDA FS FPL 2004, 3; Pinchot Institute for Conservation and The Heinz Center 2011, 31).

For residential consumers, using forest biomass for energy might also be less expensive. The Pellet Fuels Institute (2010) tracks market information for wood pellets and other thermal energy sources. Visitors to the institute's website are presented with a table that displays the national average prices for several fuel sources, including national average appliance efficiencies and calculated cost per million BTUs (MMBtu).

Table 2.1: Operating Costs and Efficiencies for Forest Energy Projects, 2004

Type	Utility	Industry	School	Commercial
Electrical				
Size (MW)	10-75	2-25		
Fuel Use (Grn Tons/Yr)	100K-800K	10K-150K		
Capital Costs ($M)	20-150	4-50	N/A	N/A
Operating Costs ($M)	2-15	0.5-5		
Efficiency (%)	18-24	20-25		
Thermal				
Size (MW)	14.6-29.3	1.5-22.0	1.5-17.6	0.3-5.9
Fuel Use (Grn Tons/Yr)	20K-40K	5K-60K	2K-20K	200-20K
Capital Costs ($M)	10-20	1.5-10	1.5-8	0.25-4
Operating Costs ($M)	2-4	1-3	0.15-3	0.02-2
Efficiency (%)	50-70	50-70	55-75	55-75
Co-Gen / CHP				
Size (MW)*	25 (73)	0.2.-7 (2.9-4.4)	0.5-1 (2.9-4.4)	0.5-1 (2.9-7.3)
Fuel Use (Grn Tons/Yr)	275K	10K-100K	5-10K	5K
Capital Costs ($M)	50	5-25	5-7.5	5
Operating Costs ($M)	5-10	0.5-3	0.5-2	0.5-2
Efficiency (%)	60-80	60-80	65-75	65-75

* Sizes for these facilities are a combination of electrical and thermal; the figure on top is electrical and the figure below in parentheses is heat. (Note: 1MWh = 3.413 MMBtu/h; 1MWh requires 1.5 to 1.8 green tons of forest biomass (NASF 2008, 24))

Source: USDA FS FPL (2004, 3).

Users can "calculate" their estimated costs by changing the national average price to what they pay out-of-pocket (see Figure 2.12). Using national prices at the time of writing, when compared to competing sources for heat, wood pellets can be cheaper than other substitute goods, such as fuel oil, propane and electricity.

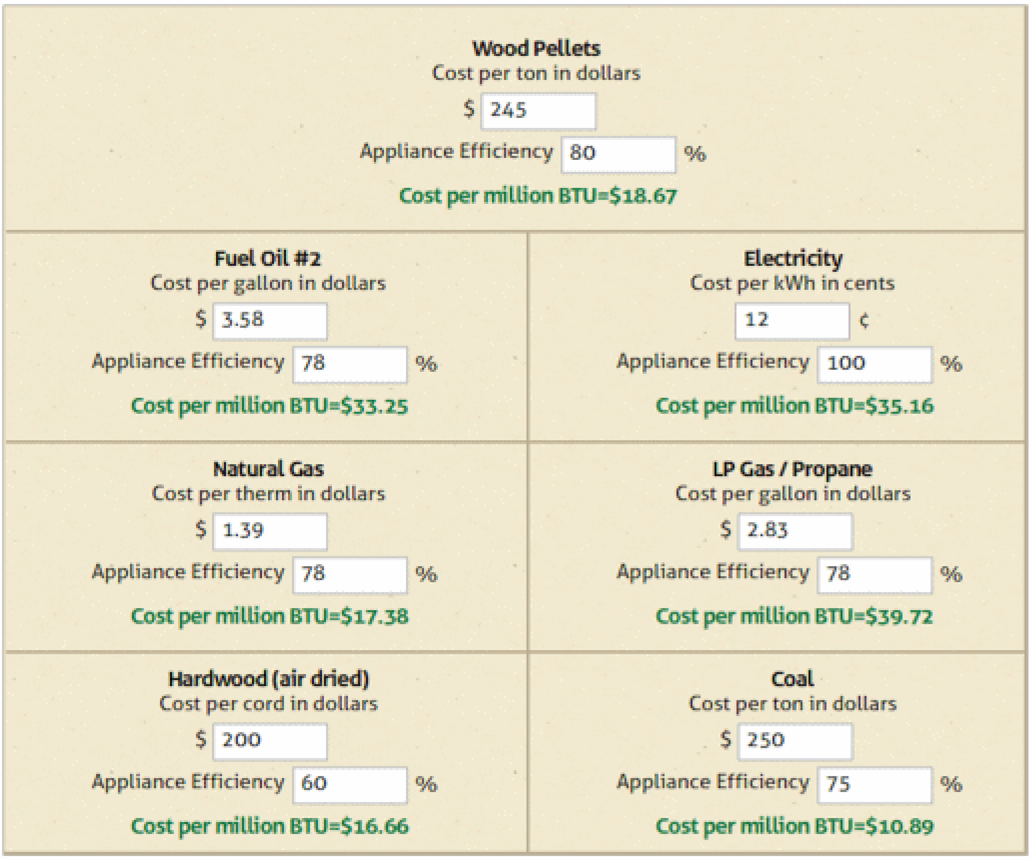

Figure 2.12: Online Comparison of Fuel Prices in Btus, 2012

Source: Pellet Fuels Institute (2012).

In order to sustain these types of forest energy projects, an adequate, continuous fuel supply must be available. One way to help ensure raw material availability is to develop a market for it. Some policy tools (e.g. loans, grants, tax incentives) promoting forest energy production have been promulgated at the federal and state level (discussed below) so conditions could be favorable for market creation. Lynch and Mackes (2003, 173) conclude that markets for products using sub-merchantable and non-merchantable forest residues should plan to include nearby processing facilities as that route is the most economical method for treating acres under a well-designed timber sale.

Market creation might be more efficient, then, if forest energy facilities are located close to or even co-located with solid-sawn wood products manufacturing plants. As an example, when local mills produce wood products (e.g. Morgan Timber Products in Laporte, Colorado, or shavings from Renewable Fiber[12] in Fort Lupton, Colorado, etc.), waste material is produced. This material could be used to power forest energy projects (USDA FS 2005, 9). Congruently, local economies should also benefit from the increased economic symbiosis. The Western Governors' Association (WGA) estimates biomass power plants could create 4-5 jobs per installed megawatt and that biomass power plants are typically the largest property taxpayers in their rural communities (WGA 2006, 26). As these jobs would require workers to be on site, they would have to be based locally and thus impossible to outsource.

A market that increases demand for new products might incentivize private industries to retool in order to handle the smaller timber and take advantage of the forest biomass market that was fiscally less attractive. Estimates suggest Colorado spends at least $4 billion on forest products annually (Lynch and Mackes 2001, iii). However, between 90% and 100% of those products, depending on the product line, are imported from other states or countries. Substantial portions of Colorado timber could be used to meet that demand (Lynch and Mackes 2002, 3). In short, Colorado has the raw material but lacks the ability to convert this raw material to meet its own forest product needs, including the demand for forest energy. Consequently, the state continues to export its monies and environmental consequences to meet its growing forest

[12] Carl Spaulding, owner of Renewable Fiber and President of the Colorado Timber Industry Association, noted that the "lowest price wood chip rides on the back of a 2x4" (Gaul 2010).

products demand. A robust forest products industry, rejuvenated by a forest energy sector, might help reverse this trend and encourage state self-sufficiency.

A strong forest products industry might also help defray the expense of treating forested acres. Forest treatments in the Western United States can cost as much as $1,000 or more per acre (USDA FS 2005, 11; Lynch and Mackes 2003, 174). Multiplying the per acre treatment cost by the 1.6 million acres that are in the WUI and are also within two miles of a community yields a total cost of $1.6 billion to treat those acres or about 25% of the FY 2009 USFS budget (USDA FS 2010). A vibrant forest products industry revitalized by a forest energy market might help reduce taxpayer burdens while also addressing forest health conditions simultaneously. As a result, industry would reduce fuel loads and treatment costs would be shifted from taxpayers at-large to forest energy consumers purchasing a sustainable, domestically produced product.

The biorefinery concept could also reduce treatment costs for managing Colorado's forests. Rather than relying on a single feedstock type, an integrated biorefinery located strategically along the Colorado Front Range would be able to take advantage of a variety of feedstocks. Such an installation could use forest feedstock (e.g. residues, short-rotation woody crops (SRWC), etc.) from restoration projects along the eastern side of the Continental Divide along with agriculture residues from the Eastern Plains counties and material diverted from municipal waste streams (e.g. construction and demolition, urban wood waste) from the heavily urbanized Colorado I-25 corridor. Also, installations relying on a variety of feedstocks might be better insulated from market shocks, i.e. if a feedstock's price dramatically increases, then the installation could purchase more of another, cheaper, substitute feedstock instead. Finally, the technology and expertise needed to build biorefineries have already been developed by the petroleum industry (Sims et al. 2010, 1577; USDE EERE 2012e, 2).

Forest biomass that does not meet the specifications for forest energy projects may be suitable for other purposes. For instance, the BLM's Lake Havasu Field Office removes forest biomass from in and around campsites, bundles the material and then sinks it, creating new aquatic habitat (Cook 2006). The National Park Service's Western Area Fire Management Program in Alaska partnered with a coal company to create defensible space around the NPS structures in Denali National Park and Preserve by removing accumulated forest fuels and then transporting the material to a coal mine for site reclamation work. The NPS saved over $363,000 in transportation, removal and labor costs (Miller 2004). Mackes and Lightburn (2003) found that wood could be used as a coal substitute when producing cement by pulverizing the wood and introducing it into the coal stream. Small forest biomass systems can function as living snow fences (Johnson et al. 2007, 16). Lynch and Mackes (2002) cataloged a short list of products that could be made from raw leftover forest energy project feedstock. In short, forest biomass has no shortage of additional, non-energy applications while on or off the stump.

2.3.2 Ecological and Environmental Advantages

Wildfires generally produce substantial quantities of air and smoke emissions. However, forest energy projects are typically much cleaner burning. When compared to wildfires, wood-fired boilers have been shown to reduce nitrogen oxides emissions by roughly 85% and also reduce hydrocarbons, sulfur oxides, carbon monoxide and particulate matter emissions by 94% or more. In addition, of all forest residue disposal operations, wood-fired boilers' air pollution emissions can be drastically lower than those of pile burning, prescribed burning and open burning when measuring particular matter, volatile organic compounds, nitrogen oxides and carbon monoxide emissions (Malmsheimer et al. 2008, 138). The Fuels for Schools Program

(2007) reported similar percentage reductions in air pollutant levels when forest biomass was consumed for thermal energy in Montana wood boilers instead of open-burning or wildfires.

Furthermore, forest energy projects may help reduce greenhouse gas (GHG) emissions to a point where forest energy projects could be considered “GHG negative.” Methane is a particularly potent GHG and, pound for pound, is 33 times more potent in the atmosphere for temperature increases than carbon dioxide (Shindell et al. 2009, 717; Henderson 2009). Forest biomass may produce methane when disposed conventionally through landfill decomposition. However, if forest biomass is used in a controlled forest energy project, the methane can be converted into water and carbon dioxide, the latter being a much less potent GHG. Thus, forest energy projects could contribute to a “net reduction” in GHG emissions (California Public Utilities Commission 2006, 18-19). Although a poor economical choice for nitrogen oxides or sulfur oxides reduction, co-firing coal with biomass could be an attractive option for “significant near-term reductions in [carbon dioxide]” emissions (Robinson et al. 2003, 5087).

Removing forest fuel loads would improve forest health by lower the competition between trees for scarce resources i.e., access to sunlight, water, and soil nutrients. As a result, trees free from competition would be healthier trees and would have improved resistance to insect attacks and other pathogens. Declining insect activity would mean less use of expensive and non-specific insecticide spraying while decreasing the number of falling beetle-killed trees potentially injuring or killing people (Harrison 2010). Less insecticide spraying would mean fewer chemicals are released into Colorado watersheds. Pesticides kill waterborne insects, which in turn shrinks fish populations. Forestry contractors were applying pesticides to healthy trees to protect them from MPB attacks in Summit County, Colorado. However, researchers discovered some contractors were illegally dumping leftover pesticide in sewers or drainages, killing aquatic insects and eliminating a food source for trout and other prized fish species (Haythorn 2008). Less pesticide use should also reduce improper pesticide disposal.

Further advantages for water quality involve reduced sediment contamination from forest biomass harvesting as compared to other forest-based disturbances. Forest operations, especially road building, often involve disturbances that can contribute to run-off pollution and sediment contamination. Harvesting biomass for these forest energy projects will, in some cases, require access roads which could lead to sedimentation. However, when the impact is compared to runoff from other disturbances, the numbers pale in comparison. Prescribed burning produces roughly 1.6 times more sediment than a comparably sized thinning operation for forest energy fuels and a wildfire produces 70 times more sediment (USDA FS 2005, 14-15).

Forest energy projects may provide indirect benefits in terms of land management. Forest residues that are burned instead of buried avoid the cost of landfill disposal. For instance, Ward et al. (2004) analyzed the possibility of shifting parts or all of the municipal solid wood waste, construction and demolition, primary and secondary wood product residue and forest thinning residue streams from landfills to more constructive purposes. They found that at least 100,000 tons were available annually for such purposes along the Colorado Front Range. In a closer inspection, Nash (2008) found that approximately 40% of the urban forest residues in the Fort Collins-Loveland-Greeley triangle area were being disposed of in landfills—a potential resource stream for forest energy projects while reducing future demand for additional landfills and open land.

Finally, the use of short-rotation woody crops (SRWC) can be environmentally beneficial, even on marginally productive lands. For the purposes of this paper, the definition of SRWC will be limited to fast-growing trees planted in the margins between productive agricultural lands and naturally occurring forests. Some SRWC systems do not require large quantities of nutrient supplements given their on-site nutrient recycling processes. Typically, minimal site preparation and efforts to establish are required, meaning less land is disturbed. As habitat, SRWC areas are shown to sustain wildlife populations that are equivalent to less intensively managed plantations and greater than neighboring agricultural fields. SRWC plantation edges are ideal raptor habitat. As compared to old-field conditions, SRWC systems can provide improved ecological contributions such as increased soil stabilization, organic matter inputs and soil and water filtration via extensive root systems (Johnson et al. 2007, 13-18).

2.3.3 Sociopolitical Advantages

FBU should also reduce the risk for catastrophic wildfires while restoring forests to “a condition that is resilient with the effects of fire” (WGA 2006, 17). One of the least expensive ways to remove forest fuel loads is by prescribed burning. However, prescribed burns are often restricted due to air pollution and smoke emissions, lack of permissible weather conditions, limited access to scarce resources (e.g. labor, funding, etc.) and overgrown fuel loads (USDA FS 2005, 10). Mechanical removals may be more acceptable and possibly cheaper provided markets exist for the removed forest material. In certain situations (e.g. dense fuel loads located near dense population centers), mechanical removal would reduce fuel loads with substantially lower risks to humans than prescribed burning while also eliminating concerns over impaired air quality from smoke emissions (Nicholls et al. 2008). Reducing fuel loads would also return forest stands to conditions more in line with their historic range of variability while possibly allowing safer fire reintroductions (USDA FS 2005). Mechanical thinning might be a preferred alternative for communities that are reluctant to trust fire as a management tool because they fear that fire could escape (Brunson and Evans 2005; Winter et al. 2002; Winter et al. 2004).

Part of the increasing interest in renewable forest energy is because of its versatility. As discussed previously, forest biomass can be burned for both heat energy and electricity. More importantly, it is the only alternative, renewable energy resource that may be converted into a liquid form i.e., biofuels, bio-oils, ethanol, etc. This feature is critical because forest energy could be used to, at least partially, maintain current standards of living while minimizing financial impacts to consumers, as fossil fuels continue to increase in price. Gas and liquid substitute products can be manufactured using forest feedstocks, i.e. non-edible feedstocks, so they avoid the fuel-or-food dilemma. Forest feedstocks can even be combined with coal in the gasification process to reduce harmful air emissions. Finally, co-products can be captured, processed and subsequently marketed in order to increase the revenue return on forest energy projects (National Academy of Sciences et al. 2009, 1, 165-166; Sims et al. 2010, 1577).

Furthermore, these gas and liquid products and their co-products have sociopolitical benefits of their own. Synthetic gas (syngas) from gasification can be used to manufacture many different products (see Figure 2.13). For energy, syngas could be used to produce electricity in CHP designs and, in some cases, these operations are cost competitive with comparable natural gas systems. Syngas can also be converted directly into hydrogen gas for ammonia and hydrocarbon synthesis, which is currently the major use for syngas, and can also be used in fuel cells. Finally, syngas can be refined into gasoline or diesel (via Fischer-Tropsch technology) or it can be distilled into ethanol or used to make methanol, which in turn can be converted into hydrogen gas (Klass 1998, 271; USDE EERE 2011; Ebert 2008; National Academy of Sciences et al. 2009, 164-165; Huber et al. 2006, 4056; Kumar et al. 2009, 571-575).

Pyrolysis produces at least two major products with significant benefits. First, bio-oil, or pyrolysis oil, is a thick, brown liquid (“liquid smoke”) that can be used in a variety of applications and is particularly attractive given its low sulfur, low nitrous oxide and low particular emissions.

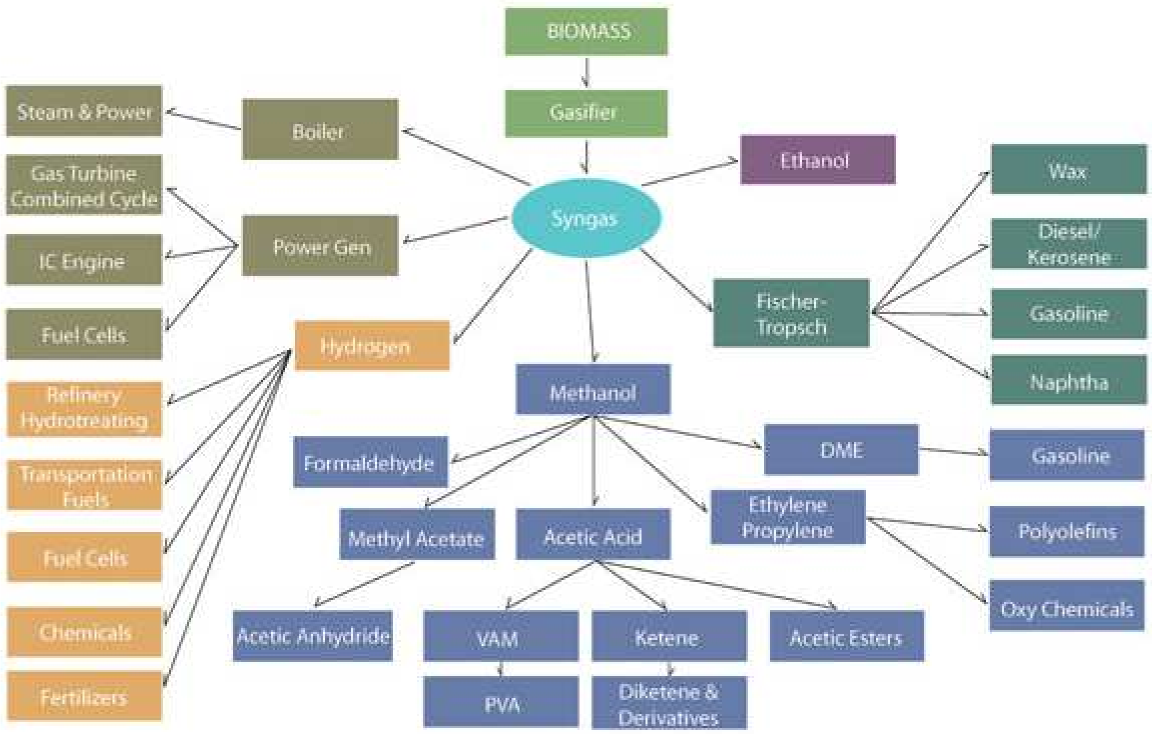

Figure 2.13: Possible Product Lines from Syngas

Source: Ebert (2008).

When combusted in furnaces, burners, or boilers or co-fired with fossil fuels, bio-oil can produce heat and/or electricity. It can be used in diesel engines with efficiencies of up to 45% to produce power or for CHP installations. Bio-oil could be used in properly designed aircraft or industrial gas turbines to produce the same energy products as in diesel engines. Bio-oil could also be upgraded to make transportation fuels. Finally, like syngas, bio-oil can be used as a building block for manufacturing petrochemicals as it contains fragments of 400 different substances, including adhesives and food flavorings (Mohan et al. 2006, 884-888; Karaosmanoglu and Tetik

1999, 1093; Bridgwater 2003, 98; Huber et al. 2006, 4061; Bergman and Zerbe 2008, 8; Czernik and Bridgwater 2004, 592-598; Ringer et al. 2006, 23-25).

Second, bio-char (or char) is a solid form of almost pure carbon that is co-produced with bio-oil in pyrolysis, although the proportions created vary with the recipe. For energy, if the bio-char is not recycled into the pyrolysis process, then it can be burned in any installation that currently burns waste biomass (e.g. sugarcane bagasse, etc.) or pulverized coal. Bio-char can also be used to make briquettes or mixed with biomass for use in high-efficiency fuel boilers. If the supply of bio-char exceeds demand, it can also be used to increase crop yields as a soil amendment[13], help meet the demand for activated charcoal in filtration, use in the construction of high-strength carbon fiber nanotubes, or, because of its longevity when buried in the ground, used as a potential carbon sink to reduce GHG emissions, although the data supporting this particular application is experimental (Kram 2007; WGA 2006, 40; Goyal et al. 2009, 40; Laird et al. 2009, 551-559; Reijinders 2009, 2840).

From the biochemical platform, cellulosic ethanol is a clear, liquid fuel that functions like grain ethanol but provides several advantages over its corn-derived counterpart. Cellulosic ethanol can be derived from a wide variety of non-food fuel stocks, uses less water during production, has carbon dioxide emissions that are near zero, reduces GHG emissions on a comparable per gallon basis with gasoline by approximately 90% and delivers a positive return on energy invested, with estimates ranging from 4.40 to 6.61 units of energy returned for every 1 unit of energy invested, which can be as high as four times more than grain alcohol on a per gallon basis (Soloman et al. 2007, 417; Wang 2007, 2; Hill et al. 2006, 11208-11209;

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[13] At the time of writing, Colorado's recreational and medical marijuana industries were just beginning to bud. Coincidentally, manufacturers have learned they have a growing appetite for bio-char.

Malmsheimer et al. 2008, 138). Finally, cellulosic ethanol production creates lignin as a by-product; lignin could be combusted through thermochemical methods to provide energy for sustaining the cellulosic ethanol production process (Bransby 2007; USDE EERE 2008; Virkajärvi et al. 2009, 1729; Johnson et al. 2007, 9). Cellulosic ethanol also can take advantage of the current grain ethanol distribution network, allowing consumers to use a renewable, liquid fuel that requires fewer resource inputs than corn (e.g. fertilizer, water, energy, etc.) while using marginal croplands and reducing air emissions (Hoover and Abraham 2009, 26-27; Hill et al. 2006, 11208). Colorado, for instance, has over sixty E85 (fuel that is 85% ethanol and 15% gasoline) fueling stations that are largely dependent on grain ethanol i.e. corn-based ethanol (Simpson 2009). As second-generation fuels such as cellulosic ethanol mature and gain widespread adoption, the liquid fuels could take advantage of the E85 infrastructure already in place (National Academy of Sciences et al. 2009, 119).

Using alternative, renewable energy helps promote national security by weaning the nation off fossil fuels. Almost half of the petroleum consumed by the U.S. is imported, split almost evenly between OPEC and non-OPEC countries. Forest energy could help offset dependence on imported fossil fuels, which constitute the bulk of the country's imported energy. Of the 98 quads of energy consumed by the United States in 2010, renewable resources account for just over 8% (less than half of which came from wood) of the total while imported fossil fuels accounted for approximately 30% (USDE EIA 2011, 9, 11, 147, 291).

FBU can also help protect national forests and the WUI from terrorism. For instance, the Federal Bureau of Investigation uncovered a plot in 2003 where Al Qaeda had planned to attack a number of Western states, including Colorado, by setting small-diameter material in national forests on fire. The terrorist organization conceptually planned to plant timed incendiary devices in key locations to maximize the economic impact of the blazes. The rationale was that by inflicting economic harm on tourism-dependent or forestry-dependent states, the fires would induce citizens to lobby for changes to U.S. foreign policy (Slivka 2003).[14] Montana media noted an Al Qaeda magazine advocated for a similar plot targeting the state's forests in 2012 (Florio 2012). Reduced forest fuel loads courtesy of forest energy projects may reduce the likelihood and success of such an attack and promote national security as well as economic security for a state that depends on forest-based tourism revenue for roughly $14.6 billion annually (Dean Runyan Associates 2011, 6). The threat from fire, whether natural or synthetic, shows that forest biomass is the only renewable energy resource that can actually harm society when it is not used.

The threat from forest biomass extends beyond terrorism. For instance, U.S. Army Corps of Engineers (ACE) policy authorizes the removal of trees within 15 feet of levee toes and floodwalls because vegetation growth threatens their structural integrity. The relevance of such a policy, especially in a post-Katrina era, is that as the ACE seeks to strengthen its flood control efforts by removing trees that could damage storm-control structures (Grissett 2010, Holden 2008), conceivably, the removed material could be used as forest energy feedstock while also being removed from the urban wood waste stream.

Forest energy also is advantageous in that it does not possess the disadvantages of other renewable energy technologies. For instance, forest energy can be generated at any time of day; solar energy depends on sunshine, which only occurs for part of the day and requires cloudless weather. Solar panels must typically be installed on south-facing surfaces in the United States. Therefore, installations must occur on south-facing slopes; failure to account for slopes and

[14] An attempt was made to obtain the actual memo from the FBI's office in Lakewood, Colorado. However, the public information officer was unnecessarily hostile and told the author that she could not find the memo and that even if she could, she would not distribute it to the public, even after 7 years and regardless of redaction.

shadows could potentially reduce power generation by the cells by 90%. Manufacturing solar cells can be costly, too, as thin film solar cells require the use of gallium and indium, which can be difficult to obtain (Jung and Wagner 2009; Fridley 2010, 5).

Other rare-earth metals, such as neodymium, are a critical component of wind turbines' magnets. A standard wind turbine will consume over 500 pounds of the element and over two tons of other rare-earth metals. China produces 97% of the world's rare-earth metal tonnage and controls almost half of the world's proven rare-earth metal reserves. Furthermore, China often restricts rare-earth metal exports; companies may locate in China but the chief export is typically the finished product. For instance, in the second half of 2010, China reduced rare-earth metal exports by 72% (Jung and Wagner 2009; Taylor 2010). Provided that the raw materials could be obtained, wind has additional problems. Like solar, wind energy is intermittent: while the possibility for increased wind production reduces fossil fuel dependence, what can actually be produced is, on average, only about one-third of the faceplate wattage (Fridley 2010, 6). Wind turbines can negatively impact aesthetics as once pristine lands are towered over by wind turbines and the spinning blades create noise. Spinning blades can also interfere with military operations by producing false radar echoes and can also kill endangered migratory species, such as eagles and bats (Nelson 2010; Streater 2010).

Other low-carbon energy technologies suffer disadvantages that biomass does not. Geothermal energy is restricted to where accessible thermal pockets exist and is plagued by potential air emissions from released underground metals. Also, geothermal energy harvesting can lead to ground subsidence or sinking. For example, although the USDE EERE (2006) touts geothermal energy plants' longevity by listing New Zealand's Wairakei field, New Zealand's Ministry for Culture and Heritage (Stewart 2009) notes that in the time between the plant's completion in 1958 and up to 2005, the land surrounding the Wairakei field sank 46 feet as underground water supplies were exhausted. Hydropower is similarly limited to where water currents exist, but installations can also have significant environmental impacts. For instance, hydropower structures can impede the ability of migratory fish species to reproduce. Dramatic reductions in salmon populations and catches in the Pacific Northwest illustrate the impacts that dams, among other anthropogenic causes, can have (e.g., Taylor 1999, etc.).

Finally, the option to use forest biomass can empower consumers to consider alternative, environmentally friendlier products. Guber (2003) suggests that Americans respond favorably to actions deemed necessary to improve the environment. The environment typically rates high when Americans are polled. However, when action is required and subsequently costs are incurred, voters often relegate the environment to last, with one exception: voters often respond favorably to economic incentives that allow them to make their own informed decisions. Provided with the option to purchase environmentally friendly alternative products that improve one's bottom line through sheer self-interest, voters will often make decisions when allowed to use their own money i.e. they often "vote at the cash register" (Guber 2003, 184). If alternative heating products were manufactured that were beneficial for the environment i.e., sustainably produced wood pellets, then consumers might be inclined to vote with their wallets by either augmenting or switching their current heating systems to a wood-fired system as a way of making an expedient political decision. To illustrate, several Denver-area Costco stores carry Colorado-made wood pellets.

Empowering consumers may also suggest that forest energy has the potential to become one of the more democratic fuels. Mitchell (2011) explores the political history of switching from coal to oil. He argues that switching from coal to oil undermined democratic processes, especially for labor, as the geophysical characteristics of oil (e.g., containerization, pipelines, etc.) removed skilled and unionized labor and their ability to protest via strike and sabotage. Large numbers of workers are not needed as much in oil as compared to coal because the liquid fuel has fewer critical junctures. Conversely, since forest energy can be relatively easily and cheaply obtained by consumers—some need only step into their backyards with a saw—the technology offers an increased potential for democratization as opposed to more limiting fossil fuel substitutes.

The number of forest energy projects has increased in part due to significant policy changes at all government levels. For instance, at the federal level, the Production Tax Credit (PTC) has stimulated interest in forest energy projects. The PTC is a tax incentive providing a monetary benefit for every kilowatt-hour (kWh) produced using renewable energy. For example, open-loop biomass facilities, which obtain forest biomass feedstock and other woody resources that were not originally designated for energy production i.e., not planted crops, can claim a 10-year credit of $0.011 per kWh ($0.0075 per kWh in 1993 dollars inflated to the present) generated. In addition, the Renewable Fuels Standard (RFS) has been amended to provide increasing quantities of renewable liquid fuels. Under the 2007 Energy Independence and Security Act (EISA), the total amount of required blended renewable fuel increased from 7.5 billion gallons by 2012 to 36 billion gallons by 2022, with 21 billion gallons required to come from “advanced biofuels,” which includes cellulosic ethanol.[15]

At the state level, the number of renewable portfolio standards (RPS) has increased markedly over the past quarter-century. An RPS requires “utilities to use renewable energy or

[15] The US EPA recently promulgated adjustment to RFS totals that are below the original EISA targets. More information about EISA, its history and its targets are in Chapter 5.

renewable energy credits (RECs) to account for a certain percentage of their retail electricity sales -- or a certain amount of generating capacity -- according to a specified schedule" (Database of State Incentives for Renewables and Efficiency [DSIRE] 2010a). In Colorado, large investor-owned utilities (IOUs) are required to supply at least 30% of their electricity using renewable energy resources (DSIRE 2010b), making Colorado's RPS the second most aggressive in the nation next to California's (33%). Even local governments have taken the initiative to pass their own RPS. In 2003, the City of Fort Collins, Colorado, passed a standard that required 2% of the utility's electric power to come from renewables by 2004 and a total of 15% by 2017 before adopting the state's RPS in 2009 (City of Fort Collins Utilities 2009, 3).

2.4 Some Disadvantages to Forest Energy Projects

While forest energy projects enjoy a number of advantages, these projects also suffer from a number of drawbacks. Most significantly, factors such as resource access, cost, supply issues (e.g. quality and quantity), net environmental impacts and social acceptability may be the most discouraging for proponents to address. The following segments address these issues.

2.4.1 Economic Disadvantages

While the raw material exists, questions persist as to the degree of abundance and sustainability. Forest biomass is a renewable energy solution to the fossil fuels crisis, albeit a partial solution at best. The billion-ton study attempted to replace 30% of petroleum demand by 2030 with biomass. Based on the study's assumptions, the possibility to substitute exists but the 30% could be met using almost exclusively "agricultural residues" (Perlack et al. 2005, 38). Forestry could also contribute an additional 370 million tons to agriculture's one billion tons, but this total does not constitute a 100% substitution of petroleum demand, so even with biomass, fossil fuels must still be a part of the nation's energy equation. Furthermore, the estimate may be problematic. White (2009) identified four economically based approaches to estimating available forest biomass using different lenses. While White (2009) does use some Perlack et al. (2005) data, he also notes instances where the estimates may be higher than what is actually possible. For instance, Perlack et al. (2005) estimated what timber harvesting residues were "technically available" but overestimated what is "economically available" (White 2009, 13). In another instance, Perlack et al. (2005) suggested greater milling residue availability from increased timber mill production due to heightened hazardous fuels reduction work, but the estimates did not consider timber mills' improving efficiency i.e. more efficient mills will produce less residue, which suggests, again, that the 370 million ton total may not be a conservative estimate (White 2009, 15). Thus, forest biomass availability estimates vary depending largely on what economic perspective a researcher assumes.

Other estimates also call in to question how much forest biomass material is available. A report by the International Council on Clean Transportation (Searle and Malins 2014) suggests that estimates for biomass yields could be exaggerated by as much as 100%. The report suggests the reason for exaggeration or overestimation is due to researchers examining a limited number of research plots that are small, intensively irrigated and weeded and carefully harvested by hand. More conventional biomass harvesting techniques yielded results that were significantly lower.[16]

The availability of raw forest biomass material does not mean the material can be removed. For instance, in Colorado, a private forest products contractor working along the Colorado Front Range would expect a timber sale to include primarily small-diameter material.

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[16] The authors were also quick to suggest that cellulosic efforts need more supportive policies, not less. They simply want the policies to be based on more realistic crop yield projections.

Given the weak markets and the sparse number of facilities able/willing to accept such material, the likelihood of a contractor submitting a bid or successfully completing the project is low. In many instances, timber sales in Colorado have expired due to a lack of bids. Furthermore, because stewardship contracts can span multiple years, the risk to the contractor increases as budgets may change from year to year. Furthermore, a stewardship contract's anticipated costs can easily dwarf a district or field office's entire budget. Subsequently, reluctance to use stewardship contracting exists, both inside and outside of the administering agencies. Inside the agency, lack of access to information and guidance compounded by high turnover rates can discourage adoption. Outside of agencies, disruptions in budget cycles and changes to county-level payments add increased risks to contractors (e.g. government contract cancellation due to unexpected budget shortfalls, etc.) and thus make stewardship contracting less attractive (GAO 2008, 44-46). Finally, forest energy project financiers expect a minimum of a 20-year guaranteed supply; the decade limit on the stewardship contracting authority combined with the year-to-year federal budget cycle are regulatory barriers to project development (Pinchot Institute for Conservation and The Heinz Center 2011, 3).

Also, the material may be referred to on a macro scale as "forest biomass" but the resource should not automatically be considered homogenous. The physical properties, including strength, stiffness, BTU content and other properties differ between tree species. Not knowing or recognizing the difference can have disastrous economic results as, anatomically, wood fibers and structures are basically identical between species but working properties can vary considerably (Bowyers et al. 2003, 216-217). For example, the former Rocky Mountain Pellet Company plant, located in Walden, Colorado, specifies that it only accepts lodgepole pine. In one instance, a truck-load of subalpine fir logs accidentally entered the processing stream. The processed pellets were of poorer quality and lacked the adhesiveness of the lodgepole pine logs. Fortunately, the pine-fir mixed pellets disintegrated in their bags before being sold to consumers.

Furthermore, trees removed for forest energy projects will vary in size but most of these trees will have small diameters. In a study of forest treatments conducted on research plots scattered randomly along the Colorado Front Range, Lynch and Mackes (2003) found that the majority of material (in at least one instance, 100% of the material) removed from forest treatments was small-diameter i.e., less than 12 inches in diameter-at-breast-height (dbh). Such material constitutes a "liability from both a fuel hazard standpoint as well as from a financial standpoint" as removal costs regularly exceeded the economic value of removed material (Lynch and Mackes 2003, 173; Patton-Mallory 2008, 1; USDA FS 2005, 7) and the energy costs involved in removing smaller material can deter forest energy proponents (Pan et al. 2008, 30).

Even if forest biomass removal became cost-effective, this biomass often requires additional treatment due to its substantial moisture content i.e., a large portion of the tree's volume will be filled with water and the additional weight will make facilitating handling and transport more difficult and expensive. For example, a cord (128 cu ft) of ponderosa pine (*Pinus ponderosae spp.*) logs, freshly cut, weighs an average of 3,600 pounds. Once seasoned (dried), that same cord weighs roughly 2,336 pounds. Thus a cord of green firewood can weigh 50% or more than a cord of seasoned firewood on a dry-weight basis. This extra weight can cause dramatic increases in transportation costs as truckers are hauling substantial quantities of water (Kuhns and Schmidt 1988). Either the material should be seasoned (i.e., left to dry) before transport or else the material will have to be pretreated at the energy project site—either case requires additional processing time and thus additional expense. Failure to allow the wood to dry may adversely impact the combustion process by requiring supplementary fuels or interfering with the self-sustained biomass combustion process (Klass 1998, 197).

One way to defray the costs of extracting small-diameter, lower-value material is to also include larger trees in the sale as the larger stems can be converted into higher-value products (e.g. boards as opposed to chips) and thus offset costs incurred by the logger (USDA FS 2003, 13; Perlack et al. 2005, 34). Yet using larger trees may engender unfavorable public opinion and risk potential increases in carbon emissions as the forest ecosystem is disturbed or destroyed (Perlack et al. 2005, 34; Ingerson 2009, 17-18).

Market creation for forest energy is key for addressing several forest health threats. First, the influx of new raw material to meet new market demand could provide a necessary stimulus for Colorado's declining forest products industry. The CSFS (2010c) noted that since 1992, Colorado has lost 16 sawmills, with a total loss of over 500 jobs. Additionally, two Wyoming sawmills, employing 150 people each that purchased much of their material from Colorado forests have shut down. Since the early 1970s, Colorado's forest products industry's capacity has shrunk by over 80% (Colgan 2011). Colorado's largest sawmill went into receivership in May 2010, leaving the largest timber producer as an aspen mill in the state's southwestern corner at that time (Associated Press 2010). In September 2012, the sawmill was purchased and resumed operations but it still has difficulty obtaining an adequate timber supply; timber sale volumes from the Grand Mesa-Uncompaghre-Gunnison, Medicine Bow-Routt, Arapaho-Roosevelt and White River National Forests, while double what they were in 2000, are less than half of what they were in 1985 (Larsen 2013). Throughout USFS Region 2, timber sale volumes are only about 70% of what industry needs (Fishering 2014).

Long-term timber supply uncertainty is a problem as long-term business planning is difficult given the amount of material actually available to the timber industry from national forests varies. For instance, national forests provided 90% of the timber harvest for Colorado in 1974; in 2002, this percentage had fallen to 38% (Morgan et al. 2006, 23). In 2007, the percentage increased to nearly 50% (Hayes et al. 2012, 22). Any federal forest shortfall must be made up by the mills via contracting with private landowners, interstate or international imports and other industry members. However, given the large numbers of private landowners scattered across the state who are concerned primarily with the small-diameter material on their property, attracting mill interest in large numbers of small sales of low-value material is difficult.

If energy efficiency does not improve, then the amount of energy demanded will increase with population. One way to meet the increased energy demand is to build large-scale energy plants. However, because of the aforementioned cost issues and energy efficiencies, forest biomass is typically a poor choice for large-scale electrical power generation. Electricity-only forest energy plants tend to require larger amounts of fuel; are often more expensive to build, operate and maintain; and have lower generating efficiencies. Revisiting Table 2.1, efficiencies range from 18% to 25% for major forest biomass electrical power plants, with an average efficiency of 20% (Zerbe 2006, 10). To place these figures in perspective, fireplace efficiencies range between 5% and 18% and modern day fossil fuel power plants are around 35% efficient[17] (Johnson 2007, 9, Zerbe 2006, 8, Skog and Watterson 1984, 744; USDE EIA 2011). By comparison, thermal forest energy applications such as U.S. Environmental Protection Agency

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[17] Fossil fuel power plant efficiency was calculated by dividing 3,412 Btu/kWh (a constant) by the EIA's historical heat rates. Of note: fossil fuel power plant efficiency increased from 22% in 1949 to 30% in 1957 to 34.5% in 2008. Essentially, efficiencies have remained flat for the past half-century. Colorado promulgated a law in 2010 mandating conversion of coal-fired power plants to natural gas power plants. However, without improving the combustion mechanism, efficiencies could remain flat though natural gas energy conversion efficiencies could exceed twice that of coal-fired plants.

(US EPA)-certified wood stoves and pellet stoves are minimally 72% and 78% efficient, respectively (US EPA 2011a).

While wood pellets may enjoy higher efficiency as a densified wood feedstock, they cost more per Btu than some of the more conventional sources such as coal and natural gas, which tend to be cheaper because they can be transported in larger quantities. For instance, while natural gas is typically delivered continuously through a pipeline and coal is often delivered by rail in 10,000 ton shipments, wood is typically transported by truck in 20-ton shipments (Gaul 2010). With a lack of an economy of scale, forest energy projects will have a difficult time competing in areas serviced by natural gas distribution pipelines or in urban areas connected by rail to coal mines.

Related to accessibility are issues involving transporting forest biomass. Humans are moving into the wildland-urban interface thus demand for forest products in these communities should increase. Thus, the stronger demand for wood products will remain in urban areas, particularly along the Interstate-25 corridor, where 80% of Colorado's population lives. Moving the raw material from the stump to shelf requires transportation. Furthermore, depending on the product line, between 90% and 100% of the wood products used by Coloradans are imported (Lynch and Mackes 2001, 23). Importing wood products from other states or countries similarly incurs expense and requires the use of (fossil) energy to transport goods over the vast distances.

The implications are two-fold. First, Coloradans relying on, or seeking out, Colorado wood products will find limited availability. Transportation costs, combined with harvesting costs, will limit the feasible delivery radii to a maximum of 50 miles (Bain et al. 2003, 2-5; Klass

1998, 206).[18] As gasoline prices increase, the radius will contract accordingly as fuel cost increases are passed along to the consumer. Second, the heavy dependence on wood product transportation, foreign and domestic, requires substantial quantities of fossil fuels. Bulk transportation (train or ship) would provide more material at reduced cost as compared to trucking. Given the proximity of Colorado Front Range communities to railheads and the increasing cost of trucking during an economic downturn, the competitive edge belongs to the rail transport. Those producers and suppliers located close to railheads i.e. Canadian wood products producers and those mills in the Pacific Northwest will enjoy the advantage.

Colorado forests are characterized by small-diameter stems. However, most forest product mills are geared toward producing traditional wood products with larger sized stems and are not adapted for small-diameter material. A switch from using the material for traditional wood products (e.g. lumber, etc.) would require significant efforts and capital to retool industrial facilities so mills could participate in a forest energy industry. With heightened economic sensitivities due to market uncertainties plus a lack of available credit, such expenditures seem unlikely in the foreseeable future.

Given the lengthy cold weather spells in Colorado, wood fuel storage is a necessity.[19] Storage areas or holders may incur additional space and expense. For example, an average 2,000 square foot home with a single pellet stove would require a 6- cubic foot bulk storage space for heating during an average winter (Confluence Energy 2009). Such requirements may discourage

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[18] The "50-mile" radius appears several times in the literature but the earliest publications dates occur when gasoline prices were half of what they are at the time of publication. This radius is likely smaller.
[19] The exception to this rule is the new wood biomass heating plant on Colorado State University's Foothills Campus. Project managers decided not to create storage space for fuel, instead preferring "on-demand" deliveries of wood. Provided winter conditions do not impede deliveries, this approach may work over the long term. Long-time residents of northern Colorado may have their doubts.

widespread adoption in areas where space is at a premium i.e., densely populated urban areas. Fuel hoppers may not be aesthetically pleasing nor loading/auger systems particularly quiet.

Finally, forest energy will necessarily rely on markets to develop an adequate fuel supply but forest energy will still be subject to the wax and wanes of market forces. For instance, in 2008, wood pellet plants were constructed in Kremmling, Colorado, and Walden, Colorado. Initial demand was strong and the plants operated around the clock. However, in 2009 the market bottomed out as warmer temperatures plus an increase in producers left manufacturers with a surplus. The initial months of 2010 saw an increase in demand, but both mills have undergone periods where they operated intermittently due to weak market demand. However, one should note that other forest products are subject to the same economic constraints as forest energy products, further impeding activities to reduce fuel loads or address insect and disease epidemics (Lawrence 2010a, 2010b; Harmon 2010).

Due to its complexity and the current economic climate, obtaining financing for forest energy projects could be difficult, especially if the project lacks community support. Also, the technologies needed are still in their infancies. Feedstock costs, without an appropriate transportation infrastructure, might be higher than in a stand-alone thermochemical or biochemical plant given Colorado’s sheer size and terrain. Less-than-optimal performance could severely impact a project’s long-term viability. With the additional feedstocks, sustainability may be more difficult to attain given the increased number of factors and constraints to consider. Finally, the technologies employed may make obtaining the necessary environmental permitting harder (USDE EERE 2012e, 2)

Forest biomass can be used in a variety of applications beyond energy. For instance, Lynch and Mackes (2002) cataloged a number of opportunities for entrepreneurs in Colorado using small-diameter material, which could be suitable also for forest energy installations. However, using forest biomass for energy will be significantly less profitable than almost any other use for the same material. For instance, in January 2013, a 40lbs. bag of wood pellets' retail cost is $4.19 at Sutherlands in Fort Collins, Colorado. If one were to change the wrapper and sell the wood pellets as a 40lbs. bag of wood pellet kitty litter, the retail cost increases to $20.80 at PetCo. If one were to change the wood and purchase a non-bulk 40lbs.-equivalent of hamster pine bedding, the value of the material spikes to $164.60 at PetCo, assuming customers are not buying in bulk or at wholesale. Without policy incentives, using the wood for forest energy is one of the worst uses for the woody material from a purely economic standpoint.

2.4.2 Ecological and Environmental Disadvantages

Forest energy projects may contribute to global GHG emissions. First, as noted previously, the raw material is still largely dependent on chainsaws and machinery for felling and for semi-trucks for product delivery meaning fossil fuels are still part of the equation. Also emissions from processing/manufacturing and final distribution should be included in any emissions calculus as forest energy projects cannot proceed without these crucial steps and GHG emissions from these steps are often not included in the "carbon neutral" calculus (Ingerson 2009, 19). Carbon debts and dividends were also a focus of a biomass study conducted by the Manomet Center for Conservation Sciences (2010) for the state of Massachusetts.[20]

Colorado's mountainous terrain presents a physical challenge for proponents trying to access the raw material. Nearly one-third of Colorado's forests are either on steep slopes (equal to or exceeding 50%), in environmentally sensitive areas (e.g. Wilderness, roadless areas,

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[20] This study was roundly criticized. See Gibson 2011 for a synopsis of a rebuttal produced by William Strauss of FutureMetrics.

national parks, etc.), or both (CSFS 2010a, 51-54). While steep slopes do not actually disallow harvesting activities, they do discourage harvesting as the total cost of extraction “significantly reduces economically-viable opportunities for product recovery” and costs for treatments on slopes exceeding 40% can at least double those of gentle slopes (USDA FS 2003, 13; Perlack et al. 2005, 34; White 2009, 21-22).

In addition, forest biomass is limited geographically to where trees grow (see Figure 2.14). Regions such as the Upper Midwest and Rust Belt will likely be poor candidates for forest energy projects given the relative dearth of forests and in some cases the inhospitable climate. Other areas such as the Snake River Valley in Idaho are relatively devoid of trees but, given the extensive irrigation for agriculture, some areas may be suitable for tree plantations or closed-loop biomass operations. Questions persist as to the ecosystemic sustainability of such endeavors and the susceptibility of harvesting sites to invasive species (The Heinz Center and the Pinchot Institute for Conservation 2009, 8; Miller and Seastedt 2009; Ingerson 2009, 18; Janowiak and Webster 2010). Transportation costs are still considerable even though forests are concentrated regionally because these same forests extend over substantial distances; related to Colorado's mountainous terrain, these distances are rarely driven in a straight line.

Demand for forest material has the potential to cause significant, adverse impacts on water quality and quantity in Colorado. For instance, harvesting operations could compact soils. Increased soil compaction reduces water infiltration, which reduces water availability to trees. Reduced infiltration rates can increase runoff and soil erosion. Combining soil disturbance and the poor water infiltration to expected large-scale disturbances (e.g. wildfires, roads, development, etc.), the potential for dramatic impacts to water quality (e.g. sediment and thermal pollution) and quantity (e.g. dwindling snowpack and mountain water levels) exists (e.g. Elliot 2010, 13-14; Stednick 2010, 149-156).

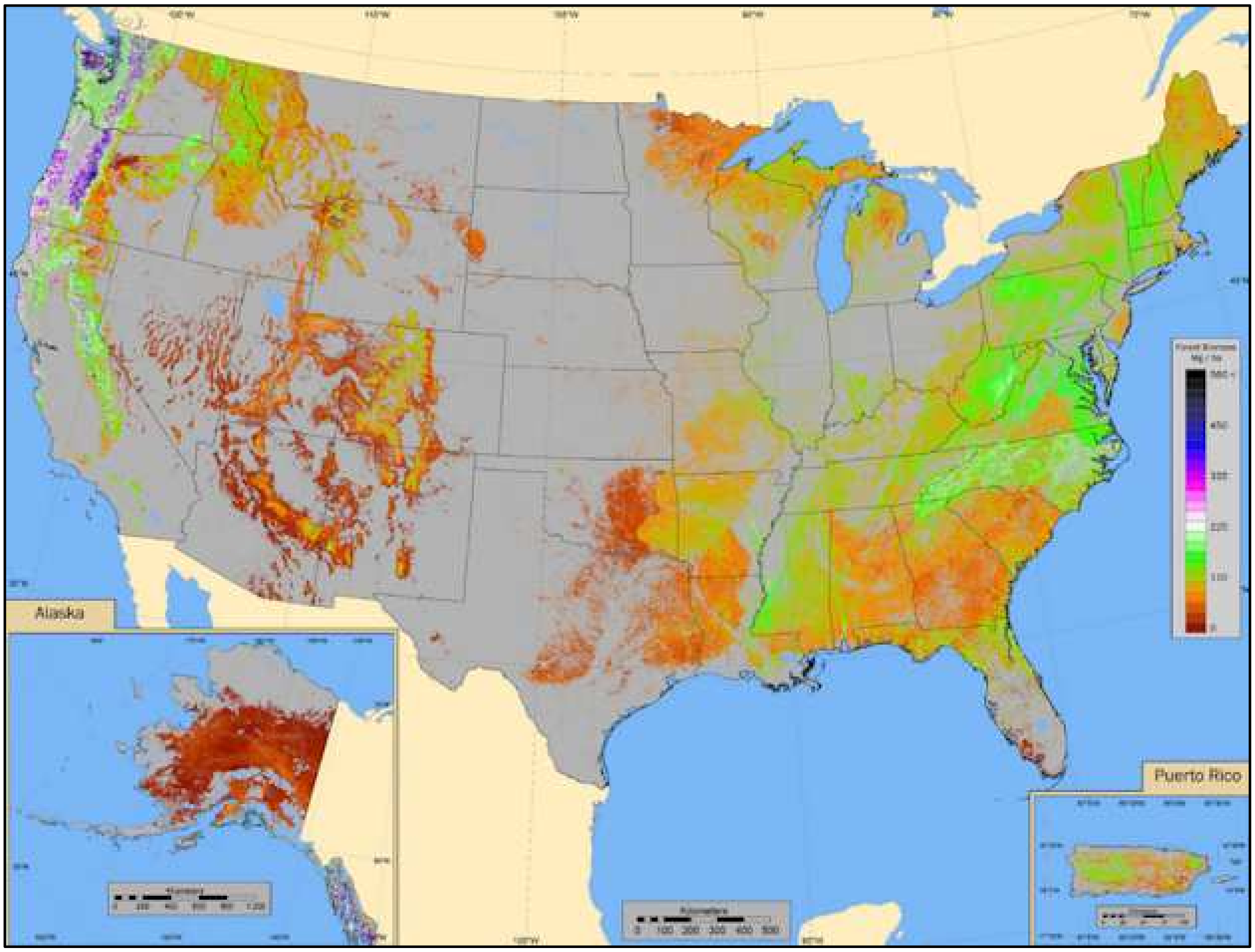

Figure 2.14: Above-Ground Estimates for Forest Biomass

Source: Adapted from Blackard et al. (2008, 1663).

Efforts to increase forest biomass production could also reduce soil quality. Thinning and clearcutting, generally, can lead to substantial carbon deficits, some as long as 20 years, as forest duff decomposes faster and the source of the duff layer (e.g. the trees) has been removed meaning that less material is available in future years. Also, removal operations could inadvertently remove the duff layer, exposing bare mineral soils and exposing hillsides to greater erosion rates (Ingerson 2009, 18; Elliot 2010, 13).

While some forest harvesting may improve wildlife habitat, the more efficient harvesting techniques could negatively impact wildlife and could reduce biodiversity. For lodgepole pine stands, the most economically efficient process for removing material is clearcutting. This technique involves removing all stems in a given timber sale area. This approach is ecologically attractive because it mimics the impact of a stand-replacing wildfire. However, it lacks the thermal energy of a blaze. Species dependent on fire for survival (e.g. serotinous cones of lodgepole pines, etc.) may be at a disadvantage if forest energy projects do not include reintroduced fire as a management tool. Furthermore, when plantation farming can be used to generate closed-loop biomass, the potential for improving habitat over agricultural lands exist. However, plantations still have a simpler vegetation scheme than naturally occurring forests. Species dependent on intact forest ecosystems will be disinclined to use such synthetic habitats (Bies 2006, 1205; Janowiak and Webster 2010, 19-20). Forest modifications may have additional, wide-ranging impacts on ungulates; small mammals; birds, including raptors and cavity nesters; reptiles; amphibians; and invertebrates, including pollinators and bark beetles (Spellman 2012).

Because of the combustion, disposing of residual byproducts may still be an issue. For instance, wood pellets are assigned one of four grades based on how much ash content a consumer may expect. Premium grade pellets are rated at 1% or less ash by weight. In smaller installations, the amount of ash produced may be relatively low—essentially a shovel-full every season. Larger installations may produce significantly more ash that will need to be disposed of e.g., a full 55-gallon drum every heating season or in larger quantities. If a suitable agricultural or landscaping needs cannot be addressed using the ash, such waste may have to be landfilled.

Concerns persist on whether or not biomass harvests will be sustainable. The National Wildlife Federation (Kemp and Sibbing 2010, 7-8), for instance, issued a report calling for more sustainability in biomass project planning. The report reminds readers that forest biomass is already in high demand from competing industries (e.g. pulp mills, composite manufacturing, etc.) so harvesting level increases from a new forest energy industry should not cause extraction to exceed the "regenerative capacity of the forest" and increasing incentives for private landowners to produce biomass should not endanger ecologically sensitive areas. The report was issued in response to what the group perceives as federal efforts to weaken sustainability constraints on biomass harvests through advancing Congressional policy initiatives (Soraghan 2010). Some incentives may encourage states to develop industries that can reduce forest fuel loads quickly in the short-term but may have difficulty surviving over the long-term, creating a perverse incentive to "feed the beast." Rocky Smith (2008), the Program Director of Colorado Wild's Forest Watch Campaign, echoed similar sentiments at a biomass policy conference held at Colorado State University in early 2008. He mentioned that creating an industry that exceeds natural capacity would repeat the mistakes of commercial logging from the mid-20th century. He also mentioned that limits should be based on what forests can provide rather than on what industry needs.

The Forest Guild, much like The Wildlife Foundation and Rocky Smith, share concerns about the sustainability of forest energy projects. However, the Forest Guild published guidelines for sustainable harvests in the Northeastern United States (Forest Guild Biomass Working Group 2010; Reese 2010). The guidelines could be applied to other states and regions in an effort to standardize definitions and clarify what are best management practices (BMPs) for forest biomass harvesting, but unless the guidelines move from recommendations to regulation, voluntary standards may not assuage skeptics, similar to the way forestry best management practices are subject to the same criticism in Colorado.[21]

More recently, the Sierra Club, National Resource Defense Council (NRDC) and Dogwood Alliance (Smith 2013) launched a "Forests Are Not Fuel" campaign in May 2013, largely in response to increased wood pellet production in the southeastern United States. While the list of negative consequences from a forest energy industry listed on their respective websites reiterates many of the aforementioned items listed in this paper, the underlying concern is clear on the NRDC (2013) campaign website: "Once a Southern forest is destroyed through industrial logging, its benefits for our communities vanish with it."

2.4.3 Sociopolitical Disadvantages

Biomass also faces a number of social and political constraints. First, despite the large forest presence in the state, forest energy in Colorado is not currently one of the key renewable energy technology foci. For instance, the Colorado Governor's Energy Office (GEO 2009, 5) did mention "woody biomass" in its report on how it would spend funds from the American Recovery and Reinvestment Act (ARRA a.k.a. the Stimulus Bill) but did so only once. Competing renewable energy technologies, including solar, wind, geothermal and hydropower were mentioned much more often. Of note, the state's energy rebate program expanded using ARRA funds but only for solar, wind and geothermal heat pump projects.

Also, the definition of "biomass" at both the state and federal level is contentious. At the state level, Colorado defines "biomass" through Amendment 37 (2004) as any "[n]ontoxic plant

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[21] While Colorado's BMPs are voluntary and non-regulatory, a recent audit conducted by the Colorado State Forest Service (CSFS 2008b, 8) of counties in the north-central part of the state found that compliance with BMPs were met or exceeded the minimums about 87% of the time.

matter consisting of agricultural crops or their byproducts, urban wood waste, mill residue, slash, or brush”; conspicuously, the word missing from the definition that is common to textbook definitions is “trees.” The federal effort is even more complicated as it is not a single definition but rather a series of definitions. A recent Congressional Research Service (CRS) Report cataloged at least 14 different definitions for forest biomass at the federal level (Bracmort and Gorte 2009; Bracmort 2012). The distinctions are significant because forest biomass producers must be mindful of nuances in each definition in order for their product to qualify for a particular program mandate or tax incentive.

Definitions are not the only forest biomass-related policy problem at the federal level. Although trees removed to safeguard levees could be suitable feedstock, errors have occurred when planting and removing trees. As mentioned previously, the ACE requires trees to be removed if they are rooted within 15 feet of a levee because they are perceived to be a threat to levee integrity. However, prior to hurricane Katrina, ACE often ignored its own policy and actually planted trees in the “vegetation-free” zones (Grissett 2010, Holden 2008). As a result, trees suitable for a forest energy program could be planted in areas where they should not be planted. In another instance in Boulder, Colorado, FEMA-accredited structures, much like the ACE policy, must have all vegetation within 15 feet of a levee removed. Yet trees granted an exception by the city were removed accidently by a contractor (Urie 2009), suggesting a lack of oversight. In an extreme case, the town of Elmhurst, Illinois, decided to eliminate 235 trees rather than lose FEMA accreditation of its 7,000-foot berm and force the town’s 1,400 homes to purchase flood insurance as they would become inhabitants of a new flood plain designation (Matthews 2010). In these instances, the unintended consequences from policies designed to maintain flood control resulted in the insured removing far more trees than necessary and could be perceived as reasons to avoid fostering federal forest energy programs.

Other related federal efforts have been slow to evolve, often at the expense of some forms of forest biomass. The Production Tax Credit (PTC) did provide a financial incentive to producers but it is limited and the scope of what counts and for how much suggests the existence of stark disparities between the effectiveness of the various renewable energy lobbies. Although discussed further in Chapter 5, the PTC was available to open-loop forest biomass electricity projects but for only half the value as compared to what other renewables receive, such as solar, wind and closed-loop forest biomass electricity projects. This lack of parity (equality) can be discouraging to proponents and implies that the open forest biomass lobby lacks the efficacy of competing renewable energy sectors. Also, the PTC is subject to periodic revisions; the PTC expired at the end of 2013. The impacts are still accruing; claiming the political uncertainty enveloping the PTC's future, wind turbine manufacturer Vestas laid off roughly 100 people in Pueblo, Colorado, due to Congressional inaction in the second half of 2012 (Proctor 2012).

Also from the federal level, one substantial drawback to using forest biomass to co-fire in coal plants involves the Clean Air Act (CAA). Under the CAA, large scale coal-fired power plants operate under a Title V permit. Unless the plant was previously permitted to burn wood with coal, as with the Aquila Plant in Canon City, Colorado, a plant seeking to co-fire with biomass to reduce criteria air pollutant emissions must re-open its Title V permit, which requires a facility to track and limit its air emissions. Not only might re-permitting expose a coal plant operator or owner to litigation, but the process is usually quite expensive and time-consuming.

Another potential problem is competition for raw materials between different forest product market segments. The Farm Services Agency (FSA) promulgated rules for the Biomass

Crop Assistance Program (BCAP) in 2009. BCAP was designed to aid agricultural land and non-industrial private forestland (NIPF) owners who wanted to produce and sell biomass feedstocks. Part of this subsidy could be used to offset the steep costs of forest energy production in Rocky Mountain states. However, the rules were poorly constructed as some of the subsidies paid for materials that were already produced. For example, the amount of mill residues that traditionally went to composite manufacturing were instead shifted to biomass as revenues for the forest biomass products were doubled under BCAP (Elperin 2010). Subsequently, the program was suspended in February 2010 for redrafting after a public comment period. The final rule was released on 27 October 2010.[22]

In May 2010, the US EPA issued its most recent "tailoring rule," which regulated GHG emissions from large, stationary sources but exempted smaller factories, restaurants and farms beginning in January of 2011. Forest energy was not exempted initially, and although the agency may consider doing so for biogenic sources of carbon dioxide, the rule discouraged proponents from planning additional projects (Bravender 2010). In July 2011, the US EPA promulgated its "Deferral Rule" which exempted biomass facilities from carbon dioxide permitting (PSD and Title V) for three years (US EPA 2011b). The US EPA (2014; Lieb 2014) is now focused on regulating wood-fired boilers and new wood stoves.

Other, non-political concerns may discourage proponents. With clearcutting, aesthetics become a concern. Although clearcut areas can regenerate, initially they can be unsightly and unpopular. Growth rates in the Rocky Mountain region are notoriously low. In some forest stands in Grand County, Colorado, two-inch dbh trees were found to be 80 years old. With the influx of

[22] BCAP was reauthorized in the Farm Bill in 2014 to the tune of $125 million over five years.

people into the WUI from states where trees regenerate faster, such aesthetic concerns may gain additional significance.

Forest energy, biofuels in particular, may have significant and large-scale social drawbacks. Clancy (2013) suggests that biofuels production may disproportionately affect lower socio-economic groups. While biofuels could prove useful for as a petroleum substitute, mitigate the environmental impacts of consumption, provide energy security and improve national economies, the other side of the coin is just as stark. Biofuels could deplete foodstuffs and agricultural land is shifted from food to fuel farms. Incentives that encourage such large-scale conversions could also lead to negative environmental impacts, including increased habitat fragmentation and increased spread of invasive biofuels crops and genetically modified organisms. The benefits of switching to biofuels production are not a guarantee as are any potential improvements in labor and human rights conditions for farm labor.

Forest energy projects that produce electricity must also wrestle with the same problem that other electricity producers face: how to transmit generated power to consumers. Colorado currently faces a chokehold in power production because the grid is at full capacity. The problem has become so severe that Xcel Energy, the major IOU in Colorado (usually operating through its subsidiary, Public Service Company of Colorado), has asked the Colorado Public Utilities Commission for a waiver towards meeting its renewable energy standard requirement of 355MW by 2015. For Xcel, generating the power is not the problem as they have significant access to wind throughout the state and solar power in the San Luis Valley. The problem is that Xcel does not have the ability to move the generated electricity out of the Valley (FitzGerald 2010; Ashby 2010). Efforts to construct power lines north through the Poncha Pass / Poncha Springs area have failed due to resistance from a billionaire landowner (Denver Post 2010). Large swaths of public lands might be available for constructing power lines but, again, general public resistance could be overwhelming.

Related to electricity production and state-level politics was the promulgation of Senate Bill 252 in 2013 by the Colorado General Assembly. The bill requires generation and transmission cooperatives to: 1) produce 20% of its electricity from renewables by 2020 and 2) if a cooperative services 10,000 or more meters, at least 1% of its retail electric sales must come from distributed generation by 2020. If a cooperative services fewer meters, then only 0.75% of its retail sales must come from distributed generation. The 18 cooperatives and their wholesale power supplier, Tri-State Generation and Transmission Association, fought the bill's passage vehemently (Jaffe 2013).

Other deterrents are due to the nature of the bio-products themselves. While forest energy products and byproducts display versatility, they also exhibit some disadvantages. For instance, the ash produced while manufacturing syngas can, while in alkali form, lead to problems with deposition and corrosion in equipment such as gas turbines that use syngas (Wang et al. 2008, 574). While bio-char is touted to be a soil additive and potential carbon sink, the benefits are not fully understood. More research is needed concerning how to appropriately and safely apply the material (Bracmort 2009, 1). Problematic characteristics of bio-oil include its "[p]oor volatility, high viscosity, coking and corrosiveness" in addition to containing a heating value that is half of Number 2 fuel oil (Bridgwater and Czernik 2004, 592; Laird et al. 2009, 551). Cellulosic ethanol requires substantial and consistent supplies of raw materials. Also, considering that commercial-scale production technologies are still in their infancy, years or decades may pass before substantial progress is made towards achieving various federal policy mandates such as the aforementioned RFS using cellulosic and other advanced bio-fuels (Eckhoff and Mackes 2010).

Finally, the ash remaining from firewood and other combustion projects, while it can be used as a soil amendment, must be treated first. If fireplace ashes were added to the soil without treatment, the high concentrations of potassium would form potassium hydroxide when watered; potassium hydroxide ("potash") is a main ingredient when making liquid soap.

Biomass may not be as convenient as other forms of energy. With solar and wind, residential projects can either be installed on a roof or in a backyard. Once installed, they operate with comparatively little maintenance. Biomass however requires attention to daily fuel management and the waste ash must be disposed of regularly. Fuel must usually be stored on-site. Smaller home systems may be inconvenient, particularly when one must clean out the ash daily during cold winter weather spells. Also, biomass is not a thermal system that activates at the flip of a switch, like natural gas. Users must factor additional time to start combustion and for the heat to circulate.

Sometimes, a forest energy project's logjam can be broken up through the skill of a *project champion*.[23] A project champion is a person who spearheads or assumes ownership of a project's fate. They become engineers, promoters and operators seemingly by choice and usually by necessity. Policy champions are critical for a project's success by touting its benefits, overcoming public apathy or governmental inertia to forest health issues and energy supply difficulties while maintaining project viability (Haase 2008). However, because much of a project's success depends on champions, the lack of such an individual or a group can be discouraging or even fatal for forest energy projects. Some Colorado forest energy projects have failed not long after the project champions terminated their involvement.

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[23] Note that the project champion differs from a policy entrepreneur. Policy entrepreneurs largely contain themselves to the political arena; policy champions are much more narrowly focused on their particular project. Areas of interest may overlap but not necessarily.

Finally, in what appears to be an isolated instance, forest biomass could be radioactive. A court in Italy seized over 11,000 tons of wood pellets imported from Lithuania because they were contaminated with cesium-137, a radioactive isotope produced by nuclear reactions. Although not confirmed, the likely source for the absorbed isotope was fallout from the 1986 Chernobyl nuclear disaster. While only the smoke and ash emissions are potentially dangerous as inhalants, the only reason these pellets were suspect is because they did not burn very well. In other words, the only reason to suspect radiological contamination comes after the smoke and ash were produced i.e., after the radioactive inhalants were released and public health threatened (Associated Press 2009; Sommerauer 2009).

2.5 Chapter Summary

Given the myriad threats facing Colorado's forests and the state's problems meeting its energy needs, a solution that addresses both issues at the same time is worth exploring. Forest energy is one such solution. Defined, forest energy is produced when forest biomass is converted into energy for human consumption. Forest energy projects can use thermochemical or biochemical platforms or they can attempt to integrate the two platforms to produce energy, depending on what products are in demand and what resources are available. Although thermochemical processes are the more established technologies and are generally simpler to implement, biochemical processes can produce liquid fuels suitable for replacing liquid fossil fuels. Integration may offer proponents a way of combining both techniques to keep as many biomass feedstock options open as possible.

Forest energy projects have many advantages and disadvantages in the economic, ecological/environmental and sociopolitical realms. Forest energy project advantages are significant. These projects can provide a sustainable, local economic stimulus to rural economies immune from outsourcing. The removed material can reduce risks for large-scale catastrophic wildland fire events while helping to restore forest health. Forest energy by-products can be used to manufacture substitutes for goods that depend on petroleum. Forest energy can improve national security by reducing dependence on foreign oil while also reducing forest susceptibility to terrorism.

However, the disadvantages are also significant. At the moment, forest energy projects are not likely to be economically feasible without some form of subsidization or without developing the full-value product chain, i.e. where the full range of wood products is produced. The overall environmental costs and benefits of forest energy project development are still being debated. Policy targets such as those in the RFS may actually exceed what is feasible and/or sustainable while forest energy products themselves present a series of technological challenges that must be overcome before the products can be used to meet energy demand.

CHAPTER 3: MODELING FOREST ENERGY POLICY CHANGE

"How many times do we have to have a flood, or how many times do you have to have a fire burn out a community or how many times do you have to have a hurricane take out a community before you say, 'There has to be a better way?'"

Jack Sahl, Director of Environment and Resource Sustainability,
Southern California Edison (D.O. Williams 2012)

3.1 Approaches to the Study of Policy Change

Forest health and energy supply issues pose significant problems for Colorado. Wildfires are burning with greater intensity and can adversely impact air and water quality, insect and disease outbreaks increase the risk of blow down and threaten public safety while climate change exacerbates these effects. Energy price spikes are occurring more frequently, disproportionately affecting lower socioeconomic groups. Economically feasible yet sustainable alternative and renewable energy solutions are largely in their infancy and fossil fuel resource extraction is suspected of contaminating water resources in an arid state amidst a prolonged drought.

Forest biomass use (FBU) represents one solution capable of addressing these problems in both the forest management and energy development policy arenas simultaneously. Forest energy projects can reduce the fuel loads in the forests while also helping Coloradans meet their energy needs. However, FBU is not without its drawbacks. For instance, while the renewable forest material can be used to produce energy sustainably, its availability and accessibility are limited by growth rates, climate and location. While FBU can reduce the amount of carbon released into the atmosphere, it is still dependent on fossil fuel combustion for harvesting, transportation and processing.

Analyzing the circumstances, even beyond forest and energy-related crises, that may help influence when and how major forest energy policy changes can be tricky. However, researchers have tools at their disposal. Several contemporary publications review approaches to the study of public policy change (e.g. Sabatier 1999a, 2007a; John 2003, Birkland 2005, Weible 2008, etc.). These approaches share common elements derived from initial works, such as Easton's (1957) model of a political system, which provided a simple rubric for subsequent advances. These subsequent analytical tools are much more complicated and refined. Four developed approaches include the policy stages model, the multiple streams theory (MST), the advocacy coalition framework (ACF) and punctuated equilibrium theory (PET). These approaches as well as instances where they have been applied to the natural resource management and/or energy policy arenas are briefly summarized and analyzed below. While many other approaches exist (e.g., Social Construction, Institutional Rational Choice, Policy Networks Theory, etc.), these approaches are most relevant for this project's objectives given their ability to explain major policy change due to "dramatic events or crises, changes in governing coalitions and administrative and legislative turnover" and that they take "serendipity" into account (Schlager 2007, 310). In addition, hybrid designs, which model public policy change by combining parts of these more developed approaches, are also considered.

3.1.1 Easton's Model of a Political System

One of the earliest and more commonly referenced political system models is Easton's (1957) model of a political system. Easton visualized a political system as consisting of five components: inputs, outputs, a political system, a feedback method and a policy environment (see Figure 3.1). Subsequent models will retain these key components. Inputs consist of both demands and support. Demands are needs that "require some special organized effort on the part of society to settle them authoritatively" while support consists of attitudes and/or actions that promote the objectives of another person (Easton 1957, 387, 390-391). Outputs are the political decisions or policies promulgated through a political system's process. Easton does not explicitly define the political system, feedback method and environment. However, he identified four primary attributes which are inherent to any organized decision-making system.

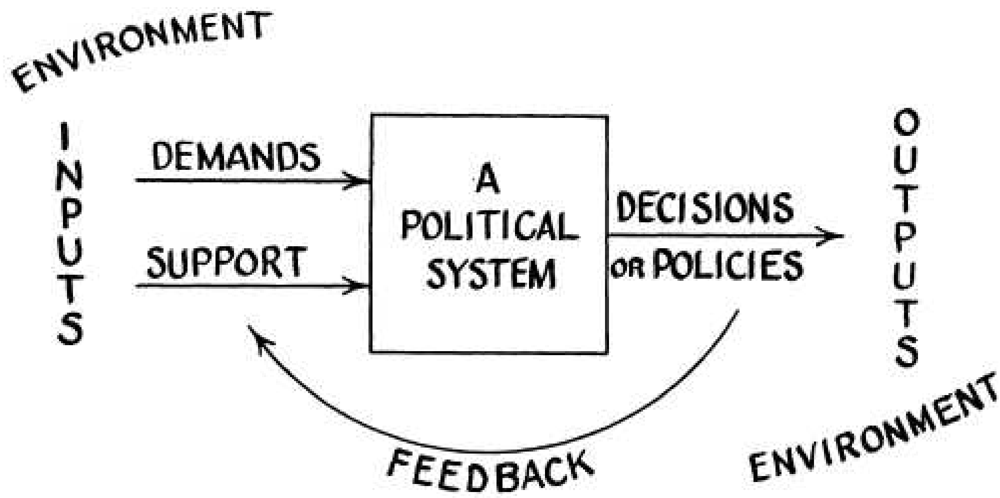

Figure 3.1: Easton's Model of a Political System

Source: Adapted from Easton (1957, 384).

A political system is a collection of units, limited in scope and authority that converts inputs into outputs through a differentiated yet integrated structure of clearly delineated and differentiated or specialized units. The feedback method provides an opportunity to address new inputs that result from outputs, "withinputs" (inputs generated by the political system while operating) and/or environmental changes. The environment is a source of stimuli exogenous to a political system that can influence inputs as well as be influenced by outputs (Easton 1957, 384-387, 388-389).

The model's primary strength lies in its deliberate simplicity: "inputs—political system or processes—outputs" (Easton 1957, 384). Researchers can measure inputs (e.g., resources, popular support, etc.) and outputs (e.g., funding allocations, promulgated legislation, etc.). However, the model's primary weakness also lies in its simplicity. The "political system" is intentionally but excessively vague as Easton's model does little to explain what actually happens once inputs enter the political system, leading scholars to label it a “black box” process (e.g. Anderson 2003, 15; Zahariadis 1999, 74; Birkland 2005, 223; etc.). Researchers are left to guess what happens to inputs once inside the “black box,” which creates problems with research replication and researcher objectivity.

3.1.2 The Stages Model

Easton’s model of a political system left room for improvement. One attempt to clarify what happens in the “black box” is the stages model. Previously, Lasswell (1956) divided the policy-making process into seven stages: intelligence, recommendation, prescription, invocation, application, termination and appraisal. Contemporary manifestations of the stages model (see Figure 3.2) adopt “a series of stages—usually agenda setting, policy formulation and legitimation, implementation and evaluation—and [discuss] some of the factors affecting the process within each stage” (Sabatier 2007b, 6) that combines Lasswell’s stages with Easton’s input-output model. Even if a researcher incorporates fewer stages, the gist remains essentially unchanged: a policy problem is identified and placed on a formal public policy decision-making agenda, alternative solutions to address the problem are proposed, a solution is or solutions are selected and then implemented and evaluated with the possibility of restarting the process to adjust the adopted course (Jann and Wegrich 2007, 44).

The stages model enjoys several advantages over Easton's model. The “political system” is much more developed than Easton’s “primitive ‘model’” (Easton 1957, 384) but still retains some simplicity. This simplicity not only aids a researcher examining the process or a teacher conveying important concepts of policy-making, but also helps as a heuristic device that allows researchers to organize their efforts while integrating the literature discipline-wide. DeLeon (1999, 21-22), for instance, catalogs substantial contributions to the literature according to the stage of the policy cycle that each contribution examines. The policy process is, similar to Easton's model, conceptualized as "sequential, differentiated by function and cumulative" and provides a logical order, which an observer could follow (Nakamura 1987, 142).

Figure 3.2: Diagram of the Stages Model

Source: Adapted from Cubbage et al. (1993, 32).

The model can be modified to fit the researcher's experience (e.g. stages can be added, subtracted, combined, etc.,) when experience warrants or findings dictate. Relationships between actors in the political system are emphasized as they proceed through the stages. In addition, the stages model can be applied to different political arenas or cultures (Anderson 2003, 26-28). Finally, the stages themselves serve as the basis for formulating central research questions as researchers evaluate the impacts of a program or how the consequences of program termination can impact future policy formation (i.e., feedback that provides new inputs for the next iteration of the policy cycle) (Jann and Wegrich 2007, 58).

However, criticisms of the stages heuristic are just as significant. The stages model may tend to grossly "oversimplify" the actual policy process by failing to account for its actual complexity and thereby "sacrifices validity for economy" (Cubbage et al. 2003, 38; Sabatier 2007b, 7; McCool 1995, 169). For instance, the stages are more realistically "meshed and entangled" continuously as policies advance through the process as opposed to the linear process shown in the flowchart (Jann and Wegrich 2007, 44-45, 56). The stages model also does not account for federalism or the impacts on policy-making stemming from not only intra-level but also inter-level government interactions (Jann and Wegrich 2007, 56-57). In addition, applications of the stages model may share similar terms but these terms could refer to different processes depending on the individual author's intent (Nakamura 1987, 142-143). Finally, the stages model does not help determine which factors or "causal drivers" propel a policy through the process i.e., the model does not describe or provide testable hypotheses for how a proposal advances from one stage to the next (Sabatier 2007b, 7).

3.1.3 The Multiple Streams Theory[24] (MST)

Unlike the stages model, Kingdon (2003, 77-79, 86-87, 116-117) theorizes that policies are generated through a less formal and less iterative process; rather than following a list of predetermined stages, policies originate from a "policy primeval soup" (Kingdon 2003, 117). This concoction in the abstract is the product of policy communities. Policy communities consist

[24] Zahariadis (2007, 65) labels the Multiple Streams Theory as, among other things, a "framework" without really defining the term. Ostrom's (Schlager 2007, 293-294) "theory" classification is more appropriate.

of specialists with “technical, specialized and detailed” knowledge about a particular policy area and can come from a variety of backgrounds, including government, academia, business, etc. (Kingdon 2003, 70, 117-118, 199-200). Nearly free-floating in the soup are three concurrently running currents or "streams": problems, policies and politics (see Figure 3.3).

Streams are metaphysical constructs consisting of participants and processes that run concurrently yet are “largely independent” of one another over time (Zahariadis 2007, 81). The problems stream involves the way that problems reach a government's agenda. The politics stream contains assessments of the “national mood,” including indicators such as the efforts of organized pressure campaigns and election results or changes in administration. The policy stream deals with potential solution generation, where solution sets are filtered and analyzed by members in their respective policy communities (Kingdon 2003, 87).

The critical moment for policy change occurs when the streams intersect, resulting in a policy window. A policy window is defined as “an opportunity for action on given initiatives” (Kingdon 2003, 166). These windows allow individuals to attempt to link their solutions to the problem involved. These individuals who willingly invest their resources to forge such a link are called policy entrepreneurs (Kingdon 2003, 122-123, 168-169). When the streams are coupled and a policy entrepreneur successfully convinces decision-makers that a link exists between their proposed solution and the widely-realized problem, the likelihood of an issue “gaining prominence” on the decision agenda increases substantially (Zahariadis 2007, 78).

The MST has a number of advantages. First, it can apply to policy developments that do not follow an orderly or incremental process (Kingdon 2003, 205). The MST also “integrates policy communities with broader events” meaning that events outside of a political sector will exert influence on the types of solutions considered when a policy window opens (Zahariadis

1999, 78). Finally, it allows for the advancement of ideas not solely on the basis of their merits but also on the way they are presented or conceptualized (Zahariadis 1999, 78).

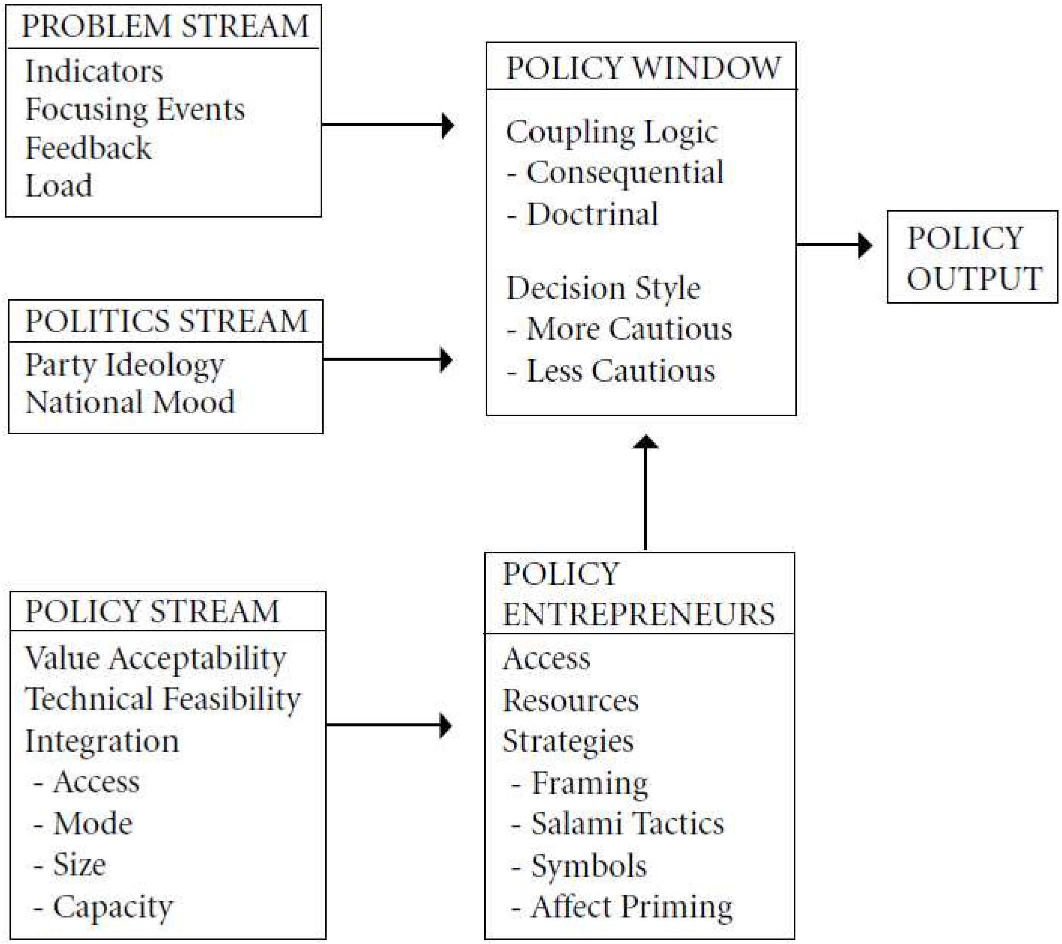

Figure 3.3: Diagram of the Multiple Stream Theory

Source: Adapted from Zahariadis (2007, 71).

The MST is also subject to a number of criticisms. Weir (1992, 191) and Mucciaroni (1992, 470-472) argue that the theory does not consider "historically grounded explanations" thoroughly enough, leading to charges of ahistoricism. The approach pays little attention to institutional arrangements, which would enhance its ability to "better identify what are the varying processes of the politics stream and how different processes affect the coupling of the streams" (Schlager 1999, 252; Zahariadis 1999, 89; Kingdon 2003, 229-230). Finally, the MST does not differentiate between major and minor policy changes (Schlager 1999, 252).

The MST has been applied to both the forest and the energy policy arenas. Boscarino (2009) uses MST to analyze "problem surfing" by The Wilderness Society and the Sierra Club and found that the groups usually attempt to attach their proposals for sustainable forestry practices to contemporary forest health problems, although the groups differed in their respective strategies. Kingdon (2003, 98-100) briefly considers U.S. energy policy as part of his research on transportation issues during the late-1970s using MST. He argued that the energy crises of the 1970s illustrate how focusing events can affect policy change when they occur in series.

3.1.4 The Advocacy Coalitions Framework (ACF)

The Advocacy Coalition Framework (ACF) envisions policy change as the result of policy subsystems (see Figure 3.4). A policy subsystem is a set of actors "who are involved in dealing with a policy problem" (Sabatier 1993, 24) and consists of between one and four "advocacy coalitions" (Sabatier 1993, 26). These advocacy coalitions are groups of individuals "who share a set of normative and causal beliefs" and "engage in a nontrivial degree of coordinated activity over time," typically over a decade or more (Sabatier 1993, 16; Sabatier and Jenkins-Smith 1993, 5; 1999, 118-120). What holds members of a coalition together are beliefs shared among these individuals that can be arranged into a tripartite scheme:

1. Deep core beliefs, which include basic ontological and normative beliefs that operate universally (e.g. individual freedom versus social equality, etc.),

2. Policy core beliefs, which include a coalition's basic normative commitments and causal perceptions across an entire subsystem (e.g. relative importance of economic development versus environmental protection, etc.) and

3. Secondary aspects, which consist of a larger set of concerns, centered on the seriousness of a problem or the relative importance of its causes, etc. (Sabatier and Jenkins-Smith 1999, 121-122).

The coalitions in a particular subsystem develop strategies to advance their respective policy objectives (Sabatier 1993, 18). These strategies often are in conflict, due to the strength of convictions held by like-minded coalition members. These conflicts are mediated by policy brokers, or individuals who have a reason to resolve such conflict (Sabatier 1993, 18-19; Birkland 2005, 226). Brokered compromises lead to subsequent policy outputs that are incorporated in two areas: revised coalition strategies and in the political environment.

The ACF views the political environment as being subject to two different kinds of factors: stable and dynamic. The first of these, the relatively stable parameters, consist of features of the political environment that, while not impossible to change, are very difficult to alter. The second kind, dynamic or external (subsystem) events, are by comparison easier to adjust, requiring only a few years to a decade and can greatly influence the opportunities and constraints facing subsystem participants (Sabatier 1993, 20-23).

The effects of these two factors are further mitigated by two sets of inputs. The first set consists of the long-term coalition opportunity structures. Included in this set are the degree of consensus needed for major policy change and the openness of the political system. The degree of consensus refers to what level of agreement a policy would need for passage. The degree of openness of the political system refers to how many access points to decision-makers exist and how accessible are those points. The second set consists of the short-term constraints and resources and refers to a treatment of the level of authority, money, information, leadership capability, etc. possessed by subsystem participants (Sabatier and Weible 2007, 199-204). Advantages of the ACF include its focus on "well-developed" classes of variables, endogenous and exogenous to the subsystem. Unlike the MST, the ACF is able to account for the differences between major and minor policy changes. The ACF also provides a more complete model of the individual, in particular its lengthy examinations of the tripartite belief system, and incorporates a more thorough treatment of institutions in its explanation of policy change, also unlike the MST. Finally, the ACF is oriented longitudinally, typically requiring a decade or more for a complete study (Schlager 2007, 313; Schlager 1999 243-244, 249, 252).

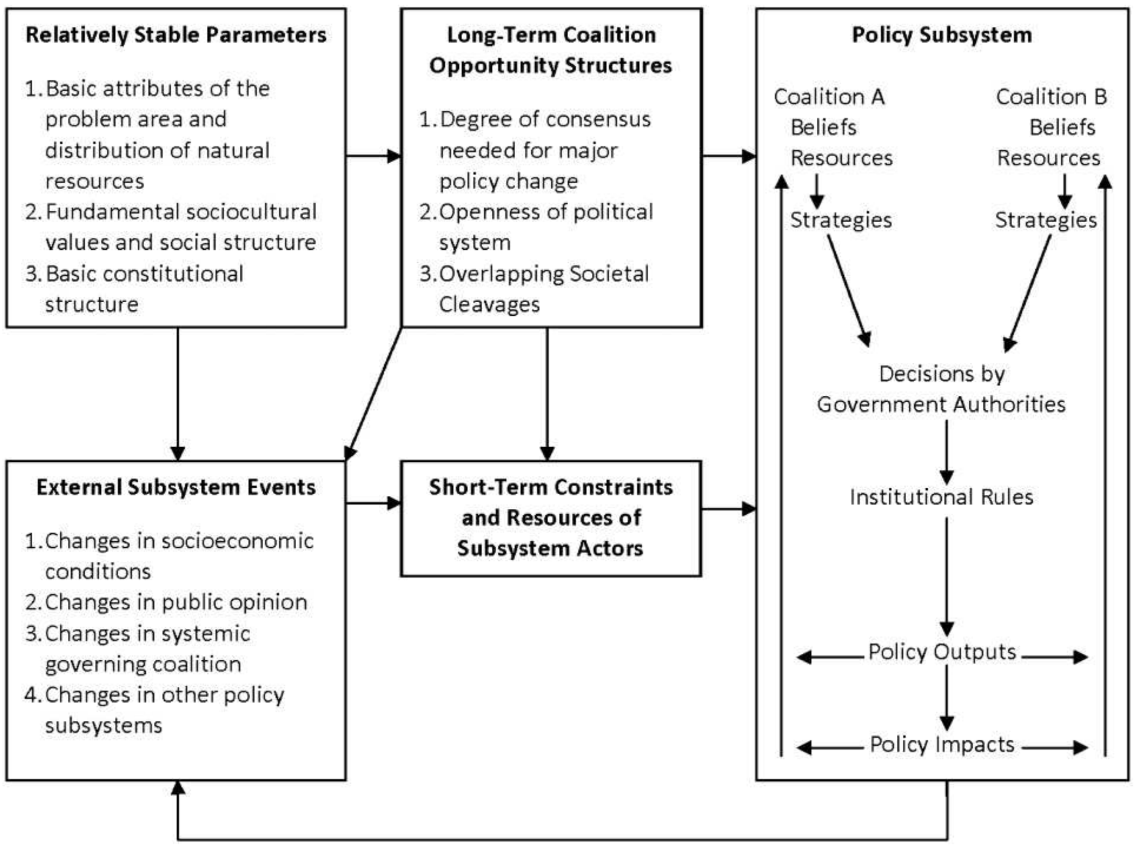

Figure 3.4: Diagram of the Advocacy Coalition Framework

Source: Adapted from Weible et al. (2011, 352).

Some of the ACF's weaknesses appear to be rooted in its strengths. Schlager (2007, 317) suggests the model of the individual needs to encompass "more dimensions than beliefs and resources in order to allow for the many varied models of [decision-making]." Weible et al. (2009) reviewed 80 studies that employed ACF and found the linkage between external perturbations and policy subsystem change was not clear. They also found ACF does not thoroughly address the interrelatedness and interdepency among subsystems. Weible et al (2011, 357) found that other ACF mechanisms were not as well developed. For instance, more work is needed on defections from coalitions and what happens when subsystems experience multiple events rather than focusing on a single event.

Many efforts used ACF to analyze forest and energy policy change. Davis and Davis (1988, 5, 18) considered whether the decisions made by USFS and BLM administrators were more akin to the traditional dominant subgovernment model or if the more diverse ACF model was more relevant. They found ACF to be more useful. Sabatier, Loomis and McCarthy (1995) used the ACF to analyze forest planning decisions. They found that forest planning needed a longer longitudinal focus and that forest planning decisions involved three coalitions: the Scientific Management, Commodity and the Amenity. They suggest that the ACF provides a solid basis for explaining the conflicts surrounding the forest planning process and the resulting deadlock in the early 1990s (Sabatier, Loomis and McCarthy 1995, 236-237). Burnett and Davis (2002), using the coalitions identified by Sabatier, Loomis and McCarthy (1995, 236), applied the ACF to Congressional hearings related to national forest policy from 1960 to 1995. They found that although the belief system was not as consistent as the ACF predicted, the ACF nonetheless provided a "useful means for conceptualizing the policy community and a methodologically sound way of analyzing data from documentary sources for the elicitation of core and secondary policy beliefs" (Burnett and Davis 2002, 226-227).

For U.S. energy policy, Jenkins-Smith and St. Clair (1993) used the ACF to examine energy leasing on the outer continental shelf (OCS). They found that belief systems were not necessarily hierarchical in advocacy coalitions; that they could identify two different, competing advocacy coalitions that remained stable over nearly two decades (one favoring more relaxed

OCS regulation and one favoring increased OCS regulation); that exogenous events (e.g crises, electoral, socioeconomic change, etc.) would explain coalition defection; and that ACF provided greater precision in coalition analysis than earlier studies. Based on this effort, Fenger and Klok (2001) argue that the ACF should pay more attention toward networking problems or the interdependency among coalition members that helps actors overcome collective action problems. Freudenburg and Gramling (2002) use the OCS study to suggest that some dominant advocacy coalitions act in such a way that their groupthink or "members' striving for unanimity override their ability to appraise alternative courses of action realistically" may inadvertently bring about a coalition's own end. Nicholson-Crotty (2005) found that the ACF, applied to the Echo Park Dam (e.g. hydropower, etc.) controversy of the mid-twentieth century, could successfully model competition between federal natural resource management agencies.

3.1.5 The Punctuated Equilibrium Theory (PET)

Punctuated Equilibrium Theory (PET) borrows from evolutionary biology's notion of punctuated equilibrium, which theorizes that a given subspecies's evolutionary history will include "long periods of morphological stability, punctuated here and there by rapid events of speciation" (Eldredge and Gould 1972, 84, 109-110). Baumgartner and Jones (1993, 4) originally suggested that a political system enjoys long periods of relative stability or equilibrium but "this stability can be punctuated with periods of volatile change" that "come at the beginning of a new policy or in its occasional restructuring." This disruption in continuity occurs as a result of an exogenous shock, whereby policy change occurs and equilibrium resumes (Repetto 2006, 8; Baumgartner and Jones 1993, 4; True et al. 1999, 97-98; Baumgartner 2009, 25-26; Jones and Baumgartner 2012, 3, 8-9).

Stability is the preferred modus operandi for political actors as it signifies a policy monopoly, a.k.a. iron triangle, policy whirlpool, subgovernment, etc. As originally conceived, an "iron triangle" is a structure of self-reinforcing quid pro quo relationships between an executive branch agency, a legislative committee and an interest group. Over time, these actors help one another benefit by satisfying their political wants and needs. Once established, these political structures can be identified by two key characteristics: they have a definite structure that limits participation in the policy-making process and they are buttressed by powerful supporting idea (Baumgartner and Jones 2009, 6-7). One of the more significant and oft-cited examples of a policy monopoly is nuclear power regulation in the United States during the mid-to-late twentieth century (see Duffy 1997).

Subsequent developments depicted policy-making as the result of larger, more nebulous "issue networks" that are not as heterogeneous in membership and uniform in purpose as the iron triangles (Heclo 1978, 278). Furthermore, the individuals that constitute a subsystem are constrained by Herbert Simon's concept of "bounded rationality." This concept means individuals can make rational decisions to better their own self-interest but fail to "maximize their potential returns" as the amount of information they can process is "bounded" or limited by the amount of attention they can pay towards a given issue and their cognitive and emotional "architecture" (True et al. 2009, 158-160; Baumgartner and Jones 2009, xxiii; Jones and Baumgartner 2012, 3). Subsequently, the environment will make multiple or parallel demands on a political system but a political system's structure means that it relies on subsystems to solve these problems in parallel as a political system is limited to serial processing.

So long as the buttressing idea that bolsters a monopoly remains widely accepted (positive) and the interested group continues to exert its influence without challenge, the monopoly will remain intact. However, if the idea begins to loser favor as those outside the monopoly begin to challenge the status quo, an issue's visibility may increase. The issue may leave the jurisdiction of the monopoly and land on the larger political system’s agenda. As the subsystems’ parallel processing capabilities meet the serial processing needs of the political system’s serial processing capabilities, the opportunity for major political change develops.

To track how these opportunities develop, researchers must track two significant independent variables when using PET:

1. Policy images, which are the way in which the public understands a policy problem, usually in a positive or negative light [“tone”], and

2. Policy venues, which consist of the existing set of institutional arrangements that have the authority to make a decision concerning the contested policy (Baumgartner and Jones 1991, 1045-1046; Baumgartner and Jones 1993, 25, 32; Baumgartner and Jones 2009, 25-27, 32).

Baumgartner and Jones (1993, 26, 28) suggest that a single policy or program may have many implications, impacting people in various ways and are thus associated with various policy images. Subsequently, political conflict is a conflict about competing perceptions of the same policy or program.

The process by which exogenous interests may disrupt a policy monopoly and induce major change is difficult. For policy change in the United States, the structural arrangements means “it’s easier to play defense” and challengers must expand the scope of the conflict (Schattschneider 1960). They may do this through one of two ways. One way is by appealing to others who are not active in the debate, thereby increasing their numbers and possibly transforming their side into the winning side. They may conduct this appeal by constructing a negative policy image that attempts to discredit the positive policy image created by the winners

(Baumgartner and Jones 1991, 1046-1047, Baumgartner and Jones 1993, 25-30; Stone 2002; Cobb and Elder 1983).

The second way to expand the scope of the conflict is through policy venue shopping. This approach relies on a policy image but not necessarily on mobilizing the masses. Challengers of the status quo “shop” for a venue that might be friendly to the policy or program. Alternative venues might include “congressional committees, state government organizations, courts, private businesses, or any other relevant institution” that might provide a friendly audience (Baumgartner and Jones 1993, 36).

Policy change is the result of both policy image and policy venue changes. Baumgartner and Jones (1993, 38) note that where the policy images are in flux, the likelihood of a policy venue change increases. When policy venues change, the possibility for policy change also increases. When alternative policy images are successfully discredited by a well-established policy monopoly or when policy venues are tightly controlled, the prospects for policy change are diminished. The interaction between image and venue can strengthen or weaken policy monopolies over time, which can describe both periods of stagnation and rapid change. Changes in image and/or venues result from Kingdon’s policy entrepreneurs, as discussed under the MST.

Advantages of PET are that it is, like ACF, is able to account for both rapid bursts of policy change as well as long periods of relative stagnation. PET, however, pays more attention to institutional arrangements and processes, which impact “policy subsystem structures and the types of policy change occurring” (Schlager 2007, 317). PET also focuses more on “attention allocation” as opposed to belief structures (Schlager 2007, 317).

PET is also subject to limitations. Studies must be conducted longitudinally, like ACF, for periods of a decade or more, which could deter its use for emerging subsystems. PET also lacks any sort of predictive capability. PET proponents acknowledge that punctuations will occur but the theory cannot predict when they will occur or their resulting magnitudes (Schlager 2007, 310). PET may have difficulties accounting for federalist system-related disparities when applied to a single policy arena, i.e., PET had difficulty explaining why federal-level and state-level results may be different concerning the same punctuation (Cashore and Howlett 2007). Finally, adapting natural science theory to meet the needs of social science theory is challenging. For instance, True et al. (2009, 167-172) applied PET to analyzing budgets but found budgets, measured in dollars, do not follow evolutionary trends. As Prindle (2012, 35) notes: "Daughter species do not unevolve back into their parent species, let alone oscillate back and forth between one species and another, as is common with budgets." Furthermore, Howlett and Migone (2011) suggest the PET adaptation does not replace political science's incremental-only policy change model but merely enhances it.

Cashore and Howlett (2006 and 2007) employed PET to analyze forest policy in the Pacific Northwest. They found that its applicability depended on which level of government was subject to the analysis. PET was much more applicable to the federal-level national forests as opposed to the incremental state-level policy-making regarding private forestland management (2006, 156-157; 2007, 542-545). Davis (2006a) used a modified version of the PET to study wildland fire suppression policy in the Western United States. He found that PET could account for the transformation of suppression-only policies to a "more flexible set of policies that currently guide agency response to the emergence of wildfires under differing conditions" (Davis 2006a, 125). Davis (2006b) also used PET convincingly to examine grazing policy changes for federal lands. He recommended that analysts should consider alternative means of affecting policy change including court cases, federal program decentralization that provides an opportunity for action by state and local entities and policy change recommendations emanating from collaborative decision-making efforts.

Concerning energy policy, Baumgarter and Jones (1993) applied PET to the nuclear power industry. By examining nuclear power longitudinally, with explicit attention paid to media coverage and venue changes, they were able to demonstrate the applicability of PET to technical and energy issues. Duffy (2005) studied changing energy politics involving coal bed methane in Montana and Wyoming using PET. He found that a “wave of criticism” developed as the negative impacts from coal bed methane development mobilized opposition from a disparate group of land users, including ranchers, real estate developers and environmentalists, which took advantage of various venues to force industry to internalize more of the consequences from energy extraction (Duffy 2005, 411). Lane (2006) used the PET to analyze U.S. policy toward GHG controls and found that, given the current equilibrium regarding climate change policies, making even modest adjustments for stricter emission controls was uncertain, and aggressive changes would be impossible. Dunn, Jr. (2006) considers the PET as it pertains to automobile efficiency standards development. Dunn, Jr., found a punctuation regarding fuel standards in the mid-1970s but since the enactment of Corporate Average Fuel Efficiency (CAFE) standards, the policy arena has remained in equilibrium.

3.1.6 Hybrid Designs

Anderson (2003, 23) cautioned policy researchers to avoid dogmatic reliance on a particular model or approach. In a similar vein, other scholars (e.g., Sabatier 1999b, 270; Zahariadis 2007, 86; etc.) encouraged researchers to use multiple theories whenever possible. Some recent efforts to model public policy change take their advice to heart. These efforts merge aspects of the previously considered approaches and apply the new designs in an effort to provide stronger analysis and conclusions.

For instance, Vaughn and Cortner (2006, 3) use a combination of the stages model with the “primordial policy soup” component from MST to analyze changes to forest policy completed during the George W. Bush presidency, including a brief treatment of forest energy provisions in the Healthy Forests Restoration Act (HFRA, P.L. 108-148) of 2003. They focused on “how problems are identified and redefined by stakeholders as they emerge on the political agenda and work themselves through various steps of the policy process” (Vaughn and Cortner 2006, 3). Birkland (1997) developed a model that merged the MST with ACF to study oil spills and nuclear power plant accidents. While Birkland does not explicitly address forest policy, his effort very well could examine forestry issues. Consider his definition of a focusing event:

> an event that is sudden, relatively rare, can be reasonably defined as harmful or revealing the possibility of potentially greater future harms, inflicts harms or suggests potential harms that are or could be concentrated on a definable geographical area or community of interest and that is known to policy makers and the public virtually simultaneously.
> (Birkland 1997, 22)

Colorado wildfires, such as those previously discussed in Chapter 1, are potential focusing events, given their frequency, proximity to communities and proclivity to inflict catastrophic damage (on this point, see also Davis 2006a, 120-121).

3.2 Methodology: Using a Mixed Method Design

Given Anderson’s, Sabatier’s and Zahariadis’s advice and the ability prior research as shown to successfully merge theoretical approaches, this study also makes use of a hybrid design. By combining the MST with the PET approaches, this study argues forest energy emerged as solution to the forest health and energy crises in Colorado via policy entrepreneurs. The addition of MST allows better historical organization for the longitudinal requirements of

PET through the three-stream structure. Including PET addresses MST's lack of an institutional focus and provided a stronger methodological structure for identifying policy windows and detecting major policy changes.

The study then incorporates both the PET and the MST while the methodology also incorporates quantitative and qualitative methods. This study adopted a mixed methods research design (Creswell 2003, 18). Mixed methods designs combine both quantitative and qualitative methods to achieve research objectives while "captur[ing] the best of both quantitative and qualitative approaches" (Cresswell 2003, 22). At least five rationales exist for choosing a mixed method design:

1. Triangulation: To increase the validity of constructs and inquiry results by counteracting or maximizing the heterogeneity of irrelevant sources of variance attributable especially to inherent method bias but also to inquirer bias, bias of substantive theory and biases of inquiry context.

2. Complementarity: To increase the interpretability, meaningfulness and validity of constructs and inquiry results by both capitalizing on inherent method strengths and counteracting inherent biases in methods and other sources.

3. Development: To increase the validity of constructs and inquiry results by capitalizing on inherent method strengths.

4. Initiation: To increase the breadth and depth of inquiry results and interpretations by analyzing them from the different perspectives of different methods and paradigms.

5. Expansion: To increase the scope of inquiry by selecting the methods most appropriate for multiple inquiry components.
   (Greene, Caracelli and Graham 1989, 259)

With research on forest energy policy change left relatively untapped, the field is ripe for study. These five rationales for choosing a mixed method approach as listed above apply.

3.3 Methodology: Applying the Mixed Method Design

This study combined the MST with the PET to analyze forest energy policy change. It used a concurrent nested procedure by developing a mixed method for analyzing forest energy policy change. A concurrent nested strategy involves a researcher performing both quantitative and qualitative methods simultaneously but where one method predominates the other. In this instance, qualitative (QUAL) predominated quantitative (Quan) (see Figure 3.5). This strategy allows a researcher to "gain broader perspectives as a result of using the different methods as opposed to using the predominant method alone" (Creswell 2003, 16, 18, 136, 217-219).

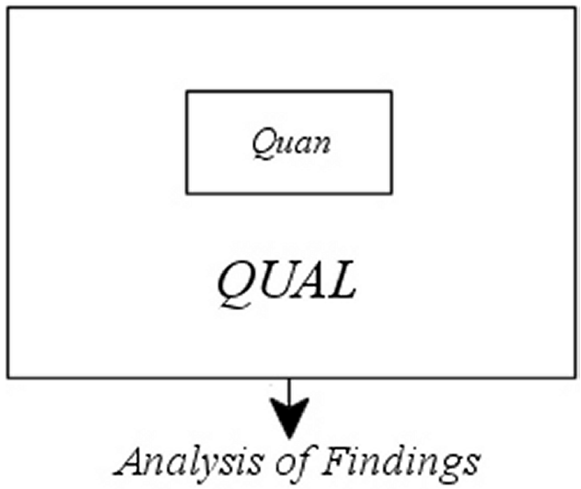

Figure 3.5: Diagram of a Mixed Method Approach

Source: Adapted from Creswell (2003, 214).

The study applied this design through three phases. The initial phase of the study relied on qualitative research to construct ("divine") Kingdon's streams for forest management and forest product use history as well as for energy development and energy use history in Colorado. The second phase of the study followed Baumgartner and Jones's (2009) approach to identifying and analyzing policy images and policy venues in both the forest policy and the energy policy arenas. The reason for completing the quantitative research portion after an initial qualitative effort was that the quantitative portion was used to "identify specific populations or issues" that needed to be explored further and in depth (Hesse-Biber and Leavy 2003, 323-324). By identifying the key venues, images and political actors, the quantitative effort provided a solid foundation to conduct the third phase, a series of open-ended interviews with key actors in the forest and energy policy arenas, including federal land management agency professionals, private industry and non-governmental organizations.

3.3.1 Phase One: Divining the Streams

The first phase traced Kingdon's three streams (e.g. problems, policies and politics) as they pertained to two policy arenas in Colorado: 1) forest health (Chapter 4) and 2) energy issues (Chapter 5). Specifically, the review searched relevant media including books, media accounts, articles, reports, etc. for any potential focusing events, using Birkland's definition. Anticipated candidates include those forest health threats and energy security risks discussed in Chapter 1.

Previous efforts to model policy change have covered forest policy or energy policy, but studies covering forest energy policy change are scarce. Mindful of the gap, part of this study is qualitative. Richards and Morse (2013, 27) suggest that qualitative methods are appropriate when the researcher wants "to understand an area where little is known or where previously offered understanding appears inadequate (thin, biased, partial)…" However, this qualifier presents as a problem as most prior PET studies rely heavily on quantitative-only methodologies. This continuing trend is so conspicuous that Baumgartner and Jones (2009, xxiii) and Jones and Baumgartner (2012, 13) argued that qualitative information is just as crucial as quantitative and using qualitative methods more in PET studies is necessary to make the PET approach more complete.

The review also functioned as a search for policy windows. At various points in time, due to a potential focusing event or events, the streams couple in each policy arena and policy windows subsequently opened. Resulting policies enacted were responses by the political system to such focusing events. While policy promulgation in the forest policy arena and the energy policy arena studied longitudinally may seem like separate exercises, they can be linked, much like the way Jenkins-Smith and St. Clair (1993) and Kingdon (2003) viewed the sequential, linked nature of the oil crises during the 1970s, through the forest energy policy arena—streams cleverly channeled and coupled by policy entrepreneurs.

Furthermore, this study allies itself with Kingdon's notion that solutions pre-empt problems. In other words, policy entrepreneurs searched for a problem (potential focusing events) to link their preferred solutions to rather than searching for solutions after problems emerged. The policy window, courtesy of potential focusing events, provided the policy entrepreneurs with a temporary opportunity to forge links.

3.3.2 Phase Two: Policy Images and Policy Venues

With potential focusing events and policy windows identified, the next phase involved applying the PET. To apply the PET, two key independent variables of concern were chosen: the constructed policy images and the chosen and changed policy venues. The dependent variable was policy change. The approach taken to operationalize these variables relied heavily on the approaches conceptualized by Kurtz (1999, 42-53) and Corwin (2002, 30-63). Briefly summarized, Kurtz divided the application of the PET into four periods (see Figure 3.6).

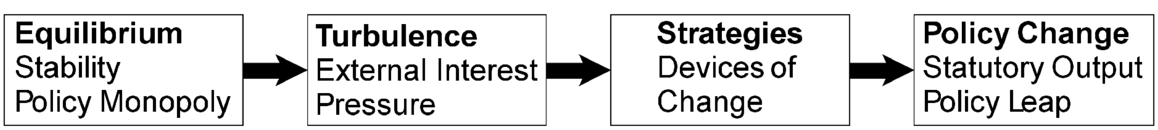

Figure 3.6: Diagram of the Punctuated Equilibrium Theory

Source: Adapted from Kurtz (1999, 42).

The first period, Equilibrium, is characterized by relative policy stability, meaning that policy change is incremental or small, and a policy monopoly is established. This monopoly will remain intact and will self-reinforce until acted upon by external interests. The second period, Turbulence, begins when these external interests, which were or felt excluded from the policy monopoly or who have previously been denied access to the agenda, bring pressure (attention) to bear and, in this case, take advantage of potential focusing events, such as those identified during the first phase. The third period, Strategies, indicates when tactics were used by those in the established policy monopoly as well as those exogenous to the monopoly to achieve their respective policy objectives. The final period, Policy Change, is the point at which one can determine whether or not a policy change has occurred and to what extent the change is major or non-major (e.g., no change, symbolic or incremental policy change) (Kurtz 1999).

3.3.3 Independent Variables

Independent variables in this study are factors thought to contribute to destabilizing current forest policy and energy policy monopolies (equilibria) in an effort to promote forest energy as a new policy arena. Forest energy policy would be framed as a solution to both forest health and energy security problems.

Following the PET diagram, the first task is to identify the change from equilibrium to turbulence. This change can be identified using a number of key quantifiable observations. Following Kurtz (1999, 43-44), this study examined five indicators, operationalized per the following:

1. Number of Congressional committee and subcommittee hearings: A change from equilibrium to turbulence should be indicated by an uptick in the number of committee and subcommittee hearings held on potential focusing events in the forest policy and energy policy arenas. For tallying purposes as well as subsequent venue shopping tallies, committee and subcommittee tallies will be separated. These tallies were quantified using ProQuest's *Congressional Publications* database.

2. Public agency official participation: A change from equilibrium to turbulence is indicated by an increased number of testimonies submitted to the aforementioned Congressional hearings from officials representing their respective agencies. Participants were classified according to their level of government: "F" for federal agency, "S" for state agency, "L" for local agency and "O" of other.

3. Interest group participation: A change from equilibrium to turbulence is indicated by an increased number of testimonies submitted to the aforementioned Congressional hearings from interest groups. Interest groups were classified according to their stance on forest energy: "+" for proponents, "-" for opponents and "0" for neutral or split.

4. Citizen activist participation: A change to turbulence is indicated by an increased number of testimonies submitted to the aforementioned Congressional hearings from citizen activists i.e., those unaffiliated with an interest group. Much like Kurtz (1999, 43), the diversity of citizen activists makes classification nearly impossible so data is restricted to tallies. However, information gleaned from testimony, media accounts, interviews and other sources is included qualitatively when possible.

5. Amount of media coverage: A change to turbulence is indicated by an increased number of articles that cover forestry, energy or forest energy. Baumgartner and Jones (1993, 49) found that "media coverage does indeed correspond to official concerns." Media coverage in their research, as well as in the research of others, is simply counting the number of articles that focus on a selected issue during a given time period. The rate i.e. the number of articles published per year indicates issue salience. The number of articles was determined by reviewing annual volumes of *The Readers' Guide to Periodic Literature* from 1973 to 2012. Relying solely on the guide differs from Kurtz (1999) in that it does not include the IAC National Newspaper Index and differs from Baumgartner and Jones (2009) in that it does not include the New York Times Index. The rationale is that Baumgartner and Jones (2009, 295) found, while the *Readers' Guide* was not exhaustive, it was comparable to other indices and coverage was so consistent, that the index one chooses to use "makes little difference."

Once turbulence has been found, the next step is to identify Strategies employed by those actors who are endogenous and exogenous to the policy monopoly. Kurtz (1999, 44-46) identified six different strategies employed by these actors. These six indicators can be condensed to two qualitative umbrella categories: policy images and policy venues (Baumgartner and Jones 1991, 1045-1046; Baumgartner and Jones 1993, 25, 32). Following Baumgartner and Jones (2009) while adapting Kurtz (1999, 44-46) and Corwin (2002, 53-55), these two umbrella categories were defined and operationalized.

Policy images were efforts made by endogenous and exogenous actors to frame the forest energy policy changes to stabilize or disrupt the policy monopoly, respectively. These policy images are constructed through media and can take many forms. For the purposes of this study, images were limited to testimonies submitted to Congress and articles' titles captured by the *Readers' Guide*. Furthermore, these images can be classified and tallied based on their "tone," which refers to whether they convey favorable or unfavorable publicity towards a policy change. In order for the researcher to classify testimony or an article based on tone, the researcher must adopt a point-of-view. For the purposes of this effort, the assumed perspective was that of a forest energy development proponent. With a viewpoint established, the counted articles' titles and testimonies given before Congress, under the Turbulence step, can be organized by those that were favorable, those that were negative and those that were neutral, contained both positive and negative elements or were unknown. For example, an article with the title "Forest Biomass Utilization Heats up Rural Economies" would be coded as a "positive" article as the title suggests that using forest energy creates a positive impact on rural economic systems. An article titled "Bio-Fools" would carry the exact opposite connotation, as the title implies that forest energy proponents are unaware of the final results of their efforts. Furthermore, previous PET studies have used multiple coders to increase accuracy (Baumgartner and Jones 2009, 293). For the more recent 15 years (1998 – 2012), articles were coded and then the articles re-coded after one year. Reliability exceeded 99%. Given the large congruence, the re-coding step was dropped for all years prior to 1998.

Policy venues provide arenas for the endogenous and exogenous actors to find favorable consideration. Venues provide one outlet for policy images to compete and a number of routes are possible. Following Schattschneider's (1960) "mobilization of bias" observation, interests can try to bring their policy image to bear. For instance, expert testimony can be submitted during a hearing to help buttress or refute an image. Interest groups can also highlight moving personal accounts and stories. The policy monopoly has an interest to limit participation while the exogenous interests will attempt to enlarge the scope of the conflict by seeking venues outside of the monopoly where their images might be effective. They also do not have to restrict their efforts to existing federal outlets. Venue shopping can be done at levels other than the federal as federalism provides for multiple levels that could be targeted. Interests may try to change state and/or local policies in an effort to push a change onto the national agenda. Furthermore, given the large number of committees, subcommittees and federal level staff, an interest that finds itself outnumbered may be able to level the playing field by strategically choosing existing, favorable venues without attempting to create dominating policy images or mobilizing segments of the population (Baumgartner and Jones 2009, 36). Venue shopping can be detected by looking for the following:

1. A change in agency jurisdiction,
2. Creation of a new oversight agency
3. Responsibility for a policy or program remains with an agency, but that responsibility expands to incorporate more of the presented policy image(s), or
4. A change in the level of government responsible for a policy's oversight (Adapted from Corwin 2002, 55).

By searching media accounts, through interviews, reviewing Congressional testimony, venue shopping was identified.

3.3.4 Dependent Variables

Policy change was the primary dependent variable and was operationalized as following (Kurtz 1999, 46-48; Corwin 2002, 57):

1. No change: Policy outputs remain unchanged as do funding allocations.
2. Symbolic change: Policy change does not include mandates, no methods for distribution or redistribution of resources and/or no methods for oversight / follow-up.

3. Incremental / Minor change: Policy change occurs at the margins while leaving the gist of the policy intact and relatively unaltered.

4. Non-incremental / Major change: New, enforceable policy is created that may create new programs / agencies, result in substantial resource transfers and/or policy oversight.

Some policies are large enough that they may contain some or all of the above. When possible, those specific titles or provisions were analyzed separately.

For policy monopolies that are firmly established, policy change, if it occurs, will likely result in one of the first three options. Policy monopolies will have the ability to limit participation and select or monopolize the appropriate venues. When external interests create turbulence and adopt strategies designed to disrupt the monopolies, either through creating a favorable image that mobilizes the apathetic or by carefully selecting venues outside of the monopoly but receptive to the policy image, then the possibilities increase for non-incremental or major policy change.

3.3.5 Study Propositions

Adapting from Kurtz (1999, 48), a number of testable propositions emerge. Relying on the list of independent variables above, the likelihood of policy change occurring was predicted using Table 3.1.

3.3.6 Phase Three: Data Triangulation

Reconstructing the policy images and determining which venues were selected and why are the cruxes of the PET approach. Note that the documents obtained previously—testimonies, reports, articles, etc.—provided an information cache suitable for completing this effort. Further triangulation was accomplished through interviews. After counting and coding, articles, hearings and reports were read to obtain the names of active participants in the FBU policy arena. These participants were potential policy entrepreneurs and were likely individuals quoted in the media, including individuals employed by the targeted federal land management agencies (BLM, NPS, USFS and USFWS).

Table 3.1: Likelihood of Policy Change Occurrence

Independent Variables	Factors that Increase Chances for Policy Change	Factors that Decrease Chances for Policy Change
External Interests	Generate turbulence by mobilizing the disinterested	Fail to expand issue(s) or efforts to mobilize bias subside
External Interests	Use subject matter experts who challenge status quo	Lack of information available to challenge status quo
External Interests	Create policy tools suitable for adoption by nation	Are ineffective, inactive or apathetic
Policy Venues	Issues are switched / expanded to venues beyond the monopoly	Issues remain firmly entrenched in the status quo
Policy Venues	More distinct and partially autonomous, open venues created	Newer venues are not created or, if created, are not open
Media Coverage	Tone is negative Coverage is increasing	Coverage is decreasing or nonexistent
Issue Scope	Become more nationalized	Become less nationalized

Source: Adapted from Kurtz (1999, 48).

The initial scope of potential interviewees was limited to the national forest, national park, field office, or refuge level but was expanded through a snowballing technique. Furthermore, to learn the names of key entrepreneurs, the reviewed documents provided a list of some “experienced and knowledgeable” participants in the given policy arenas (Rubin and Rubin 2005, 64-67). Once these participants were identified, they were contacted for in-depth, semi-structured interviews following the structural approached outlined by Rubin and Rubin (2005, 129-200).

Incorporating interviews with qualitative accounts gleaned from other sources (e.g., media, Congressional testimony, etc.), rich case studies can be created. The third phase produced these case studies (a.k.a. longitudinal case studies or case histories) for each of the four targeted federal land management agencies in Colorado [see Klyza (1996) and Clarke and McCool (1996) as examples]. Defined, a case study is:

> ...an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.
> (Yin 2003, 13)

More specifically, this project used Yin's (2003, 41) multiple-case, holistic design (Type 3 Design). Selecting a case study approach is appropriate when one asks "a 'how' or 'why' question...about a contemporary set of events, over which the investigator has little or no control" (Yin 2003, 9) and "is often adopted for post-facto (after the event) studies rather than ongoing issues or questions" (Berg and Lune 2012, 326) . A multiple-case study is advantageous as compared to single-case designs because the evidence from the cases is often considered more compelling, and subsequently the effort is regarded as being more robust (Yin 2003, 46-47).

The case study approach has traditionally been subject to a number of criticisms, including charges that it fails to incorporate adequate rigor, that it serves as a poor basis for generalization, and that it takes too long to complete and then only "result[s] in massive, unreadable documents" (Yin 2003, 10-11; Thomas 2003, 35). While applicable to an extent, these charges can be systematically addressed and the researcher can be careful and thorough enough to avoid them. Yin (2003, 21-28) identifies five elements that are critical to any case study research design:

1. Study questions,
2. Propositions, if any,

3. Unit(s) of analysis,
4. Logic linking the data to the propositions and
5. Criteria for interpreting the findings.

This study contains all of five elements. Study questions were presented in Chapter 1. Propositions were presented in a table in Section 3.3.5. Units of analysis focus on the four federal land management agencies, also identified in Chapter 1 as the USFS, BLM, NPS and USFWS. The final two elements are presented in the remaining chapters.

Additionally, Yin (2003, 33-39; see Table 3.2) prescribes four separate tests that one can measure in an effort to assess the quality of a case study research effort:

1. Construct Validity
2. Internal Validity
3. External Validity
4. Reliability

Construct validity consists of establishing the correct operational measures for the concepts being studied. Multiple tactics exist for establishing construct validity, including using multiple sources of data (e.g., interviews, Congressional testimony, media accounts, etc.), establishing a chain of evidence (i.e., the reader can “trace” a study from original research questions to final conclusion and do so moving in either direction) and having the study’s informants review a draft copy of the constructed case studies. Internal validity refers to establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from happenstance or spurious relationships. One way to establish internal validity is to conduct explanation building. Explanation building is a special type of pattern matching where the goal is to analyze case studies’ data by building an explanation around the cases. The explanation typically follows an iterative process where a theoretical statement is developed and then revised and the process repeated until rival explanations are eliminated (Yin 2003, 120). External validity involves establishing the domain to which a study's findings can be generalized. For this study, the same logic was applied to all four case studies. Finally, reliability requires the researcher to demonstrate that the operations of a study can be repeated with the same results.

Table 3.2: Case Study Tactics for Four Design Tests

Tests	**Case Study Tactic**	**Phase of Research in Which Tactic Occurs**
Construct Validity	Use multiple sources of data Establish chain of evidence Have key informants review draft case study report	Data Collection Data Collection Composition
Internal Validity	Do pattern matching Do explanation building Address rival explanations Use logic models	Data Analysis
External Validity	Use replication logic in multiple-case studies	Research Design
Reliability	Use case study protocol Develop case study database	Data Collection Data Collection

Source: Adapted from Yin (2003, 34).

The analytical strategy for this project focused on pattern matching (Yin 2003, 116-120). As defined, pattern matching compares an empirically based pattern with a predicted one. Kurtz (1999, 52) identified two patterns using PET:

1. Turbulent periods in which the existing policy monopoly dominates resulting in negligible to minimal policy change, and

2. Turbulent periods in which external interests succeed in disrupting the existing issue monopoly and redefining the agenda.

By paying attention to the elements of case study research, quality tests and pattern matching, the researcher stands a much better chance of deflecting traditional criticisms of the case study approach.

3.4 Chapter Summary

Forest health and energy supply issues are significant and result in public policy changes. However, anticipating policy changes and their subsequent results can be difficult. Fortunately, several approaches were available for modeling public policy change. Several contemporary models were summarized and analyzed in addition to hybrid approaches, which model public policy changes by incorporating elements of more conventional approaches.

This study used a three-phase hybrid approach that combined elements of the Multiple Streams Theory and Punctuated Equilibrium Theory. The first phase used a qualitative method to divine Kingdon's three streams. The second phase used a mixed methods approach to identify policy images and policy venues that were involved in policy change. Finally, the third phase used a multiple case study design to explain how forest energy policy emerged as a policy arena.

CHAPTER 4: FOREST POLICY AND FOREST ENERGY

"We can use it or lose it. We can't have an industry that's too big, and we can't have one that's too small."

– Carl Spaulding, President of the Colorado Timber Industry Association, on creating a forest energy industry in Colorado (Gable 2008)

4.1 Historical Overview of Federal-State Forest Policy Conflicts

Turbulence has riddled forest management in the United States since the earliest Euro-American settlements (e.g. Dana 1956; Hirt 1994; Davis 2001; Floyd et al. 2002; etc.). Despite early reports that they were limitless, Euro-American settlers would learn that North American forests would eventually be subject to the same scarcity as Europe's forests. This scarcity led to struggles that initially were over who could access which forests and to what end. Later, the focus would include the need to conserve forests and to determine the appropriate rate and means for resource extraction as the trees became scarcer. These struggles led to conflicts that were often characterized by violent, local resistance against agents of a centralized power, whether a foreign monarchy or a subsequently established national government. Overall, the emerging historical trend appears to be a long, ingrained and, at times, simmering conflict between the edicts of a distant, centralized authority and regional or local needs-based economic systems.

4.1.1 Federal-State Forest Policy Conflicts to 1858

One early example of these conflicts occurred in the Massachusetts Bay Colony. In 1691, the Colony received a new Royal charter after the previous charter was invalidated by the High Court of Chancery of England seven years earlier. Contained in the new charter was a clause which reserved timber of mast-size for the Royal Navy (Poore 1877, 942, 954). Specifically, any tree at least 24 inches or more in diameter measured at a height of one foot from the ground that was not on private land was reserved for the Royal Navy and as such was marked with a “broad arrow,” which consisted of three ax blazes in the stem in the shape of an arrow (see Figure 3.1) to signify the tree’s reserved status (Dana 1956, 11; Cronon 1983, 110-111). Subsequent edicts further expanded the species range and reduced the minimum reserved tree diameter sizes as larger trees were depleted and often done so with incredible waste (Dana 1956, 11-12; Cronon 1983, 110-111; Little 1888, 185-186). Those who illegally removed reserved timber as well as those who cut counterfeit arrows into trees to discourage competitors from harvesting the largest trees and thus reserve choice trees for themselves could face monetary penalties or jail terms (Dana 1956, 11-12).

Figure 4.1: Broad Arrow Mark

Source: Adapted from Hammarstrom (1976, 21).

The Colonists’ response to this Broad Arrow Policy was one of “vigorous” defiance and helped spark the American Revolution (Dana 1956, 13, 15; Rutkow 2012, 25-33). According to Robert Armstrong, General Surveyor of Her Majesty’s Woods and Forests in America, for every one mast that was sent to England for the Royal Navy between the years 1701 and 1721, 500 reserved trees eligible for the same purpose had been illegally removed for other uses (Dana 1956, 14). Royal timber agents who attempted to legally re-sell confiscated timber to colonists would be unable to find buyers; had their material re-seized by colonial woodworkers, who would in turn alter the evidence so that the material no longer violated the law; or would endure threats against their lives or even directly assaulted when “ducked into local mill ponds” (Dana 1956, 13).

One particularly illustrative incident was the Pine Tree Riot of 1772, which began when Royal timber agents attempted to enforce the Broad Arrow Policy. On April 13th, an unpopular Sheriff Benjamin Whiting, Esq., and his Deputy, John Quigley, Esq., entered the town of Weare in the New Hampshire Province with the intent of arresting one of the more egregious offenders, Ebenezer Mudgett. When the agents apprehended Mudgett, he assured them that, if he were released on his own recognizance, then he would have bail ready by the morning. The agents spent the night at a local inn. At dawn, Mudgett stormed into the Sheriff’s room and told him that bail was ready. Mudgett and about two dozen other men, faces blackened, promptly whipped Whiting mercilessly with pine branch switches. Quigley was able to put up some resistance but ultimately succumbed to the mob, too. Both men were forced against their will to mount horses, which had their “ears cropped, manes and tails cut and sheared,” and rode out of town while enduing the taunts of the mob. Eight of the perpetrators were later arrested and indicted but were only fined 20 shillings and court costs (Little 1888, 185-191). Such light sentences suggest that the court was more sympathetic to popular opinion than the policy, its enforcement and, above all, its enforcers.

With just as much civility, the conflict between national management policies and local or regional need-based priorities, continued after the American Revolution and during the course of the next half-century. Policies were promulgated to provide for the orderly settlement of newly acquired lands. However, many of these legitimate distribution schemes suffered from poor policy design and execution. The United States vacillated between a system of cash sales and credit sales for land between 1785 and 1862; these sales were typically preceded by a public auction where few could afford the minimum offerings. Furthermore, these same lands were the only source for timber—a resource necessary for agriculture and industrial growth (Dana 1956, 22-29; Gates 1968, 121-218). Essentially, timber resources were locked up without a formal decree, encouraging squatting and timber trespass by Euro-American settlers and mirroring the previous forest resource sequestration under the Broad Arrow Policy.

Exacerbating the timber shortage while trying to help ensure national security, the United States instituted a system of "naval reserves" for naval stores that in some respects resembled the Broad Arrow Policy in that particular provisions were made for preserving certain indispensable species, namely live oak (*Quercus spp.*) stands (Dana 1956, 46-55). Again, the law would eventually broaden to include all tree species found on public lands. These policies also produced similar results to the Broad Arrow Policy: enforcing agents were largely incapable of arresting timber trespass or timber trespassers. The accused were typically tried by local, sympathetic juries and, much like in 1772, faced trivial fines (e.g. "one cent") upon conviction (Dana 1956, 51-52).

One of the more striking examples of resistance involves a zealous General Land Office (GLO) official in 1853. Isaac Willard, a "particularly obnoxious timber agent," faced threats of "force and violence" for attempting to arrest timber poachers on public forests. Incensed by the public rebuke, Willard recovered and then offered "a large quantity of stolen timber" for sale at Manistee, Michigan (Dana 1956, 55). The material, much like confiscated material under the Broad Arrow Policy, was stolen back by locals or, if it could not be physically relocated, burned-in-place. Attempts to arrest the offenders either failed flatly or were met with violent resistance and rebuffed. When Mr. Willard summoned federal troops, arrests were made but sentences, again, consisted of light jail time or negligible fines, which is somewhat surprising given that federal agents were killed in action during the melee (Dana 1956, 55).[25]

The conflicts of the mid-1850s were not only conspicuous for their violence but also for failing to stimulate reforms in national forest policy, particularly in addressing timber trespass on public lands. The newly-created U.S. Department of the Interior (USDI) started the 1850s actively prosecuting timber trespass. However, by 1854, the USDI deferred to the GLO, which quickly transferred authority from its timber agents to local land officers (with no commensurate transfer of funds). Agent Willard's supervisor was transferred to the Office of Indian Affairs. The net result: timber trespass officially was decried but unofficially was treated with leniency. Perpetrators were assessed a "liberal" stumpage fee, which was not based on any attempt to assess the material's true value and funds were not guaranteed to reach the U.S. Treasury. Material removed was done so at the whim of the perpetrator, not the owner (i.e. the federal government). In essence, the federal government, however, could claim that it was addressing timber trespass and settlers could claim that they were acquiring timber legally. This "compromise" or equilibrium quietly endured for roughly the next twenty years (Dana 1956, 53-58).

Other industries increased timber depletions as Euro-Americans moved westward. The fur trade, particularly beaver and buffalo pelts destined for European markets, lasted until the 1840s, when stocks were all but depleted and international fashions shifted from pelts to silk (Mehls 1984, 24; Ubbelohde et al. 2006, 36, 39-40). The vacuum left by the loss of the fur trade

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[25] In a letter to Arthur Davison Ficke in 1930, Edna St. Vincent Millay (1972, 240) wrote: "It's not true that life is one damn thing after another—it is one damn thing over & over." The surprise might be tempered given the Pine Tree Riot verdicts.

was filled by an increasing sense of nationalism under the Manifest Destiny doctrine with settlers actively seeking routes to Oregon and California to escape poor prospects (e.g. recession, disease, poor climate, etc.) in the East or to proselytize Native Americans in the West. Settlers heading westward found another incentive as gold was discovered in California in 1848, encouraging the first of a series of mineral land rushes in the American West that would span the 1850s. The California Gold Rush of 1849 involved hundreds of thousands of people crossing the West and necessarily some would traverse what would eventually become Colorado. Migrants prospected along the way and some did discover gold in Colorado, although the finds paled in comparison to California's. Mining increased the demand for wood material for timber supports, flumes and eventually a vicious cycle of boom-and-bust communities (Butler and Lansing 2008, 81; Hine and Faragher 2000, 185-189, 199-200; White 1991, 190-192; Limerick 1987, 41-42, 45; Mehls 1984, 33; Abbott et al. 2005, 44).

4.1.2 Federal-State Forest Policy Conflicts from 1858 to 1910

Similarly to the California rush, entrepreneurs from the East, following rumors from previous expeditions and information from Native Americans, ventured into Colorado in 1858 to try their luck. The discovery of gold near the confluence of the South Platte River and Cherry Creek spawned a gold rush the following year. Tens of thousands of new settlers flocked to the area, including discouraged miners from California and other areas. Within two years, the Colorado Territory was organized and statehood was achieved in August 1876, earning the state its "Centennial State" nickname.

Colorado's "Fifty-Niners" are significant in that the increased number of people primarily occupied with mining, just as in California a decade earlier, led to a dramatic increase in the amount of timber consumed (see Figure 4.2). Forests were cleared to make room for mining towns, for grazing and for transportation improvements. Part of the clearing was done by fires. Euro-Americans could clear the land with little effort exerted, but fires could also be used to drive away Native Americans or even other Euro-Americans.

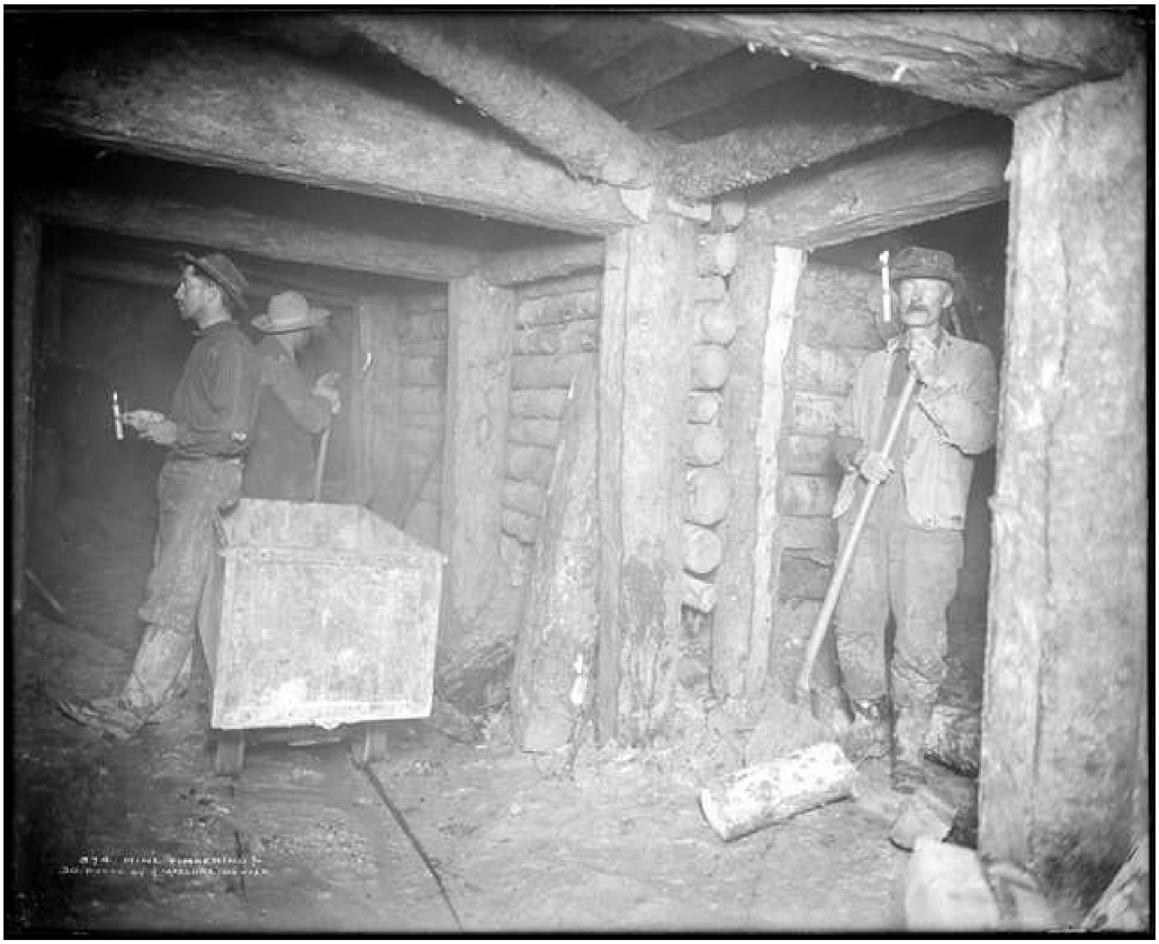

Figure 4.2: Timber Use in a Colorado Mine

Source: Denver Public Library, Western History Collection (2009).

Often fire was used to sacrifice a limited amount of living timber along the edge of a government reserve. The reasoning: if a plot’s edges were burned, under regulations at the time, the entire plot encapsulated by charred stems could be classified as “dead,” which would permit timber extraction. Miners used the timber for mine supports, rail ties and buildings (Veblen and Donnegan 2005, 53-55).

As the toll incurred from forestry-related activities increased, the seeds for a new way of viewing forests were planted. George Perkins Marsh's (1885) *Man and Nature*, originally published in 1864, suggested that the downfall of major civilizations could be linked to the way they failed to manage their natural resources, especially deforestation's disastrous consequences, and how the United States might incur those same consequences without more careful thought as to how it manages its own forests. Marsh's thinking on denuded forest lands would resonate with readers and later influence conservation leaders, including Gifford Pinchot and John Muir.

The notion that forest resources were not limitless was not completely lost on voters in the Colorado Territory either. Although General William Larimer declared that "[o]ur pineries are convenient and will last for generations to come" during a Christmas celebration at Cherry Creek in 1858, dissenters existed. Frederick J. Ebert was a German-trained forester who "was largely responsible for the formation of a committee on forest culture at the constitutional convention" (Ubbelohde et al., 2006, 275). Although his idea for a state board of forestry was defeated, he successfully inserted two clauses into Colorado's constitution during convention. The first clause required the General Assembly "to enact laws to prevent the destruction of and keep in good preservation the forest" on state lands and those conferred to the state by Congress (CO Const. art. XVIII, §6). The second clause became Section 7, which allowed the legislature to exempt from taxation the increase in a parcel's value if that increase resulted from tree planting. These provisions are significant because they are the first provisions incorporated into a state constitution "that specifically authorized a definite forest policy," although no corresponding, effective legislation was enacted to support this provision for another decade (Kinney 1917, 5; Ubbelohde 2006, 275-276). An effort not long after statehood to extend tax rebates for tree planting went nowhere (Ubbelohde et al., 2006, 276). After half a century, the results from

Colorado’s use of constitutional provisions instead of legislation appeared to have been a matter of convenience rather than a push for efficacy (Illick 1938, 290).

The West continued to grow. Following a decade of field observations, John Wesley Powell (1878) concluded that settling the West would remain largely contingent on the amount of water available to settlers (Graf 1990, 1-2). The decade after Powell’s report witnessed many proposed federal policies for regulating the irrigation of arid intermountain lands. These legislative efforts culminated in 1888 with the creation of the Irrigation Survey under control of the United State Geological Survey (USGS), which was headed by Powell. They also reserved all lands from public sale that could support irrigation development until irrigation project construction sites were identified (Graf 1990, 16). These reservations, coincidentally initiated by Representative George Symes of Colorado, were a preemptive strike against land speculators. Plots nearest potential dam or irrigation sites would be prized and thus demand a higher price.

These reservations also mark the beginning of the first of at least five distinct Sagebrush Rebellions (Graf 1990, 16-17). Defined, a Sagebrush Rebellion is characterized by organized resistance in the American West to federal public land policies (Graf 1990, xv). Realizing belatedly that the Irrigation Survey would most likely impede instead of expedite Western development, the Sagebrush Rebels organized and subsequently pushed to eliminate the Irrigation Survey and remove Powell from a position of authority. Rebels believed that reserving lands would essentially be a land lockdown of an uncertain duration (e.g. “decades”) as the time-consuming work conducted by the Irrigation Survey was contingent on available resources. By 1890, the Rebels largely succeeded (Graf 1990, 45-47).

However, the Sagebrush Rebels were not content with simply eliminating the Irrigation Survey.[26] In 1890, they attempted to pass a law that would "cede all unappropriated lakes and rivers to state or territorial control," in effect eliminating federal control over the water resources and subjugating vital watersheds to western managers (Graf 1990, 49). This push failed but stimulated interest in passing additional land reforms. The net result of this additional interest was the General Revision Act of 1891 (a.k.a. Creative Act, Forest Reserve Act or General Land Law Revision Act). This act repealed a number of policies that aided homesteaders attempting to settle in arid environments not conducive to farming and also attempted to reduce corruption concerning land disposal. Tucked inside the Act, however, was Section 24, an (illegally) inserted clause that allowed the President to reserve sections of public forests (Graf 1990, 49-50, 61; Steen 2004, 26-27; Ise 1920, 114-118; Dana 1956, 100-102). The forest conservation movement had finally come of age.

Presidents seemingly wasted little time in exercising their newfound powers. President Harrison added 13 million acres to the forest reserves before the end of his administration in 1893, including five forest reserves in Colorado totaling just over 3 million acres (Colorado State Forest Service [CSFS] 2002, 7; Abbott et al., 2005, 121). President Cleveland reserved another 4.5 million acres by the end of the same year and added an additional 21 million acres by early 1897. With over 40 million forested acres reserved by 1898, the largest political problem with the forest reserves was not necessarily so much the size of the reserves or their location, but that their intended use had not been explicitly stated in the authorizing legislation meaning that the

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[26] Nor were they content to leave John Wesley Powell alone. Between 1891 and 1894, the US Geological Survey's budget was reduced by 66%. Professionals vacated. In 1894, Powell resigned from his leadership position in the agency. Ironically, the same legislators who decimated the US Geological Survey were the same elected officials who argued for increased USGS appropriations just prior to 1900 (Graf 1990: 51).

reserves were more like preserves, mirroring the previous lockdowns of the Broad Arrow Policy, naval reserves, etc. The reserves were also essentially unmanaged and unfunded (Dana 1956, 102, 105; Steen 2004, 27-28; Hays 1959, 36; Wyckoff 1999, 93).

Western interests opposed the reserves but the opposition was different during this second Sagebrush Rebellion. Traditional opponents to the reserves, such as mining, grazing and timber groups, who normally would uniformly oppose restricted resource access, were fractured by economic incentives. For instance, timber groups who would logically be expected to decry restricted or prohibited harvesting on public lands might actually support the reserves if the members were of large enough size i.e., owned significant amounts of timber. Conceivably, significantly amassed timber stockpiles would increase in value as westward population expansion increased the demand for forest products while the available supply decreased due to the reserves (Graf 1990, 64-65; M. Williams 1992, 440). In addition, farmers, who depended on forest-based watersheds for irrigation, and urban dwellers, who relied on those same waters for drinking, feared floods from denuded forest lands and lent their support to the reserves (Graf 1990, 64-65, 68-69).

Efforts to establish uses for the forest reservations began not long after the 1891 General Revision Act passed. Although a number of bills attempted to either open the reserves or at the very least to provide uses for timber on the reserves, none of the attempts succeeded. Not until the advent of the McKinley Administration did prospects change and then only after the intervention of the National Academy of Sciences, which included Gifford Pinchot's efforts. The result was the Organic Act of 1897 which, after making concessions to and compromises with western interests, finally established three main purposes of the forest reserves: 1) to improve and protect forests within the reserves' boundaries, 2) to secure favorable conditions of water flows and 3) to furnish a continuous supply of timber for the use of all citizens of the United States, not just the West (Ise 1920, 122-142; Dana 1956, 102-110).

The most important aspect of the 1897 Organic Act for the purposes of this study is the opening of the reserves to all citizens of the United States while noting, however, that the location of the reserves would remain completely west of the 100th Meridian until the Weeks Act in 1911. While subsequent developments are significant as they would enhance and expand the forest reserve system, the combination of President Theodore Roosevelt and Gifford Pinchot in the USFS would more than triple the size of the forest reserves (see Table 1.1), now renamed National Forests, and reserve more public lands exclusively from the Western states. These states lacked the political organization of a unified front powerful enough to undo the changes but were able to curtail the President's power to set aside additional reserves in six western states in 1907, including Colorado. Reluctantly, the Rebels were forced to accept the change from disposal to a more aggressive custodial approach to managing public lands but not before over 15.7 million forested acres were reserved in Colorado or about 24% of the state (Graf 1990, 87-88, 121, 131-134; Clawson 1983, 31-33; Dana 1956, 392; Ubbelohde et al., 2006, 277).

Hostilities towards the National Forests appeared to be for the moment defused as the Sagebrush Rebels accepted or rather were forced to accept the new management approach to National Forests. Tensions between rural economies heavily dependent on resource extraction clashed with larger national interests that prioritized a more structured, managed approach. However, the ashes from previous uprisings still smoldered. Although the terms of future debates would change, the underpinnings for each Sagebrush Rebellion would, not surprisingly, remain constant.

4.1.3 Federal-State Forest Policy Conflicts from 1910 to 1973

Even though managing grazing was the USFS's "dominant activity" until just after World War I, the chief concern of the fledgling agency had been "fire from the start" (Hays 2009, 20-21, 27-33). Fires in the latter part of the nineteenth-century influenced the agency's priorities. Large blazes, such as Peshtigo in 1871, etc. burned with such severity and instilled such fear that fire control came first and foremost in the minds of forest administrators. In the early 1900s, wildfire seasons would commonly consume between 20 million and 50 million acres, or an area the size of Vriginia, West Virginia, Maryland and Delaware combined (MacCleery 2002, 25). The "spark" that brought greater visibility to fires and national forests occurred with the "Big Blowup" of 1910. In August, conflagrations in Montana and Idaho impacted the nation and served as a catalyst for the young USFS as a 3 million acre area (roughly the size of the current mountain pine beetle epidemic footprint in Colorado) burned in a day and a half. The smoke plume darkened the Boston sky. Nearly 80 firefighters were killed and no totals were kept of the dead immigrants who were conscripted into the firefights.

The negative media covering these conflagrations created a perceived need to manage fires, preferably by subjugating them to direct and expedient human control. The initial focus for fire suppression was on "frontier fires," or those fires emerging near settlement while agency personnel contended with a lack of adequate resources. After 1930, the focus switched to "backcountry fires," which included fires in more remote, mountainous terrain but also those fires on lands that had been abandoned. During this time, suppression gained further momentum with the Tillamook fires in the early 1930s. The "10 A.M. Policy" in 1935 emerged as the nation's first national forest fire policy, and significantly, this policy, or what Pyne et al., (1996, 256) called "panic legislation," remained unaltered for over 30 years (National Interagency Fire

Center [NIFC] 2001). With military personnel returning and surplus war equipment available after World War II, the focus again shifted to rapid mobilization for attacking mass fires. The persistent political ramifications of both the lingering physiological and psychological scarring can still be seen in contemporary budgetary authorizations and appropriations for USFS wildfire suppression as the allocated percentage has more than tripled over the past two decades (Pyne 2001a, 253-254, 281; Pyne 2010, 35; USDA FS 2007, 2010).

Table 4.1: Growth of the National Forest System, 1891-2012 (in acres)[27]

Years	Acres	Years	Acres	Years	Acres
1891	2,437,120	1904	56,000,000	1920	156,032,053
1892	5,353,040	1905	75,352,175	1930	160,090,817
1893	17,564,800	1906	94,159,492	1940	174,769,543
1897	18,993,280	1907	132,731,865	1950	179,685,328
1898	40,719,474	1908	147,819,660	1960	180,843,513
1899	46,021,889	1909	172,230,233	1970	182,571,102
1900	46,772,129	1910	168,028,752	1980	183,060,464
1901	46,410,209	1911	168,165,163	1990	187,083,200
1902	60,175,765	1912	165,027,163	2000	192,383,077
1903	62,354,965	1915	162,773,280	2012	192,976,743

Source: Adapted from Williams (2007, 44) and USDA FS (2012). Shaded areas cover the Roosevelt-Pinchot era.

[27] Note that these numbers use net acres as opposed to gross acres. Repeated accounts use the gross acre totals which would include private lands and non-forested acres. Also, "national forests" were not created until 1907; pre-1907 acres refer to "forest reserve" lands.

In addition to public safety, fire was also viewed as a direct threat to the national forests' ability to produce wood. Until the 1920s, industry showed little interest in sustainable timber harvesting through the centuries' "cut and run" patterns, where businesses would remove timber and then either sell the cleared land to farmers or abandon the land (and their subsequent tax liability), causing the depleted lands to revert to government ownership (Hays 2009, 3; MacCleery 2002, 33). The harvesting methods used during "cut and run" tended to be wasteful and the large amounts of residue left behind led to fires, whose suppression and prevention became the government's responsibility. Thus, the fledgling USFS had a precarious relationship with the commercial timber sector and would maintain its guarded relationship for nearly the next half-century. Pinchot believed more regulation of forest resources, private and public, was the appropriate course of action. These "regulated forests," where slow-growing old growth forests were deliberately replaced with faster-growing "crop" rotations, would theoretically meet the nation's sustained timber yield needs and improve the forests' productivity (Hays 2009, 8, 38-41; Hays 2007, 9-10).

However, the federal intransigence left industry looking for other partners. The need to produce wood meant that the fire threat had to be addressed and industry was amenable to action as fire rendered timber investing speculative and logging and land ownership risky. States began to increase their roles in forest management with a "patrol-and-suppression" fire management policy promulgated through the Weeks Act of 1911 and the Clarke-McNary Act of 1924. The greater cooperation between public forest and private forest advocates led to a strengthening of the bonds between state-level government and private industry, although some states such as Colorado were initially reluctant to partake in the cooperative state fire protection scheme as the area experienced relatively mild fires and the infrastructure in place was able to adequately address flare ups (Hays 2009, 9, 59-60; Godfrey 2012, 150).

Change followed World War II. The demand for wartime goods, including material but also complementary goods like packaging and shipping containers, increased the pressure on private forests to produce. After the war, the returning soldiers immediately began starting families, leading to a “baby boom.” The new families needed homes and national forests were a source for raw material for building homes (e.g., Levittowns, etc.) that would also reduce the strain on private forests. The “rapproachment” between the USFS and industry was mutually beneficial. The timber industry needed replacements for dwindling raw material supplies. The agency viewed timber harvesting as an integral part of its mandate. By cooperating with the timber industry, the USFS could supply rural, local economies (e.g., mills and supporting jobs) while attempting to achieve its management objectives and working to “make the forests pay.” Often times, the USFS would find itself capitulating to local pressures as “sustained yield” became “sustained communities,” where the cutting levels exceeded sustainability limits. These demands placed on the agency led to more economical harvesting processes, including clearcuts (Hays 2009, 56-60; MacCleery 2002, 42).

Clearcuts involve cutting entire timber sale areas. They are comparatively quick. Because they harvest all trees in a given area, they maximize economic yield. In some cases, they mimic natural processes e.g., a clearcut would mimic the stand-replacing process that lodgepole pines follow during a fire-initiated regeneration, as the species is wont to do. They also have drawbacks. For instance, while they may mimic what fire would have done, they do not actually reintroduce fire into fire-dependent ecosystems, such as those same lodgepole pine stands. They also are unattractive and, as a result, their aesthetics tend to evoke a negative, visceral reaction (see Figure 4.3).

Figure 4.3: A Clearcut on the Leadville National Forest, Roughly 10 Miles West of Leadville, Colorado.

Source: USFS (2007). This photo was taken on September 16, 1915. The trees were used for making charcoal for mining operations. Note the high stumps. Although the harvesting practices would become more efficient over time, the emotional reaction one may experience is unchanged. Special thanks to Dave Steinke, USFS.

As the use of clearcuts increased in the mid-20th century, their impacts became more apparent and widespread. The large, desolate tracts were visible from adjacent hillsides by locals and overhead via airplanes. The impacts on environmental quality, such as increased runoff pollution and stream sedimentation degraded water quality, wildlife habitat and recreational opportunities. Conflicts between multiple uses emerged.

The USFS responded by requesting guidance from Congress. Congress responded by essentially letting the USFS to draft its own legislative response. The result was the Multiple-Use Sustained Yield Act of 1960. The legislation is short and simple—about a page and a half. The major point is that the USFS must manage for “outdoor recreation, range, timber, watershed and wildlife and fish” and do so that no one use is treated greater than any other as they are in alphabetical order. However, the use of the word “outdoor” before recreation is suspicious because it is unnecessary: how many people choose to recreate in national forests for their substantial “indoor” opportunities? Also, the phrase “wildlife and fish” is the reverse of the more often used “fish and wildlife” phrase that is also in the name of a related federal land management agency. Why do these discrepancies exist? (Dana and Fairfax 1980, 201)

The answer stems from the rising prominence of the recreation and preservation communities after WWII. The increased demand for housing and related wood products after World War II was dramatic; the annual cut from national forests increased from about 3 bbf in the late 1940s to about 11 bbf in the early 1960s (MacCleery 2002, 42; Hirt 1994, xliv). Colorado was no exception. For instance, in Fiscal Year 1953, Region 2, an administrative unit of the USFS that includes Colorado, cut almost 218 mmbf (Colorado was over half the total). In Fiscal Year 1955, Region 2 cut over 290 mmbf (Godfrey 2012, 249). While the cuts were increasing, these same forests were also suitable for a “recreation boom,” which was now possible given the post-war economic boom. The increasing demand for “outdoor recreation” opportunities resumed after the interruption by the war, including visits to the national forests. For instance, in 1954, the San Isabel National Forest had 981,000 visits, which was a 300-percent increase over 1950. In 1955, Region 2 experienced over 7 million visits, which was an increase of nearly 950,000 visits over the previous year’s record (Godfrey 2012, 252). However, an acre of forestland can provide material for home construction or for recreation amenities; an acre of forestland cannot do both equally well at the same time.

Recognizing the threat to forests and coupled with the growing demands and improved technological harvesting, preservationists and recreationists pushed for policies to help protect recreational spots. The “Mission ‘66” plan was developed by the National Park Service starting in 1956 to restore and modernize the National Park Service units and also allow them to accommodate visitors until the year 2000. The USFS responded with its own “Operation Outdoors,” which also attempted to improve its recreational facilities (Hays 2009, 73). (The inter-agency competition undoubtedly helped spur the “outdoor recreation” language contained in MUSYA.) Also, they pushed for legislation to protect remaining wild or “untrammeled” places in the U.S. After years of trying, Congress passed the Wilderness Act of 1964 that allowed Congress to designate Wilderness areas that would be off-limits to extractive uses, including logging. Finally, after a number of environmental disasters including an oil spill near Santa Barbara, California, and the repeated ignition of oil slicks on the Cuyahoga River in Ohio, the newly created environmental movement helped push for a number of laws that would substantially regulate environmental impacts including forest management activities, such as the National Environmental Policy Act of 1969 and the Endangered Species Act of 1972. However, the conflicts between local, use-based economic priorities and national preservationist priorities were still intensifying.

4.2 Multiple Streams and Forest Policy from 1973 to 2012

For exploring how forest policy and energy policy are intertwined, beginning in the early 1970s with the Nixon Administration makes some sense. Forests faced a number of conflicting demands, including increased demand for timber and an increased demand for providing recreational opportunities, and simultaneous crises. The policies for long-term forest management planning were insufficient for addressing these multiple, conflicting demands. The politics surrounding environmental protection, including forests, became extremely volatile. When viewed together with the corresponding problems developing in energy (e.g. the Energy Crisis), the foundations for forest energy become more apparent. Following the approach taken by Kingdon (2011, 231-241), this section divines the three streams: problems affecting forests, policies crafted to manage forests and the politics enveloping national forest management and stakeholders.

4.2.1 Forest Problems

At the end of the 1960s, national forests faced several problems simultaneously. The timber industry continued its push for increasing harvests as demand and subsequently prices increased. Between 1967 and 1968, wholesale lumber prices increased by 37% over 18 months. One option for ameliorating the supply shortage would have been to increase production from national forests as the increase in supply would cause prices to fall. However, the opposition to clearcutting, the most economical form of timber harvesting, was just as determined as the industry. Environmental degradation from terraced clearcuts on the Bitterroot National Forest in Montana and sanctioned clearcutting on Monongahela National Forest in West Virginia had been increasing since the mid-1960s. In addition to the conflicting demands placed on the forest, natural change agents were still active. By 1973, the mountain pine beetle became “the most serious insect pest in the Rocky Mountains,” including Colorado and Region 2, as annual timber losses to the beetle exceeded those from any other cause, including fire (Godfrey 2012, 289-292, 297; Hirt 1994, 256-261).

The more significant problems stemmed from timber extraction's environmental impacts. Senator Lee Metcalf appointed a commission to study the USFS's process; the resulting Bolle Report in 1970 excoriated the agency and found that "multiple use" was not practiced and instead the agency's approach to timber harvesting showed little concern for the environment and other forest uses. The Church Report in 1972 was just as critical of USFS timber harvesting in the Monongahela National Forest and went so far as to develop guidelines for when and where harvesting should occur. On the heels of these two significant reports, turkey hunters in West Virginia sued the USDA in the case of *West Virginia Division of Izaak Walton League of America, Inc. v. Butz* (1975). At issue was the legality of clearcuts. According to the Organic Act of 1897, which spelled out the purposes of the national forests, the only trees that could be harvested had to be dead, mature or large growth trees that had been clearly marked. For clearcutting practices, the only trees that were clearly marked where the outlining trees in the timber sale area i.e., the only trees that were painted were timber sale border trees that indicated to loggers where to stop harvesting. As a result of this court decision, in order for a clearcut to occur all trees in the sale area would need to be marked, thus severely curtailing the use of clearcutting as the time and expense for the additional required labor would be cost-prohibitive. Congress was compelled to act but its efforts to reform the USFS did not pan out as either side had hoped. Public debate and litigation increased as loopholes for bypassing clearcutting and harvesting allotment limits and pressures on the USFS to deviate from the limits were substantial. From the late 1970s through the 1980s, harvest levels remained unsustainable and old-growth liquidation continued. Increased conflict was inevitable (Hirt 1994, 262-265; Hays 2007, 16-19; Burnett and Davis 2002).

Despite predictions of “mild and gentlemanly conflict” (Clawson 1983, 8), Koontz (2002, 1-3) and Davis (2001, 26-27) cataloged a number of instances where on-duty federal land management agency personnel received threats or experienced severe acts of violence due to intensifying federal-state and even federal-local tensions regarding land use policy. These tallies increased after the listing of the Spotted Owl in 1990 and resulting timber reductions in the early 1990s. The Washington-based Public Employees for Environmental Protection (PEER) maintains a database on violence against federal land management employees; since 1995 their findings show that levels of violence remain quite high (PEER 2012a, 2012b). Of the federal agencies considered, the vast majority of cited incidents targeted Forest Service employees (PEER 2012b). For instance, the number of reported violent incidents committed against USFS employees in 2001, the same year the federal courts banned logging in spotted owl habitat, increased by 136 percent. The largest increase was in 2004 at 302 percent. The incidents’ brutality is just as shocking. For example:

> A bomb detonated outside the home of a Forest Service district ranger in Carson City, Nevada, destroying the family van, which was parked in the driveway, and blowing out the front windows of his home. The office of that district ranger had previously been firebombed.
> (PEER 2012b)

The intensity and scope of the violence suggests a continuation or even an exacerbation of hostilities between national and regional / state / local stakeholders.

Different objectives at different government levels can complicate the decision-making process as they may be incongruent or in conflict. For the Spotted Owl controversy, which dramatically reduced average annual timber output from federal forests after 1990, the economic needs of forest-based industries in rural communities were at odds with federal mandates to protect endangered species. Both the industries and the owls were dependent on the same local forest resources. These differences suggest forest policy decisions that span jurisdictions are perceived essentially as zero-sum games, where one party necessarily improves its position at the expense of another, with long-term trends remaining uncertain for all.

Wildfire suppression is the quintessential example. Wildfire suppression efforts over the course of the twentieth century constituted a double-edged sword. With one edge, the US Forest Service attacked fires with increasing efficiency believing that fire suppression could improve ecological stability while reducing economic losses (NIFC 2001). More than $200 million in surplus war equipment was sent to state and local cooperators after World War II to help suppression efforts (Williams 2007, 199).

The compounding of effects constitutes the sword's second edge, manifesting itself in more recent years. In 1993, the Malibu fires that burned southern California shocked the nation. The bigger fires happened in subsequent even-numbered years. The South Canyon fire burned in 1994, near Glenwood Springs, Colorado, and killed 14 firefighters, almost half of the firefighters killed that year. That same year saw the largest amount of acreage burned for the past half-century and marked the first time that fire suppression costs exceeded $1 billion. From 2000 to 2011, the total number of acres burned exceeded seven million for seven out of the past eleven years and had not exceeded seven million acres between 1960 and 1999 except for once, in 1963 (NIFC 2012). Large wildfires occurred in Colorado in 2000, 2002 and in a record-setting season for 2012. Funding for addressing catastrophic wildland fires has increased in response. In 1991, the US Forest Service spent 13% of its budget on wildland fire suppression and by 2008, spent nearly half of its budget on fire suppression, leading many Congressional leaders to quip that the U.S. Forest Service was becoming the "U.S. Fire Service" (Pyne 2010, 52-53; USDA FS 2007, 3; Berman 2007; Bontrager 2008).

Furthermore, as the immediate impacts increased in severity, so did the costs for suppression and rehabilitation (Arno and Allison-Bunnell 2002, 23). Recent scholarship suggests that wildland fire expenditures are not sustainable and efforts are misdirected (Busenberg 2004; Steelman and Burke 2007; Schoennagel et al. 2009). Costs associated with wildfire suppression continue to climb, having often exceeded $1 billion dollars per year during the past decade (General Accounting Office [GAO] 2004, 1; USDA FS 2007, 3). Predictions suggest this trend is likely to continue as suppression costs could total as much as $12 billion by 2015 (GAO 1999, 41). If one were to consider costs beyond those incurred by government agencies (e.g. insurance and tax losses, rehabilitation / restoration efforts, compensation for injury/deaths, etc.), the cost for implementing wildland fire policies increases dramatically beyond mere reported suppression cost totals (Lynch 2004). At the end of the Obama Administration's first term, the USFS finds itself spending heavily on fire while other concerns, while no less important, continue to their budgets depleted and diverted.

4.2.2 Forest Policies

With the myriad threats facing national forests at the end of the 1960s, policy solutions became more important. One of the first attempts to "solve" the conflicts over timber management was the Timber Supply Act of 1969. This bill, largely the work of the National Forest Products Association (NFPA), would attempt to induce the USFS to permit increased harvesting in order to increase supply and thereby lower price. The NFPA proposed doing so by creating a "high yield timber fund" that would collect all nondedicated receipts from the sale of logs on national forests. Rapid liquidation of old-growth stands combined with encouraging increase logging, not only for lands not previously reserved for wilderness but also for a period of a few decades after promulgation. Monies in the fund could be used to justify such increased harvests because they would go to reforestation and restocking, thinning and forest management, including pest control and wildfire suppression (Hirt 1994, 254-56).

However, environmentalists balked at the proposal. With such priority given to timber harvesting, the Timber Supply Act ran counter to the Multiple Use-Sustained Yield Act of 1960. Furthermore, by re-designating lands not considered for wilderness preservation, the bill effectively eliminated expanding Wilderness on national forests. The push for greater harvests meant increased use of silvicultural operations, most notably clearcuts, whose environmental impacts were manifesting themselves both in forests and surrounding ecosystems. Finally, with these receipts slated for timber harvesting, funds would not be available for the other uses listed under MUSYA. With united opposition, the Timber Supply Act, as well as other attempts to increase timber production, failed (Hirt 1994, 256).

Timber extraction was only one area ripe for policy developments. Given the lack of progress via the executive and legislative branches, environmentalists turned their attention to the judicial branch, using tools such as the aforementioned NEPA and ESA to file lawsuits opposing clearcuts and defending non-timber resources on national forests (Hirt 1994, 251-254). For instance, when the USFS conducted the first Roadless Area Review and Evaluation (RARE I) (from which over 600,000 acres in Colorado were recommended for further study) required by the Wilderness Act, the environmental groups successfully sued to dismiss its results, arguing the USFS failed to fully comply with NEPA. Meanwhile, the USFS was also trying meet the budget priorities of the Nixon Administration. For Region 2, including Colorado, the fiscal change meant reducing funding for timber sales, road construction and other timber-related infrastructure work in order to improve environmental quality and reduce pollution (Godfrey 2012, 289-292, 297).

With so many problems, the situation could have been ripe for compromise. In 1970, Bill Towell, head of the American Forestry Association, invited members from the opposing forest management interest groups to meet informally and try to find common ground. Although this “Areas of Agreement Committee” met for six years, it could not resolve the major issues, instead adopting a position where forests could be managed to meet all needs for all groups, a physical impossibility that Hirt (1994, 257) called the “old utopian conspiracy.” The committee was not an anomaly. For Colorado, Region 2 Regional Forester David Nordwall believed that users and preservationists could be appeased at the same time. In the same year, he wrote:

> I firmly believe we can ‘have our cake and eat it too,’ at least on public lands. We can, on our National Forests, for example, produce the water needed for irrigation, grass for domestic stock and wildlife, all forms of recreation, and timber for homes. We can do these things—WITHOUT HAVING THE WORLD COME TO A POISONED, RUINOUS END. (Godfrey 2012, 288)

The shine of the “old utopian conspiracy” started to fade. In Colorado, Region 2 Regional Forester Nordwall retired in June 1970, after serving for 37 years. Nationally, Towell’s group did not defuse tensions but it did help lay groundwork for congressional action.

With pressure on the national forests, a new effort started. Towell’s “Area of Agreement Committee” helped create a foundation for legislation that would help broke a process for national forest planning that would be acceptable to the major stakeholder groups. Introduced in 1973, the Forest and Rangeland Renewable Resources Planning Act (RPA) was a planning statute designed to provide long-term planning for forest and rangeland resources management. The RPA required five documents, three from the USFS and two from the President. The USFS had to provide an assessment of forest and rangeland resources, a program for national forest management, updated every five years, that contained objectives and budget estimates for achieving those objectives and an annual report detailed how well the USFS met its RPA obligations. The President was to submit an annual policy statement with each five-year RPA update and, if any discrepancy existed, also submit a document that explained why budget requests fell short of what was believed to be necessary to achieve the goals contained in the policy statement (Hirt 1994, 259). Finally, because the RPA was supposed to be implemented in concert with NEPA, it contained stronger local foci and stronger public participation opportunities during the forest planning process (US Office of Technology Assessment [OTA] 1992, 1, 42).

However, the RPA was not enough to defuse the conflicts surrounding the accruing negative impacts from clearcuts. In response to the Bolle report, Church Report and *West Virginia Division of Izaak Walton League of America, Inc. v. Butz* decision, Congress passed the National Forest Management Act (NFMA, P.L. 94-588) in 1976. This act created a system for national forest management and planning designed to restrict clearcutting and increase public participation while including opportunities for appeal. Forests would be managed by a "smoothly running decision-making system under the direction of a professional and value-free administrative agency" (Hays 2007, 18). First, forest management plans had to be developed for all National Forest System units by 1985 and renewed every 10 years. These plans had to be interdisciplinary in scope. Furthermore, these plans had to "maintain viable populations of native wildlife species and natural vegetation diversity" (Hirt 1994, 244). The act also legalized clearcutting, subjecting it to restrictions where it was consistent with resource protection, enhancement or regeneration.

Superficially, the NFMA appears to be a compromise. While it allows for clearcutting, it restricts its use while simultaneously planning to restore and regenerate the forest environment. The resulting forest plans suggest the compromise was somewhat tilted. Forest plans crafted in the 1980s still prioritized wood production over the environmental concerns. Plans crafted between 1982 and 1992 “uniformly adopted unjustifiably optimistic assumptions to support high timber harvest targets” (Hirt 1994, 244, 265). Budgetary allotments for timber harvesting under the new RPA procedures were higher and closer to targets than any other USFS program. Under Reagan, the totals were higher and closer than under Carter, and in two years, actually exceeded RPA targets. Furthermore, the increased targets were not sustainable; according to the 1984 General Accountability Office, 93 percent of the USFS’s timber sales in the Rocky Mountain Region (Region 2, including Colorado) were below-cost for 1981 and 1982. In other words, the federal government was increasing the amount of money spent on timber harvesting on national forests and was losing money with each increase (Hirt 1994, 268-269, 279).

What brought the rise in timber harvesting to a halt was the listing of the Northern Spotted Owl in 1990. As an endangered species, the owl was entitled to federal protections. However, the USFS and BLM “believed they would win in court” until Judge William Dwyer decided against them. In 1991, he banned new timber sales in the owls’ habitat, which halted logging on 60,000 acres and postponed 80% of proposed timber sales on the west side of the Cascade Mountains (Vaughn and Cortner 2005, 200). Controversy ensued. While environmentalists and ecologists successfully employed lawsuits through the judicial branch, logging supporters seethed. They purchased bumper stickers that read “I Like Spotted Owls—They Taste Like Chicken,” “I Like Spotted Owls—Let’s Exchange Recipes” and “Kill a Spotted Owl—Save a Logger,” while sawmills threatened by the ban might hang plastic owls in effigy.

The controversy led to an increase in threats and violence directed at federal agents who managed the acres now off-limits. Although the courts certainly played a role in the dispute, the differences between federal and state/local/private objectives for forest management and recent developments in natural resource policy are historically and politically ingrained, making the field agents more convenient and likely targets.[28] For instance, President Clinton's response to the crisis was to shepherd the Northwest Forest Plan in 1994, which sought to provide predictable, sustainable timber outputs after the spotted owl crisis. However, timber harvest levels never met their average annual permissible sales quotients (PSQs) as detailed in the environmental impact statement (EIS) and by 2003 timber harvest levels were less than 25% of their 1980 levels (Charnley 2006, 5-9; Rapp 2007, 28). Federal environmental guidelines trumped state and local economic needs.

Helping to explain differences between federal and state approaches to forest management, Koontz (2002) found that different levels of government working in the same state tended to manage similar forest resources for different outputs. At the state level, emphasis was placed on economic drivers. State forests provided "much higher timber sales" than their federal counterparts, given their economic-based concerns and fewer legislated constraints and as evidenced by "substantially" higher budgetary allotments for providing timber (Koontz 2002, 188). States tended to have higher profit returns i.e. lower per unit costs and higher per unit returns. States also transferred "substantially greater revenue sums" to local governments than the federal government transferred (Koontz 2002, 188).

At the federal level, greater emphasis was placed on environmental protection and citizen involvement (see also Farnham et al. 2005). Concerning environmental protection, Koontz (2002, 188-189) found that federal forest managers took greater action regarding ecosystem-level management, rare species identification and protection, ecosystem research and monitoring and

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[28] PEER (2012a) prominently displays a quote from political strategist Frank Luntz of "Luntzspeak" fame: "Programs have friends, but bureaucrats do not, so focus your fire on the bureaucrats."

soil and watershed protection and improvement. Federal forest managers also spent more resources on soliciting and encouraging public participation and tended to receive more input from individuals favoring preservation whereas individuals favoring timber production were more likely to provide input to state agency officials and both preservation and timber groups reported similar abilities to influence federal and state officials, respectively (Koontz 2002, 189-190).

Federal laws and rules (e.g. NFMA, Planning Rule of 1982, etc.) force federal forest officials to abide by additional constraints, including mandating considerations for rare species protection, consideration of citizen input and options for providing timber, as compared to their state-level counterparts (Koontz 2002, 189). Even agency composition seems to reinforce the federal-state dichotomy. These laws, rules and mandates increase the likelihood that more non-forestry professionals will be hired to achieve objectives and their backgrounds, both professional and personal, will vary (Koontz 2002, 158-159). State forestry agencies lack the additional legislated constraints and heterogeneous employee demographics of their federal counterparts, resembling more of the federal forest agency from 1967 than of 2007 (Koontz 2002, 157).

However, given the time since Koontz's (2002) initial work, the political landscape facing federal agencies is different. Given the federal administration changes that occurred during the emergence of severe wildfire seasons through the 21st-century's first decade in Colorado, the federal emphasis on environmental protection and citizen involvement decreased given the additional incentives for timber production under the Bush Administration (e.g., the Healthy Forest Initiative of 2002, the Healthy Forest Restoration Act of 2003, etc.) while seeing an increase in protections during the first Obama Administration. For the Bush Administration, additional regulations reducing opportunities for citizen input, budget constraints and different incentives in those statutes are partly responsible (Vaughn and Cortner 2005, 218-223). For the Obama Administration, the protections are included in a new national forest planning rule, designed to replace the rule crafted in 1982 under the auspices of the NFMA.

4.2.3 Forest Politics

The "use vs. preservation" dichotomy[29] characterized the national political debates surrounding forest management as the Nixon Administration began in 1969, just as it had for decades before. The preservationists, bolstered by increased attention paid to and demand for outdoor recreation in the post-WWII era, fought for increased protections for national forests. The industry pushed for greater access to the resource as market conditions threatened its survival. The Nixon Administration found itself in the crossfire. President Nixon, aware of the movement's growing influence but also sensitive to his key business constituencies, (reluctantly) signed a number of key environmental bills into law, including the National Environmental Policy Act of 1969 on New Year's Day in 1970. He, however, showed little genuine respect for the movement, privately telling his Assistant for Domestic Affairs John Ehrlichman to "just keep [him] out of trouble on environmental issues" and that environmentalism was "overrated" and "crap for clowns" (Drew and Schlesinger 2007, 51-53). Although he requested his aide help him maintain the façade of concern, President Nixon's token devotion to the movement was not well disguised. For instance, when the President signed a bill to strengthen the Clean Water Act of 1967, Senator Ed Muskie (D-ME) was not invited to the ceremony, despite being the original

[29] The "use vs. preservation" dichotomy is a gross oversimplification. Pinchot, for instance, enjoyed elements preserved in nature, particularly walking under waterfalls. Muir became wealthy when he was given vineyards—lands in "use"—as part of a dowry. The reason the dichotomy survives is that is a very easy-to-understand model. Models are wrong, but they are useful.

sponsor of the Act (Drew and Schlesinger 2007, 52). The façade did little to help the President with scandals that eventually forced his resignation. President Nixon stepped down in August of 1974 but left several bills unsigned, including the RPA.

When President Ford assumed office, he was a Republican President facing a Democratic Congress. He inherited an office disgraced by scandal. One of his first dilemmas was whether or not to sign the RPA. Political considerations factored into play. The bill, in part, allowed the legislative branch to more strongly influence budgetary procedures regarding forest management. One provision in the RPA is that the USFS was to establish management objectives for the national forests, develop corresponding budgets to achieve those objectives and then report back to Congress, essentially sidestepping the executive branch. Another provision required the President to submit a policy statement with the five-year update and a separate explanation if a budget request was less than what was needed to accomplish objectives within the policy statement—an additional requirement forced onto the executive branch by the legislative branch. However, despite some apparent reluctance and contrary to the advice of the Office of Management and Budget, President Ford decided to sign the bill regardless just a few days after President Nixon's resignation rather than defy the Congress. The only hint of President Ford's reservation was a single sentence contained in his signing statement (Hirt 1994, 258-259; Ford 1974).

The remaining years in the Ford Administration were contentious years for national forests and public lands. Not long after the RPA was passed, the *West Virginia Division of Izaak Walton League of America, Inc. v. Butz* decision threatened to end clearcutting on national forests. An effort was made to circumvent the 1897 Organic Act. The USFS had hoped to simply repeal the Act in order to maximize its discretion. Environmentalists wanted a bill with stronger protections included. The timber industry wanted to focus on timber harvesting and wood production and sought to reintroduce a new version of the Timber Supply Act of 1969. The USDA and the OMB had irreconcilable differences so the Ford Administration could not assemble its own bill and was reduced to commenting on proposed legislation. The resulting NFMA did repeal the Organic Act of 1897 but replaced it with a bill that was far more prescriptive. During the same year, Congress also passed the Federal Lands Management Policy Act (FLPMA), which retained public domain lands under Federal ownership. The resulting backlash ignited a fourth Sagebrush Rebellion (after the irrigation, forest reserves and grazing rebellion, which lasted from the mid-1930s through the mid-1940s—see Graf 1990) emerged and demonstrated against what was perceived as a heavy-handed, environmentalist-favoring federal overreach (Hirt 262-263; Vaughn and Corner 2005, 14; Cawley 1993, ix, 1-9; Godfrey 2012, 306).

The late passage of both NFMA and FLPMA left implementation to the Carter Administration. The Carter years were no less contentious than the previous administration. For instance, the Administration tried to complete RARE II, which was assailed by both sides of the wilderness issue. Furthermore, Congress in 1977 enacted steep agency budget cuts, including the USFS. Congress also only required the USFS to fill three out of every four open positions. What followed was a scramble by the agencies to do more with less in the face of increasingly complex land management policies and regulatory obligations. Foresters and business managers were less in demand as the new policies required the agency to hire more “ologists” – a term still used contemporarily – that includes biologists, hydrologists, ecologists, etc. and related specialists like landscape architects and social scientists. The complexity, costs and inefficiencies led to a “crisis of confidence” in government, which helped usher in the Reagan Administration (Godfrey 2012, 303; Vaughn and Cortner 2005, 15).

The Reagan Administration attempted a full-fledged rollback of the environmental regulations enacted during the prior two decades. However, instead of targeting legislation, the Reagan Administration focused more on personnel and budgets. To help, President Reagan selected John Crowell to be assistant secretary for the USDA, which included control over the USFS. Crowell was formerly a general counsel to the Louisiana-Pacific Timber Company, which was the largest national forest timber purchaser and his appointment was seen as positive from industry. However, to enact Reagan’s changes required navigating several obstacles. First, Congress was divided and political efforts from both sides stalemated. Additional steep budget cuts severely impacted the USFS, including Region 2. The country faced a severed economic recession in 1982. The gridlock, lack of direction and financial crisis eroded morale, reduced the size of the agency and led to infighting within the USFS. Public trust in the USFS fell to an all-time low. Given the economic recession, the timber sale contact buybacks made by the USFS, the 80% drop in national forest timber sales that occurred after 1985 and the increasing attention paid to below-sales timber contracts, the USFS suffered real budget declines and the agency’s budget became “embroiled in unprecedented controversy” (Godfrey 2012, 306-307; Vaughn and Cortner 2005, 14-15; Hirt 1994, 266-281; Hays 2007, 59; MacCleery 2011, 48).

Strengthened environmental protections came with the Clinton Administration on the heels of the spotted owl controversy. President Clinton appointed Jack Ward Thomas, a wildlife biologist, to head the USFS. His tenure began with a push to rebuild confidence in the USFS but had trouble translating that push into discernible achievements, partly due to the influences within the executive and legislative branches. Clinton’s pledge to hold a summit after the election on the spotted owl habitat, under Thomas's watch, led to the Northwest Forest Plan in 1994, an attempted compromise for the logging and environmental communities. However, Pacific Northwest timber harvests were restricted to one-fifth of the remnant old growth areas and harvested volumes would not exceed 25 percent of the highest harvests made during the 1980s. An attempt by the Clinton Administration to create a Roadless Rule created considerable controversy and took over a decade to resolve (Hays 2007, 59; Hirt 2004, 291-292).

Simultaneously, as the forests were coming under greater protections, they were starting to burn more often and were becoming more destructive. The 1994 wildfire season was the first season to incur more than $1 billion in suppression costs. But the fire season in 2000 were more massive and destructive. The Clinton Administration developed a series of recommendations called the National Fire Plan, which attempted to reduce wildfire risk with attention paid to the wildland-urban interface; Congress followed the plan with a nearly $3 billion infusion to help the Plan achieve its objectives. Environmentalists supported the plan largely to help deflect criticisms that their protections had led to the fires originally (Pyne 2010, 52-53; Vaughn and Cortner 2005, 122, 129).

The fires would continue, highlighting the transition from the Clinton Administration to the Bush Administration. The 2002 fire season saw records broken in four southwestern states, including Colorado. For example, the Hayman Fire began burning in June 2002, scorched almost 138,000 acres and cost over $200 million in damages and suppression costs, with additional costs accruing annually at over $22 million. Governor Owens of Colorado remarked on national television that all of Colorado was on fire and that the state looked like it had experienced a nuclear winter. In reality, less than 1% of the state's acreage had burned, but the comment helped spur a nearly $2 billion loss in tourism revenue, one of the state's largest industries and sources of revenue, as confirmed visitors and vacationers called to cancel their reservations (Lynch 2004, 46-47).

With the wildfires creating a sense of urgency, the Bush Administration developed the Healthy Forests Initiative (HFI) in 2002, which attempted expedite hazardous fuels reduction efforts by restricting appeals, analysis and litigation. Congress soon followed. Representatives Greg Walden (R-OR) and Scott McInnis (R-CO) introduced the Healthy Forests Restoration Act of 2003 (HFRA, P.L. 108-148). Complementing the President's HFI, the HFRA was significant for its efforts, albeit unfunded or in part reliant on duplicitous funding transfers, to reduce forest fuel loads and also for its provision to promote a forest biomass industry through Title II, the HFRA sailed through the House within a month by May and was passed by the Senate near year's end. Fires in California may have helped expedite the Senate's work (Vaughn and Cortner 2005, 1-2, 161-162, 171). Other conflicts emerged when Congress and the Bush Administration pushed efforts to roll back the Clinton Administration's roadless rule and to update the national forest planning process. Both efforts engendered considerable controversy and subsequent litigation.

While the roadless rule issue was largely resolved by the judicial branch and a new national forest planning rule was established during the first Obama Administration (with a lawsuit filed by industry groups in August 2012), the wildfire threat persisted. The 2012 fire season was the most expensive in Colorado history. Property losses alone were over $500 million. Six people lost their lives during the Lower North Fork, High Park and Waldo Canyon

Fires. Combined with intense partisanship and polarization, record Congressional deadlock[30] and a weak national economy, hopes for quick and lasting solutions faded. The end of the first Obama Administration left a forest health problem in desperate need of a solution.

4.3 Searching for Policy Windows

Having applied the Multiple Streams Theory to the years 1973-2012, the next step is to look for policy windows. The search should first look for instances where attention towards a particular issue increased significantly. Quantitatively, this increase should be a spike in the total number of articles written about a particular issue. The best way to observe this spike is to count the number of articles written about the issue over an extended period of time, at least a decade, and then look for dramatic increases or spikes in the tallies.

For this project, forestry-related keywords from the *Readers' Guide to Periodical Literature* ("*Guide*" henceforth) were identified (see List of Keywords). Part of the identification process involved looking for words that were used repetitively in newspapers, magazines and peer-reviewed journals. Then the analysis looked for each keyword in each year of the *Guide*. Forestry-related article titles were first tallied between 1973 and 2012. Articles were then coded based on their titles' tone. An article that sounds positive from the perspective of the pro-FBU perspective was coded "positive," titles that an FBU-proponent would not have been happy to see were coded as "negative" and titles where the tone was either unclear or showed both positive and negative connotations were coded "neutral." Normally, this approach will use two or more evaluators analyzing the same lists of article titles. However, given the analysis was

[30] Just prior to the 2012 election, the 112th Congress had passed 173 bills, the lowest rate of any Congress since World War II, when the total number of bills passed started to be tracked (Weisman 2012). The 113th Congress was on schedule to produce even less than the 112th Congress at the time of writing.

performed solely by the author, two passes were made by the author but each pass was separated by a period of one year. Over 4,000 articles were identified, counted and coded. The amount of agreement between the first and second tallies was substantial, exceeding 99.7 percent. Final counts and coded tallies are shown in Table I.1 in Appendix I.

While the table contains the data, gleaning any spikes may be difficult. For ease of comparison, the figures are better comprehended if presented graphically (see Figure 4.4).

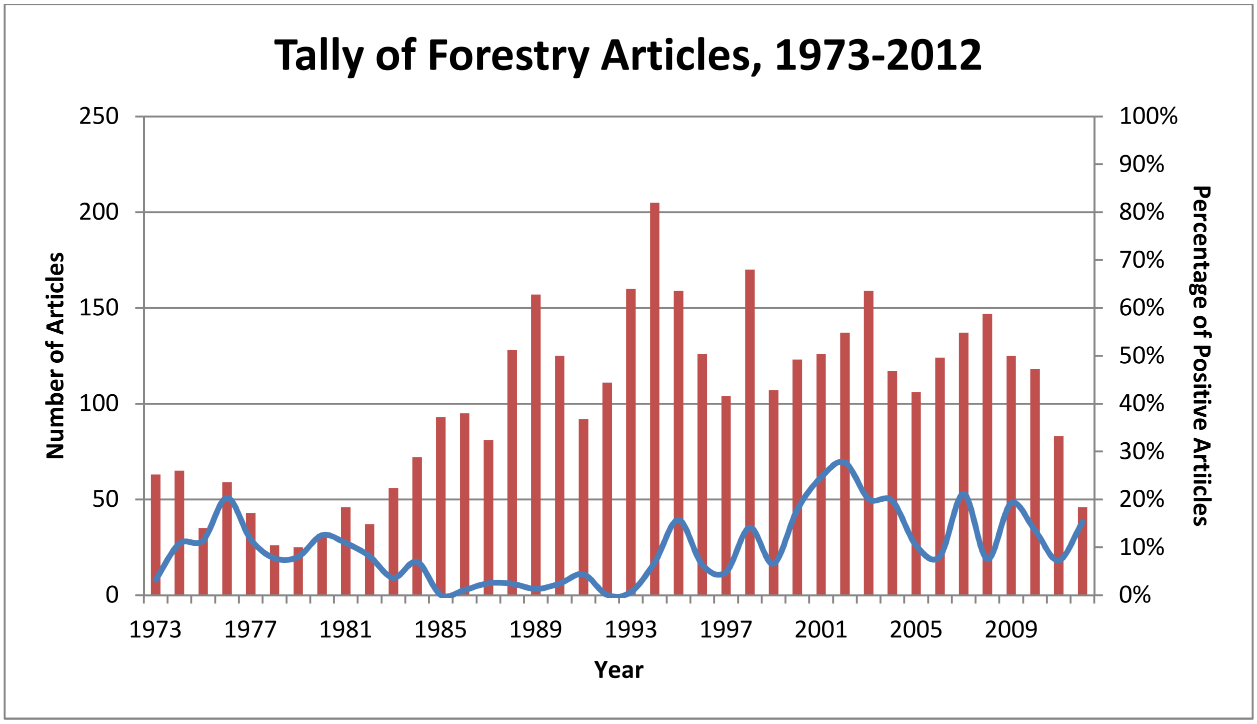

Figure 4.4: Forest-Related Articles, Counted and Coded

Source: Author's compilation from the Readers' Guide to Periodical Literature, 1973-2012.

On the left hand y-axis are the counts of articles. Each increase in the bar indicates an article observed under a keyword in the *Guide*. On the right-hand y-axis is the percent of articles whose titles displayed a positive tone. The Percent Positive Tone is low and conspicuously so as compared to other efforts (e.g. Baumgartner and Jones on nuclear energy, etc.). The reason for the low percentages is that the articles written about forestry in the popular literature contained significant numbers of titles that appeared unrelated to FBU, neutral or contained both positive and negative elements when viewed through the narrow pro-FBU perspective. An article discussing increased harvest rates in the Amazon rain forest in 1999 (keyword: deforestation) would not necessarily directly address FBU in the United States, although the media coverage may bring additional attention to domestic forest management and wood product consumption issues. A refinement may be in order.

Given what Pyne (2010, 53) identified as the increased significant impacts from wildfires in the Western United States beginning in 2000, one may suspect that a substantial amount of attention focused on fire during the past 15 years. One should expect to observe a punctuation starting in 2000 and see lower totals prior to the year 2000. If wildfire was as significant as Pyne suggests, a spike or series of spikes should appear. Attention increases are significant in that they could give pro-FBU policy entrepreneurs the issue saliency (or “policy window” or opportunity) to link their forest energy solutions to the wildfire crisis. Refining the data so that one looks at only the *Guides’* forest fire and wildfire keywords over the 1973-2012 would show what attention was paid to fire over the past 15 years. The data for this refinement is presented in Table I.3 in Appendix I and graphically in Figure 4.5.

Of interest is the increase in attention to fires beginning in 2000 and lasting through 2004 and spiking again in 2007 and 2008 as indicated by the larger number of articles. The punctuation’s timing makes sense. The increase in media attention starts in 2000, a year with the first perceived uncontrollable major wildfire outbreak and where the number of acres burned exceeded 7 million for the first time since 1963. The next major year for wildfires occurred in 2002. Oregon, New Mexico, Arizona and Colorado all had record-breaking losses related to forest fires. The nation saw wildfires consume another roughly 7 million acres. The articles coded retained a positive tone as the titles suggested action could improve forest health and reduce wildfire risk and damages by increasing forest management activity and residue use. The year 1998 presents a special case: why did a spike in attention exist in 1998?

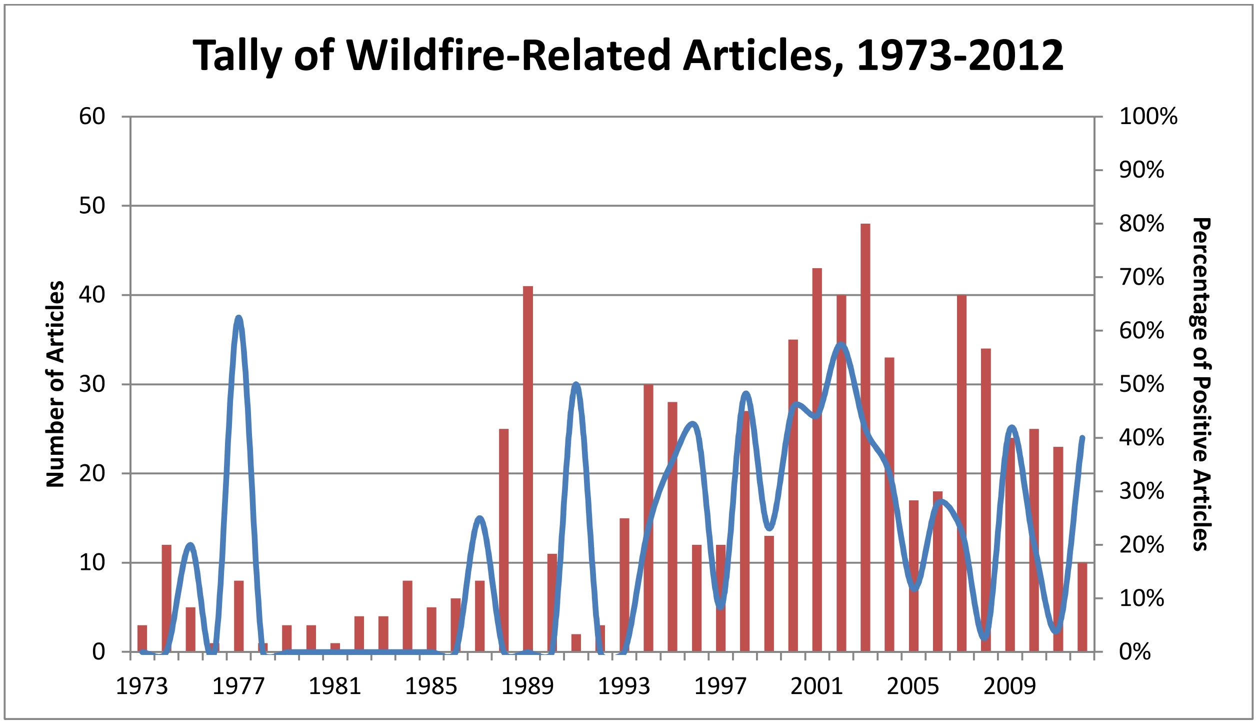

Figure 4.5: Wildfire-Related Articles, Counted and Coded

Source: Author's compilation from the Readers' Guide to Periodical Literature, 1973-2012.

Three factors were identified based on article titles. First, wildfires in Florida erupted. The final tallies showed over 500,000 acres burned, $133 million was spent on fire suppression, over $600 million lost in tourism revenue and the state sustained nearly $400 million in losses from over 330 homes and over 30 businesses that were destroyed (Word 2006; Federal Emergency Management Agency 2011). Second, 1998 was the 10-year anniversary of the Yellowstone fire. Third, many articles were written about threats to the Amazon rainforests as the rate of deforestation increased after the experiencing three consecutive years of decreasing (Butler 2014). However, while the increased attention to forest loss, particularly to Florida and

Yellowstone were substantial and would have made the public sensitive to wildfire, sustained media attention (more than two years of consecutive years of high media attention) paid to wildfires did not begin until 2000.

4.3.1 Congressional Attention

To triangulate the data from the media accounts, one can also search for venue shopping. Venue shopping is when policy entrepreneurs “shop around” for a hospitable venue or venues in which to propose attaching their favored solution to a problem or problems. For the purposes of this paper, congressional committees and subcommittees were the targeted venues. If pro-FBU proponents are seeking to change policy, then one should see an increase in the number of congressional hearings at the committee and subcommittee levels. Conversely, if FBU proponents are enjoying a policy monopoly, then the number of hearings should be small as the proponents are able to keep competing policy ideas off of the government agenda.

Using the ProQuest database of Congressional documents, searches compiled tallies of the number of Congressional committee hearings pertaining to forests using the “forest*” keyword. Tallies of the committee and subcommittee hearings are shown below in Table 4.2. For easier comprehension, Table 4.2 results are displayed in Figure 4.6. Examining Figure 4.6, several “spikes” exist. The first period of heighted Congressional attention occurs during the 1970s during the clearcut controversies and shift to increased regulations regarding forest planning. A second spike occurs in the early 1990s, which makes sense given the combined attention paid to the Northern Spotted Owl and the subsequent Northwest Forest Plan. Nationally, several problems emerged at nearly the same time. Pyne noted that a new era in wildfire started with the 1994 wildfire season. In Colorado, the mountain pine beetle epidemic began at roughly the same time. An economic boom in the late 1990s encouraged growth, with increased development in the wildland-urban interface (WUI). A smaller pike occurs in 1998, which one might expect given the three causes mentioned previously. However, given the attention paid to wildfires in the media earlier, one would expect attention to remain high or even increase. Rather, given the lower totals, one may wonder what percentage of these Congressional hearings from 1998 to 2012 was related to wildfires.

Table 4.2: Annual Congressional Committee and Subcommittee Hearings Tallies on Forestry, 1973-2012

Year	Totals
1973	82
1974	52
1975	77
1976	57
1977	102
1978	72
1979	94
1980	61
1981	69
1982	79
1983	88
1984	76
1985	72
1986	63
1987	84
1988	78
1989	87
1990	88
1991	83
1992	63

Year	Totals
1993	102
1994	80
1995	81
1996	53
1997	62
1998	69
1999	74
2000	67
2001	44
2002	53
2003	47
2004	35
2005	29
2006	24
2007	41
2008	30
2009	25
2010	22
2011	31
2012	26

Source: ProQuest's Congressional Publications database (1973-2012).

Filtering the forestry-related hearings for those committees and subcommittees focused on “wildfire*” provides a clearer idea of Congressional focus. The findings are presented in Table 4.7. The chart shows that Congressional attention i.e., the number of hearings focused on wildfires did increase, beginning in the year 2000. As wildfire seasons increased in their intensity, duration and severity, so too did the number of hearings. The drop in 2005 is conspicuous but may be explained that over half of the acres lost (~4.4 million) were in Alaska (National Interagency Fire Center [NIFC] 2006) and not as visible as if the wildfires had occurred in a more populated area, like Malibu or the Colorado Front Range.

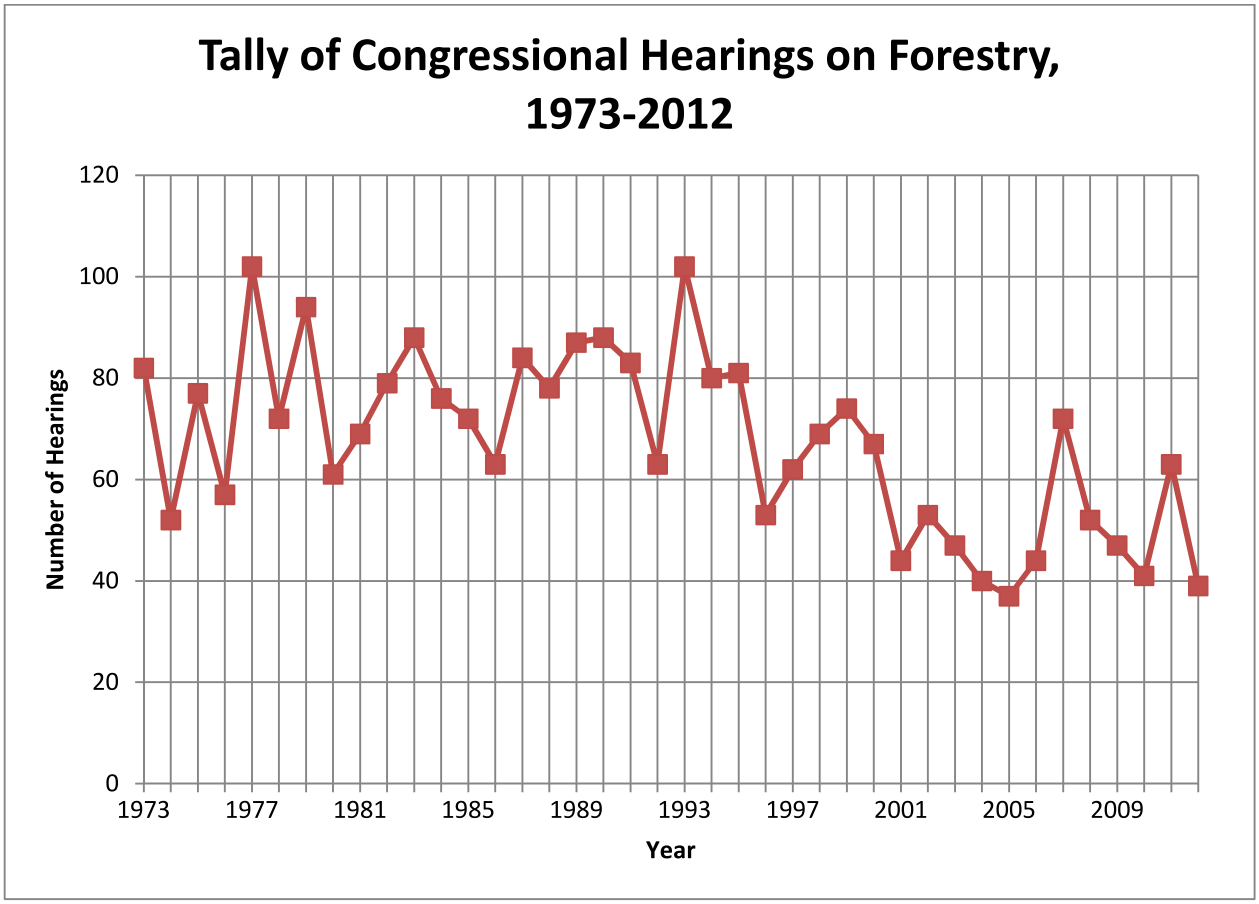

Figure 4.6: Congressional Hearings on Forestry, 1973-2012

Source: Author's compilation from ProQuest's Congressional Publications Database, 1973-2012.

4.4 Analysis

The question remains: was Congress paying more attention to the wildfire issue as the amount of attention paid to forestry decreased? One way to answer this question is to compare the percentage of hearings dedicated to wildfires versus all other forestry-related Congressional committee and subcommittee hearings (see Figure 4.8). What the chart shows is that, yes, Congress was paying a proportionately greater amount of attention to wildfire than other forestry issues beginning in the year 2000.

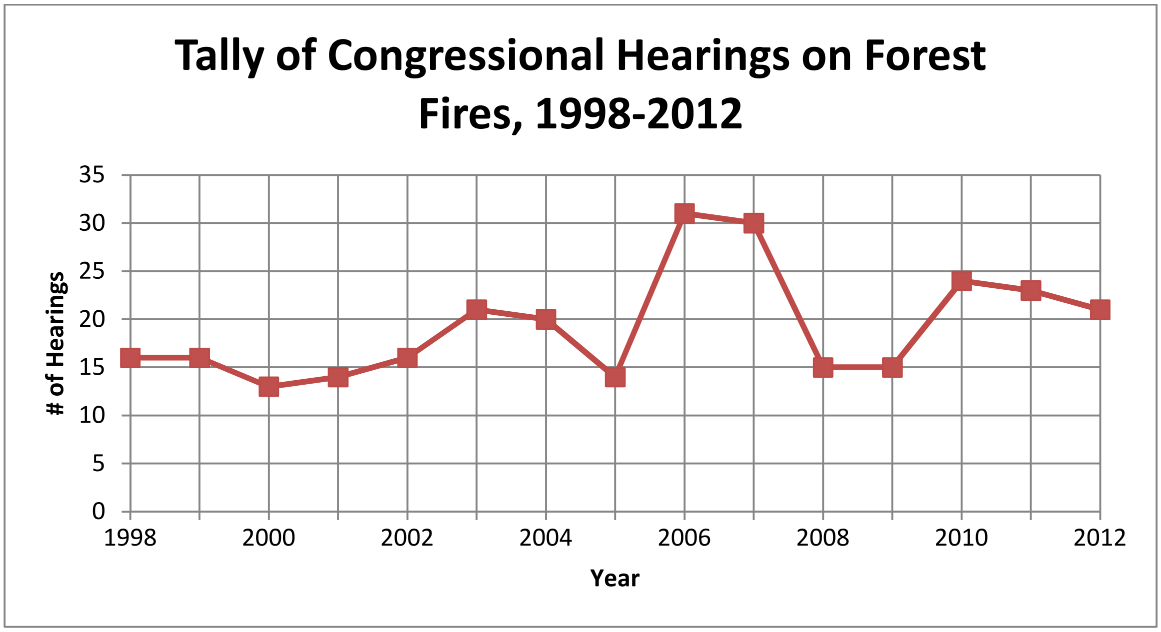

Figure 4.7: Congressional Hearings on Forest Fires, 2000-2012

Source: Author's compilation from ProQuest's Congressional Publications Database, 1998-2012.

What this chart suggests is that Congress was facing greater pressure to act on wildfires. This chapter began with a summary of tensions surrounding forest management. Those tensions still exist. The amount of attention paid to wildfires, including their impacts and their costs, suggests that those impacted, particularly western states with disproportionately larger percentages of their acres designates as federal forests, were clamoring for help managing the federal forest wildfire problems in their backyards. Beginning in the year 2000, FBU-proponents would have seen a policy window open courtesy of the wildfire outbreaks occurring in proximity to populated areas.

4.5 Chapter Summary

The history of forest management in the United States is punctuated with conflicts between local resource users and distant resource managers. Early timber conflicts pitted colonists against the British monarchy.

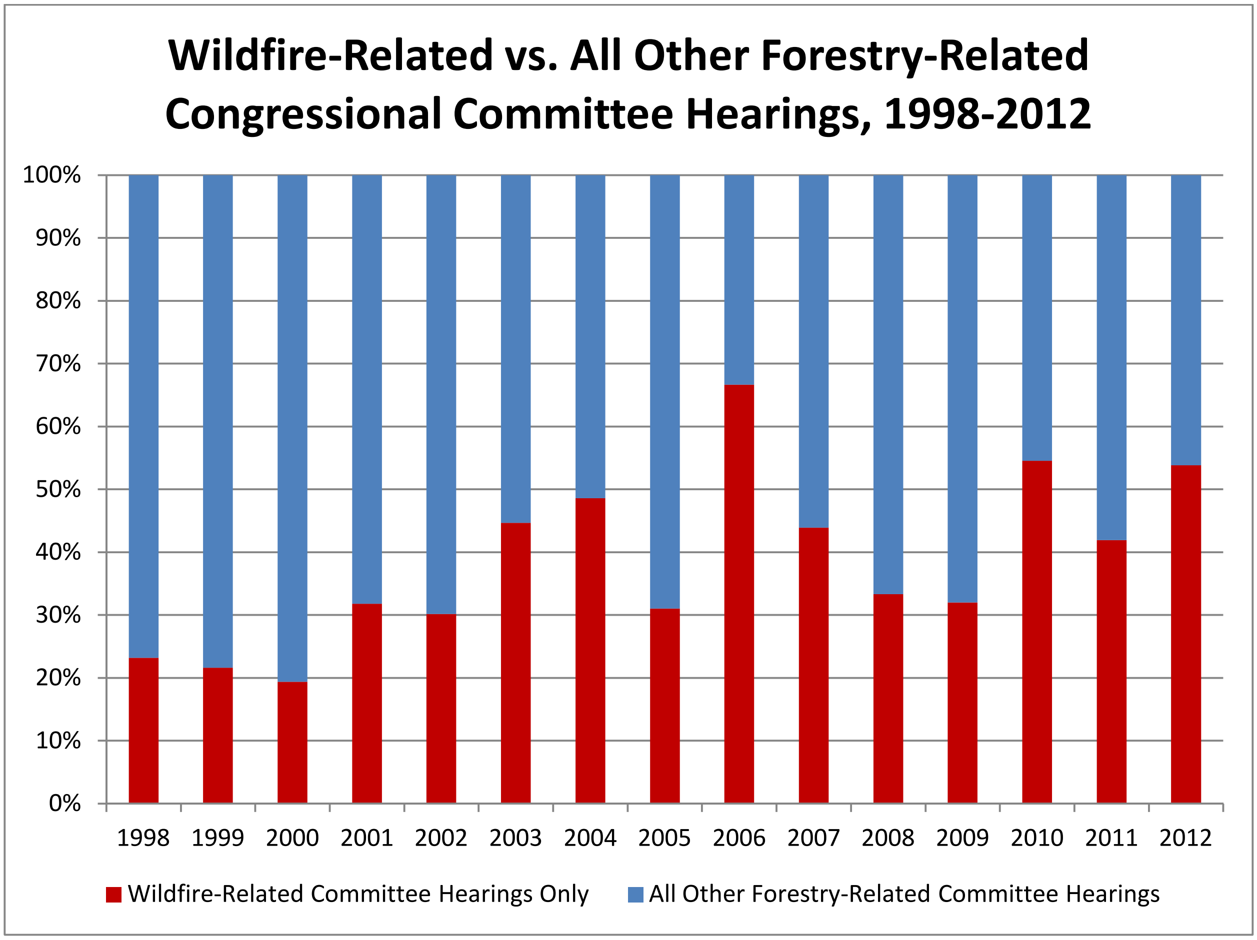

Figure 4.8: Wildfire-Related vs. All Other Forestry-Related Congressional Committee Hearings, 1998-2012

Later conflicts pitted local timber users against national or regional resource managers. Beginning with the 21st century, the pressures created by a century's worth of fire suppression erupted. The political conflicts, compounded by the physical problems impacting the national forests, created conditions ripe for widespread conflagrations and widespread constituent dissatisfaction with far-reaching consequences, geographically and temporally.

The chapter began with an account of tensions between distant centralized authorities or powers and state/local actors. In the early part of the 21st century, the wildfire seasons were particularly disastrous and affected those state actors dramatically. The number of media accounts increased during the worst fire seasons that impacted populated areas. Congressional attention tracked the increased media attention as solutions were sought for the wildfire crisis. Beginning in 2000, forest energy entrepreneurs would have been able to seize the momentum to begin linking their solutions to the perceived national crisis.

CHAPTER 5: ENERGY POLICY AND FOREST ENERGY

"Woody biomass is a natural for us here in Colorado. It's a low cost, renewable energy source that will keep forests healthy at the same time."

Jeff Forte, Chief Executive Officer of Colorado Springs Utilities, on how the company views forest energy (Colorado Springs Utilities 2012)

5.1 A Brief History of Energy Use in the United States

Energy in the United States appears to be slowly returning to its roots, at least in part (Heal 2010). Initially, the nation was heavily reliant on its forests for energy, including firewood and charcoal. As the nation expanded and demands for energy increased, additional sources were discovered, developed and depleted. Newer technologies that offered greater energy per unit volume, or greater energy density, or offered more convenience gradually replaced those technologies that were more labor and time intensive. One of the more recent and significant transitions has been the emergence of non-renewable energy sources, including coal, then petroleum, followed by natural gas and then nuclear energy. However, as domestic supplies of these non-renewables began to shrink and some of their unintended environmental consequences accrued, reliance on imported fossil fuels and alternative and renewable technology development began to increase. The more recent gas price spikes (see Chapter 1) suggest that continued dependence on fossil fuels is, for many reasons, unsustainable.

What is most conspicuous is how the United States and Colorado are responding. Both appear to be increasing their dependence on renewable energy sources, including wood (often paired with forest management and forest health concerns), as recently promulgated legislation attempts to promote alternative, renewable energy projects, such as forest energy projects among many other technologies, for electricity generation, creating thermal energy and liquid fuels synthesis. Essentially, the nation and the state appear to be making a turn towards those low-carbon emission technologies, after some contemporary technological advances, upon which the nation was, in part, founded. However, given the substantial contributions from fossil fuels, the high-carbon emission technologies will continue to be part of the nation's net energy portfolio for decades to come.

5.1.1 Energy Use in the United States to 1858

No single energy source has ever or currently is able to meet the United States' energy needs. Even prior to Euro-American settlement, indigenous cultures relied on a diversified energy portfolio. For instance, archaeological evidence suggests that people were present in the Colorado area well before statehood. Substantial amounts of energy had to be exerted (i.e., muscle energy) for migrating and for hunting and gathering. Earlier cultures could take advantage of waterways as highways for transporting people or material. Native Americans also needed energy for heating and cooking. Wood made an excellent energy source and would most likely have been predominantly smaller-diameter material given the lack of suitable tools for harvesting larger-diameter stems. Charcoal remnants collected at Native American sites from 6,000 years ago from along Colorado's Palmer Divide were small-diameter material, with very small, branch-like pieces of ponderosa pine, pinyon pine and Douglas-fir constituting the preserved fuel residues (Eckhoff and Mackes 2006).

For Euro-American settlers, Dukert (1980: 13) noted that: "If England was 'built on an island of coal,' her upstart colonies…were perched along the edge of what must have seemed like a continental forest." The perceived endless forests encouraged exploitation and wood became the nation's primary energy source (see Figure 5.1). The largely unchecked harvesting spurred a profligate approach to forest management and forest energy. Colonists built fireplaces that were twice the size of those in England. New England schoolhouses consumed large quantities of firewood, since they operated during the winter when the fields did not require tending. The surrounding residents, however, resented the responsibility of supplying the raw material for schools and churches. Reverend Samuel Paris, who presided over the Salem Witch Trials, enraged his parishioners when he repeatedly berated them for not supplying his house with adequate fuelwood (Burns 2005: 72-73).

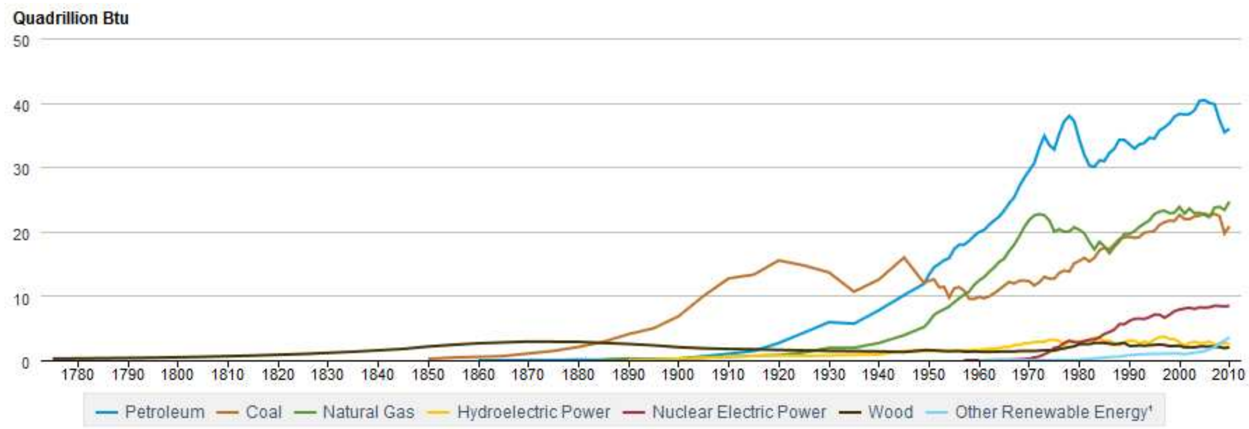

Figure 5.1: U.S. Primary Energy Consumption Estimates by Source, 1775-2011

Source: USDE EIA (2012a).
Note: USDE EIA (2012b) shows wood use data for the U.S. dating to 1635.

The growing colonies harvested trees faster than the forests could regenerate. As a result, people had to exert more of their muscle energy to transport fuelwood over the greater distances. As a result, the price for fuelwood increased; in one instance, prices increased so much that as early as 1730, Boston, Massachusetts, ironically was forced to import English coal. The widespread use of the large, inefficient fireplaces contributed to the rapid deforestation; most of a fireplace's heat leaves through its chimney. Large amounts of wood had to be consumed in order to warm a room, especially since they were often built with leaky, log walls. Some attempted to make fuelwood consumption more efficient. In Philadelphia, Benjamin Franklin (1744: 1-2) wrote a pamphlet promoting his “Pennsylvanian Fireplace” (a.k.a. the Franklin Stove) and noted that over the past century, wood that initially could be harvested near a person’s front door “must now be fetch’d near 100 miles to some towns, and makes a very considerable article in the expense of families,” especially given that these families needed home heating for at least eight months of the year. Conversely, some of Franklin’s contemporaries building homes further inland would build fires with the proximal fuelwood that were so large that the doors (and even windows, when available) were opened in the dead of winter just to alleviate the excess heat. (Burns 2005: 72-74; Dukert 1980: 14).

While the increased transportation distances caused fuelwood prices to increase, they also, however, helped spur the transition to non-muscle energy use. Major urban centers were port cities. Raw materials, including fuelwood, could be shipped downstream, taking advantage of currents. However, barges hauling loggers and supplies had to move against the flow i.e., transporters had to expend energy to overcome the currents. Initially, the problem was overcome by using muscle power, usually draft animals towing the barge using rope. Later, steam engine technology, by boat and then by rail, drastically reduced the need for muscle power as the machines could sustain travel for longer periods of time.

Wood, however, was not the only energy technology. Revisiting Figure 5.1, the chart shows wood as the only fuel source in early U.S. history. The reality is a little more complicated as U.S. energy development history has been “dispersed geographically,” “largely spontaneous” and “pluralistic” (Dukert 1980, 6). Coal would come of age in the middle of the nineteenth-century, it had been an energy source for quite some time before. Coal was discovered in early 18th century Virginia and the first significant commercial-scale quantities were mined near present-day Richmond. However, although its use for energy was “virtually nil” by the time of the American Revolution, it was actively sought for manufacturing, particularly cannons and other munitions and also converted to coal-gas illuminant (Dukert 1980, 15, 17, 25-26). Waterpower was principally the domain of northeastern states after Samuel Slater famously smuggled plans for the United States' first textile mill from England, who was reluctant to share its technology. Liquid fuels also start to emerge during this time. Natural gas ("gas") was available but was difficult to harness and use since the infrastructure was lacking. It was more frequently regarded as a hazard associated with oil drilling or even a curiosity. Most of the time, the gas was either used on-site, if possible, or it was flared or burned in place. However, the breakthrough in natural gas occurred in Baltimore, Maryland, in 1818. Rembrandt Peale used it to illuminate a museum at night, not coincidentally close to where the city council met—he soon after won a municipal contract to provide lighting for city streets in the area (Dukert 1980, 26).

However, because of its celerity, the dominant approach to land management for the early county was slash-and-burn, with energy use in the United States being primarily, but not exclusively, limited to muscle power and wood. These resources were cheap (i.e., "sparing of man-hours"), accessible, familiar and easy-to-use. Muscle power came in the form of colonists, animals and slave labor. Wood was initially plentiful and proximal through abundant and seemingly limitless forests. Over time, other renewables were used, including wind and water (e.g., Slater's mill in 1798). Non-renewables were also used but not nearly to the extent they would be after the mid-nineteenth century (Dukert 1980, 15).

5.1.2 Energy Use in the United States from 1858 to 1930

Westward expansion increased the speed at which Euro-Americans consumed their forest resources. As a result, wood became less available due to consumption, less convenient as Euro-Americans reached the Great Plains and new energy sources were needed. At the same time, the move westward also increased the distance from more convenient waterways (the ocean; frequent, large rivers, etc.) so new forms of transportation were also needed. Steampower, now no longer merely a curiosity could help with both problems.

Steamboats emerged during this time period. Traversing waterways lined with trees, the primary fuel source. Railroads were developed and the steam locomotives also relied on wood located near the lined tracks. After 1840, however, forest depletions caused wood prices to increase, putting coal prices on a more equal footing. Subsequently, around 1850, coal use became more significant and by 1885, 35 states were producing it. Other fossil fuels followed: petroleum was discovered in Colorado in 1860, and all states except Hawaii were producing it by 1885. As the production of these substitute fuels increased, wood consumption for energy in the United States started to decline by about 1870, although wood-burning would remain significant for several decades. More fuelwood was consumed in the United States in 1885 than in 1845. As the population doubled and the per capita energy use doubled, essentially, quadrupling the nation's energy demand between 1880 and 1918, the per capita cordwood consumption declined from nearly three cords to less than one during the same time period. Wood was falling out of favor (Dukert 1980, 23-24, 35, 46; USDE EIA 2008b; Scamehorn 2002, 43).

As Euro-Americans moved west to what would eventually become Colorado, they began an energy transformation; Dukert (1980, 32) argues that the railroads were "pivotal" for what became the "nation's switch from wood to coal." The switch was necessary primarily because of the lack of convenient, cheap wood in the middle of the country. Wood available in the Rocky Mountains would help delay the switch to coal but the change to coal, which can contain up to four times the amount of heat energy as the same weight of premium hardwood firewood, was inevitable for the Centennial State. Coal became the dominant source of energy in Colorado by about 1890 but wood would continue to play a supporting role as shown in Figure 5.2 (Dukert 1980, 32-33; Scamehorn 2002, 1).

In addition to its physical properties, coal had as a chief supporter David Moffat, a founding member of the First National Bank of Denver and became a “pioneer elite” (Wyckoff 1999, 247).

Figure 5.2: “Timbering of a Slope”

Source: History Colorado, the Colorado Historical Society (1890)
Note: This William Henry Jackson photograph was taken sometime between 1890 and 1900. Note the extensive use of wooden support timbers.

His vision for the northwest part of the state led him to assess the area’s potential for economic development about a decade after coal surpassed wood. By developing the railroad infrastructure, not only to facilitate agricultural exports and travel between Denver and Salt Lake City but also to tap the region's potential six billion tons of accessible coal, the idea seemed sound, at least to Moffat. He began financing the development of the state's northwest region's mineral potential by funding the start of the Denver, Northwestern and Pacific Railroad. However, the endeavor was more expensive than anticipated, the project ended as the line reached Steamboat Springs and Moffat died in 1911, penniless (Wyckoff 1999, 247-249).[31]

While Moffat did not fare well, coal, however, did well in the state, particularly in the 1870s, with the large influx of cheap labor from southern and eastern Europe, and again for the roughly first 20 years of the twentieth century. But the success came at a price. Labor conditions were oppressive and strikes were commonplace. The Colorado General Assembly established a State Board of Arbitration in 1897 to help mitigate disputes and avoid strikes. The main problem for the Board was that either side could choose to ignore it. The failure to find an equitable means for resolving disputes contributed to the massacre at Ludlow on April 20, 1914. At that event, a twelve-year old boy was shot and killed, one militiaman sent in by the state was killed, the leader of the Ludlow strikers was shot in the back after having a rifle butt smashed over his head and, perhaps most horrifically, two women and eleven children were killed when they took cover in shallow pits under a tent that was eventually set ablaze and asphyxiated them. By the end of the event, eighteen strikers, several militiamen and National Guardsmen and several others, including at least one unlucky onlooker were killed. Although the extreme violence of the event would not be repeated in Colorado, the discord between employer and employees would

[31] Mining towns were frequent subject to boom-and-bust cycles. Mark Twain once allegedly described a mine as "a hole in the ground owned by a liar" (Hammond 1935, 97).

not resolve itself anytime soon and was further exacerbated by the replacement of coal with other fossil fuels (Scamehorn 2002, 10-19; Andrews 2008, 271-273).

Other fossil fuels gained prominence during this era. The same year that explorers discovered gold in Colorado, another discovery in Pennsylvania would help jumpstart the push for liquid fossil fuels. Edwin Drake, after nearly going broke and enduring the relentless taunts from onlookers, struck oil in Titusville, Pennsylvania. Drake had been looking for a substitute for lamp oil as illumination fuels at the time were expensive, dim, smoky, smelly and/or explosive. The trick was to find a liquid fuel source that was dependable and could more easily be refined into a kerosene-type replacement at reasonable cost. The next year, in September 1860, crude oil was discovered just outside Cañon City. Initially, it was sold as lamp oil and also used as a lubricant or sold as medicine. Efforts to explore and discover additional oil fields increased; for the first two decades of the 20th century, Florence, Colorado, was the seat of the state's most productive oil fields. During the same time, Boulder, Colorado, was a hotbed for drilling speculation (Dukert 1980, 38-39; Scamehorn 2002 43-58).

This search for oil was "fueled" in part by the invention of the "horseless carriage" or automobile. In 1900, the U.S. had about 8,000 cars, but that number increased to nearly half a million ten years later. In Colorado, the state recorded over 13,000 cars in 1913 and that number increased to just over 300,000 by 1930. As a result, annual gasoline consumption in Colorado increased from 5.8 million gallons in 1913 to nearly 180 million gallons in 1930. However, by the start of the Great Depression, the increasing consumption would falter as supply outpaced demand, and expansion would not resume until World War II (Scamehorn 2002: 59, 70, 154).

By the time of the Great Depression, coal had lost its position as primary energy source for Colorado, replaced by liquid substitutes. Although coal had supplied over 90% of the energy demand in Colorado in 1890, that percentage dropped to 58% by the end of the 1920s. Conversely, petroleum and natural gas shared 5% of the fuel energy market in 1900 and enjoyed a combined share of 32% by 1930, almost entirely at the expense of coal (Scamehorn 2002, 18).

Meanwhile, electricity and hydropower emerge during the late 1890s through the early part of the decade. A number of international expositions featured electric exhibits; President Grover Cleveland was present to activate one of the demonstrations. At another exposition in 1901, the electricity demonstrations were powered by a hydroelectric plant constructed six years earlier at Niagra Falls. Hydropower was contributing a small percentate of the nation's total energy demand by 1920 (Dukert 1980, 47).

Electricity generation, however, would initially experience problems. Thomas Edison and George Westinghouse competed over whether direct current or alternating current would prove more satisfactory for transporting power over long distances, respectively. Westinghouse would win out but not before Edison attempted to derail Westinghouse by publishing pamphlets on the dangers of using alternating current. He had an audience in President Harrison. President Harrison was the first president to install electric lighting in the White House to replace its gas lamps. However, due to Edison's writings, President Harrison was afraid of being electrocuted if he operated the switches. So he issued an order that one of his aides would operate turn the lights on at dusk; meanwhile, the President and the First Lady maintained gas lamps in their private residence (Dukert 1980, 48).

The increase in electric usage would come not from political support, but again from technological developments that relied on electric power. The electric iron, electric fan and the electric range were invented in the 1890s. Vacuum cleaners and washing machines would be invented the next decade, followed by the toaster a decade later. Colorado utilities were supplying electricity by the 1880s. Denver switched their municipal lights from gas to electricity in 1885 and most Denver residents were using electric lamps by the 1890s (Dukert 1890, 49; Scamehorn 2002, 74-76).

Finally, the interest in liquid fuels during the early 20th century also spurs interest in liquid synthetic fuels or “synfuels.” The major interest in Colorado was from extracting oil from shale. Euro-American settlers were familiar with the material. In one anecdote from the Western Slope, settlers built a schoolhouse using the locally available rocks for the fireplace. They held a ceremony honoring the completion of the schoolhouse, complete with a fire. When they returned to the schoolhouse in the morning, it was a pile of ashes as the celebratory fire had ignited the oil shale used to build the chimney. In another instance in Colbran, a settler used “concrete slabs” harvested from a neighboring mountain to build his cabin. During the first major snowstorm of the season, he lit a fire to keep warm only to have the house begin to off-gas kerosene and subsequently ignite; the “concrete” was oil shale. Interest in oil shale increases when oil prices do. The years 1916-1917 represent the first increase in interest followed by episodes in the 1920s, during and just after World War II and in the mid-1970s to the early 1980s; in each instance, the “fledgling oil shale industry” would collapse as petroleum supplies increased, thereby causing prices and thus interest in oil shale to collapse (Scamehorn 2002, 145-147).

5.1.3 Energy Use in the United States from 1930 to 1973

At the start of the Great Depression, energy markets suffered as other industries did. Efforts to help energy industries during the 1930s were not effective. Coal production waxed and waned and did not experience a turnaround until wartime demand increased. Oil and natural gas experienced a similar trend in Colorado. For the World War II years, the wartime demand proved to be a substantial boon to all three fossil fuel sectors (Scamehorn 2002, 90, 114, 129).

After the war, these fuels experience mixed fortunes. Coal would suffer severe declines in the initial post-war environment as consumers switched to cleaner-burning oil and natural gas. Railroads switched from coal to diesel-electric locomotives (Scamehorn 2002, 90). Oil and natural gas would enjoy booms. Soldiers returning from the war began getting married, buying cars and homes and started families. Incomes increased as did leisure time. As Americans traveled to the woods, not only did they increase the strain on the forests, but to get there, they expended energy and thus increased the strain on the nation's energy resources.

The push for more energy in the American West after World War II led to a push for more electricity generation. Demand for coal began to experience a resurgence in large-scale, stationary power plants. Between the years 1965 and 1971, a "rush" for coal allowed mining companies to secure leases on 433,000 acres of federal lands at "bargain rates" where most of the coal deposits were strippable. Oil consumption increased dramatically; the U.S. was a net exporter of oil as late as 1947 but by 1973, was importing about 24% of its petroleum (Scamehorn 2002, 100, 102, 124).

Natural gas has a slightly more interesting story. Consumption increased in the post-war years so that by 1970, the United States relied on natural gas for about 30% of its energy portfolio. Gas, like oil, was more convenient than coal. Efforts to produce more gas intensified. In one of the more bizarre twists in U.S. energy development history, the Atomic Energy Committee created a Division of Peaceful Nuclear Explosions that would attempt to use nuclear power for nonmilitary purposes[32]. Operation Plowshare was a project designed to detonate nuclear devices underground in an attempt to liberate natural gas was locked in sandstone and

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[32] See also Dan O'neil's (2007) "The Firecracker Boys" for an account of how the father of the Hydrogen Bomb, Edward Teller, sought to create a new Alsakan harbor by detonating six nuclear bombs.

shale formations. Engineers suggested large nuclear explosions could release large amounts of gas. At least two tests were conducted in Colorado, near Rulison and in the Piceance Basin in Rio Blanco County. The explosions did increase gas yields but not by enough to justify the expense. Also, the gas released was contaminated with radiation. With rising public opposition, a referendum was passed by Colorado in 1974 ending the practice of using nuclear devices for exploration without consent of the electorate (Scamehorn 2002, 136-140).

The West continued to rely on hydropower. In one example of the Big Dam Era, the Bureau of Reclamation had to clear 35 square miles of forests to build Hungry Horse Dam in Montana. One way of doing this was to attach a large eight-foot wide, four ton steel ball by chains between two tractors (see Figure 5.3). As the tractors moved downslope, the ball would knock over the trees quickly and with little risk to the tractor operators. Large hillsides could be denuded quickly, often with tremendous wood waste. However, the dam could be completed quickly, the reservoir filled and with all potential marine hazards "bowled over." Five such steel balls were used (Shaw 1967; "'Bowling' Down Forests for a Super Dam" 1950). The need for cheap electricity trumped the need for managing forest resources while minimizing waste, including timber and forest energy.

5.2 Multiple Streams and Energy Policy from 1973 to 2012

For exploring how forest policy and energy policy are intertwined, beginning in the late 1960s with the Nixon Administration makes some sense for energy, too. The environment was at the forefront of concerns. In addition to scares regarding chemicals and pollutions, the consequences of energy extraction and pollution gained more attention. The Cuyohoga River in Ohio repeatedly caught fire prior to the 1970s as the surface was frequently contaminated by fossil fuels. The Santa Barbara spill on the California coast provided television images of struggling sea life and mammals covered in oil and carcasses washing ashore. A brown smog cloud, the result of air pollution caused by primarily car exhaust, choked Los Angeles as early as 1946, a cloud which Mayor Brown claimed that same year would be vanquished within four years (Aimsworth 1946, 7). The era of environmental concern arrived.

Figure 5.3: Bureau of Reclamation Clearing Trees for Hydropower

Source: Adapted from "'Bowling' Down Forests for a Super Dam," (1950: 90).

When the unintended consequences of energy production and consumption are viewed together with the corresponding problems developing with forest management, the foundations for forest energy become more apparent. Following the approach taken by Kingdon (2011, 231-241), this section divines the three streams: problems affecting forests, policies crafted to manage forests and the politics enveloping the national forests and their stakeholders.

5.2.1 Energy Problems

Coincidentally, the Energy Crisis of 1973 erupted during the same time as the discussions on long-term forest planning. The crisis, perhaps one of the most significant events in U.S. history (e.g., Fiege 2012, 358-402) resulted in severe fuel shortages, long queues at gas stations and high fossil fuel prices. Snipers killed several truck drivers who were ignoring a strike that was initiated to call for government aid. The catalyst for the flurry was the Yom Kippur War in 1973. As hostilities escalated in the Middle East, Arab nations attacked Israel directly but also sought to isolate Israel by attacking its allies indirectly, in particular the Netherlands and the United States. OPEC decreased production and the price of oil quadrupled by early 1974. The resulting fuel shortage, the first since World War II, and subsequent economic crisis prompted a push for developing domestic fossil fuels supplies augmented by alternative and renewable fuels (Canadian Broadcasting Centre [CBC] 2007; D.H. Davis 1993, 105).

Pertaining to renewable resources, the switch to wood can be seen in the market changes. Between 1972 and 1980, the number of residential wood stove-type heating appliances operating in the United States increased by 400%. In Vermont, single-family homes using wood as the primary source for heat increased two-fold between 1976 and 1978, and by 1981, a state survey indicated that wood was used for heat in more homes than electricity, natural gas, kerosene and coal, and that wood, as a consumed energy source, was second only to oil. Fuelwood consumption in Colorado during the 1970s increased rapidly. By 1980, Colorado was consuming approximately one million cords of firewood, about 96% of the harvests were for residential consumers and 70% of all those wood-burning households were harvesting firewood simply to meet their own needs. Roughly 8% of Colorado's heat energy demand was being met with firewood. Even warmer climates were switching to renewables; by the mid-1980s, nearly 40% of all wood-heating appliances were in the Southeast (Roper 1984, 273-274; Betters, Wilcox and Ryan 1984; McLain and Booth 1985, 8).

The problem may have had a slight silver lining for Colorado. Increasing fossil fuel productivity meant depending on western supplies. In 1974, six western states held nearly half of the nation's proven coal reserves, with most of this coal easily accessible for strip mining and low in sulfur content. Pressure to develop domestic petroleum and natural gas supplies followed suit. The second energy crisis in the late 1970s served as a reminder for the earlier problems as the Iranian Revolution in 1979 resulted in curtailed oil exports. However, this crisis was more severe as the crisis-related problems during this time are two-fold: 1) the sudden disruption to energy stocks for a nation accustomed to cheap fossil fuel and 2) the unintended, accruing environmental consequences from using alternative and renewable energy technologies. For instance, wood stoves and tee pee burners are wood burning particulate emitters targeted by the Clean Air Act Amendments of 1977's Visibility Protection section for Federal Class I lands, which includes wilderness areas and national parks. The Surface Mining Control and Reclamation Act of 1977 established standards for reclaiming public and private lands, reducing groundwater pollution and levying production taxes to pay for such efforts (Scamehorn 2002, 104, 169-170, 177-178; Roper 1984, 285).

With Reagan's election, energy prices began to fall and stabilize. Through steps taken during the 1970s to decontrol fossil fuels, prices for crude oil, for instance, fell by nearly 33% from nearly $32 per barrel in 1981 to just over $24 per barrel in 1985. Natural gas also declined when a "gas bubble" burst in the late 1970s after prices had increased by 600% per thousand cubic feet from 1973 to 1980. Natural gas was completely yet gradually degregulated from 1978 to 1985. Declining prices and declining consumption resulting from increased efforts at conservation by industrialized countries meant fossil fuel prices would remain comparatively low until the late 1990s (Scamehorn 2002, 178-180).

The late 1990s and early 2000s witnessed a number of events that would have dramatic increases on fossil fuel prices. California in 1996 began to deregulate its electric utility industry. Enron took advantage of the transition, causing blackouts that left millions of people without power due to rolling blackouts and caused an artificial power shortage that in turn caused utility prices to skyrocket. Wholesale power prices increased from between a range of $20 and $50 per megawatt hour to $1,400 per megawatt (essentially costing consumers $10 to run an air conditioner for an evening), subsequently costing the state between $40 and $45 billion. The attacks on September 11, 2001 were detrimental to the national economy and travel-base industries (Weare 2003, 4; Fusaro and Miller 2002, 97).

Following the Enron scandal's blackouts, the country was reminded again how much its livelihood depended on energy and just how fragile the nation's energy transmission infrastructure remained. In the summer of 2003, temperatures were very high. As the temperatures remained high and as the northeastern U.S. and southeastern Canada continued to rely on air conditioning to stay cool, the lines began to sag. As the power lines sagged, the drooped closer to the ground and closer to the surrounding tree cover. If utility corridors are properly cleared and maintained, the resulting line sagging should not present problems. Yet in this instance, the result was a flashover, where electricity "jumps" over the gap, makes contact with a tree or trees and ignites them. The result is a forest fire that not only most likely destroys the forest but also destroys part of the power transmission system by destroying wires and melting transmission towers. Figure 5.4 shows the United States at night prior to the ensuing blackout.

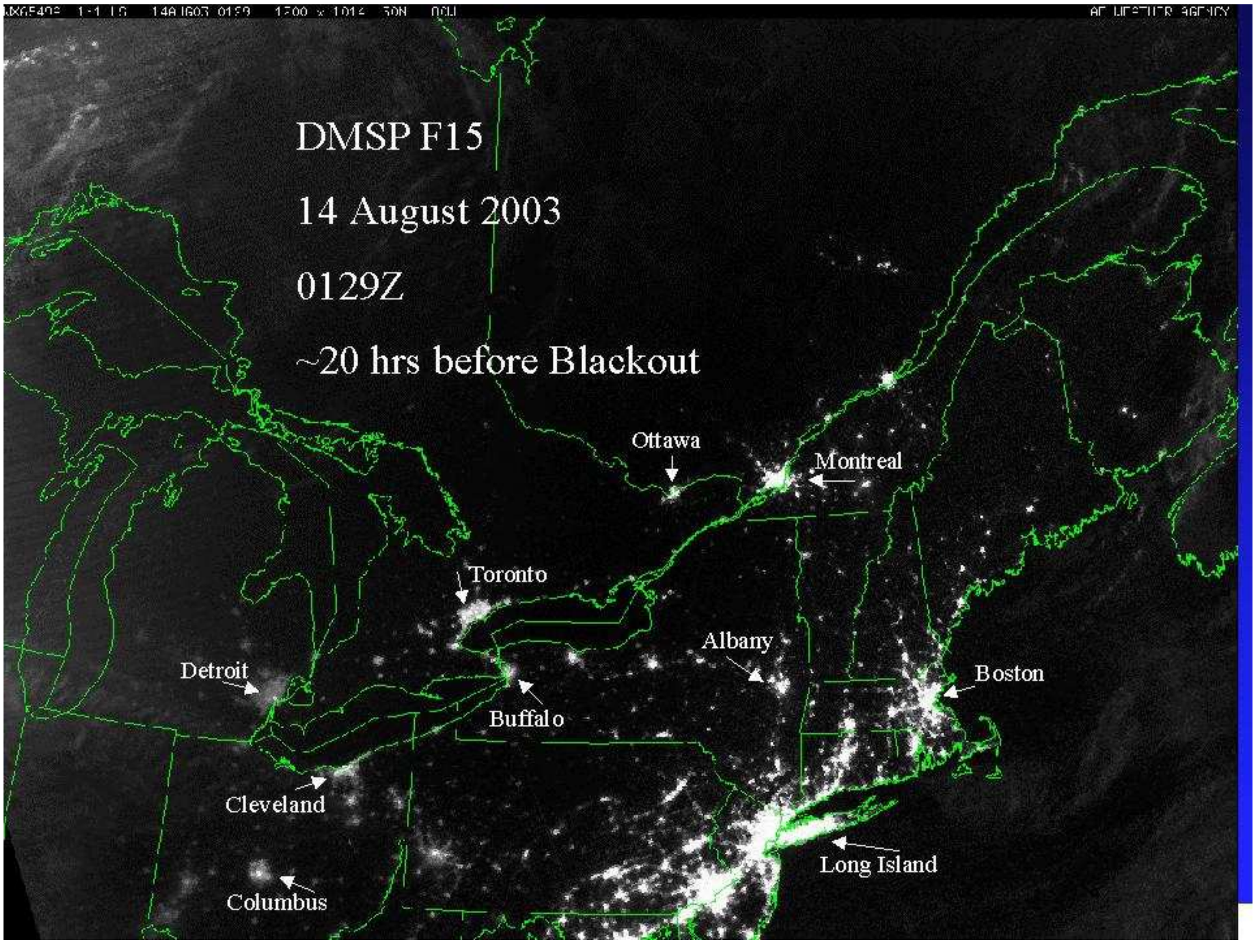

Figure 5.4: The Northeastern United States 20 Hours before the Blackout

Source: NOAA (2003a).

During the afternoon of August 14, 2003, such a flashover occurred when power line corridors belonging to First Energy of Ohio that had not been properly cleared or maintained were just close enough to the trees (likely within 10 feet) and ignited them. The damage was widespread. As Figure 5.5 shows, major cities in southeastern Canada, in the Rust Belt and even locations as far away as Long Island were impacted as 55 million people lost electricity.

For the remainder of the decade, gasoline prices would continue to climb minus a steep drop during the Great Recession in 2008. The price shocks drew comparisons to the crises from 30 years prior. The increased demand globally contributed to oil shortages lasting between 2005 and 2008 caused a six-fold increase in the price of oil, subsequently creating a price shock that was approximately three times the size of the shocks from 1974 and 1979.

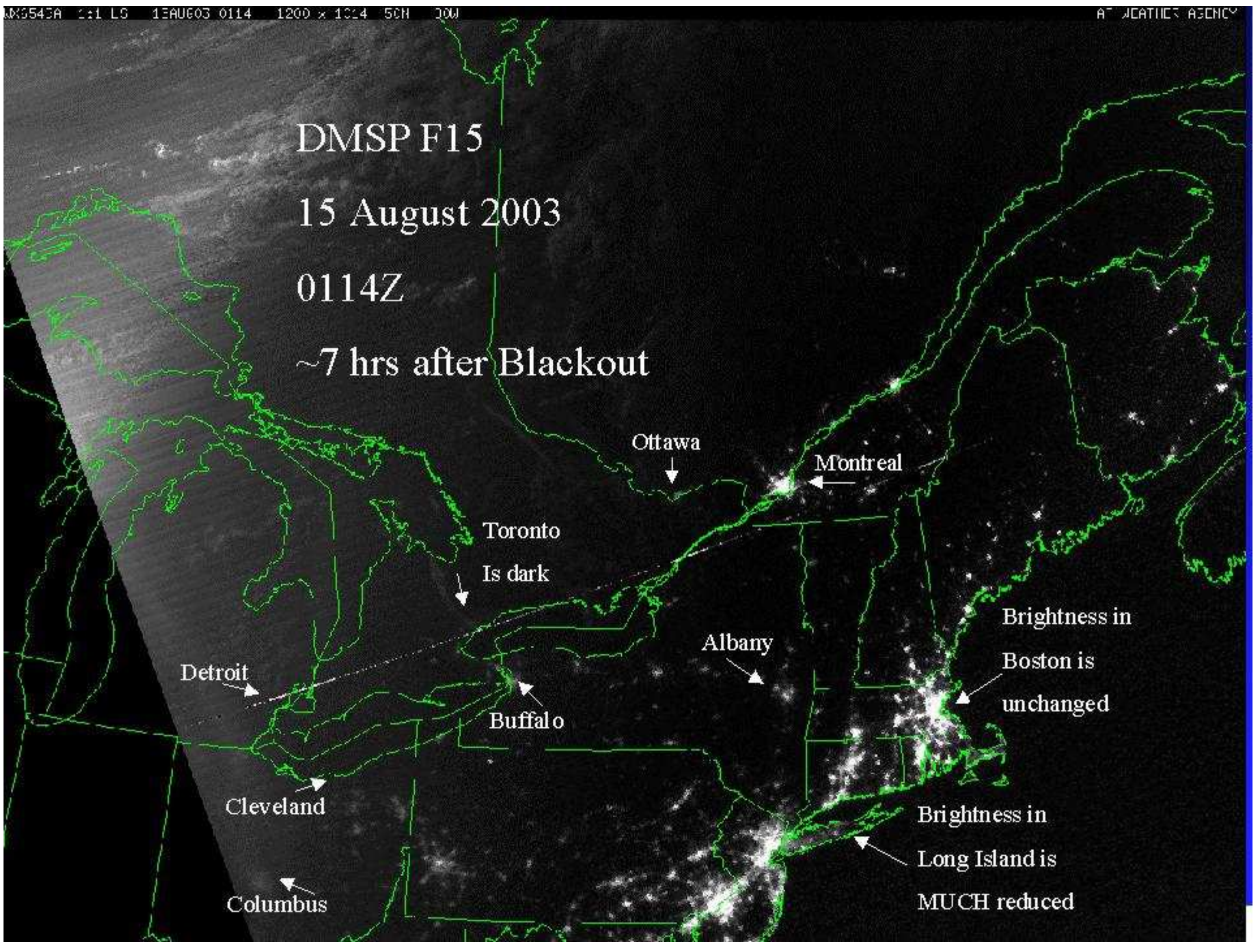

Figure 5.5: The Northeastern United States 7 Hours after the Blackout

Source: NOAA (2003b).

This shock, among other economic factors, helped trigger the global economic crisis of 2008-2009 (Mitchell 2011, 233).

5.2.2 Energy Policies

From the executive branch, one of the first major efforts to address national energy policy in 1973 was President Nixon's "Project Independence," which was a ten-volume plan to make the United States energy independent by 1980 and marks the first of series of presidential pledges for national energy independence. The routes taken would affect energy production, conservation and consumption. Production from fossil fuels would have to increase, including nuclear power plants and accelerating off-shore leasing of federal lands for oil exploration. For conserving, Nixon asked homeowners to set their thermostats to 68-degrees Fahrenheit during the colder months, while also asking business owners to reduce their energy consumption by 10%. States were to restrict highway speeds to 55 mph. Proposals for closing gas stations on Sundays, banning outdoor lighting and advertising and rationing gasoline supplies were also considered (Scammerhon 2002, 167-168; D.H. Davis 1993, 15; Grossman 2013, 2).

Congress also attempted to capitalize on the effort; the 93rd Congress introduced over 2,000 energy-related bills and resolutions. Among this flurry of energy-related policy interest in the early 1970s, Congress passed the Forest and Rangeland Renewable Resource Planning Act (RPA) of 1974. While discussed previously (see Section 4.2.2), the RPA does consider energy as the RPA Assessment of 1980 was the first time an assessment considered a "wood for energy" category (Doub 1976, 715; US Congress, Office of Technology Assessment [OTA] 1990, 17, 1992, 40).

At the same time as Congress was looking at renewable resources on national forestlands and rangelands and determining how to best manage those resources and lands, Congress was also acting to diversify energy production and attempting to lower energy costs. Writings such as M. King Hubbert's (1956, 1969) work on "peak oil" predictions for 1970 and others (e.g., *The*

Limits to Growth, The Tragedy of the Commons) provided ammunition for those who wanted to see larger and more significant changes. One of the changes was part of the National Energy Act of 1978. The Public Utility Regulatory Policy Act (PURPA) required utilities to purchase power from co-generators (i.e. steam produced concomitantly with electricity) and small utilities that produced electricity from renewable sources ("qualifying facilities" or QFs), thereby encouraging the development of non-utility (renewable) electric power (Joskow 1997, 124; Adamson 2005, 6). Rates paid by the utility were not to exceed the cost that would have been incurred by the utility had it decided to produce the electricity itself i.e., the avoided cost.

However, avoided costs were set using formulas that over-estimated future costs given that existing direct market costs were unknown i.e., without a standard for comparison, prices for renewable energy production were determined administratively using forecast models that proved to be widely inaccurate. For instance, price estimates in the 1980s for a barrel of oil in 2000 were predicted to exceed $100; in 2000, the price for a barrel of oil was below $30 per barrel. Consequently, retail ratepayers faced overpriced generation costs for renewables-derived electricity as compared to what they would have paid normally using conventional fossil fuel technologies (Lesser and Su 2008, 982). Higher prices for energy via renewables combined with decreased petroleum prices under the incoming Reagan administration subsequently caused enthusiasm for renewable energy wanes.

Subsequent developments would relax PURPA requirements and attempt to provide additional incentives for alternate, renewable energy production. The Energy Policy Act (EPAct) of 1992, generally, provided for "greater wholesale competition" (Union of Concerned Scientists [UCS] 2009) and authority granted under this EPAct to the Federal Energy Regulatory Commission (FERC) could force utilities to open their transmission lines to competitors (UCS

2009; Adamson 2005, 6; Anthracite Region Independent Power Plant Association [ARRIPA] 2009). Furthermore, the 1992 EPAct introduced two new types of federal incentives for alternative, renewable electricity production, including biomass: the Renewable Energy Production Incentive (REPI) and the Production Tax Credit (PTC). The REPI provided incentive payments of $0.015 per kWh to publicly-owned electric utilities and rural electric cooperatives who applied for the credit. The PTC provided $0.015 per kWh to private entities, subject to the federal business income tax, that generate electricity from renewable sources and then sell this electricity to an unrelated party.

However, these credits were not available for all types of biomass. The PTC, for instance, favored private entities that produced electricity from wind or closed-loop biomass. Closed loop biomass that is planted and designated for use in a qualified facility to generate energy (electricity in the tax code). Although the PTC was originally set to expire in 1999 and renewed several times thereafter (Jordan-Korte 2011, 85), not until the American Jobs Creation Act was passed in 2004 was the definition of biomass expanded. Under this act, open-loop biomass was now included, which for forests is biomass typically obtained from mill residues, pre-commercial thinnings and other hazardous fuels material or from solid wood waste streams (e.g., pallets, construction and demolition debris). The credit open-loop biomass received, however, could only be taken for five years, not 10, and the credit itself was for only half the value that other renewables received per kWh.

Future enactments would continue to extend the PTC but keep the equality or parity in place. The Energy Policy Act of 2005 (EPAct) extended to PTC to 2007. The EPAct of 2005 also extended the duration of the REPI until 2026 but subject to congressional appropriations, making the incentive less effective as it renders investors’ planning less certain. Furthermore, the appropriations were to be split if appropriations were insufficient to cover claims: 60% would go to wind, solar, etc. while 40% would go to "other projects," including open-loop biomass. The Tax Relief Health Care Act of 2008 extended the PTC to last until the end of the year. The Troubled Asset Relief Program of 2008 extended the credit to the end of 2009 and the American Recovery and Reinvestment Act of 2009 extended the PTC to the end of 2013, where it was ended due to congressional inaction. At the end of 2013, the credit for open-loop biomass was still half of what other renewable technologies[33], like wind and closed-loop biomass received.

Renewable liquid fuels also received a boost starting in the late 1990s. Given the attention paid to increasing fuel prices and the accruing environmental impacts of continued fossil fuel combustion, a push was made by both the executive and legislative branches to produce cleaner-burning, alternative, renewable liquid fuels. The more significant actions promoting liquid fuels involve the Renewable Fuels Standard (RFS) and revised Renewable Fuels Standard (RFS2) promulgated under the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007, respectively. What these standards promote is mandating a certain quantity of alternative, renewable fuels in the nations fuel mix. The RFS mandated that eventually required the U.S. to use 7.5 billion gallons of biofuels by 2012. The RFS2 increased these totals to 9 billion gallons by 2008 and 36 billion gallons by 2022, 16 billion had to be cellulosic-derived biofuels and no more than 15 were corn-starch ethanol (Schnepf and Yacobucci 2013). Debates continue at the time of writing between ethanol and petroleum interests regarding limits and waivers established by the U.S. EPA.

[33] Of note, privately owned and investor owned solar facilities could not apply for the PTC. They instead received credits under a business Investment Tax Credit (ITC) first authorized under EPAct 1992 and extended until 2016 via the Energy Improvement and Extension Act of 2008 (Jordan-Korte 2011, 85-86).

5.2.3 Energy Politics

Energy politics under the Nixon Administration were just as complicated as the forest politics. The National Security Council (U.S. Department of State 2011, 199) believed oil embargoes were a "*possibility*" (emphasis in original) at least as early as 1971 but its realization combined with an increasingly angry public spurred the Administration into action. On November 25, 1973, invoking images of technological triumph via the Apollo mission, President Nixon announced the start of "Project Independence," which was a plan to make the United States energy independent by 1980 and marks the first of series of presidential pledges for independence (Scammerhon 2002, 167-168; Grossman 2013, 2; Dukert 2009, 168).

The problem for the Nixon administration was initially inflation. In an effort to combat inflation, the Nixon Administration began institute price controls in phases. The price controls had the effect of keeping oil prices in the U.S. artificially low while prices globally climbed. In November 1973, the price for a barrel of oil in the U.S. was $5.25; at roughly the same time on the world market a barrel of oil sold for over $12 (Grossman 2013, 16-17).

With Nixon's fall due to the Watergate scandal, President Ford assumed an energy policy mess. Grossman (2013, 124) provided a "party anecdote" that gives an idea of what the new administration faced:

> A friend of mine worked for the Ford administration on energy policy. When he started, he and his group were told that they needed to come up with a plan to make the U.S. energy independent in ten years. After studying the problem a while, they decided that their first job would be to redefine "independent." Their second job would be to redefine "ten years."

But energy was not Ford's chief concern; inflation was relentless and energy concerns barely registered in a Gallup poll conducted early during his administration. Partisanship became a more significant factor by the fall of 1974 and, although energy did not rank highly among the polled, it did rank highly among government and advocates who were competing for larger shares of the bureaucratic turf. Between the 92nd and the 93rd Congresses, the number of agencies that investigated energy-related issues increased from two to 30 (Grossman 2013, 125-126).

In this environment, President Ford proposed the Energy Independence Act of 1975. The idea supporting the bill was to change the deadline for Project Independence from 1980 to 1985 and to implement decontrol procedures for oil and gas. Constrained by the idea inherited by the Nixon Administration, the idea of achieving energy independence over the next decade would recur during future administrations for the next three decades (Grossman 2013, 126).

President Carter's Administration continued the push for energy independence but with a heavy dose of morality. Drawing heavily from his religious background, Carter's speeches were charged with religious imagery and made frequent reference to the energy war. Americans were at first reluctant to follow him as they were beyond the first crisis. But not the second. Despite passage of the National Energy Act in 1978 and efforts to prevent a repeat of the first energy crisis, energy-related problems led to a crisis of confidence for Carter (Grossman 2013, 166-196).

Reagan's election coincided with the beginning of nearly two decades' worth of low, stable prices for gasoline. Even with the Iraq invasion of Kuwait and a resulting spike in gas prices, fluctuations remained relatively mild (see price charts in Chapter 1). The early 1990s, however, saw a push for deregulating electric utilities, first promulgated under George H. W. Bush's Administration in the EPAct of 1992, by encouraging independent power producers to enter the market. In 1994 the California Public Utilities Commission began a rulemaking process to allow the state to take advantage of EPAct of 1992's provisions. In 1996, California became the first state to enact an electric utility deregulation plan; prior to this step, California utility producers had not faced competition (Congressional Budget Office 2001).

With mounting price increases for oil, wild fluctuations in natural gas prices and mounting pressure for developing independence, both the George W. Bush and Barack Obama Administrations found themselves grappling with how best to proceed. President Bush acknowledged the need when he mentioned in his 2005 State of the Union Address that the country was "addicted to oil." President Obama's Administration has supported alternative, renewable energy technologies. At a campaign event at Colorado State University in 2011, the President celebrated the fact that electricity produced by wind and solar had doubled from 2008 to 2012 (Obama 2012; Robertson 2012).

5.3 Searching for Policy Windows

As with Chapter 4, this study applied the Multiple Streams Theory to the years 1973-2012 for the energy policy arena. The next step for this study is to look for policy windows. The search first looks for instances where attention towards energy-related issues increased significantly and subsequently, the media output should increase; an observer would need to count the total number of articles written about energy issues. The best way to observe this spike is to count the number of articles written about the issue over an extended period of time, at least a decade, and then look for dramatic increases or spikes in the tallies.

For this project, energy-related keywords from the *Readers' Guide to Periodical Literature* ("*Guide*" henceforth) were identified (see List of Keywords). Part of the identification process involved looking for words that were used repetitively in newspapers, magazines and peer-reviewed journals. Then the analysis looked for each keyword in each year of the *Guide*. Forestry-related article titles were first tallied between 1973 and 2012. Articles were then coded based on their titles' tone. An article that sounds positive from the perspective of the pro-FBU perspective was coded "positive," titles that an FBU-proponent would not have been happy to see were coded as "negative" and titles where the tone was either unclear or showed both positive and negative connotations were coded "neutral." Normally, this approach will use two or more evaluators analyzing the same lists of article titles. However, given the analysis was performed solely by the author, two passes were made by the author but each pass was separated by a period of one year. Over 8,000 articles were identified, counted and coded. The amount of agreement between the first and second tallies was substantial, exceeding 99.7 percent. Final counts and coded tallies are shown in Table I.2 in Appendix I.

While the table contains the data, gleaning any spikes may be difficult. For ease of comparison, the figures are better comprehended if presented graphically (see Figure 5.5). On the left hand y-axis are the counts of articles. Each increase in the bar indicates an article observed under a keyword in the *Guide*. On the right-hand y-axis is the percent of articles whose titles displayed a positive tone. The Percent Positive Tone is low and conspicuously so as compared to other efforts (e.g. Baumgartner and Jones on nuclear energy, etc.). The reason for the low percentages is that the articles written about energy in the popular literature contained significant numbers of titles, even more so than forestry, that appeared unrelated to FBU, neutral or contained both positive and negative elements when viewed through the narrow pro-FBU perspective. An article discussing increased coal industry business mergers would not necessarily directly address FBU in the United States, although the media coverage may bring additional attention to domestic energy production issues and suggest the consolidation and strengthening of an industry that would compete directly against forest energy. Table Appendix I.2 is presented graphically in Figure 5.6.

The chart shows interest in energy "spiking" in the 1970s and again beginning in the early 2000s. These increases in attention coincide with significant increase in fossil fuel energy prices. When prices are decreasing or relatively stable, minus a small uptick in the early 1990s (Iraq invaded Kuwait), the amount of attention paid to energy articles remains relatively flat.

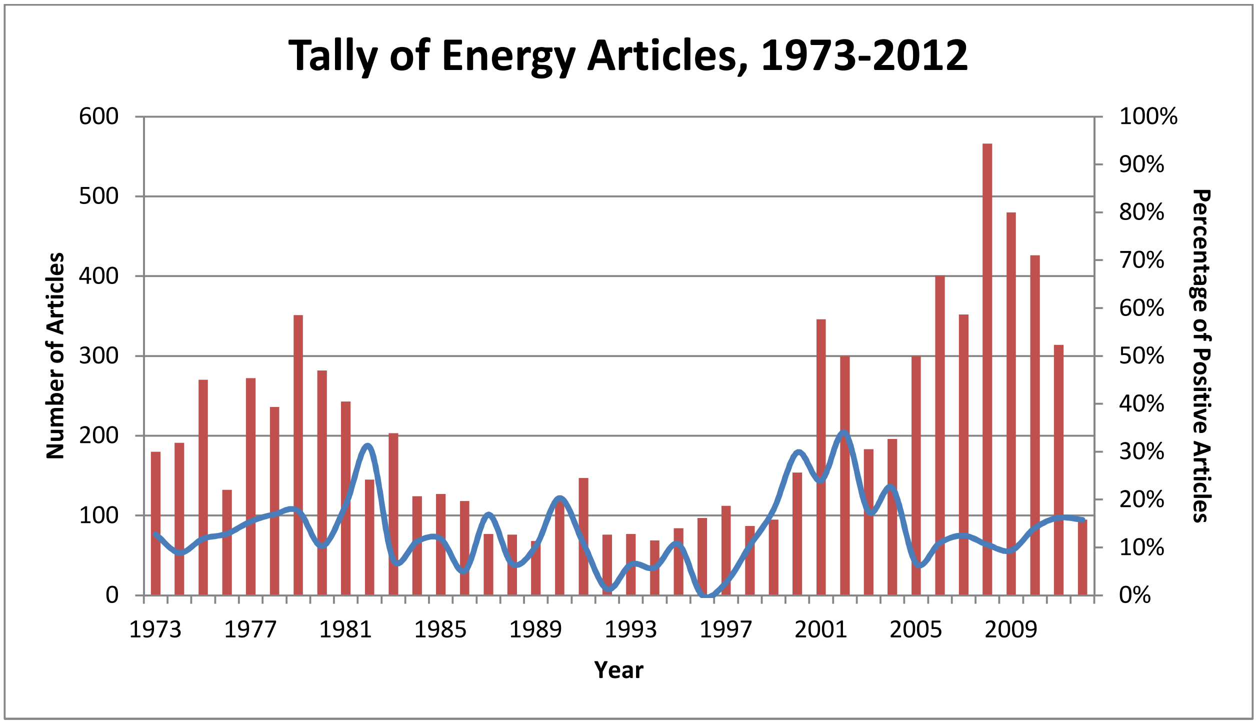

Figure 5.6: Energy-Related Articles, Counted and Coded

Source: Author's compilation from the Readers' Guide to Periodical Literature, 1973-2012.

Yet this pattern may be coincidence. The most significant drawback to using "energy" as a keyword is because the topic is vast and all-encompassing. Energy-related keywords in the *Guide* can include industry news, such as mergers; prices, including deregulation; policy; and news pertaining to employees and working conditions. A refinement may be in order. Given the amount of attention paid to energy prices (e.g., price controls, deregulation, search for renewable, alternatives to decrease reliance on imports), using a keyword filter pertaining to "energy prices" may be helpful. The data for this refinement is presented in Table I.4 in Appendix I and graphically in Figure 5.7.

On the left hand y-axis are the articles tallies for energy price-related articles. On the right-hand y-axis is the percent of article titles showing a positive tone from the perspective for entrepreneurs who would support forest energy.

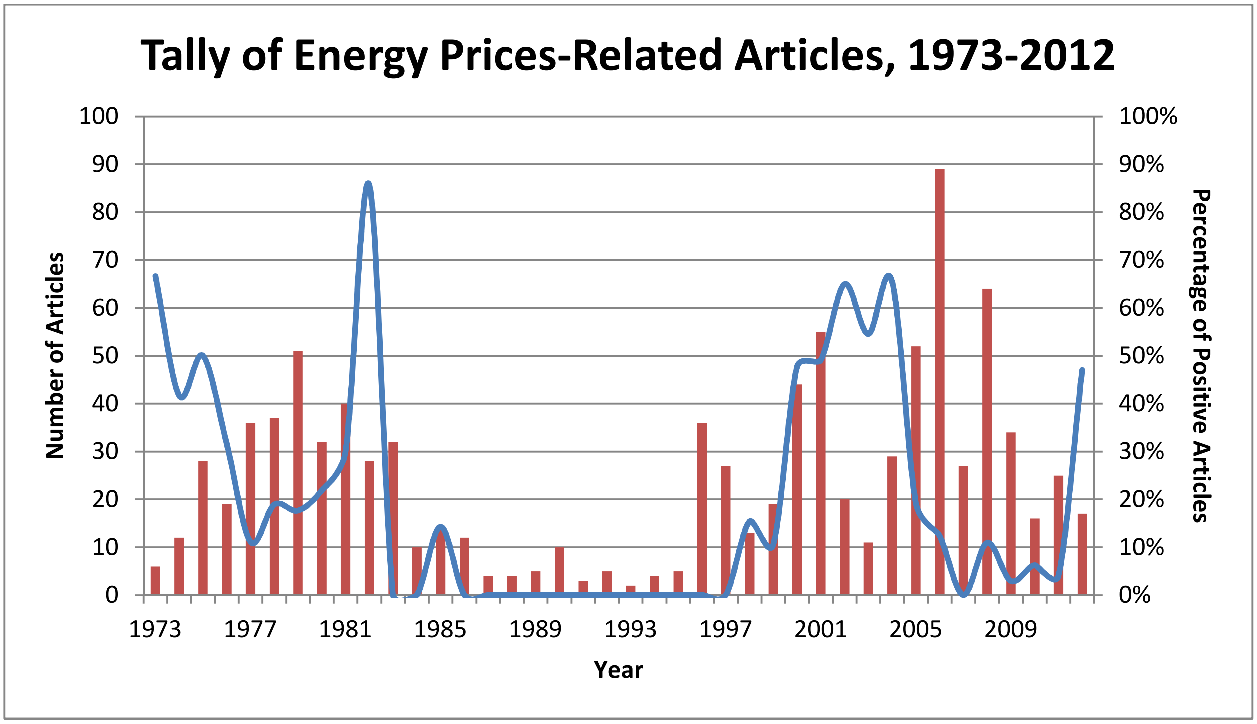

Figure 5.7: Energy Price-Related Articles, Counted and Coded

Source: Author's compilation from the Readers' Guide to Periodical Literature, 1973-2012.

What the pattern shows is increased enthusiasm for energy prices as they decrease after Reagan enters office (e.g., Iran resumes production, decontrol policies gradually reduce prices). Enthusiasm and article counts remain low until the mid-1990s as states, especially California, begin to restructure their electric industry regulations. FBU-proponents would be encouraged by articles written in the early part of the 2000s as they focus on the continued increases in fossil fuel prices because those increases encourage the development of renewable, alternative energy sources.

5.3.1 Congressional Attention

Increased public interest in energy can lead to increased congressional interest in energy. In Table 5.1, all congressional committee and subcommittee hearings are tallied. The 1973 Energy Crisis initiated an upward trend in committee and subcommittee activity.[34]

Table 5.1: Annual Congressional Committee and Subcommittee Hearings Tallies on Energy, 1973-2012

Year	Totals
1973	143
1974	213
1975	312
1976	248
1977	369
1978	275
1979	570
1980	353
1981	375
1982	279
1983	298
1984	249
1985	250
1986	208
1987	266
1988	214
1989	273
1990	236
1991	273
1992	202

Year	Totals
1993	189
1994	146
1995	127
1996	105
1997	116
1998	102
1999	168
2000	145
2001	179
2002	132
2003	142
2004	100
2005	148
2006	178
2007	281
2008	200
2009	225
2010	155
2011	251
2012	205

Source: ProQuest's Congressional Publications database (1973-2012).

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[34] To maintain consistency between the forestry and energy chapters, the chart starts with 1973. However, the years 1970-1972 all had only about 60 hearings per year. In 1973, the total number of hearings doubled.

Congressional interest increases until hitting a "spike" in 1979 as interest in the 1979 Energy Crisis was even more dramatic. Interest resumes in energy starting in the late-1990s as interest turns to energy prices and developing alternative, renewable energy sources.The data in Table 5.1 is shown graphically below in Figure 5.8.

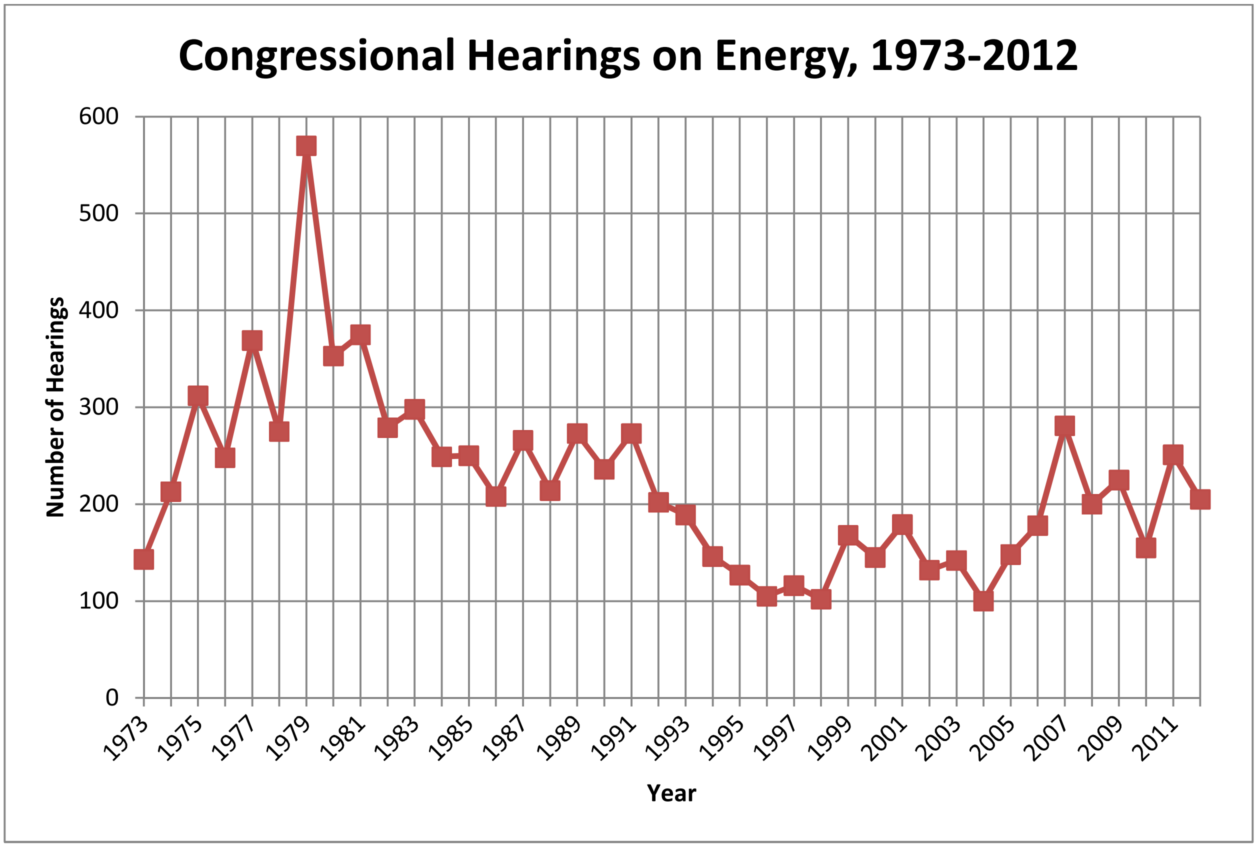

Figure 5.8: Congressional Hearings on Energy, 1973-2012

Source: Author's compilation from ProQuest's Congressional Publications database, 1973-2012.

As mentioned earlier, and also with forestry, using "energy" as a keyword can involve many diverse topics. As with forestry, and given the attention to prices, this study refined the above data using the keywords "energy" and "price*" in the ProQuest Congressional Publications database for the years 1998 through 2012. Given the uptick in interest in the late-1990s, using the 1998 date makes sense. The data are presented graphically in Figure 5.9. The trend in congressional attention, not surprisingly, loosely follows (or responds to) the price line for gasoline during the same time period as reprinted from Chapter 1. As with wildfires, one question is how much attention did Congress pay to energy price increases as compared to other energy-related issues? The proportion of congressional committee and subcommittee hearings focused on energy prices as compared to energy is shown in Figure 5.10.

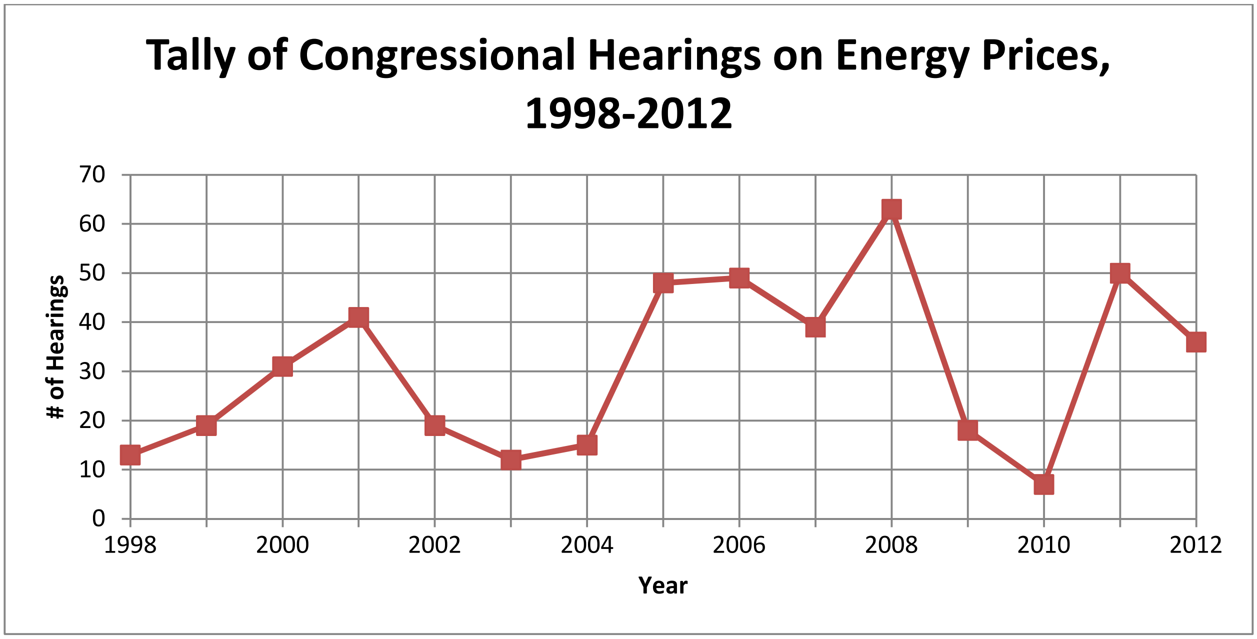

Figure 5.9: Congressional Hearings on Energy Prices, 1998-2012

Source: Author's compilation from ProQuest's Congressional Publications database, 1973-2012.

Although the results are not as dramatic as wildfire, the trend does suggest increases in proportion to increase in gasoline prices. However, energy prices are not a majority of the cases.

5.4 Analysis

While some years do show Congress paid significant attention to prices, the attention was not nearly as high consistently as with wildfires in the forest policy arena. Possibly other factors may have greater significance. Energy contains many different topics. Also, energy subheadings contain multiple topics. For instance, "energy policy" was consistently one of the largest categories of articles in the *Guide* and contained articles that seemingly were just as broad-ranging as energy on the whole.

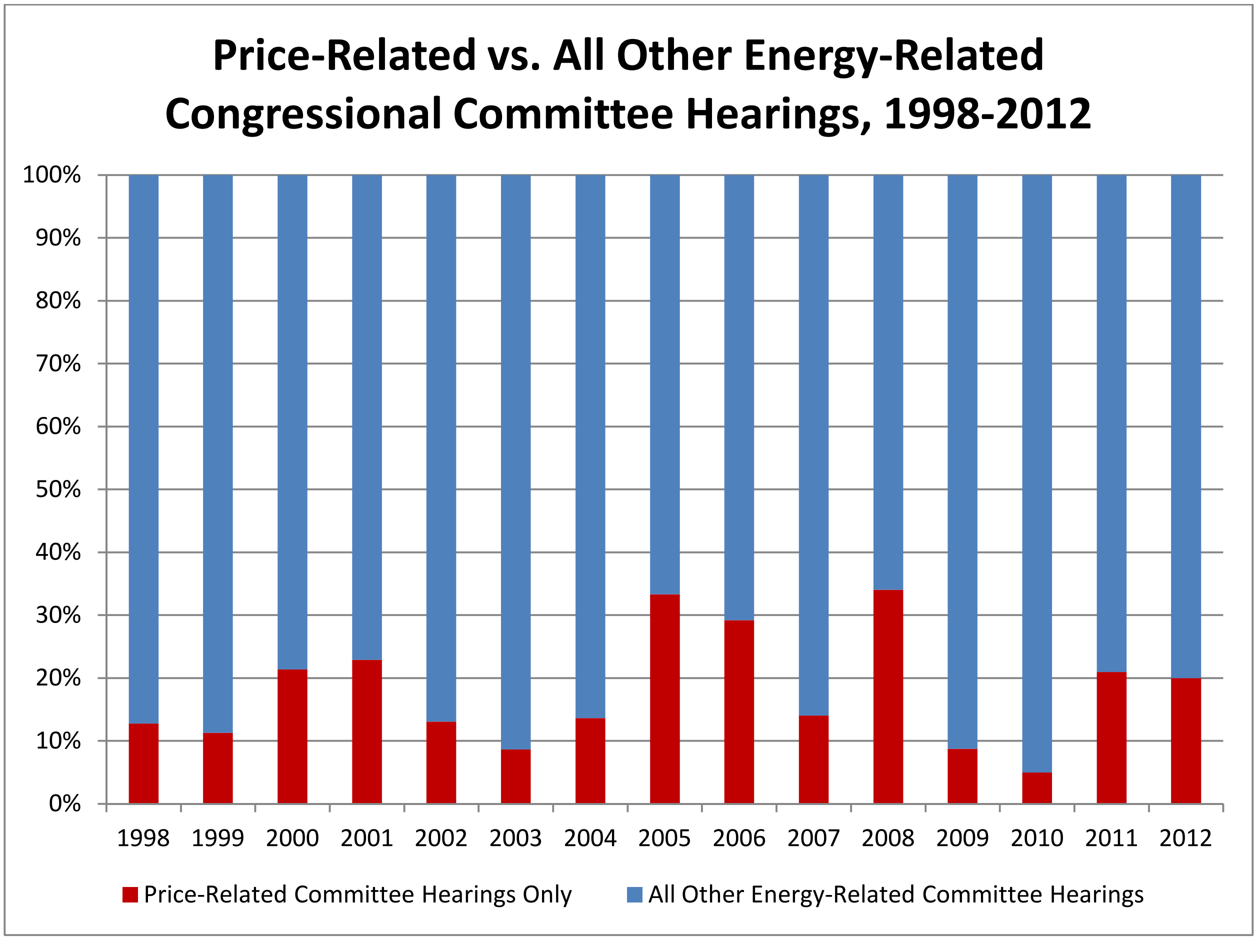

Figure 5.10: Energy Price-Related Hearings as a Percentage of Congressional Committee and Subcommittee Hearings, 1998-2012

Source: Author's compilation from ProQuest's Congressional Publications database, 1973-2012.

In other words, while energy prices may not be as large a proportion as wildfires were for forestry, it may demonstrate congressional sensitivities to, if not fossil fuel prices-at-large, gasoline prices, especially since such price spikes and volatility would impact their constituents. The findings may also suggest that while Congress does respond to prices, hearings may be geared more toward exploring policy solutions or focusing on incentives for technological solutions to energy security. The next chapter will sharpen the focus on forest energy.

5.5 Chapter Summary

The United States began with heavy reliance on low-carbon technologies, including wind, water and wood. Over time, as wood became scarcer and as high-carbon technologies were developed, the nation switched increasingly to fossil fuels. As fossil fuels began to increase in price due to resource depletion and scarcity and as they began to show negative environmental impacts through their use, extraction or through human accident, pressure increased to identify and develop alternatives.

The push for alternatives increased dramatically during the Energy Crisis of 1973. Efforts to increase energy efficiency and provide incentives for alternative and renewable fuels were center-stage in the late 1970s. With the start of the Reagan Administration, the enthusiasm for renewables waned as energy prices decreased and global political troubles settled. Not until the end of the Clinton Administration and more so with the first years of the George W. Bush Administration did interest in alternatives resume. With increasing prices, greater awareness of global political troubles and realizations about climate change, interest in energy increased during the second half of the Bush Administration and continues to do so during the Obama Administration.

Congressional attention to energy seems to track disruptions in supply and subsequent price shocks. However, when the number of congressional committee and subcommittee hearings on energy prices was compared to the number of hearings on energy-at-large, the number of price-related hearings did not constitute a majority of the hearings. At best, energy price-related hearings represented one out of every three hearings in 2005. These findings suggest, that while energy prices were significant, congressional attention may have been focused on other areas.

CHAPTER 6: AGENCY CASE HISTORIES

"The Secretaries support the utilization of woody biomass by-products from restoration and fuels treatment projects wherever ecologically and economically appropriate and in accordance with the law."

– Secretaries of Interior, Energy and Agriculture (USDA et al. 2003)

6.1 Revisiting Contemporary Forest and Energy Policy Arenas

In the previous chapters on forestry and energy, punctuations were identified by filtering the results to reduce potential static and cross-contamination from other possible policy arena concerns. What the charts showed was increasing and sustained attention paid to forestry issues starting in 2000 and the similar increasing attention paid to energy issues beginning in about 1998. By filtering for some of the issues impacting Colorado's forests and energy supplies, media and congressional attention appear sensitive to wildfires and energy pricing issues. These increases in attention could be considered policy windows.

Having applied the Multiple Streams Theory to the years 1973-2012 for forest and energy policy arenas, the openings, coincidentally, appeared at almost the same time. However, suppose the analysis filtered the previous results so that they focused exclusively on the intersection of forestry and energy. In other words, the analysis would look only at articles pertaining to forest energy using keywords such as biomass energy, forest biomass energy and wood for energy. The results might give some indication as to whether or not biomass energy was increasing in relevance and/or significance and if forest energy might be a consideration for the public or government agenda. If the issue appears to have gained saliency, then an opportunity exists through the policy windows for entrepreneurs to attach their preferred solutions to these concurrent policy problems. Figure 6.1 shows the results of applying this filter.

On the left hand y-axis are the counts of articles. On the right-hand y-axis is the percent of article titles showing a positive tone for media articles pertaining to biomass as viewed from a pro-FBU viewpoint.

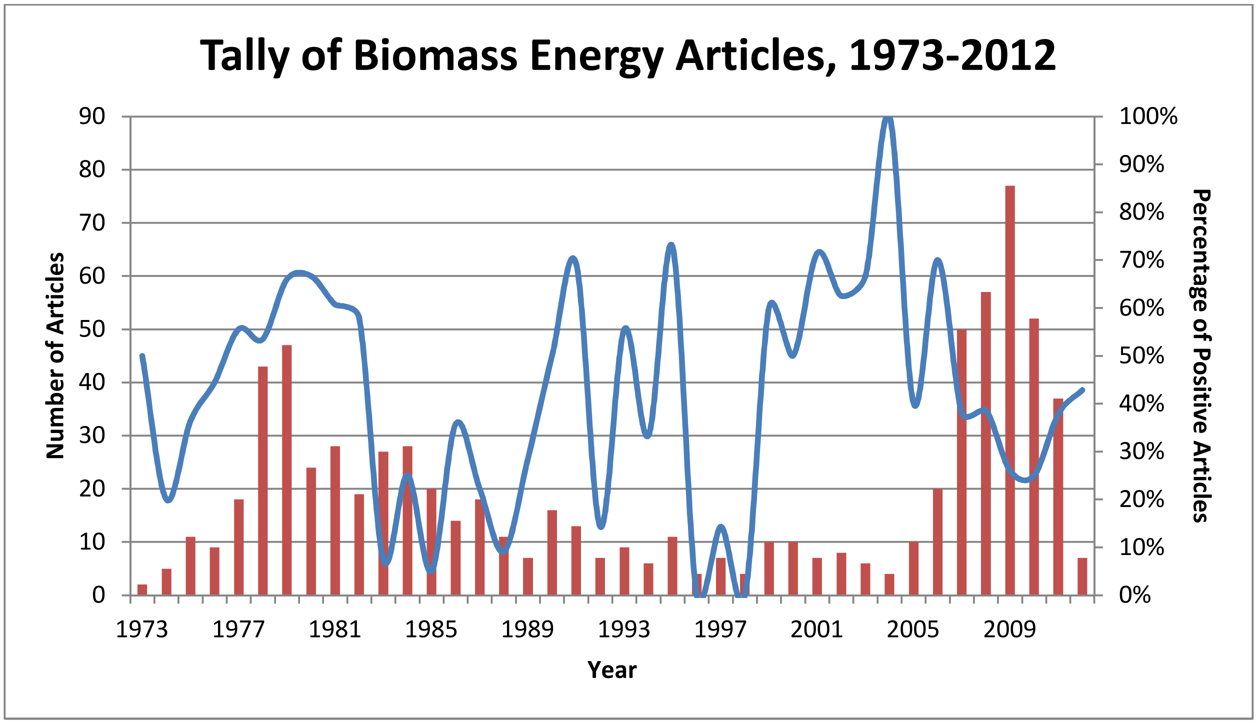

Figure 6.1: Biomass Energy-Related Articles, Counted and Coded

Source: Author's compilation from the Reader's Guide to Periodical Literature, 1973-2012.

As one might expect, the interest in biomass energy was substantial in the late 1970s as the energy crises spurred interest in alternatives to fossil fuel. As fossil fuel prices began to decline and stabilize after Reagan was elected, interest gradually subsided for the more convenient and more energy-dense fossil fuels. So long as energy prices remained stable, interest in biomass energy appears to remain rather flat or even decreasing. However, this filtering is also incomplete. Using "biomass energy" as the keyword includes other forms of biomass, including corn-starch ethanol, switchgrass, methane, etc. while also including wood. Another revision may be warranted. If instead the study were to look at only those articles that involve using wood, and only wood, for energy, then the results would look like Figure 6.2.

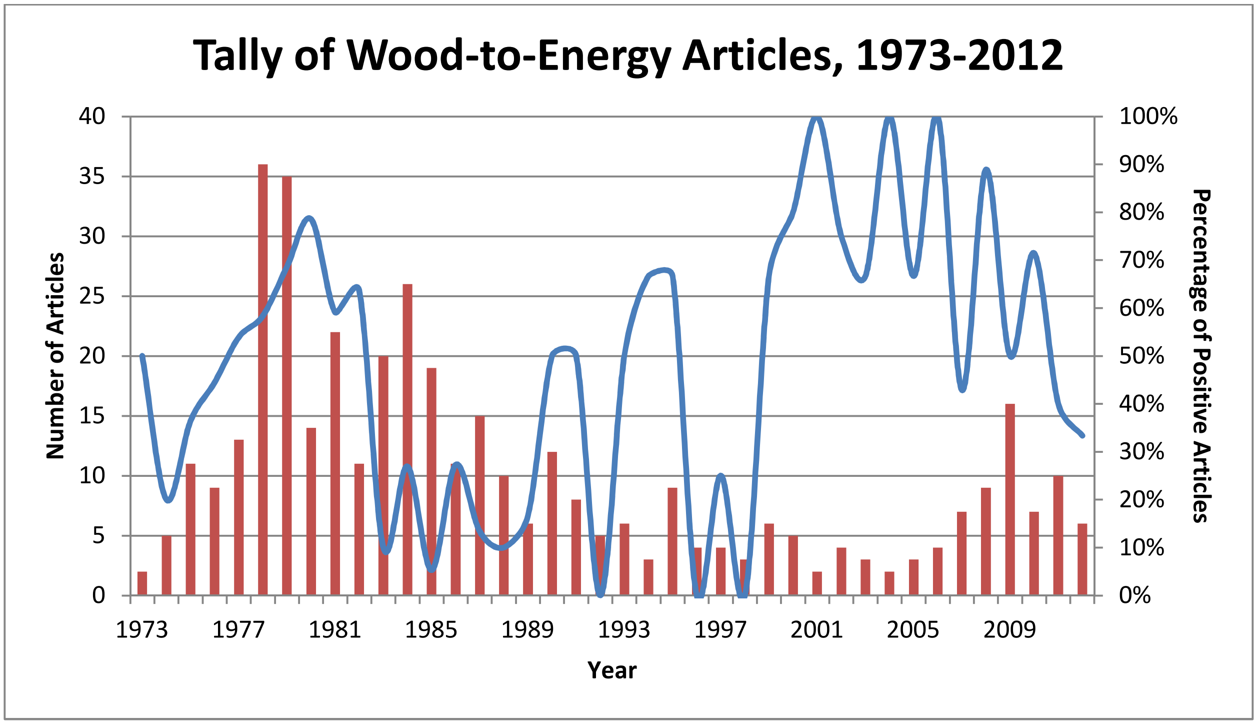

Figure 6.2: Wood Energy-Related Articles, Counted and Coded

Source: Author's compilation from the Reader's Guide to Periodical Literature, 1973-2012.

What the figure shows is that interest in forest energy increased in the late 1970s, much as it did for the biomass category. In fact, forest energy was almost the entire "biomass" concern per the *Guide* for the late 1970s to the mid-1980s. The media interest in wood energy declines substantially until about 2005. Interest in forest energy increases, but since the biomass article count is noticeably higher than the wood-to-energy article count, media interest in other biomass feedstock sources was increasing. Curiously, however, the tone of the forest energy articles increases at the same time as the biomass articles but remains higher for longer. For the biomass energy figure, the positive tone spikes in 1998 but then dissipates about a decade later.

One possible explanation that fits for the initial curve of both graphs is that interest in biofuels, wood and others, increases in the late 1990s given rising national affluence; mounting environmental, political and economic problems from continued reliance on imported fossil fuels; and, as Grossman (2013) stated, the need politically to "do something." The increase in tone is a positive sign for biomass proponents. Often when a new technology is gaining attention or interest in an old technology is being renewed, a limited number of initial articles will be positive and attempt to generate further interest. As interest is sustained, attention to the technology grows. As that interest grows, that increased attention attracts criticism from those who may feel threatened by the potential wood energy usurpers. Over time, as the conversation continues and critics garner attention, the percentage of positive articles declines. In other words, the tone charts show interest in biomass energy, renewed interest in forest energy and a national conversation developed concerning these technologies. Bioenergy feedstocks such as corn-starch ethanol are much easier to criticize given the "food vs. fuel" issue and the high reliance on fossil fuel inputs for fertilizers, farm equipment, pesticides and transportation from stalk to shelf. Forest energy is not as vulnerable to these criticisms, particularly the "food vs. fuel" issue, and might be more appealing i.e., forest energy, when compared to corn-based biomass energy, might seem to critics like the lesser of two evils and thus help explain the more gradual decrease in positively themed articles.

6.2 Applying Punctuated Equilibrium Theory to Forest Energy Policy

Given that media interest in energy appeared to increase again starting in the late 1990s and that the positive tone in forest energy articles became overwhelming positive during the same time period, this study will now attempt to look for subsequent policy changes resulting from the renewed media interest during the 1998-2013 timeframe. This analysis is first looking for policy images crafted for specific policy venues. A policy image's success can be gauged by how well a policy crafted meets or fails to meet the policy-based objectives of those stakeholders who crafted the image. The next step, venue shopping, will attempt to explain why those proponents chose particular political venues to attempt advancing those policy-based objectives. Finally, the analysis will identify what policy changes occurred as a result from their efforts and why the resulting promulgated policies represent incremental or non-incremental change.

6.2.1 Forest Energy Policy Images

The search for policy images is a search for how FBU-proponents attempted to define and characterize forest health and energy issues as they view them. Given the attention paid to the wildfire issue combined with the long-ingrained history of federal versus state approaches to natural resource management, one may suspect that images from the forestry side should focus on wildfire and other forest health impacts that could be traced back to a perceived lack of active management. Images constructed by forestry-based interests would attempt to create a sense of urgency by recounting or suggesting risks to public safety and to ecosystem health. From the energy side, initially, images should focus on prices and the environmental consequences from continued use of cheap yet non-renewable fossil fuels. Proponents may also attack what they see as the disproportionate and unfair subsidies balance between fossil fuels and renewable fuels and how consumers ultimately pay the price. The way to voters' minds is through their wallets.

This search will focus primarily on Colorado media. By conducting a search through the archives of *The Denver Post* from 1998 through 2013 searching for "(forest* OR wood*) AND biomass AND (energy OR fuel*)" as a keyword term, only articles focusing on forest energy should appear. Any hits in the first few years should allow the study to "see" how the forest energy was characterized prior to seeing how such concern translated into action in Congressional committee venues. Over 120 “hits” or written articles were returned.

One of the first mentions in the Denver Post concerning forest energy was a column written by Bill Schroer (1999) with the Western Biofuels Consortium. The column asks readers to ponder “How long will cheap gas last?” and argues for using collaboration to join public and private entities to produce alternative fuels including ethanol made from forest wood waste, quickly noting that “Forests are healthier if this wood is thinned out.” A year later, Tom Wolf (2000), author and frequent contributor to *High Country News*, echoed a similar sentiment albeit more from the forestry than the energy side. Wolf wrote that one possibility for using the trees “choking many of our forests” is to burn them for fuel. The op-ed suggests that the wildfires of 2000 may suggest to public and private entities that “careful thinning” may help “overgrown forests” return to “ecological health while making them less prone to conflagration.” Public pressure appeared to help spur federal action. A month later, *The Denver Post* (Greene 2000) reported that the Department of Energy was creating a “National Bioenergy Center” at the National Renewable Energy Laboratory in Golden, Colorado.

At the same time, *The Denver Post* (Stein 2000) launched a series covering the 2000 wildfire season in Colorado “perhaps the worst in the West in at least 50 years” where “[n]early 7 million acres have burned and firefighting costs are expected to reach $1 billion.” Just as quickly as the attention to forest health increased, so did the criticism. Proponents with the Colorado Timber Industry Association suggested that industry could help convert small-diameter trees thinned by the U.S. Forest Service into products, including “biomass fuels” provided they are guaranteed a steady supply. In the same article, conservation groups such as the National Forest Protection Alliance, the Native Forest Network and The Land and Water Fund of the Rockies were critical of commercial logging and thinning on Colorado's national forests. The National Forest Protection Alliance advocated a complete ban on logging on the national forests. The Native Forest Network suggested the call to log was an "overreaction" to the wildfire season. The Land and Water Fund of the Rockies suggested logging was a possibility so long as the cuttings were supported by the ecological science adding that they did not want to "go back to a situation where logging drives the management of the forests." Interest in forest energy, including impacts to energy and national forest management spurred interest on the governmental agenda.

6.2.2 Venue Shopping

The first step to analyzing venue shopping is to examine which Congressional committees were most often focused on forest energy. For the purposes of this dissertation, searching for the relevant Congressional committee hearings involve search the the ProQuest Congressional Publications database using the following keywords: "forest* or wood*", "biomass" and "energy or fuel*" in all but the full text search. Specifically, this analysis looked for the number of Congressional hearings, the committees and subcommittees holding the hearings and the types/affiliations of witnesses called to present testimony (see Tables 6.1, 6.2, 6.3 and 6.4). In Table 6.1, the choice for forest energy proponents between chambers is relatively evenly split with 20 hearings held in the U.S. House of Representatives and 16 held in the U.S. Senate. However, forest energy proponents appeared to have preferred targets in each chamber. For the House, forest energy proponents, more often than not, sought hearings with the Agriculture and Resources committees and their forestry-related and energy-related subcommittees. In the Senate, the preferred venue was overwhelmingly the Committee on Agriculture, Nutrition, and Forestry, with 14 of 16 hearings held by the entity. In addition, one hearing in the Committee's Subcommittee on Research, Nutrition, and General Legislation was also held on forest energy.

Chronologically, the results from Table 6.1 are displayed graphically in Figure 6.3. Initially, attention seems somewhat sparse.

Table 6.1: Forest Energy Congressional Committee and Subcommittee Hearings, 1998-2013

ENTITY	**TOTALS**
U.S. House of Representatives	**20**
Committee on Agriculture	3
Subcommittee on Conservation, Credit, Energy, and Research / Subcommittee on Conservation, Energy, and Forestry	4
Subcommittee on Department Operations, Oversight, Dairy, Nutrition, and Forestry	1
Committee on Appropriations	
Subcommittee on the Department of Interior and Related Agencies	2
Committee on Resources	3
Subcommittee on Energy and Mineral Resources	1
Subcommittee on Forests and Forest Health	3
Committee on Science / Committee on Science and Technology	
Subcommittee on Energy and the Environment	2
Committee on Transportation and Infrastructure	
Subcommittee on Water Resources and Environment	1
U.S. Senate	**16**
Committee on Agriculture, Nutrition, and Forestry	14
Subcommittee on Research, Nutrition, and General Legislation	1
Committee on Energy and Natural Resources	1
TOTAL NUMBER OF HEARINGS	**36**

Source: Adapted from ProQuest's Congressional Publications Database

The hearings in 1999 focused on creating substitute liquid fuels to replace the nation's soaring petroleum consumption in response to wildly fluctuating yet increasing prices while also attempting to reduce environmental degradation stemming from persistent fossil fuel consumption. Hearings in 2000 were largely in response to phasing methyl-tertiary-butyl-ether

(MTBE) out of gasoline due to increasing evidence of unintended health consequences when leaks of the substance entered several municipal drinking water tables. MTBE is a chemical additive designed to increase gasoline's oxygen content in order to reduce pollution while also improving the fuel's anti-knocking capabilities as lead was removed from gasoline (U.S. EPA 2013). Hearings in the years 2001 and 2003 involved a greater emphasis on national energy policy, including implications from including more biofuels in the nation's fuel consumption mix as well as implications from removing feedstock from public forestlands and developing greater forest energy research capabilities and advancing carbon sequestration efforts.

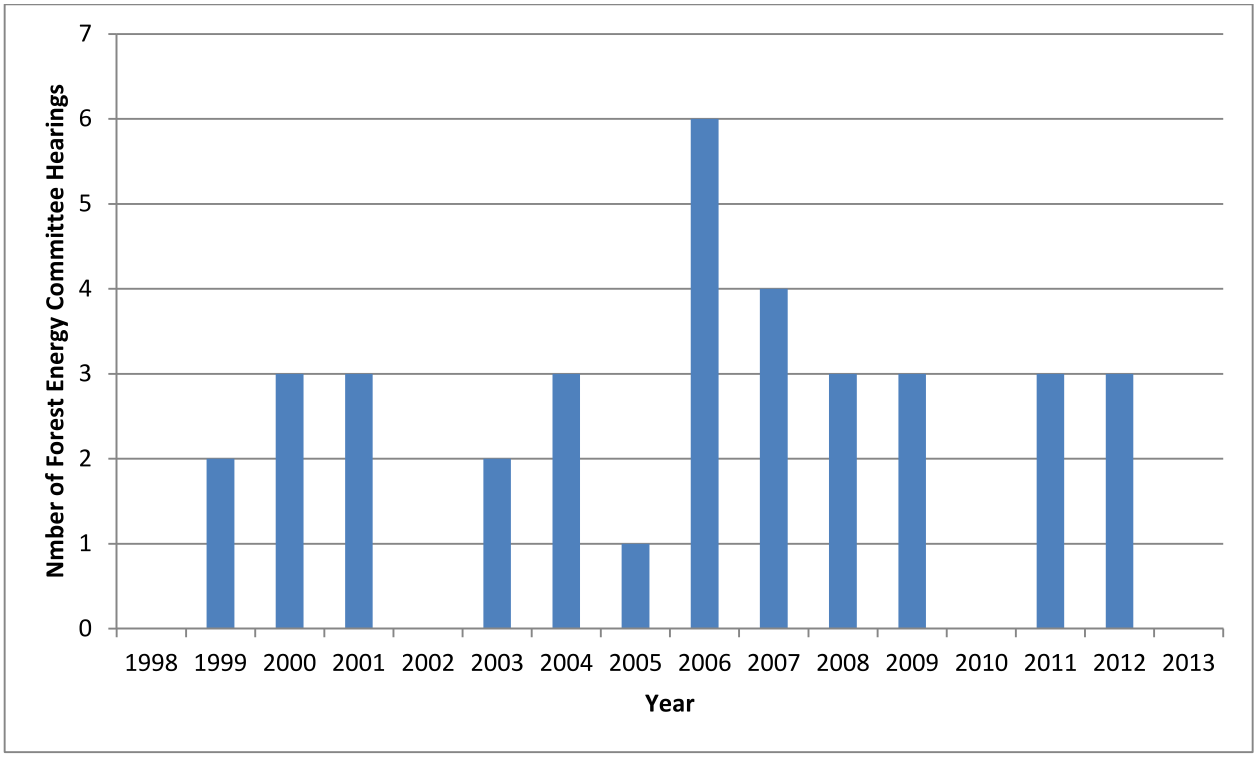

Figure 6.3: Forest Biomass Energy-Related Congressional Committee Hearings, 1998-2013

Source: ProQuest Congressional Publications database.

Hearings from 2004 through 2007 focus almost entirely on creating liquid fuels from forest biomass. Not until near the end of 2009 does the word "thermal" appear in a congressional hearing title, although the concern for "other products" from forest biomass emerged as early as the 1999 hearings.

Concerning participation rates, nearly 300 people testified in congressional committee and/or subcommittee hearing related to forest energy from 1998 to 2013. The largest number of private citizen participants occurred in 2001, when the hearing focused on national energy policy and was perhaps the less specialized of all the congressional hearings identified.

Table 6.2: Agency Participation in Congressional Hearings, 1998-2013

YEAR	FEDERAL	STATE	LOCAL	OTHER	TOTAL
1998	-	-	-	-	**-**
1999	4			3	**7**
2000	5	3		2	**10**
2001	1	1		2	**4**
2002	-	-	-	-	**-**
2003	2	1			**3**
2004	4	2		6	**12**
2005	1	1			**2**
2006	9			2	**11**
2007	4		1	11	**16**
2008	2	1		5	**8**
2009	4	1		2	**7**
2010	-	-	-	-	**-**
2011	5	1		1	**7**
2012	1				**1**
2013	-	-	-	-	**-**
TOTAL	**42**	**11**	**1**	**34**	**88**

Source: Adapted from ProQuest's Congressional Publications Database

The hearings that engendered the greatest amount of public agency/entity were hearings in the middle of the decade. These hearings focused on the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007 and the 2008 Farm Bill. While most of these hearings were dominated by primarily agricultural interests, several hearings featured forest energy-related speakers or, in some cases, forest energy-related witness panels. Towards the end of the observed period the number of hearings seems to stabilize at three, although some hearings were only tangentially related to forest energy/health through submitted documents and other hearings probably should be discounted. For instance, one hearing in 2011 on U.S. EPA mining policies should probably not have been examined.

Table 6.3: Interest Group Participation in Congressional Hearings, 1998-2013

YEAR	PRO-FBU	CON-FBU	NEUTRAL / UNKNOWN / SPLIT	TOTAL
1998	-	-	-	-
1999	3	1	1	**5**
2000	1	1	9	**11**
2001	2	2	7	**11**
2002	-	-	-	-
2003	2	2	10	
2004	6			**6**
2005	1		5	**6**
2006	12		23	**35**
2007	12		29	**41**
2008	6		9	**15**
2009	6		10	**16**
2010	-	-	-	-
2011	1			**1**
2012	5			**5**
2013	-	-	-	-
TOTAL	**57**	**6**	**103**	**152**

Source: Adapted from ProQuest's Congressional Publications Database

6.2.3 Evaluating Forest Energy Policy Change

Revisiting Chapter 3, this study is looking for ways to explain policy change. Using the tables above combined with policy images identified previously, this study can now suggest reasons why the likelihood for significant policy change increased. First, concerning external interests, the number of people interested in forest energy increased, suggesting greater participation was encouraged among actors that were previously not engaged. The larger numbers in the "Other" are primarily researchers from public universities, suggesting that forest energy proponents were able to identify and present subject matter experts to further their cause. Proponents were successfully able to suggest and develop tools for the national legislature to consider and potentially adopt, including tax credits, production quotas and funding mechanisms (e.g., grants, loans).

Table 6.4: Citizen Participation in Congressional Hearings, 1998-2013

YEAR	PRO-FBU	CON-FBU	NEUTRAL / UNKNOWN / SPLIT	TOTAL
1998	-	-	-	**-**
1999	2		1	**3**
2000	2		4	**6**
2001	6		6	**12**
2002	-	-	-	**-**
2003				**0**
2004	2			**2**
2005				**0**
2006				**0**
2007			2	**2**
2008	2			**2**
2009	1			**1**
2010	-	-	-	**-**
2011				**0**
2012				**0**
2013	-	-	-	**-**
TOTAL	**15**	**0**	**13**	**28**

Source: Adapted from ProQuest's Congressional Publications Database

For policy venues, note that the number of hearings for forest energy were greatest not in committees and subcommittees with an energy-related focus, although some attention was paid in the energy subcommittee of the House Agriculture Committee, but rather proponents focused their efforts on the agricultural and forestry-related committees and related-subcommittees. Proponents were also able to take advantage of multiple, open venues. For instance, they were able to secure congressional committee field hearings. In one instance, a Senate Agriculture, Nutrition, and Forestry Committee hearing was held in Rapid City, South Dakota, to discuss the potential for forest biomass to be converted into liquid fuels to help meet the requirements of the Renewable Fuels Standard. Proponents were also able to use federalism to their advantage; when repeated attempts to pass a federal RPS failed (e.g. Cusick 2007), they were able to begin passing them through state legislatures and local governments. Finally, while the USFS for instance has remained manager over National Forest System lands, the increased attention to hazardous fuels reduction through legislation largely incorporates the wildfire policy image.

Concerning tone and scope, forest energy proponents were able to create positively toned media attention focused on wood-to-energy. They had help. At the same time they were promoting forest energy, others were increasing their focus on the fossil fuel price increases and the environmental impacts from increased domestic exploration (fracking). As these impacts and consequences persisted and the use of fracking expanded, energy issues became much more nationalized. In sum, the chances for significant policy change are substantial.

From 2000 to 2009, non-incremental policy change for forest energy was almost an annual occurrence. In 2000, the Biomass Research and Development Act combined with the National Fire Plan provided opportunities for increasing biomass use through grants, technical expertise and hazardous fuels reduction efforts. The 2002 Farm Bill featured a funded Energy Title for the first time in addition to other biomass energy-related provisions. The Healthy Forest Restoration Act of 2003 provided millions of dollars in grants for forest energy projects through its biomass title. The American Jobs Creation Act of 2004 expanded the federal Production Tax Credit (PTC) to include open-loop biomass. The Energy Policy Act of 2005 created the Renewable Fuels Standard (RFS, first edition) which included a mandated quota for cellulosic ethanol. Although incremental, the Tax Relief and Health Care Act of 2006 extended the PTC to the end of 2008. The Energy Independence and Security Act of 2007 drastically changed the RFS (RFS, second edition or RFS2). These policies involve substantial changes to agency scope, resources/funding transfers and new programs and are major or non-incremental policy change.

6.3 Case Studies

The application of the PET to the legislative branch is instructive. Biomass energy proponents targeted their efforts at primarily agricultural and commodities-linked congressional committees. Their efforts over the past decade have largely paid off. Forest energy proponents have targeted forestry-related congressional hearings. However, they have not had the same degree of success. Incentives have been authorized for forest energy projects. In some cases, those authorizations never received appropriations. In other cases, the authorization did received appropriations but their expenditures were curtailed or efforts to support forest energy projects were less than their renewable energy counterparts.

Forest energy proponents would also attempt to achieve their objectives by engaging executive-branch agencies. The initial push for increased FBU was made by the executive branch under President Clinton hrough Executive Order 13134 (1999). Similarly themed efforts were continued under President George W. Bush with the Healthy Forests Initiative. The initiatives launched by these two presidents directed their executive branch agencies to engage in biomass and forest energy-related projects. The following are case studies to examine how these efforts translated into on-the-ground results in Colorado as gleaned by interviews with federal, state and regional/local personnel and entrepreneurs working in Colorado. Selected agencies include the U.S. Forest Service, the Bureau of Land Management, the National Park Service and the U.S. Fish and Wildlife Service.

6.3.1 Colorado Forest Energy and the United States Forest Service

Of all four selected agencies, the U.S. Forest Service may have the best developed and certainly the most productive forest biomass program. The history of that program dates to approximately the same time as the nation started to pay greater attention to the forest health/wildfire issue. Several U.S. Forest Service (USFS) employees believed that, nationally, efforts to promote wood-to-energy applications began with the horrendous wildfire season of 2000. During that year, an escaped prescribed fire in New Mexico destroyed over 230 homes and threatened the U.S. Department of Energy's nuclear weapons lab. Other states also sustained losses; by the end of the season, wildfires charred more than 7 million acres, destroyed 850 structures and cost over $1 billion to suppress (Pinchot Institute for Conservation 2002, 6).

The result was the promulgation of the National Fire Plan (NFP) under the Clinton Administration. In particular, some employees drew attention to the hazardous fuels reduction and biomass utilization component contained in the NFP. The NFP, subsequently combined with Healthy Forests Initiative, the Healthy Forests Restoration Act and a joint memorandum signed by the Secretaries of Agriculture, Energy and Interior in 2003, provided the direction for the USFS. The USFS was to actively manage national forests while providing technical expertise and, in some cases, funding related to forest energy / biomass projects.

The USFS has produced guidance for forest biomass use. The agency produced a Woody Biomass Utilization Strategy in 2008 and a partnering Strategic Energy Framework document in 2011, both aimed at developing the agency's forest energy resources sustainably. Efforts to develop these resources in Colorado on USFS lands has remained fairly consistent, exceeding 190,000 green tons for the past two years and 180,000 green tons the year before. Funding from the USFS and the USDA has helped developed projects and potential projects that have or may serve as market outlets for some removed material. For instance, Colorado benefited from two long-term stewardship contracts (LTSCs). The first contract supports feedstock procurement for an 11.5MW combined heat and power plant in Gypsum, Colorado, which is expected to need about 70,000 bone-dry tons each year. A second LTSC will support a gasification power plant in Pagosa Springs, Colorado, capable of generating 5MWe. The state will also benefit jointly from a $10 million research grant from the USDA that will support the Bioenergy Alliance Network of the Rockies (BANR) with Wyoming, Montana and Idaho.

Yet, the USFS in Colorado, as with the agency elsewhere, is subject to budgetary disruptions during long-term projects because of the budget cycle. Not a single year as passed in the past decade where the agency has not been under the threat or at the mercy of a continuing resolution (CR). A CR means that an agency should plan to spend either the amount proposed for the upcoming fiscal year or the amount that was allocated to it during the past year, whichever amount is lower. Such uncertainty may disrupt forest energy project planning and implementation and, most importantly, discourage private investment.

However, the agency has additional resources it can bring to bear. The USFS is part of the Woody Biomass Utilization Group, an inter-departmental group with members from USDI, USDE, BLM and BIA. The USFS also has a Woody Biomass Utilization Team that is an intra-agency group with members from the National Forest System, Cooperative Forestry and Research. Both groups meet to share information and provide updates on various programs. Furthermore, the USDA Wood to Energy Initiative was established in fall of 2010 and has been the main driver of the most recent activities and brought USDA Rural Development’s three agencies into the effort along with FSA.

The USFS also has a national biomass coordinator and regional biomass coordinators for each of the agency's nine regions. Most recently, the regional biomass coordinators will help with solicitations for the Wood to Energy grant (W2E) and the Statewide Wood Energy Team (SWET) grant. The W2E grant will fund engineering services for forest energy projects necessary for final design and cost analysis. The SWET grant provides funding to states for advancing the installation of commercially viable wood-to-energy systems. The SWET grant is modeled after the USFS "Fuels for Schools" program, a pilot program that began with the National Fire Plan. The idea behind the SWET grant was to help engage local-level decision-makers while providing technical and financial support and assistance. Finally, the coordinators are assisting the USDA and the Wood-2-Energy database hosted at the University of Tennessee. This database provides a listing and maps wood-to-energy plants and forest biomass producers for each state.

6.3.2 Colorado Forest Energy and the Bureau of Land Management

Like the USFS, the BLM was motivated by a concern for public safety. Initial efforts began in the early part of the 21st century. However, the Colorado BLM's Public Domain (PD) forestry program is comparatively smaller, with only five employees to manage over 4 million forested acres, with most of that in the piñon-juniper forest type. The Colorado BLM, like the rest of the agency, supports the use of forest biomass as part of its New Energy Frontier. In some cases, agency support may mean project promotion. For instance, the BLM is engaged with Utah State University Extension on market development and outreach. The BLM is also part of the aforementioned Woody Biomass Utilization Group.

The BLM did produce a biomass utilization strategy in 2005 and revised and updated the strategy in 2009 while also providing additional instructions via Instruction Memorandum for including woody biomass use in BLM contracts. Factors listed in the strategy for encouraging the use of forest biomass for energy include reducing the risk for major fires and also reducing dependence on foreign oil. For BLM Colorado, biomass productivity is approximately between 8,000 and 10,000 bone-dry tons per year.

The Colorado BLM is not without its difficulties as well. In one instance, the funding for BLM Public Domain funding has recently been restored. In Fiscal Years 2010 and 2011, funding for the agency's forest management program was $10 million dollars. In 2012, this funding level was reduced to $9.7 million. For Fiscal Year 2013, the President's initial budget actually eliminated funding for the program. The Office of Management and Budget restored about 65% of the original budget. Yet the level, $6.3 million (or closer to $6 million after sequestration cuts) put the agency under some strain when trying to conduct stewardship contracts, generate biomass, etc. In some cases, the agency lost expertise and scientific knowledge regarding planning programs. Funding was restored in Fiscal Year 2014, but in some cases the full effect of the budget cuts has yet to be realized. In some states, BLM could not hire foresters to replace foresters lost to the cuts. In some instances, when a forester is lost, the next closest forester could be as much as four hours away. BLM Colorado was able to transfer funds from some accounts, so the actual cuts to PD Forestry were reduced closer to 20%, which is still significant.

In another instance, the agency was adversely impacted by a 2009 $40 million infusion from the USDA to battle the bark beetle in Colorado. For the USDI's BLM, this infusion meant some of the agency's contracts in Colorado went no-bid. Regarding the no-bid contracts, one BLM employee noted: "Why should loggers bid on a contract when they can get paid to remove the material? Also, when they get paid to remove the material, they can turn around and sell it. They get paid twice for the same material."

Finally, the BLM, including BLM Colorado, is at a financial disadvantage compared to the USFS. The agency does not provide grants like the USFS. While the agency tries to keep existing industry afloat by supplying forest biomass and works to increase NEPA clearances to keep "critical" and "on the ropes" facilities operating, as one employee said: "Really, we're at the mercy of the market."

6.3.3 Colorado Forest Energy and the National Park Service

The National Park Service (NPS) does conduct forest management activities but its ability to use wood removed from their lands is considerably more limited and targeted than the USFS and the BLM. When asked, NPS employees at all levels mentioned that the agency lacks a specific biomass strategy or policy, but all quickly added their actions are guided by policies that target removals in general, based in turn on the agency's organic act. In part, this limited approach is self-imposed due to the agency's mission contained in its Organic Act of 1916:

> "…to *conserve* the scenery and the natural and historic objects and the wild life therein and to *provide* for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (NPS 2014, *emphasis added*)

The difficultly lies in the seemingly contradictory language (Winks 1997): the NPS is to strike a careful balance between "conserving" and "providing" simultaneously. As a result, removing material of any sort is carefully and strictly regulated, including forest material.

These restrictions on removals are not absolute. These restrictions on removals are not absolute. Starting in 2003, the NPS in Colorado started removing large volumes of beetle-killed hazard trees and other forest material out of concern for public safety due to the mountain pine beetle epidemic. These efforts were costly. Initially, Rocky Mountain National Park was paying around $100,000 per year to remove hazard trees. By the time of the epidemic's peak in 2008, the Park was paying roughly $600,000 and was expecting to pay a total of about $7 million in total to address the beetle-killed tree problem. Included in this total is a 2010 effort to clear hazard trees from beside heavily traveled scenic drives. One popular 12.5-mile stretch of road was cleared by an Oregon company at a cost of about $800,000 or $64,000 per mile. Removals were achieved by service contracts. Companies bid on projects and winners are asked to take "ownership" of the material and are subsequently allowed to dispose of the material by piling and burning or hauling for other uses. Hauled material was used for variety of purposes when possible: wood pellets (Kremmling), timber (Montrose) or log cabins (Idaho Springs). Proceeds from the contracts were used to help offset costs incurred by the Park for the completed work.

The NPS legally cannot give away material nor can it profit from removals; however, it can charge a modest administrative fee to help cover the costs of overseeing and regulating the removals. The permit process is the basis for another way the NPS has creatively combated the MPB epidemic. Rocky Mountain National Park instituted a firewood program. This program allows interested individuals to purchase a permit for a modest administrative fee ($20) and can remove up to 5 cords. In 2009, 105 firewood permits were issued. This program has had some hiccups. Initially, permits were offered on a first-come, first-served basis. However, the agency received complaints from interested parties who did not learn about the program until after the permits were exhausted. In subsequent years, the permit program switched to a lottery system, but this too ran into problems. For instance, some permit holders took 20 cords instead of five, while other permit holders would only take a pick-up truck's worth of firewood. Such disparities make planning for the appropriate amount of permits difficult.

Firewood purchased at Rocky Mountain National Park is part of a different program. The Park enters into an agreement with a concessionaire for supplying firewood. The current supplier is based out of Loveland. Firewood is transported to the Park and is distributed in bundles of approximately six pieces, wrapped in twine, for $5 per bundle. The irony, noted by some NPS employees and Estes Park residents, is that the Park does manage the forests on about 5% of its land, particularly the high hazards along roads and corridors. The Park can produce anywhere from 1,000 to 6,000 piles of woody residues, with each pile about 500 to 600 cubic feet in volume. In essence, the Park, in a Class 1 airshed, imports firewood from Loveland while being forced to resort to pile burning material not collected by the firewood permit holders.

One alternative could be to encourage the development of on-site forest energy projects for NPS structures. However, on-site forest energy projects seem unlikely in the near future. First, the NPS removed the wood-fired stoves that used to heat employee housing and other facilities due to public safety concerns (fire hazard). Second, the costs to do so are expensive and the Park is already struggling with a backlog of maintenance concerns. Finally, any efforts that may alter the appearance of Park buildings would be subject to administrative approval as cosmetic changes would change the visitors' experience.

6.3.4 Colorado Forest Energy and the United States Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) has the least developed efforts for wood-to-energy in Colorado and for good reason: they lack access to the resource (see Figure 6.4). With the focus on refuges, most of their resource is considered prairie or wetland. The only major timbered USFWS land in Colorado is the Leadville National Fish Hatchery, which has 3,000 timbered acres, 2,500 of which are in the Mt. Massive Wilderness Area (U.S. Congress. House. Committee on Natural Resources 2009). To develop a forest energy program, refuges would need to import forest material from areas well beyond the refuge and is often infeasible economically. Whenever possible, attempting to complete projects on-site so that they are fully contained makes more economic sense, which would suggest a preference for solar, wind and geothermal, while carefully considering any potential wildlife impacts.

To this extent, the USFWS has developed a renewable energy program. To start, the USFWS did appear to generate a draft strategy for managing and using biomass in the National Wildlife Refuge System. While several attempts were made from 2010 through 2013 to locate either a hard copy or electronic copy of the strategy, and while no interviewed USFWS personnel at the federal, state or refuge-level knew about the strategy, the best hypothesis appeared that a draft strategy was created in response to the joint USDA/USDI/USDE memorandum in 2003.

Figure 6.4: Arapaho National Wildlife Refuge in Northern Colorado

Source: Adapted from Sangres.com (2014)
Note: Trees are sparse and are primarily riparian vegetation.

Recorded on the USDA-USDI's forestandrangelands.gov (2014) website, the draft USFWS strategy consisted of five key aspects:

1. Identify locations within the Refuge System and among Refuge System partners, that focus on refuges for which biomass utilization has been identified as a significant management opportunity.
2. Ensuring that Refuge System personnel know and understand the "Option for Woody Biomass Utilization in Procurement Contract" policies.
3. Pursuant to the National Fire Plan, the Refuge System refers appropriate personnel to the internet-based information system developed by the DOI. This website provides technical information about biomass utilization and identifies DOI programs and other federal programs involved in biomass utilization.
4. The FWS continues to coordinate biomass utilization efforts with the Biomass and Forest Health Program Manager, DOI Office of Wildland Fire Coordination and other agencies and partners, to increase the possibilities and knowledge of biomass utilization.
5. Identify and rectify management alternatives in Management Plans that may inappropriately impede effective biomass utilization. These efforts will assist Refuge Systems and partners in helping our country meet the needs for alternative energy sources. FWS is committed to taking care of both human and biological communities.

Repeated efforts to verify the existence of and located a hard copy of the strategy, both at the national and the regional levels were unsuccessful. External affairs personnel at both levels were not aware of the strategy listing on the forestandrangelands.gov website nor could they locate any USFWS employee with knowledge of the draft's development.

In addition, several employees mentioned that USFWS has made larger strides with renewable energy in other parts of the country. For instance, over $180 million from the

American Reinvestment and Recovery Act (Stimulus) went to the USFWS, in part for developing alternative, renewable energy projects to reduce the agency's power consumption nationally (Gibbons 2009). The Mora National Fish Hatchery in the Northern New Mexico mountains uses solar panels to offset the energy needs for producing 10,000 Gila trout each year (USFWS 2011). The USFWS also removed 185 forest biomass piles from the Mid-Columbia National Wildlife Refuge Complex in Oregon and Washington that were used to supplement natural gas consumed by a local paper mill's dryer (Forestandrangelands.gov 2009). Finally, the USFWS (2014) Division of Habitat and Resource Conservation provides guidance for licensing other energy sources, including wind power (and voluntary guidelines for reducing impacts to wildlife (USFWS 2012)), solar, geothermal, hydropower and oil, coal and gas leasing. Nationally, the USFWS does have renewable energy and energy efficiency in mind; however, in Colorado, and understandably so, forest energy is not as strong a part of their renewable energy portfolio as other renewables or as forest energy is with the USFS and BLM.

6.4 Colorado Forest Energy and the Role of the State

Federal-level efforts have been significant, but they have been somewhat slow to emerge over the past decade and more patchwork in nature as compared to developments at the state and local levels. Efforts have been made to integrate efforts intra-agency as well as inter-agency but comments gleaned from the interviews suggest that room for progress exists. Furthermore, one of the single largest criticisms that can be directed at both the federal executive as legislative branches as well as the majority of state incentives is that these incentives do not target wood's primary advantage: producing thermal energy.

This oversight was not lost on policy entrepreneurs who, seemingly frustrated with the slower federal pace, have found ways to make the same links between forest health and energy insecurity at lower governmental levels via venue shopping. Their approach makes sense. Given what Koontz (2002) found earlier regarding the state and local levels' greater sensitivity to economic issues, the impacts, whether they are lost revenue from forest fires adversely impacting tourism and recreation revenue or incurred environmental problems stemming from fossil fuel energy extraction and fracking, would provide a basis to act. What follows is a brief sample catalog of actions that state and local actors have taken to incentivize and promote forest energy projects in Colorado.

One of the first major efforts at the state level was the formulation of the state's renewable energy standard (RES) or renewable portfolio standard (RPS). Briefly, an RPS requires a utility to produce a certain percentage of its energy sales by using renewable energy sources. The utilities are thus free to determine how best to meet the regulation by using whatever mechanisms they choose. The effort to pass an RPS in Colorado began in 2001 but failed each time for three years. Then, in 2004, the General Assembly made a pitch to voters using the citizen referendum process. Amendment 37 was the first RPS passed in the nation using this route.

Initially, Colorado's RPS required utilities serving more than 40,000 customers to produce 10% of its electric retail sales using renewable energy. However, note that with the RPS not all energy sources are created equal. For instance, of the 10% generated by renewables, at least 4% of that had to come from solar energy. This designated quotient or "carve-out" is direct boon to the solar power industry and suggests that the solar lobby wields more influence than wind, biomass and other sources that do not have a statutory set-aside. In 2007, the RPS was increased to 20% by 2020 and increased again in 2010 to 30% by 2020. One point worth noting is that biomass is eligible for consideration. Biomass is defined as "[n]ontoxic plant matter consisting of agricultural crops or their byproducts, urban wood waste, mill residue, slash, or brush." Note that the word "trees" is missing from the definition.

A second example of Colorado's commitment to forest energy occurred in 2011. Senator Gail Schwartz introduced and championed a bill that created the Colorado Forest Biomass Use Workgroup. The group consisted of about a dozen members from federal and state government, environmental non-governmental organizations (ENGOs), the forest products industry and other professionals. The group was tasked with developing a report that outlined the barriers to and opportunities for developing a forest energy industry in the state. The report was divided into three main sections. The first section looked at issues related to accessing the material. The second section focused on financing barriers and opportunities. The third section concerned itself with the policy challenges and opportunities for forest energy. Some of the recommendations in the report served as the basis for proposed legislation and resolutions.

A third example occurred with Senate Bill 269 passed in 2013 creating the Colorado Wildfire Risk Reduction Grant program. Open to community groups, local governments, utilities, state agencies and non-profit groups, applicants are required to provide 100% matching for projects designed to reduce wildfire risk in the wildland-urban interface. One component of these grants is to consider options for using forest biomass removed during the execution of the grant. Follow-up visits / consultations with wood use / wood energy professionals in the CSFS CoWood program are part of the program.

6.5 Selected Colorado Forest Energy Project Examples

One of the earliest forest energy projects currently working is the Boulder County Parks and Open Space (BCPOS) campus in Longmont, Colorado, which was installed in 2005. An approximately 4 MMBtu wood-fired boiler from Messersmith Manufacturing heats 95,000 square feet in five buildings on the BCPOS campus.[35] The project's feedstock is felled on Boulder County's forest land north of Nederland, Colorado, by BCPOS personnel or by private contractor, is then chipped by BCPOS employees and then is transported to the Longmont campus via county vehicles. The fuel is then loaded either directly into a loading area or can be dropped onto a designated asphalt landing pad next to the boiler plant. The fuel is then combusted to heat a water-glycol solution that is then pumped through a district heating network for each of the BCPOS campus buildings (Glowacki 2013; Duda 2008, 1-4).

The project has enjoyed a number of successes. Although the system cost about $350,000 to install, fuel savings average over $16,000 per year ($40,000 per year if including the Boulder County Jail), suggesting a simple payback time of approximately 21.3 years, depending on fossil fuel prices (e.g. natural gas) and the system is expected to operate for at least 25 years, as of 2008. As of 2013, using the most recent data suggest the BCPOS system will pay for itself by 2017 or after 12 years (Glowacki 2013). The BCPOS typically thins between 100 and 200 acres per year of its 30,000 acre forested charge and the wood fuel demands from the plant approach 65 acres per year, which is well within what the agency manages, an amount that it can easily process and the amount removed is sustainable (Duda 2008, 36; Golden 2008; Helena Independent Record 2009). Policy champions for the project such as Scott Golden, Forest Health & Utilization Specialist for BCPOS, and Therese Glowacki, Resources Division Manager for BCPOS, manage the project and continue to serve as stalwart champions by leading groups on tours, responding to public inquiries and granting media interviews for the major local network affiliates. As a result, public engagement and satisfaction with their facility experience is quite

[35] While heating figures are usually given in terms of square feet, Duda (2008) correctly notes that the fleet garage building has a ceiling in excess of 30 feet and that using cubic footage is probably more appropriate for future research efforts.

high. Finally, the wood chips used to fuel the system are obtained from BCPOS' forested holdings so the fuel removed to supply the heating plant is improving forest health and reducing wildfire risk concomitantly while the small quantities of waste ash is a potential soil enhancer.

The Gilpin County Road and Bridge building operates a similar but smaller system, identical to but about one-quarter the size of the BCPOS installation, near Black Hawk, Colorado. Material is purchased by the County from both public and private sources, weighed and then stored for eventual chipping when needed. The wood chips are stored in a building located next to the offices and garage. The local champion, Bill Paulman, Facilities Manager for Gilpin County, is a staunch supporter and leads tours for public groups and decision-makers. While the payback period is fairly long, depending on the price of natural gas and what the county pays for the forest feedstock, the project should pay for itself well before the boiler's life expectancy. The Gilpin County facility was modeled after viewing the BCPOS effort.

The Salvation Army's High Peak Camp located just south of Estes Park, Colorado, uses a cordwood boiler to meet its heating needs. After several years of operating, the boiler has produced enough waste to occupy a small, metal "shoebox" at the foot of the boiler. Beetle-killed lodgepole pine trees are located on-site. Satisfaction with the project so far has led project champion, Russ Chandler, to consider implementing forest energy projects elsewhere on-site as the Camp plans to dramatically expand over the next few years, including some residential structures and a large lodge.

6.6 A Note of Caution

However, while these examples have shown years of continued success (i.e., in some cases, the boilers continue to run without significant problems and the project's savings are anticipated to cover project costs or even run a surplus), other examples may detract from or provide caution for potential proponents. One of the first efforts to develop a forest energy project started in the Town of Nederland, Colorado. Nederland contracted with engineering groups that attempted to install a CHP system for its Community Center but quickly ran into problems. Stakeholder groups were communicating intermittently, and eventually the communications became distrustful and even hostile. The fuel storage location was open to the public so wood chips were mixed in with dumped household trash, used diapers and, once, literally the kitchen sink. The steam produced was insufficient for operating the steam turbine i.e., no electricity could be produced. The dump site lacked a concrete or asphalt pad so dirt contaminated the feedstock and caused "clinkers" to develop, which are glass-like silica deposits that form inside of a boiler and must be manually removed over time—time where the boiler is obviously not working to warm a building. A winter storm collapsed part of the roof of the wood boiler was supposed to heat. Major stakeholder groups pulled support. Even Mayor Scott Bruntjen decided not to run for re-election, costing the project its primary champion. The net result is that the Town does not have a biomass project that works and is left to its own to try to recoup a roughly $400,000 loss. While some of the components were later sent to the Boulder County Jail to provide heat and hot water, others who find themselves immersed in an unsuccessful project may have trouble identifying an "out."

The Recreation Center in Fairplay, Colorado, is another unsuccessful project. Designed to provide heat to the swimming pool room, the setup suffered from major design problems. The firebox is located adjacent to the swimming pool room but is not actually connected to the building, meaning that a supplementary source of heat had to be added to the firebox to keep the components from freezing. The feedstock consists of wood pellets that are stored in an adjacent silo. Pellets are then fed via a vacuum pipe from the bottom of the silo to the top of the firebox, as opposed to taking advantage of a gravity-fed system. Intermittent heat combined with a design which was inappropriate to Fairplay's climate and produced by an engineering firm that was just entering the forest energy firm led to Recreation Center abandoning the project. The firebox was used as a storage crate by employees. While the Center expressed an interest in returning to forest energy if the economic conditions were right, a natural gas pipeline reached Fairplay in December 2012, further discouraging wood-to-energy projects.

Even some of the successful examples listed previously have experienced issues. The Salvation Army Camp initially encountered problems with air emissions from its cordwood boiler, which in turn created problems with the Colorado Department of Public Health and the Environment. The problem stemmed from high levels of carbon monoxide in the exhaust when one of the boiler's components was not properly installed. Additional testing will be required to determine if the project (and cordwood boilers generally) will meet air emission standards for Colorado. For the BCPOS project, while noted previously for its triumphs, experienced initial difficulties at start-up. Trees were chipped and the chips were scooped off the ground, which inevitably led to the introduction of debris to the heating system. Problems with the lack of uniformity in wood chip sizes and ice formation on outdoor wood chip piles and in the storage area during winter months provided additional problems for heat production. Fans had to be installed in the storage bin as humidity levels were too high as the wood chips dried. Eventually these problems were successfully addressed but could present challenges to others without the necessary resources and/or technical expertise.

Finally, these projects are subject to the same economic constraints as other energy projects or even other forest energy projects. One of the major obstacles to forest energy projects succeeding is access to a guaranteed, adequate supply. Ideally, trees harvested in Colorado would be manufactured into products that maximize their utility. In other words, trees, whenever possible, would be converted into solid-sawn products and their residues could serve as the feedstock for forest energy projects. Given that most of Colorado's forest products industry is geared to construction (Lynch and Mackes 2001), attempting to capitalize on lumber production wastes would be ideal. However, from 2001 to 2009, Colorado sustained an 85% drop in the number of housing building permits (see Figure 6.5). One of the major, if not the largest, problem for Colorado's forest energy projects is that they will have to locate other sources for biomass feedstock, at least until the housing market rebounds.

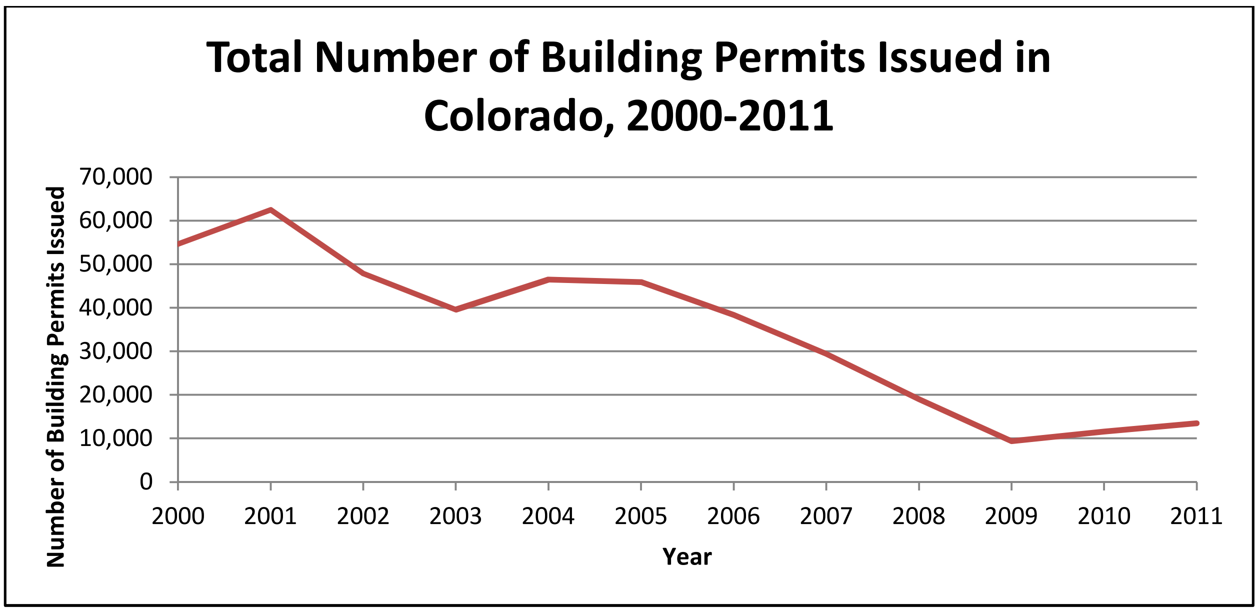

Figure 6.5: Total Number of Building Permits Issued in Colorado, 2000-2011

Source: U.S. Census Bureau (2012).

6.7 Chapter Summary

Forest energy is an emerging policy arena that had the potential to increase in relevance and significance has forest health threats and energy insecurity persist. Policy windows for both forestry and energy policy arenas, which coincidentally emerged around the late 1990s-early

2000s concurrently, facilitated growing public interest in forest health problems and energy security issues. Responding, both the executive and legislative branches promulgated policies designed to increase the amount of forest biomass material removed from overstocked forests and promote the use of some of this material for forest energy projects.

The case histories suggest that alternative energy is actively considered by federal land management agencies in Colorado, but that these efforts have limits. Reasons for considering forest energy were largely derived from the agencies' "public safety" charges. In all of the case studies, access to the resource was paramount. For most of the USFS, BLM and NPS, resource access was determined or restricted administratively i.e., the resource existed but prohibitions on harvesting stemmed from land management planning or policies. For the USFWS and some NPS units, implementing forest energy projects was not done simply because the resource did not exist on their lands and technical concerns rendered the project impractical (e.g., importing the necessary feedstock was too expensive, renovating the federal building to accommodate forest energy was cost-prohibitive, etc.).

In the interim, many federal employees and some state employees mentioned the strides made at the state level. Many of the forest energy projects were completed at the county level or local level with assistance from federal, state and/or local resources. In a few instances, public facilities were receiving feedstock from private suppliers. Success for these projects can very but on the whole, efforts started during the past decade have, generally, been successful. Not every project will enjoy such success.

CHAPTER 7: DISCUSSION AND CONCLUSION

"If history is any guide, oil will eventually be overtaken by less-costly alternatives well before conventional oil reserves run out. Indeed, oil displaced coal despite still vast untapped reserves of coal, and coal displaced wood without denuding our forest lands."

– Alan Greenspan (2005)

7.1 Summary

Forest health and energy insecurity in Colorado are intertwined. Forest health threats in Colorado gained prominence in the early part of the 21st century at about the same time as energy insecurity issues garnered attention through dramatically increasing fossil fuel prices. Forestry bills, such as the Healthy Forests Restoration Act of 2003 and the promulgated iterations of the Farm Bill during the past decade contain significant energy provisions. Energy bills, such as the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 made allowances for forest-based feedstocks. Colorado has developed a number of forest energy projects located across the state capable of developing electric, thermal, CHP and liquid fuels into viable renewable, alternative energy sources. This dissertation argued that policy entrepreneurs, in both the public and private sector, who saw the possibility of linking forest health improvements and fossil fuel dependency reductions to forest energy, made some significant policy gains at the federal and state levels during the last almost 15 years.

7.2 The Multiple Streams Theory and Policy Windows

The Multiple Streams Theory was applied to both the forest policy arena and the energy policy arena in the United States for the period spanning 1973 to 2012. For forest policy, although some preliminary spikes occurred earlier in the examined period, sustained, significant attention was paid to the wildfire issue starting in the year 2000. For energy policy, media attention paid to energy prices begins its return to 1979-levels also in the year 2000. Increases in media attention paid towards wildfires and to energy price spikes appear to emerge at approximately the same time.

7.3 The Punctuated Equilibrium Theory and Forest Energy in Colorado

The Punctuated Equilibrium Theory (PET) was applied to federal-level forest energy policy efforts for the years 1998 through 2013. The argument is that as policy entrepreneurs saw the policy windows open in both the forest policy arena and energy policy arena at approximately the same time. Subsequently, they acted to join their solutions to the simultaneously emerging problems.

Liquid fuels proponents tended to be more active in agricultural circles, targeting congressional agricultural circles. This approach makes sense. Given the amount of energy and attention engendered by corn-starch ethanol producers, forest liquid energy proponents did well by “piggy-backing” on the corn-starch ethanol producers’ efforts. Eventually, as the drawbacks to corn-starch ethanol became better known, forest liquid energy proponents did well as shown in the set-asides in the Renewable Fuel Standard revisions in the Energy Independence and Security Act of 2007.

The electric power and thermal approaches seemed more reliant on the wildfire narrative. Rather than providing a substitute for higher priced liquid fossil fuels, these technologies are suitable for replacing stationary electrical and/or heating plants. As such, while agricultural committees might make sense, these proponents appeared to enjoy greater success in the committees with a stronger natural resources and public lands bent (e.g., Senate Energy and Natural Resources). Their efforts appear to be more successful when targeting elected officials with connections to large amount of public forest land.

For the power and thermal folks, considerable progress has been made also through the executive branch. Multiple grant programs, business loan funds, etc. were made possible through efforts by USDA, USDI and USDE. In Colorado, these funds supported and continue to support increased agency capacity for assisting forest energy proponents and policy entreprenuers (e.g., Gypsum, Pagosa Springs). Even forest liquid energy is beginning to enjoy some benefits as shown in the Bioenergy Alliance Network of the Rockies (BANR) $10 million project, spearheaded by Colorado State University. These results suggest that policy entrepreneurs were successful in achieving major policy change over the past 15 years.

7.4 Future Directions for Forest Energy in Colorado

Federal efforts are significant. However, they are also subject to periodic reauthorizations, government shutdowns and congressional inaction. Alternative venues have also proven useful. Colorado state government has also made progress by increasing its capacity to implement forest energy projects. One way of looking at this policy development is that policy entrepreneurs, attempting to "solve" the entangled problems associated with forest health and energy insecurity, expanded the scope of their conflict so that more people realize they are directly impacted by both forest health issues and problems related to domestic energy production. Subsequently, they pursued sympathetic state legislators to advance their policy ideas.

However, room exists for additional developments; only a small fraction of the ideas proposed in the Senate Bill 11-267 report have been enacted. Efforts to promulgate more of those ideas have stalled. Below a list is compiled of possible future actions that observers should look for that could be taken by private and/or public sectors policy entrepreneurs to help develop forest energy solutions as opportunities emerge.

7.4.1 The Future Role of the Federal Government

The future role of the federal government is somewhat murky. Congress appears gridlocked while the approval rating for the President is declining. Agencies continue to fund forest energy projects through grants, loans, etc. However, room for improvement at the federal level exists. A "wish list" for forest energy proponents might include, but would not necessarily be limited to the following.

- Increase the maximum length of stewardship contracts from 10 to 20 years
- Reinstate the Production Tax Credit for renewables, level the playing field among all renewables (which would also remove the distinction between open-loop and closed-loop biomass)
- Establish a single definition for biomass at the federal level
- Reinstate the tax credit for wood stoves and wood heaters that expired on December 31, 2013
- Encourage state forest agencies to become the focal point for forest energy projects
- Encourage USFS Regions to contribute funds to small-scale forest thermal energy projects in areas where the economics for power and liquid fuels do not work
- Take greater efforts to promote National Forest Products Week in October
- Promulgate a national Renewable Thermal Energy Standard (or at the very least help develop guidelines for states to develop their own)

7.4.2 The Future Role of Colorado Government

Colorado's state government has already taken several steps to help the forest products industry and the renewable energy sector. However, room for additional progress exists at this level as well.

First, Colorado could pass its own “Renewable Thermal Standard” or RTS. Similar to a “Renewable Portfolio Standard” or “Renewable Electricity Standard,” an RTS would require so much thermal energy be created from alternative, renewable sources, including forest energy by heat-supplying utilities. Arizona already has such a standard and New Hampshire recently promulgated its own RTS. Passing an RTS in Colorado will be difficult. Problems with the RTS include a lack of support from major constituencies, including some environmental groups, who opposed reopening the RPS or doctoring it with an RTS, and some utilities as they will already meet the current RPS requirements using existing resources. Furthermore, implementation of an RTS could be difficult without education and outreach to train consumers and utility professionals how to assess Btus consumed for purposes of meeting the standard.

Another idea would be to provide incentives to better consolidate or integrate the state’s forest products industry. Currently, the state’s larger mills are located in Walden, Montrose, Delta and Saguache, with smaller operations scattered across the state. Pellet mills are located in Walden, though not near the mill, in Kremmling and Silver Plume[36]. In other words, Colorado lacks venues that provide the full-value product chain at a single location i.e., large logs could go to a mill and the residues produced while manufacturing high-value solid wood products could be used to make wood pellets and other low-value non-solid wood products. The profits from the high-value solid wood products could be used to cover the costs of utilizing the lower-value products, meaning that forest products companies could help address Colorado’s forest health needs while also addressing its heat energy needs simultaneously. However, the costs of such incentives could be quite high.

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[36] At the time of writing, the pellet mill in Silver Plume was relocating to Parshall, Colorado, to take advantage of the waste stream created by a recently opened stud mill. This co-location is precisely what the paragraph is discussing.

A similar concept is to develop incentives for "District Energy Parks" or "Community Energy Parks." Borrowing from the BCPOS example, a central wood-fired energy plant could be located in a municipal or industrial park, where many occupied buildings are in proximity. Insulated piping would run hot water or steam to the buildings. Municipal centers, such as government complexes, hospitals, prisons and educational institutions, would be ideal.

Finally, the ideas contained in Colorado Senate Bill 267 are worth revisiting during future legislative terms. For instance, in the absence of a federal wood stove tax credit, the state could consider creating one. Funding could be provided to support the Colorado State Forest Service's Wood Utilization and Marketing Program's (CoWood) efforts. Recently, CoWood has helped create and air a series of public service announcements to promote the state's forest products industry, helped create a revolutionary iBook that allows the reader to virtually tour some of the state's forest thermal energy facilities (without leaving the couch) and continues to host seminars and workshops on various topics pertaining to wood use in Colorado, such as using wood from Russian olive or emerald ash borer-killed trees.

7.4.3 The Future Role of Research

Future research efforts must consider the role of states in developing, implementing and evaluating forest energy projects. For instance, several forest energy projects operate in Colorado and have a proven, successful track record, although they admittedly have been running for less than a decade. Primarily, these facilities have been involved with thermal energy only. Other facilities have experimented with co-generation, including The Town of Nederland and most recently, Fort Carson. Large-scale utilities, like the Aquila Power Plant in Canon City, Colorado, and Colorado Springs Utilities, were or are investigating co-firing i.e., burning coal with a small percentage of the feedstock replaced with wood. However, the most convincing, established projects consist of several non-residential installations equipped to burn cordwood, wood chips, or wood pellets to produce thermal energy and most installations are located in the north-central area of the state near densely populated urban corridors with a road network and access to the feedstock either on-site or in proximity to the forest energy project site (Center for Energy and Environmental Security et al. 2010). Research efforts should attempt to gauge the longitudinal effectiveness and efficiencies of these projects in terms of actively managing forests while providing thermal energy.

7.5 A Sustainable Strategy for Forest Energy Development in Colorado

As suggested in Chapter 2, forest energy has the potential to increase public participation in democratic processes. Forest biomass can be widely available, can be obtained relatively cheaply or at least cheaper than some non-renewable fuel substitutes and requires little technical knowledge or experience. As such, any strategy that attempts to increase forest energy project development and implementation would necessarily try to take advantage of these strengths.

Combined with the research suggestion above, the best route forward will likely be a series of public-private partnerships. In Colorado, electrical energy and liquid fuels appear to be garnering the most attention. Electrical energy was and continues to be the target of the state's Renewable Portfolio Standard. The Gypsum Power Plant will produce electricity, although it will produce some energy in the form of CHP. The Pagosa Springs gasification project is expected to produce 5MWe of energy. The recent USDA $10 million award to Colorado State University for the Bioenergy Alliance Network of the Rockies (BANR) project is designed to explore the potential for liquid fuels and biochar production.

Yet these emphases miss wood's primary advantage: wood is designed to burn. Advanced wood combustion systems currently deployed in Europe approach 90% efficiency.

Distributed thermal energy systems in Colorado have shown they can be successful by paying for their initial investment before the end of their life expectancies. The Boulder County Parks and Open Space, for instance, will pay for itself by 2017. Any operating time afterwards is gravy.

So could the same principles apply to smaller, residential systems? Conceivably, yes. Colorado's best move forward to addressing its forest health and energy crises may be to incentivize the adoption of a large number of small residential systems, particularly targeting residents in the Wildland-Urban Interface (WUI). This market segment is critical for two main reasons. First, they are in proximity to the fuel source; often the needed trees are on their property. If they're in an area undergoing an insect epidemic or a recent burn, they may have additional incentive to eliminate candidate trees (i.e., eliminate the pests' ability to spread or remove hazard trees). Second, they most likely are the ones who stand to benefit the most while also being the most likely to accept the change given their likelihood to use the more expensive propane for heat. These WUI residents are quite literally on the front lines of Colorado's forest health battle.

What might such a strategy entail? Revisiting the Senate Bill 11-267 report, the state, possibly with federal funding and technical assistance, should develop a strategically focused wood stove program. Note that this program would not necessarily be a wood stove change-out or "Cash-for-Clunkers" type program. The idea is to give residents flexibility to choose fuel types based on market and other conditions. Similar to the "Flex Energy" concept promoted by Dan Bihn of Bihn Communications, homeowners could switch to the more appropriate fuel (i.e., cheaper, available, more convenient, etc.) fuel when they desire. Having alternative systems is critical. Suppose that wood were unavailable or that homeowners were unable to gather or obtain fuelwood. Having a propane back-up would be essential for survival.

One possible candidate for this strategy could the Sunshine Canyon Fire Protection District (SCFPD) in Boulder County, Colorado. The SCFPD was hit particularly hard by the Fourmile Canyon Fire in 2010. Before the fire, the SCFPD had 164 homes. The fire destroyed 56 homes. Since then, 29 have been rebuilt, leaving 137 homes in a roughly 4 square mile area or about 2,500 acres.

An acre of Front Range forestland will produce roughly eight-to-ten cords of firewood when treated. With a standard 2,500 square foot home consuming an average of two cords per season, a treated acre will support the heating needs for roughly 4 homes. If all 137 homes used exclusively wood, an unlikely but possible scenario, then the total firewood demand annually for the SCFPD would be approximately 274 cords. To meet that demand, the district would need to treat between 28 and 35 acres a year. At that rate, an assuming all 2,500 acres are capable of producing eight-to-ten cords, then the district would treat all of its acres in roughly 71 years. In other words, assuming these acres would be treated on a 30-year rotation, the SCFPD may be able to sustainably harvest firewood from its own forests to meet its own heating demand and possibly have material left over for other products for homeowners, for contactors or for community needs. The products may help offset the cost of the periodic treatments.

The main problem with this approach is that communities looking for help with forest energy have different expectations. Residents are familiar with propane (or natural gas) which requires considerable less effort to prepare, operate and maintain than a forest thermal energy system. As one forest energy proponent noted: “The problem with pushing forest thermal energy is that you are trying to sell ‘Little House on the Prairie’ systems to people that are expecting technology from ‘The Jetsons.’” However, the counter argument that could be made by FBU-proponents is that homeowners in the WUI have a choice: either that woody material can burn on the inside of their homes or, if left untreated, that same material can burn the outside of their homes. Through their actions, or lack thereof, they choose.

7.6 Final Thoughts

This dissertation started with a quote from Shakespeare's *The Tempest*. The quote, which is carved on a statue outside the National Archives and gained renewed fame during the Biden-Palin Vice Presidential Debate, argues that prior conditions set the stage for future developments. Colorado's forest health and energy security conditions set the stage for the rise of forest energy as a potential solution.

Forest energy solutions have many benefits. Yet they are not problem-free. In a review of a forthcoming book on climate change from the German Advisory Council on Climate Change, Achim Steiner, UN Under-Secretary General and Executive Director, UNEP (United Nations Environment Programme), said:

> Biofuels have been represented by some as a silver bullet to the climate change threat, and by others as a fatal mistake set to destroy forests and increase hunger; they are neither. Sane and sensibly developed they offer a chance to reduce emissions, generate employment and diversify rural livelihoods. But widespread commercialisation without proper sustainability standards could prove a disaster, causing more environmental and human harm than good.
> (German Advisory Council on Global Change, 2008).

As part of a commitment to improve energy security and address climate change, the U.S. government has invested heavily in a number of programs and incentives to promote development of renewable energy, including bioenergy from woody biomass. The majority of these investments have been (and continue to be) in the production of cellulosic transportation fuels. To use this resource as flexibly and effectively as possible, it will become increasingly important for federal policies to address the full spectrum of ways in which low-carbon density woody biomass can serve as a substitute for high-carbon density fossil fuels. This includes production of electric power, thermal energy, combined heat-and-power (CHP), and biobased products at a variety of scales. In addition, policies should prioritize improving the sustainability and economic feasibility of bioenergy applications and feedstock development. Federal incentives should encourage site-level assessment of potential biomass projects in order to determine the appropriate scale and to select management practices that will minimize negative impacts and maximize the effectiveness of biomass harvesting as a means to engage in forest stewardship activities, such as stand improvement, habitat management, and restoration forestry. Without cost-effective and profitable methods for harvesting and utilization of woody biomass, it is unlikely that this resource will achieve its potential as a renewable solution to climate change. A continued commitment to research will be needed to achieve the two goals above – there is much to be learned regarding environmental impacts, harvesting methods, cellulosic conversion technologies and the economics of biomass markets. Finally, policies that promote community projects, public-private partnerships, and stakeholder collaboration will be instrumental in achieving social acceptance for bioenergy, building public trust, and developing bioenergy projects that will be equally beneficial to our climate, our forests, our communities, and our economy. These activities will be necessary to overcome much of the skepticism and opposition that is directed towards wood-based bioenergy.

Given the aforementioned forest energy technological pathways and recent research advances, the avenues for future applications and additional research appear limitless. However, boundaries exist in a sense given the lack of significant federal progress in both the forest health and the energy policy arenas. For instance, in Colorado national forest harvests supplied 90% of the state’s timber needs in 1974; by the year 2002, that number had dropped to 38%. Frequently litigated timber sales combined with strong public support for non-extractive values have left the managers of the state's federal forests in a very difficult position, trying to balance the myriad demands placed on themselves and the resources.

When comparing likely routes for developing renewable energy pathways, a more effective measure may be Energy Returned on Water Invested (EROWI), especially for energy resources in arid environments, such as the Western United States. By using another limited resource as a measure of "efficiency," project developers would have a better idea of which energy technologies make sense given the additional necessary inputs rather than using energy conversion efficiency ratios alone (Mulder, Hagens and Fisher 2010).

Although somewhat understated and while last but certainly not least, conservation and certainly those energy conversion efficiency ratios have much stronger roles to play in the future. For instance, to avoid one ton of carbon dioxide by using solar saves about $30. To avoid producing a ton of carbon dioxide using wind power saves about $38. But if an average-sized home switches all of its incandescent bulbs to LEDs, the savings per ton of carbon dioxide avoided is $159 while switching to energy-efficient appliances runs about $108 per ton of carbon dioxide saved. Investments in energy efficiency pay dividends and learning to consume less or "to do more with less" is in society's best interests. In short, while the interest in renewables is growing, efficiency should come first; our current incentive structures, while still well-meant, are backwards (Krieger 2009).

EPILOGUE

This dissertation was written primarily from 2010 to 2013, in the midst of some of the state's worst wildfires. Costs and impacts are still being tallied as they continue to accrue. However, the reader may appreciate an idea of what Colorado has recently experienced plus some historical perspective. Below is a list of some of the more significant wildfires in Colorado shown in decreasing order in size from 1989 to 2013 (Adapted from Examiner.com 2012; KKTV 2013).

Boldface type indicates the wildfire caused injuries and/or deaths.

2002	**Hayman Fire, southwest of Denver - 137,760 acres; 5 deaths*, 16 injuries, 600 structures**
2012	**High Park Fire, Larimer County - 87,284 acres (active); 1 death, 250+ structures**
2002	**Missionary Ridge Fire, near Durango - 71,739 acres; 1 death, 52 injuries, 56 structures**
2012	Last Chance Fire, Washington County - 44,100 acres; 11 structures
2002	**Spring & Fisher/James John fires (Trinidad Complex) - 32,896 acres; 6 injuries**
2002	Burn Canyon Fire , Norwood area - 31,616 acres; 9 injuries
2002	Mount Zirkel Complex, Steamboat Springs area - 31,016 acres
2012	**Heartstrong Fire, Yuma County - 24,000 acres; 3 injuries, 2+ structures**
2012	Little Sand Fire, Pagosa Springs area - 22,240 acres (active)
2000	Bircher Fire , Mesa Verde area - 19,709 acres
2012	**Waldo Canyon Fire, Colorado Springs area - 18,247 acres (active); 2 deaths, 346 homes**
2002	Big Fish Fire , Steamboat Springs area - 17,056 acres; 8 structures
2013	**Black Forest Fire, near Colorado Springs Area – 14,280 acres, 509 homes, 2 deaths**
2012	Pine Ridge Fire, De Beque area - 13,920 acres (active)
2002	Spring Creek Fire , New Castle area - 13,490 acres, No structures
2002	Coal Seam Fire , Glenwood Springs area - 12,209 acres; 113 structures
1996	Buffalo Creek Fire , Jefferson County - 12,000 acres; 10 structures
2000	Hi Meadow Fire, Bailey area - 10,800 acres; 51 structures
2000	Bobcat Fire, Larimer County - 10,599 acres; 18 structures
2012	Weber Fire, San Juan National Forest - 10,133 acres (active)

2002	Million Fire, South Fork area - 9,346 acres; 11 structures
2012	Hewlett Fire, Ft. Collins area - 7,685 acres
2010	Fourmile Canyon Fire, Boulder area - 6,388 acres; 174+ structures
2012	**Sunrise Mine Fire, Gateway area - 5,742 acres; 2 injuries**
2000	Pony Fire, Mesa Verde area - 5,250 acres; 4 structures
2002	Bear Fire , Dinosaur National Monument area - 4,800 acres
2002	**Iron Mountain Fire , Canon City area - 4,436 acres; 200+ structures, 3 injuries**
2002	**Big Elk Fire, Estes Park area - 4,413 acres; 3 deaths, 1 structure**
2012	**Lower North Fork Fire, Conifer area - 4,140 acres; 3 deaths, 23+ structures**
2002	Schoonover Fire, Douglas County - 3,860 acres; 13 structures
1990	Olde Stage Fire , Boulder County - 3,000 acres; 10 structures
2010	Crystal Fire, Larimer County - 2,940 acres; 13 structures
2002	Snaking Fire , Bailey area - 2,590 acres; 2 structures
1994	**South Canyon Fire (Storm King Mountain) - 2,115 acres; 14 deaths**
1989	Black Tiger Gulch Fire - 1,778 acres; 44 structures

*The five firefighters died in a car accident while en route to the Hayman Fire.

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APPENDIX I: ARTICLE TABULATIONS

Table I.1: Forestry Articles Coded by Tone in Titles

Year	Positive	Negative	Neutral / No Code	Totals
1973	2	0	61	63
1974	7	1	57	65
1975	4	3	28	35
1976	12	2	45	59
1977	5	2	36	43
1978	2	2	22	26
1979	2	3	20	25
1980	4	2	26	32
1981	5	6	35	46
1982	3	7	27	37
1983	2	0	54	56
1984	5	0	67	72
1985	0	1	92	93
1986	1	0	94	95
1987	2	3	76	81
1988	3	5	120	128
1989	2	7	148	157
1990	3	11	111	125
1991	4	5	83	92
1992	0	5	106	111
1993	1	0	159	160
1994	14	3	188	205
1995	25	3	131	159
1996	8	5	113	126
1997	5	18	81	104
1998	24	20	126	170
1999	7	14	86	107
2000	22	8	93	123
2001	31	3	92	126
2002	38	6	93	137
2003	32	1	126	159
2004	23	4	90	117
2005	11	0	95	106
2006	10	9	105	124
2007	29	4	104	137
2008	11	2	134	147
2009	24	15	86	125
2010	16	1	101	118
2011	6	1	76	83
2012	7	1	38	46

Source: The Readers' Guide to Periodical Literature, 1973-2012. (n=4,020)

Table I.2: Energy Articles Coded by Tone in Titles

Year	Positive	Negative	Neutral / No Code	Totals
1973	23	3	154	180
1974	17	1	173	191
1975	32	5	233	270
1976	17	2	113	132
1977	42	2	228	272
1978	40	2	194	236
1979	62	1	288	351
1980	29	6	247	282
1981	46	20	177	243
1982	45	11	89	145
1983	15	5	183	203
1984	14	8	102	124
1985	15	2	110	127
1986	6	2	110	118
1987	13	5	59	77
1988	5	2	69	76
1989	7	1	60	68
1990	24	2	92	118
1991	16	1	130	147
1992	1	2	73	76
1993	5	2	70	77
1994	4	0	65	69
1995	9	0	75	84
1996	0	1	96	97
1997	3	1	108	112
1998	9	2	76	87
1999	17	9	69	95
2000	46	0	108	154
2001	83	6	257	346
2002	102	1	197	300
2003	32	2	149	183
2004	44	3	149	196
2005	20	1	279	300
2006	44	4	353	401
2007	44	7	301	352
2008	60	10	496	566
2009	45	29	406	480
2010	60	31	335	426
2011	51	15	248	314
2012	15	6	74	95

Source: The Readers' Guide to Periodical Literature, 1973-2012. (n=8,170)

Table I.3: Wildfire Articles Coded by Tone in Titles

Year	Positive	Negative	Neutral / No Code	Totals
1973	0	0	3	3
1974	0	0	12	12
1975	1	1	3	5
1976	0	0	1	1
1977	5	0	3	8
1978	0	0	1	1
1979	0	0	3	3
1980	0	0	3	3
1981	0	0	1	1
1982	0	0	4	4
1983	0	0	4	4
1984	0	0	8	8
1985	0	0	5	5
1986	0	0	6	6
1987	2	0	6	8
1988	0	1	24	25
1989	0	0	41	41
1990	0	0	11	11
1991	1	0	1	2
1992	0	0	3	3
1993	0	0	15	15
1994	7	0	23	30
1995	10	0	18	28
1996	5	0	7	12
1997	1	2	9	12
1998	13	1	13	27
1999	3	0	10	13
2000	16	0	19	35
2001	19	0	24	43
2002	23	3	14	40
2003	20	0	28	48
2004	11	0	22	33
2005	2	0	15	17
2006	5	2	11	18
2007	9	0	31	40
2008	1	1	32	34
2009	10	0	14	24
2010	5	0	20	25
2011	1	0	22	23
2012	4	0	6	10

Source: The Readers' Guide to Periodical Literature, 1973-2012. (n=681)

Table I.4: Energy Prices-Related Articles Coded by Tone in Titles

Year	Positive	Negative	Neutral / No Code	Totals
1973	4	0	2	6
1974	5	0	7	12
1975	14	2	12	28
1976	6	0	13	19
1977	4	0	32	36
1978	7	0	30	37
1979	9	0	42	51
1980	7	4	21	32
1981	12	10	18	40
1982	24	0	4	28
1983	0	0	32	32
1984	0	5	5	10
1985	2	0	12	14
1986	0	0	12	12
1987	0	0	4	4
1988	0	0	4	4
1989	0	0	5	5
1990	0	0	10	10
1991	0	0	3	3
1992	0	0	5	5
1993	0	1	1	2
1994	0	0	4	4
1995	0	0	5	5
1996	0	0	36	36
1997	0	0	27	27
1998	2	0	11	13
1999	2	2	15	19
2000	21	0	23	44
2001	27	3	25	55
2002	13	0	7	20
2003	6	0	5	11
2004	19	0	10	29
2005	10	0	42	52
2006	11	1	77	89
2007	0	0	27	27
2008	7	0	57	64
2009	1	5	28	34
2010	1	3	12	16
2011	1	2	22	25
2012	8	0	9	17

Source: The Readers' Guide to Periodical Literature, 1973-2012. (n=977)

LIST OF ABBREVIATIONS

ACF: Advocacy Coalition Framework

ARRA: American Recovery and Reinvestment Act of 2009

BBF: Billion Board Feet

BCPOS: Boulder County Parks and Open Space

Bd ft: Board Foot

BLM: Bureau of Land Management (U.S. Department of the Interior)

BLS: Bureau of Labor Statistics (U.S. Department of Labor)

Btu: British thermal unit

CAA: Clean Air Act

CHP: Combined Heat and Power

COGCC: Colorado Oil and Gas Conservation Commission

CR: Continuing Resolution

CSFS: Colorado State Forest Service

Cu Ft: Cubic Foot

DSIRE: Database of State Incentives for Renewables and Efficiency

EERE: Energy Efficiency and Renewable Energy (U.S. Department of Energy)

EIA: Energy Information Administration (U.S. Department of Energy)

EISA: Energy Independence and Security Act of 2007

ENGO: Environmental, Non-Governmental Organizations

EPA: U.S. Environmental Protection Agency

EPAct: Energy Policy Act (of 1992 or of 2005)

FB: Farm Bill

FBU: Forest (Woody) Biomass Utilization

FEMA: Federal Emergency Management Agency

FERC: Federal Energy Regulatory Commission

FPL: Forest Products Laboratory

FS: Forest Service (U.S. Forest Service a.k.a. USDA Forest Service)

FY: Fiscal Year

GAO: General Accounting Office (pre-2004) / Govt. Accountability Office (post-2004)

GEO: Governor's Energy Office (Colorado)

HFI: Healthy Forests Initiative

HFRA: Healthy Forests Restoration Act

IOU: Investor-Owned Utility

LTSC: Long-Term Stewardship Contract

MBF: Thousand Board Feet

MPB: Mountain Pine Beetle (*Dendroctonus pondersoae Hopkins*)

MCF: Thousand Cubic Feet

MMBF: Million Board Feet

MST: Multiple Streams Theory

MW: Megawatt

NASF: National Association of State Foresters

NCDC: National Climatic Data Center

NFMA: National Forest Management Act

NFP: National Forest Plan

NIFC: National Interagency Fire Center

NOAA: National Oceanic and Atmospheric Administration

NPS: National Park Service (U.S. Department of the Interior)

NREL: National Renewable Energy Laboratory

OEMC: Governor’s Office of Environmental Management and Conservation (Colorado)

PET: Punctuated-Equilibrium Theory

PTC: Production Tax Credit

PURPA: Public Utility Regulatory Policy Act

QF: Qualifying Facility

REPI: Renewable Electricity Production Incentive

RPA: Forest and Rangeland Renewable Resource Planning Act of 1974

RES: Renewable Electricity Standard

RFS: Renewable Fuels Standard

RPG: Renewable Portfolio Goal

RPS: Renewable Portfolio Standard

RTS: Renewable Thermal Standard

SRWC: Short-Rotation Woody Crops

USDA: U.S. Department of Agriculture

USDC: U.S. Department of Commerce

USDE: U.S. Department of Energy

USDI: U.S. Department of the Interior

USDL: U.S. Department of the Labor

USFS: U.S. Forest Service (U.S. Department of Agriculture)

USFWS: U.S. Fish and Wildlife Service (U.S. Department of the Interior)

WFLC: Western Forestry Leadership Coalition

WGA: Western Governors' Association