Theory and Evidence…..

Drilling for Oil in the Arctic National Wildlife Refuge:

A Cost-Benefit Analysis

by

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ABSTRACT

The spike in crude oil prices above $50 per barrel breathed new life into the domestic petroleum debate. Americans consume more oil than any other national group. After decades of low, stable crude oil prices, U.S. consumers took for granted the world's limited supply of fossil fuel. Individuals and businesses have been seeking a solution to rising energy prices. The United States has limited petroleum resources beneath its surface, forcing it to import a majority of its supply. Oil producers, motivated by rising oil prices, propose drilling in new domestic zones, specifically the Arctic National Wildlife Refuge (also known as ANWR).

The ANWR, as a federally-protected wilderness area, stores sizeable oil deposits beneath its surface. Simultaneously, it serves as a rich habitat for many Arctic creatures and plants. The fate of this area divides industrialists and environmentalists. To compare the demands of both parties, I develop a cost-benefit model. I determine the incremental wealth added to the American economy (benefit) and the loss of environmental value (cost) in the event of development. Pricing the utility of wilderness poses inherent problems. I propose the use of contingent valuation as a base metric, which improves the quality of cost prediction. Ultimately, I determine that the limited benefits of drilling do not justify the ecological costs of production.

INTRODUCTION

Fifty years ago, the federal government made a commitment to preserve the pristine Alaskan wilderness. By 1980, the government designated over 19 million acres in northeast Alaska as a safe haven for regional wildlife. The Alaska National Interest Lands Conservation Act of 1980 forbids human interference in the selected zone. Section 1002 of the Act forbids petroleum production on the coastal plain without the approval of Congress. The "1002 Area", located 50 miles from the booming North Slope coastal plain, has substantial oil deposits beneath its surface. Developers believe tapping the 1002 Area's deposits will significantly increase American oil production. The recent spike in crude oil prices invigorated a thirty-year debate over the fate of the Arctic National Wildlife Refuge (ANWR).

Congressmen and special interest groups congregate in Washington periodically to argue the merits and disadvantages of increased Alaskan petroleum production. Oil companies, eager to exploit new resources, highlight the benefits of lower gasoline prices and energy independence. Domestic production boosts government revenue and creates jobs in local economies. Environmentalists, on the other hand, support an extension of the moratorium on ANWR drilling. They believe increased domestic production cannot justify substantial ecological damage. Developing ANWR postpones green initiatives. Naysayers oppose drilling because it offers a short-term solution to a long-term problem. ANWR polarizes the economic and scientific community, resulting in strong biases and one-sided research. In this paper, I objectively reconcile the benefits and costs of ANWR oil development. I apply a dollar figure to the qualitative concerns of the environmentalist base. Ultimately, I determine that ANWR development is not worthwhile on a national basis. My analysis also suggests areas of crucial further research.

BENEFITS OF DRILLING

Production Schedule

Drilling in the ANWR will increase oil supply and drive down energy cost. To quantify this benefit, I developed a potential production schedule. The United States Geological Survey conducted several seismic studies to determine the volume of oil in northern Alaska. The USGS surveyed the entire coastal plain. Though drillers may currently enter state and native lands on the coastal plain, they will only do so if the 1002 Area opens; a majority of the recoverable oil is located in the 1002 region. For this reason, my analysis assumes development of the entire coastal plain and not just the 1002 region (see Appendix A for detailed maps). Congressional approval of ANWR drilling would add approximately 10.4 billion barrels of oil to the world petroleum market. The USGS determined its estimates based on current technology, engineering efficiency, and industry standards. They ignored the impact of oil prices as incentives to drill more aggressively. Results from the 1998 survey appear in Table 1:

Table 1: 1998 USGS Oil Survey Results[1]

	Volume of Oil (in Billions of Barrels)		
Region	95% Probability	Mean	5% Probability
1002 Area	4.25	7.67	11.80
Entire Coastal Plain	5.72	10.32	15.96

Note on interpretation: The USGS provides a probability of oil existence above estimated levels. For instance, there is a 95% chance that more than 4.25 billion barrels of oil exist beneath 1002 Area's surface. There is only a 5% probability that more than 11.8 billion barrels exist there.

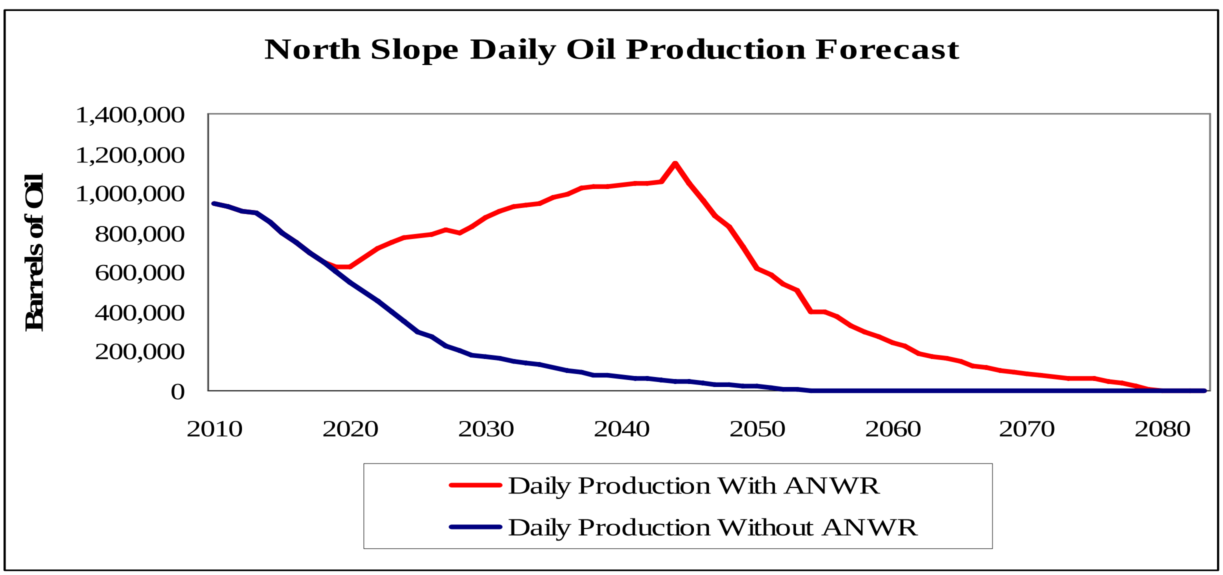
According to the USGS, development would not begin for ten years after Congressional approval. The Bureau of Land Management (BLM) would need two to three years to develop and conduct an auction. Exploratory drilling typically takes three years on the frigid Alaskan North Slope. Once drillers find a sufficient well, they must submit a development plan to the BLM. Finally, creating pipelines, refineries, and transportation arrangements would take three to four years.[2] The Badami and Alpine oil fields, located on the North Slope, experienced a ten year lag between conceptualization and production. Thus, I will assume that ANWR drilling can begin no earlier than 2019.

ANWR oil would expand the existing North Slope production network. Pipelines would connect ANWR rigs and platforms to the Trans Alaska Pipeline, nearly 50 miles away. Oil would travel across the state to the Port of Valdez for further distribution. Fortunately, industry experts believe drillers can comfortably add ANWR oil supply to the existing Trans Alaska

[1] Energy Information Administration, 2000, Table 1
[2] Energy Information Administration, 2008, p. 3

Pipeline System. The pipeline's maximum capacity is 2.136 million barrels per day.[3] It is feasible to use the existing pipeline due to the general (rapid) decline of North Slope oil production. Moreover, the Trans Alaska Pipeline depends on ANWR supply to sustain its operations. The Department of Energy sets a minimum oil throughput rate of 300,000 barrels of oil per day.[4] Without ANWR production, the flow will decline to 300,000 by the year 2025. Oil vessels would have to transport the remaining volume. High cost and logistical difficulty would limit the amount of vessels able to enter the Arctic Sea. Without new oil deposits, North Slope production will end in 2025. After applying the Department of Energy's North Slope forecasts to the USGS's ANWR production timeline, I determined that using the Trans Alaska Pipeline will be feasible until 2058. ANWR extends the life of the North Slope/Alaskan oil industry by 30 years, assuming that drillers bring oil to market at the most safe, efficient rate possible.

Figure 1: Production Forecast[5]



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[3] Alyeska Pipeline Service Company, 2009, section "Pipeline Operations"
[4] National Energy Technology Laboratory, 2007, p. 1-4
[5] National Energy Technology Laboratory, 2007, p.1-4 and Energy Intelligence Administration, 2000, section 2

Impact on the Oil Market

Supporters promote ANWR drilling because it will drive down oil prices. While this argument agrees qualitatively with basic supply and demand theory, it does not capture the quantitative reality of ANWR potential. Ten billion total barrels in ANWR would contribute a miniscule amount to world oil supply. The table below (Table 2) shows that all of ANWR's oil equals less than four years of North Slope production. At its peak, ANWR oil development would produce around 1 million barrels per day around the 25th year of production (see Appendix B). An incremental 360 million barrels annually pales in comparison to world production in the tens of billions of barrels. Hence, adding ANWR reserves will not noticeably impact oil prices. Neither will it make the U.S. energy independent. The United States consumes an average of 20 million barrels of oil per day. Peak production will fulfill less than 5% of domestic oil demand. ANWR production will not reduce U.S. reliance on foreign oil.

Table 2: Annual Oil Production[6]

(in Million of Barrels)

	North Slope	Total Alaska	World
2001	362	374	28,355
2002	363	374	28,101
2003	362	372	29,055
2004	342	351	30,333
2005	322	329	30,871
2006	277	283	30,858
2007	265	270	30,816
2008	257	262	31,197

[6] State of Alaska Department of Revenue: Tax Division, 2008, p.3

Impact on U.S. Economy

In 2007, the domestic oil industry, from drillers to pipeline operators, added over $241 billion to the U.S. economy. The valued added by the entire domestic oil industry constitutes less than 2% of annual gross domestic product. The Alaskan petroleum industry contributes even less to the national economy. The value added as a portion of sales by this capital-intensive industry increases as the price of oil increases. As firms compete for fewer oil resources, particularly in periods of high oil prices, the amount of required labor and capital increases. According to the American Petroleum Institute, oil field service costs have increased dramatically. The price of drilling for an onshore well of 10,000 to 12,499 feet increased from $111 per foot drilled to $294 per foot drilled. Alaskan onshore drilling costs increased from $283 to $1,880 per foot drilled in the same period.[7] Equipment must be fortified to withstand harsh Alaskan conditions. The remote location makes equipment transportation cost much greater than in the contiguous states. While the API anticipates a moderation of drilling service costs, they do not expect prices to return to 2000 levels.

In Alaska, the ratio of oil production value added to sales averages 70% (see Appendix C). However, the proportion increases slightly when crude oil prices rise. High oil prices encourage investment and aggressive research, making labor and capital more productive. Using the regression estimate, I projected the dollar impact of ANWR production on U.S. GDP at various oil price levels. To obtain this datapoint, I multiplied the estimated valued added ratio by the expected production in each year. Value added measures the net benefit of drilling. However, it assumes that idle capacity of labor and capital exist. It presumes that no workers leave jobs in other industries to participate in ANWR drilling. Realistically, workers and capital will transfer

[7] Energy Information Administration, 2008, p. 7

from other sectors. In this case, drilling in ANWR does not add to GDP; it takes value added away from other businesses. To counter this phenomenon, I also computed a sensitivity analysis that assumes value added will increase only 50%. Incremental value added captures the economical net benefit of drilling. It is from this value that I will deduct various ecological costs to fully represent the net profit of drilling. My results are presented in the "Conclusion" section of this paper.

A Note on Taxes

Typically, taxes negatively impact business because they reduce net income. However, from a national perspective, taxes increase public welfare. Tax revenues support public programs and national interests. For this reason, deducting taxes paid by oil companies is inappropriate. Oil companies pay for land lease immediately and for oil production annually. Generally, firms pay 12.5% of their production value to the state. They may pay in cash or "in kind", transferring barrels of oil, which the state can later sell. These royalty payments are deductible for income tax purposes. The state of Alaska gains what oil companies pay in the form of royalties and income taxes.

Alaskan residents directly benefit from oil and gas production via the Alaska Permanent Fund. The Permanent Fund receives one quarter of the collected production royalty. In 2007, the Fund earned well over one billion dollars per year on average for the trailing five year period.[8] Every man, woman, or child residing in the state in the previous year collects an annual dividend check. The state will pay almost $4,000 to eligible dividend applicants this year. Surprisingly, many of the residents who receive dividend checks live in other U.S. states, primarily Oregon. For a list of historical dividend payments, please see Appendix D. Foregoing drilling

[8] State of Alaska Department of Revenue: Permanent Fund Dividend Division, 2007, p. 28

opportunities in ANWR would reduce dividend income for these people. Preventing ANWR production has a significant impact on Alaskan residents and other dividend recipients.

Taxes on the petroleum industry constitute the largest source of income for the state of Alaska. One quarter of the royalty revenues sponsors the Education Fund; the remaining royalty revenue flows to the General Fund. Oil majors pay 25% tax on income, net of royalty fees. The General Fund earned $2.9 billion in 2007 and $7.5 billion in 2008 (a year of high energy prices) due to oil and gas production.[9] ANWR production is crucial in replacing declining income from older Alaskan wells. As I previously mentioned, opening ANWR extends the life of North Slope drilling by almost 30 years. Alaskan residents, thus, depend on the development of ANWR to increase personal income and sponsor public programs for the foreseeable future.

DRILLING COSTS

The extraction of oil and natural gas requires the input of various resources and efforts. Oil producers must erect drilling rigs, refineries, supporting equipment, and distribution channels, maintain an efficient output level, and generate a profit for investors. These costs have an identifiable monetary value. Firms such as Exxon keep thorough records of capital expenditures, inventories, lease contracts, and cash flows. However, non-producing parties also incur costs (whether monetary or intangible) due to oil production. Costs “ignored” by the producer and forced upon other persons or entities are known as *externalities*.

Externalities are an inevitable aspect of business; a company cannot know, much less internalize or eliminate every impact it has on society. Unmitigated pollution is one of the most common examples of an externality. More subtle examples exist in mundane business practices.

[9] State of Alaska Department of Revenue: Tax Division, 2008, p. 14

A company may severely disrupt traffic flow when it builds headquarters near a busy intersection. If it never accounts for this disruption, the firm imposes an externality on the local citizens. To compensate for its social burden, the company may have to build a special traffic loop or pay higher city taxes to subsidize traffic improvement initiatives. Local governments usually hold corporations accountable for the costs they impose on the community.

Individuals can also impose externalities onto society. Imagine sharing an apartment with a nocturnal roommate. His demanding work schedule forces him to complete his homework at night, as you try to sleep. The loud typing sound and bright computer screen wake you in the middle of the night. Typing cannot occur in total silence and darkness. Further, he must work in the bedroom because he cannot easily move his computer and reference books. He may offer to buy you an eyepillow and earplugs so that you can sleep better. Or, he may offer to pay for your relocation costs if you decide to move out. Maybe, you will settle for him performing most of the chores. Regardless, you refuse to tolerate his overbearing, unfair behavior. You demand compensation for his noisy externalities.

Oil producers impose externalities on the environment. When oil producers drill, they disturb the natural habitat of the surrounding area. For instance, their oil and gas pipelines may interfere with migration patterns of animals. The commotion and noise interrupt the Arctic calm, shift the food-chain, and displace animals from their shelters. Presumably, these effects would not occur so quickly and dramatically in the absence of drilling. Developers, like the noisy roommate, cannot eliminate disturbance altogether without stopping operations. Producers who enter ANWR must therefore reduce these external effects to a negligible amount (which is difficult if not impossible to do given the minimum, “fixed” disturbance of drilling operations) or adequately compensate the community.

Determining the value of said compensation requires sharp understanding of the disturbance perception and its value to the effected community. Contingent valuation, which I will discuss later, places an approximate monetary value on these externalities. For some parties, such as the environmental lobby, nature has a very high dollar value. Other constituents believe that the value is high, but not so high that they fail to recognize the benefits of drilling. Oil producers cannot ignore these costs when determining project value. Drilling in the Arctic National Wildlife Refuge has been so contentious because drillers have not been able to reconcile their value from incremental revenues with the value perceived by those who enjoy the idea of a pure and undisturbed ecosystem. Integrating the following costs will help companies better determine the minimally acceptable “hurdle rate” on their drilling projects. As with all investment decisions, an accurately priced oil project will adequately compensate investors and effected constituents.

The Damages

Oil Spills

One of the most dire consequences of oil drilling is the potential for major spillage. Images of oil-covered ducks linger nearly two decades after the Exxon Valdez spill. Fortunately, major oil spills have been fairly uncommon in Alaska. According to Matthew Kotchen and Nicholas Burger, there have only been three major spills in the history of the Trans-Alaska Pipeline System. The monitoring systems failed to detect a leak, which eventually dumped 267,000 gallons of crude oil onto the Alaskan terrain. In 1978, a group of vandals poured

700,000 gallons out of the pipeline. A hunter shot the pipeline in 2001, causing a 285,000-gallon spill.[10] Aside from these isolated incidents, massive spillage has been uncommon.

According to the Environmental Protection Agency, oil spills generally occur in small quantities. If the spill permeates six to ten inches of soil, hydrocarbon-eating microbes can generally remove the excess crude oil. Larger spills require more effort. The area is usually flooded with water to dilute the oil and bring it to the surface. A large device that resembles a vacuum cleaner then sucks the oil from the ground. This process is usually simple and prompt when the weather cooperates.

The oil industry has learned to contain the impact of spills in Alaska. 59% of the crude oil spills that occurred in fiscal year 2008 involved less than ten gallons.[11] The North Slope had the least amount of hazardous spills by volume in fiscal year 2008. To the extent that clean-up crews can restore the habitat to its pre-spill state, spills are not an externality. Guilty parties pay for cleaning as an operating expense. The government sets aside industry taxes to pay for clean up when they cannot identify the guilty party, or when non-negligent liability exceeds $5 million. Of course, one may not be able to perfectly restore an area subject to substantial spill damage. Animals may migrate away from the area indefinitely due to undetected side effects. It is difficult to truly gauge spill impact. The residual, imperceptible effects of oil spills fall under the larger issue of habitat change due to oil development.

Habitat Change

One may think that physical damage to the Alaskan environment, as in the form of an oil spill, is the sole cost to nature. However, habitat change poses serious challenges to the surrounding ecosystems. Oil companies alter the environment even if they invest heavily in

[10] Kotchen & Burger, 2007, p. 4725
[11] Alaska Department of Environmental Conversation, 2009, p. 8

diligent work and eco-friendly practices. As a primarily capital-intensive business, drilling requires machinery, pipelines, platforms, and rigs. The workers who manage the equipment need homes and support buildings. The mere presence of the industry affects the habitat.

Technology and civilization necessarily change the Arctic ecosystem; just the presence of an oil rig starkly contrasts with the pristine snow and white habitat. Access roads are required for various vehicles. Gravel roads are the most common, as they offer the best traction on unstable ground. The roads must be packed sturdily enough to survive freeze and thaw cycles without insulating the soil and melting the permafrost; permafrost releases methane when it melts. Kotchen highlights the impact of pre-drilling site testing on near-by animals. Drillers drive "large sound-emitting vehicles over the landscape in a grid pattern, with lines spaced anywhere from four to one and one-half miles apart."[12] Seismic testing startles the animals living near the test site. Drilling itself causes harsh noise. While plants are not needlessly slashed and animals are not needlessly killed, the above disturbances inherently impact local ecosystems. The industry may mitigate the effects, but it cannot avoid them altogether.

These disturbances seemingly only pose slight inconveniences and aesthetic displeasures. After all, if the drilling rig does not harm the grizzly bear directly, what harm does it do to the ecosystem? If the ground vibrations do not kill the wolf, can the animal not eventually adapt and ignore it? If this were the case, if animals could largely ignore the oil industry in Alaska, oil and gas companies could avoid public dissention simply by managing spills and drilling in sites not known for tourism. Unfortunately, many zoologists believe animals cannot ignore the effects of civilization. They believe Arctic creatures migrate away from the oil sites, and thus disrupt the balance of the local food chain.

[12] Kotchen & Burger, 2007, p. 4725

In a climate where few species can flourish, the absence or abundance of one animal can eliminate the entire population. For instance, if caribou avoid gravel roads, they will affect the local wolves that usually eat them. Either those wolves will escape in search of other caribou herds, or they will eat more of the other large animals remaining in the area. So doing, they will allow the food-sources of their prey to flourish, which may affect other species. The caribou that originally started this problem may not necessarily flourish in their new habitat, forcing their own fertility levels down. Ultimately, if one species avoids the oil industry, it sparks a dangerous chain-reaction that changes the flora and fauna populations in the entire area. Understanding the behaviors of the animals in the Arctic National Wildlife Refuge is crucial in determining the true damage done by oil companies. Observing and rationalizing animal avoidance behavior is a challenging task, plagued by uncertainty and contention.

Caribou

Caribou have become the icons of the ANWR debate. Biologists cite human development and oil drilling as the cause of unstable caribou migration. Matthew Kotchen bases his negative conclusions on studies of the Procupine Caribou Herd. These animals, approximately 123,000 in number, migrate to the Arctic National Wildlife Refuge to breed. If the ANWR opens to oil drillers, female caribou are expected to migrate 30 miles away. The move would "reduce calf survival by 8.2%".[13] According to his model, a 4.6% decline in survival rate would halve population growth. Thus, if Kotchen's research is correct, drilling in ANWR will nearly eliminate the Porcupine Caribou Herd within a few generations.

Chris J. Johnson and his team believe caribou are most sensitive to habitat quality during the post-calving season, during late summer and early autumn. Caribou density decreases

[13] Kotchen & Burger, 2007, p. 4725

dramatically in the presence of human development, especially during this season because the animals require serenity and stability to breed successfully. At Prudhoe Bay in northern Alaska, caribou "avoided high-quality habitats within four kilometers of roads and oilfield production facilities".[14] In Alberta, Woodland caribou avoid 22-48% of high-quality habitat; they avoid oil and gas wells by 1,000 meters and seismic lines by 250 meters. Johnson claims that development in Norway reduced hospitable caribou habitats by a staggering 70%. Pipelines also pose a problem because they trap herds, preventing natural migration tendencies. Caribou are a crucial link in the Alaskan food chain; displacing them will fundamentally change the ecosystem. The famous studies of Kotchen and Johnson raise serious concerns about the food chain impact of oil development.

Wolves and Grizzly Bears

Wolves and grizzly bears are the primary predators of the Alaskan terrain. One would expect animals of such aggressive and vicious nature to exhibit the least avoidance behavior. Chris J. Johnson and his colleagues observed otherwise. Wolves strongly favor heavily forested areas to areas covered with peat bog and lichen veneer. According to Johnson's study, wolves avoided major developments by 61 kilometers[15]. Oil developers will have to clear trees to make room for rigs, buildings, and pipelines, forcing wolves to migrate away.

Grizzly bears, on the other hand, simply follow caribou in the autumn, when other food sources are scarce. Caribou especially avoid human development during this time, when they raise their calves. Poor-quality habitats increase by 34% during this season[16], meaning bear populations decrease near oil developments. Once bears abandon a specific region, they are not

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[14] Johnson et al., 2005, p. 26
[15] Johnson et al., 2005, p. 19
[16] Johnson et al., 2005, p. 21

likely to return. The absence of predators sparks population growth of smaller woodland creatures. In the North Slope, near substantial oil developments, the densities of Arctic foxes, ravens, and glaucous gulls has grown.[17] They no longer compete with many wolves and grizzly bears for food. Foxes now only compete with local brown bears that seek food in the rubbish depositories on the outskirts of villages. Changing the food chain at the top impacts every creature at the bottom.

Amphibians

Mari K. Reeves and a team of researches examined the nature of frog abnormalities due to human civilization. The group hypothesized that human activities contributed to deformations in frog species. They selected the ANWR because it is largely uncharted territory with only small, contained human disturbances; thereby, they isolated the existence of roads as a variable for eye and skeletal deformities in frogs. *R.Sylvatica*, better known as “wood frogs”, are the only amphibian common in Alaska. When the snow melts in late April, the frogs breed and lay their eggs. The scientists studied frogs in Alaskan wilderness in hopes of determining if human development has a negative impact on frog populations. Understanding this correlation may help conservationists protect the future of this dying animal kingdom.

The team observed over 9,000 frogs from five geographically similar regions; each region exhibited different levels of human development. The Arctic and Innoko zones are considered wilderness, accessible only by boat or plane. The Yukon Delta is slightly more civilized. This refuge is located near the town of Bethel, a transportation and shipping hub. Though the area contains no major road system, Bethel contributes “potential contaminant sources such as gravel operations, landfills, sewage treatment facilities, and defunct military

[17] Sovacool, 2007, p. 192

communication sites".[18] A major highway that supports the oil and gas industry runs through Kenai, the fourth site. Soil in the area showed traces of contaminants such as "pentachlorophenol, petroleum products, polychlorinated biphenyls, mercury from historic mining, and historic herbicide applications."[19] Finally, the Tetlin region exhibits the most human development, including part of the Alaska-Canada highway and a natural gas pipeline, which was sprayed with dioxin-containing herbicide in the 1960s.

The scientists collected data on frog location and abnormality from all of these sites. The frog's proximity to the road increased its chances of suffering from an abnormality. Kenai, the region with a major road system supporting the petroleum industry, provided the only frog with an extra limb. In fact, 20% of the frogs observed in Kenai in 2005 exhibited an eye or skeletal abnormality; this is the highest prevalence rate of any location. 7.9% of Kenaian frogs exhibited abnormalities during the seven-year study period. This rate even outpaces Tetlin's 5.9% prevalence rate. Innoko and Arctic zones, the wilderness regions, had 3.0% and 2.0% prevalence rates, respectively. In summary, "all sites with abnormality prevalence greater than 6% were within 10 km of a road".[20] The scientists could not determine the exact reason for the strong correlation between road presence and frog abnormalities. They hypothesize that road access increases soil contaminants and predator presence, making wood frogs more prone to defects.

As roads are required to support an industry, oil companies cannot avoid affecting Alaskan amphibians. It is important to note, however, that the roads of Kenai and Tetlin are major roadways. They have been formally paved to support relatively heavy volumes of commercial traffic. Industry experts foresee using either narrow gravel roads or roads made of packed snow in the ANWR. Workers in northern Alaska have relied on ice roads and small

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[18] Reeves et al., 2008, p. 1010
[19] Ibid.
[20] Reeves et al., 2008, p. 1011

airplanes for most of their transportation needs.[21] Lawmakers have already mandated that new development simply extend the existing network. Drillers must attach their infrastructure to the Trans Alaska Pipeline; they cannot create a new infrastructure network. Experts suggest using directional drills to access oil five miles from the drill pad, reducing the need for roads and platforms. Limiting road pavement will reduce harm to frog populations.

Adaptive Creatures: An Alternative View

Not all scientists agree that oil development will fundamentally change the existing Alaskan ecosystem. Proponents of development attack the gravel road argument. Gravel is used to cover the permafrost to create a sturdy surface for vehicles and drilling platforms. The rocks insulate the ground, trapping heat and thawing more layers than would naturally melt in the summertime. Some biologists believe excess melting results in soil erosion and vegetation destruction. By blocking water flow, the gravel roads increase dust levels, which increase the acidity of the soil. The excess dust "disrupts wet conditions necessary for peat formation of alkaline tundra soils resulting in extensive damage … to vegetation patterns".[22] Joe C. Truett and his research team disagree that dust increases on gravel roads- it is counterintuitive. They contend that caribou, muskoxen, and geese benefit from the seasonal flooding of unabsorbed water because it improves vegetation yield in a region that is usually inhospitable to plants.[23] Moreover, Alaska's Department of Natural Resources forbids the use of gravel roads where ice roads are possible. In the ANWR coastal plain, where drilling would occur, ice roads are possible. Building a gravel road requires government approval. Thus, I question the concerns over gravel roads in ANWR, as they will be rarely used.

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[21] Streever, 2002, p. 181
[22] Sovacool, 2007, p. 191
[23] Truett et al., 1994, p. 318

Matthew Cronin rejects claims that oil development has a negative impact on caribou. The population of Central Arctic Herd caribou has grown since the beginning of oil development in the North Slope from 5,000 animals in 1975 to 20,000 animals in 1997.[24] This rate of growth is comparable to those of caribou in undisturbed Alaskan regions. He also mentions that zoologists have observed caribou walking on gravel roads and hiding in the cool, parasite-free shadows of buildings during the summer. This is hardly avoidance behavior. Cronin also addresses data incompleteness. Many studies mention the decline of caribou in the western range (where the oil fields are located) from 14,842 in 1992 to 6,327 in 1995. During this same period, the population grew from 8,602 to 11,766 animals in the remote eastern range. Cronin extends the data to 1997, revealing a competing argument. In 1997, the population of caribou in the western range increased to 11,997. It declined to 7,733 in the remote eastern range.[25] Additionally, calf-to-cow ratios have always been higher in the western region. Cronin is not convinced that caribou avoid human development. He finds that the animals have adapted well to industry. In his view, the caribou case cannot justify the moratorium on drilling in the ANWR.

Adaptive Birds

Alaskan birds assimilate to human development in the tundra. Many biologists complain that gravel roads are the most disruptive to the ecosystem; the birds, however, seem to appreciate their presence. Many bird species nest in the infrastructure because it offers better protection from predators than does the open tundra. According to Joe C. Truett's study, "ruddy Turnstones and Barid's sandpipers nest on gravel or peat filled material in preference to undisturbed tundra".[26] The gravel catches pools of water where the birds can feed. Flat tundra terrain rarely

[24] Cronin, 2000, p. 920
[25] Cronin, 2000, p. 921
[26] Truett et al., 1994, p. 320

provides such comforts. The lesser golden-plovel (Pluvialis dominica), semipalmated sandpiper (Calidris pusilla), red-necked phalarope (Phalaropus lobatus), and Lapand longspur exhibited higher breeding densities near abandoned peat roads than in similar zones undisturbed by human development.[27] The crucial qualifier, here, is the word “abandoned” peat roads. Most animals search for remote nooks when breeding and giving birth. Their young must be nurtured in quiet, warm areas that are far from the clutches of predators. Unfortunately, workers would have to use the roads, or else they would not lay them in the first place. Still, the observation is crucial; Alaskan animals can adapt to made-made structures. Workers can develop a schedule to minimize the use of roads during peak breeding seasons to minimize the impact on local birds.

Stephen Murphy, Robert H. Day, John A. Wiens, and Keith R. Parker studied the impact of oil spills on bird population. They used the 1989 Exxon Valdez spill as a model for major oil spillage. Due to the negligence of the vessel captain, nearly 11 million gallons of crude oil filled Prince William Sound. The most obvious victims of the tragedy are of course those that lived in the water. Though coastal birds largely avoided direct contact with the crude oil, they still felt the effects of the environmental damage. They experienced a dramatic decrease in available food sources and clean nesting areas. One would hypothesize that the spill forced fish-eating birds out of the south Alaska region, thereby disrupting the food chain balance. This is precisely the question the zoologists set out to answer.

The scientists mimicked a bird population survey conducted in 1984, five years before the spill. By comparing the number of birds before and after the spill, the scientists determined the degree of population shift due to oil spillage. They studied ten locations, four which they considered “uncontaminated or only slightly contaminated” and six “moderately or heavily contaminated” by oil. Surprisingly, “the abundance of birds during mid-summer generally was

[27] Truett et al., 1994, p. 320

not significantly affected and redistribution of birds back into heavily oiled bays was occurring for nearly all taxa by the second summer”.[28] Within two years of the spill, most bird species resumed their migration to the Prince William Sound. Only three of the eleven species experienced significant population decline. If Murphy’s analysis is sound, we can say that there is limited oil spill impact on birds.

Conflicting interpretations of animal behavior data complicate decision-making. A major contributor to this conflict is the highly personal nature of the research. Few issues polarize communities quite like environmental conservation. Even research scientists, who should approach every topic with an unbiased view, are prone to the “us-them dichotomy”.[29] A biologist who fails to identify negative response behavior in caribou unintentionally aligns himself with the oil companies. If he opposes drilling in ANWR, he has an incentive to interpret data in a favorable manner. These personal biases flourish in a topic full of ambiguity.

The test subjects, here, are animals. The observer has the responsibility of rationalizing animal behavior. One cannot state with full confidence that the caribou left a drilling region due to the psychological disturbance. Additionally, data collection is a tedious, inconsistent, and long process. Proper migration studies have a multi-year life span and track individual animals over time. It is inherently difficult to track and explain the migration of wild animals. Thorough analysis must take place over a time span of more than 10 years; attraction or avoidance in any particular year may be anomalistic. Unfortunately, waiting an additional decade to decide on ANWR drilling is very costly given the amount of set-up time required for such projects.

At best, we can say that oil development probably disturbs Alaskan wildlife, at least to a small degree. Some species, like the caribou and birds, have successfully adapted, even finding

[28] Murphy et al., 1997, p. 311
[29] Streever, 2002, p. 179

an advantage to the infrastructure's existence. Others, such as the wolves and frogs, escape or suffer. Is this really so bad? Will the effects of permanent displacement of certain species necessarily destroy the local ecosystem? After all, grazing herds rarely stay in one area forever- they search for plentiful pastures and hospitable climates. The ANWR ecosystem will change, of course, but one cannot know for sure that the new environment will spell the end for Arctic creatures in general. Oil is located in a small fraction of Alaska's terrain; caribou and wolves have plenty of land to establish new habitats, where the oil industry has no incentive to invest. Biologists have not published much research on the impacts of displaced Artic creatures. How have the caribou changed the natural balance in their new habitats? Could this change have occurred without the interference of humans? Is this change necessarily worse than the status quo? How do we define "worse"? Many questions remain unanswered, though they are crucial to forming a sound opinion on drilling.

Costs of Damage

Harm inflicted on the environment comes at a price. If oil developers could freely extract, pollute, and disturb, there would be no externalities. The cost of production would solely be a function of equipment fees, labor costs, overhead, taxes, and financing. We know that drilling in the Arctic National Wildlife Refuge is not "free". Lobbyists and special interest groups contest oil companies on grounds that drillers will destroy one of the last remaining pure ecosystems. Ignoring public outrage imposes an externalized cost onto society.

Firms that ignore externalities ultimately suffer from boycotts or lawsuits. Chinese textiles dump dye into local rivers to avoid properly discarding waste products. The chemicals have oxidized the rivers, killing fish and algae. The Chinese government is only beginning to regulate environmental matters. Pollution has severely affected the health of millions of residents. Chinese companies that once had an economic advantage by polluting have jeopardized the well-being of future generations. This phenomenon is not limited to the natural resources. When customers discovered that Nike outsourced its goods to sweatshops in Asia, they stopped buying their products. People still refer to Nike as the quintessential corporate social irresponsibility case. Their ignorance, intentional or unintentional, of the fair value of Asian labor resulted in very costly brand image (and revenue) destruction.

Costs are classified into use and nonuse costs. Use costs arise from the actual use of the land. Take, for instance, the use of Manhattan Island as a hypothetical oil-drilling site. The developer would have to first clear away the office buildings. He would pay per dismantled square foot the amount of revenue generated by the property. Landlords would demand at least the amount of foregone rental income. Businesses would charge at least the amount of foregone sales, if their business could not be relocated. If it could be moved, they would at least charge moving and setup costs. Developers would spend a considerable amount of money before they could begin drilling because many parties, who must be compensated for eviction, already use the island of Manhattan.

The Arctic National Wildlife Refuge, however, has no true use by human beings. It does not have a residential community or a retail center. It does not even have a tourism sector. Drilling, therefore, does not impede on other income-generating activities. Nonetheless, public property cannot be exploited for personal use. Oil drillers cannot simply dump drilling fluids and oil, leave trash, or chop down trees to sell to pulp companies. Public land is *not* free-use land. Treating the ANWR as unclaimed territory permits parties to openly, freely exploit use its resources in a destructive “tragedy of the commons” manner. The government forces oil companies (or other culprits) to clean up oil spills and other environmental damage even though no person experiences the effects. The Oil Spill Liability Trust Fund collects a per-barrel tax to cover clean-up costs if a guilty party cannot be identified. It also pays for damages above $10 million if the guilty party acted within the bounds of reasonable duty of care. Drillers already pay for use value; they must also consider non-use costs.

Nonuse is difficult to value. Unlike use value, nonuse values have no tangible attached cost. *In theory*, if the Arctic National Wildlife Refuge disappeared, most people would not experience any change in their daily routines. Arguably, only Alaskans and Artic ecologists would notice its absence. Opening up the region to drillers might somehow impede on their state pride or cultural and personal values. However, as we can see from grassroots political activity, they are not the only ones who oppose development. Most people who campaign against ANWR drilling experience only nonuse value, or "existence value", in the region. Though no tourists visit the ANWR, most people appreciate its existence as untouched wilderness. Existence value is:

> "captured by human emotion, whether this emotion stems from a semi-spiritual connection that the individual feels with other species, from a sense that the way he treats other species is representative of his ability to respect others, or from a sense that those species deserve respect merely because they, too, are alive".[30]

To the extent that use value is negligible, the benefits of drilling must at least exceed the value of maintaining the status quo- that is, preserving the ANWR as an undeveloped region.

[30] Dobbins, 1992, p. 880

The public understands, in varying degrees awareness, the effects of industrialization on nature. Knowledge about caribou migration and grizzly bear avoidance influences the value individuals place on conservation measures. Many economists favor the contingent valuation method for calculating existence value.

Contingent Valuation

Contingent valuation is a relatively new and revolutionary science (and art). It began in the 1960s as a way of determining the value of public land projects. Today, researchers use it as a valuation tool in opinion surveys across many fields. As monetary values are the most tangible and objective value-metric, researchers determine the mean dollar amount subjects place on the asset at hand. Respondents are asked a series of questions regarding their Willingness to Accept or Willingness to Pay for a change in the status quo policy.

Willingness to Accept surveys ask respondents how much money the government (or other policy-generating body) would have to pay the respondent in order for him or her to accept the policy. Under this approach, economists assume that people feel a sense of ownership in public land, and thus, deserve compensation for change. In Willingness to Pay studies, the researcher asks the respondent how much they would pay the government to *prevent* the change in policy. The underlying theory here is that the government owns the public land. The respondent must “invest” in the land to make management decisions. This dollar amount generally estimates the value the respondent sees in the status quo. In theory, Willingness to Accept and Willingness to Pay questionnaires should generate the same value. However, as one may predict, respondents generally pay less than they would accept. A study of wetland preservation programs found that duck hunters were willing to pay $247 but were willing to accept $1,044.[31] Conservative analysts should, thus, examine willingness to pay measures.

Assigning a dollar value onto a subjective interpretation of the environment seems arbitrary and somewhat irrational. How can we punish oil drillers for destroying our appreciation of nature's beauty? How can we know how much it is worth to us? However, the application is not an esoteric, foreign concept. Jeffery C. Dobbins draws the analogy to pain and suffering compensation in civil trials. The judge forces the defendant to pay the plaintiff for lost wages, rehabilitation and miscellaneous medical expenses, and emotional suffering. Experts can calculate the first two costs easily by multiplying wage rate by lost hours and by consulting doctors. No objective method exists for pain and suffering damages. There is neither an active, transparent market nor a formal standard for pain and suffering compensation. When possible, the judge applies awards from similar cases in the past. If precedence does not exist, jurors must "arrive at an appropriate figure for compensating pain and suffering based on their experience with the general run of humanity, their background and experience, and their enlightened conscience".[32]

Test subjects, at varying degrees of consciousness, have an emotional attachment to nature. Based on their knowledge of ecology, politics, and economics, they can intuitively guess how much it is worth. Compensating Alaskans for the development of the ANWR will not protect the environment, just as paying the plaintiff will not reverse the pain and emotional suffering he has experienced. Nonetheless, the federal court system determined that oil companies cannot escape this liability. The outcome of Ohio vs. The Department of the Interior case in 1989 mandated the inclusion of existence value in damage calculation. In 1992, the U.S.

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[31] Knetsch & Sinden, 1984, p. 508
[32] Dobbins, 1994, p. 891

National Oceanic and Atmospheric Administration (NOAA) concluded that contingent valuation studies are reliable enough to be used at least as a starting point in determining the passive-use value lost in instances of natural resource damage. They admit that it has many shortcomings, yet it has no better alternative.[33] Hence, I will use the contingent valuation method to calculate the existence value of the ANWR.

Designing a sound contingent valuation study requires skill in the area of survey design. The survey must adequately and neutrally provide background information. R.T. Carson dedicates a substantial portion of his chapter on contingent valuation to the art of survey design. According to him, "the valuation estimate obtained from preference information given that the respondent is said to be contingent on the details of the constructed market for the environmental good put forth in the survey".[34] Reliable surveys describe the status quo of the public good; they highlight the attributes of the good, the impending changes, the effects of the changes onto the status quo, the means of the change, and the method of paying for the change. Neglecting these facts forces the respondents to form inconsistent assumptions about the fact-pattern.

Tom Tietenberg highlights potential limitations of surveys due to respondent biases. Providing thorough background eliminates the information bias, which arises when respondents have little or no knowledge about the underlying issue. Tietenberg's remaining three assumptions are difficult to avoid, even in the best survey. The strategic bias causes the respondent to exaggerate in order to obtain a favorable outcome. If they subject knows his opinion can prevent oil drilling in the ANWR, he will provide an answer large enough to guarantee a moratorium. The value will be much larger than what he would truly pay to prevent development. Due to the hypothetical bias, respondents say their ideal answer because they know

[33] National Oceanic and Atmospheric Administration, 1993, p. 3
[34] Carson & Hanemann, 2005, p. 824

they will not have to pay the stated amount. The starting point bias discusses the impact of scale manipulation. Providing a pay scale gives the respondent a reference point for what he should pay. Despite this weakness, researchers favor pay scale surveys to open-ended options.

A contingent valuation researcher must select the appropriate subject group. Naturally, one would ask those closest to the public good. However, solely asking Alaskans is problematic. Drilling in the Arctic National Wildlife Refuge is a national debate. Environmentalists across the country rally in Washington to oppose the oil business. Additionally, Alaskans receive an annual dividend from the Permanent Fund. They receive compensation for drilling activities while other Americans do not. Citizens of states who do not receive dividend checks will not weigh the benefits of drilling as heavily as Alaskans do. This is a national issue, and thus, deserves national study.

Some economists question the validity of valuation studies outside of the region most affected by the policy. They cite "Nimbyism" as a bias factor in the respondent's valuation equation. Nimby stands for "Not In My Backyard". A nimby objection depends on the respondent's proximity to the public good; he values neighboring land more than he does land far away. Nuclear power surveys often display nimby bias. Polls show that Americans are less opposed to nuclear power if the plants are located far from their towns. In theory, Americans should either oppose or support nuclear power as a concept. Opinion should not hinge on proximity.

Kristy Michaud questioned nimby effects in the environmental lobby. She wondered if environmental lobbyists represented only the voice of residents near oil spills. If this is the case, a national-scope study should ask diversify its sample population. Surveying West Coast dwellers will reveal a much higher value of externalities if nimby biases exist. A national average WTP must exist to capture the opinions of those living near and far from oil industry. Michaud asked southern Californians if they supported drilling near Santa Barbara, near a remote California coast, and in the ANWR. She expected Santa Barbara residents to exhibit the most opposition to drilling because of the major spill that occurred offshore in the Santa Barbara Channel in 1969. Her study found that proximity to Santa Barbara had little correlation with survey response. In fact, “Santa Barbara residents were actually more supportive of oil development than people living elsewhere in the state”.[35] In the oil sector, it is reasonable to assume that opposition is due to universal views on the environment.

If nimby effects do not exist, we can assume all registered American voters can value the ANWR similarly. Unfortunately, no survey has exactly measured the WTP to preserve ANWR. I will use the values generated by related studies to develop a range of general approximations of ANWR’s existence value. Kotchen found that “the average willingness to accept compensation to allow drilling in ANWR ranges from $582 to $1782 per person of voting age, with a mean estimate of $1141 ($38 per year for 30 years)”.[36] Americans are willing to accept between $14.50 and $54.90 per year for the next 30 years to permit oil companies to drill in the ANWR. Another study finds that “US households are willing to pay an average of $147 (in 2005 $ terms) in a one-time payment to prevent an oil spill with damages like those that occurred in Prince William Sound, Alaska”.[37] This measure translates into only $4.90 per year to prevent substantial ecological damage. These two surveys do not answer the ANWR question. Willingness to Accept, in the first study, is generally too high to reflect true value. Asking respondents how much they would pay to prevent a disaster does not specifically address environmental policy-respondents react only to extreme events.

[35] Michaud et al., 2008, p. 28
[36] Kotchen & Burger, 2007, p. 4721
[37] Kotchen & Burger, 2007, p. 4726

I will add three additional surveys to my analysis, though they address entirely different areas. Richard Walsh's 1980 study in Colorado involved a state tax that would amend an existing preservation law. He asked state residents how much they would pay to increase the amount of "wild land" in Colorado. He determined that they would pay an average of $31, $11.41 of which is due to existence value.[38] A second survey generated much more conservative results. Randall A. Kramer asked Americans how much they would be willing to pay to protect tropical rain forests. He found that on average, they were willing to make a one-time $31 payment, or $1.03 per year for the next 30 years.[39] Finally, a contingent valuation study in Iceland asked citizens how much they would accept from the government to permit hydroelectric development in the frozen wilderness. I divided the solution by four, using Knetsch's and Sinden's WTP to WTA disparity ratio, because even the most conservative answer was exceptionally high. Adjusting for this ratio, Icelanders value the wilderness at $104.85 per person per year.[40] I multiplied all of the aforementioned contingent values by the number of Americans above the voting age, as per the 2007 US Census Bureau's estimates, to determine the value of the annual externalities resulting from ANWR development. This cost must be deducted from value added to capture the true net present value of the proposed petroleum operations.

CONCLUSION

Should the petroleum industry or the environmentalist groups decide ANWR's fate? I draw my conclusion based on the present value of incremental economic growth (measured by value added) and the perceived loss of ecological utility in the event of drilling approval.

[38] Walsh, Loomis, & Gillman, 2004, p. 24
[39] Kramer & Mercer, 1997, p.205
[40] Lienhoop & MacMillan, 2007, p.289

Many economists favor the use of incremental value added as a measure of economic benefit. Value added is the contribution of a business to gross domestic product. As I mentioned on page 6, incremental value added assumes idle capacity of labor and capital. If the oil business puts to work individuals who otherwise would stay at home, value added represents economic growth. If the oil business must attract workers and machinery away from other industries, it will not necessarily benefit the economy. In the latter example, the oil sector merely rearranges the source of existing economic growth. To combat this limitation, I create two sets of sensitivity tables. One set of tables shows full value added benefit, and the other assumes that the oil sector must divert resources from another sector. Alternatively, I could have studied the amount companies bid for a tract of land, given the estimated number of underlying barrels of oil. This measure captures the value of oil in the ground. Unfortunately, I have not been able to find reliable estimates of such auctions on a per-barrel basis.

To measure the ecological cost of drilling, I examine two variables. The first variable is lost existence value in the event of drilling. The second variable is the cost of additional carbon emissions. I add these two values together because I assume that contingent valuation surveys do not draw attention to carbon emissions when they investigate wilderness value. Due to the uncertainty involved in the measurement of both of these variables, I conduct sensitivity analyses on both of these costs. I present my results in several stages. In the first stage, I demonstrate the net present value of incremental value added in light of lost existence value of wilderness. In the second stage, I incorporate the impact of carbon emissions and climate change as an additional externality cost. Finally, I adjust my calculation for the limitation of value added theory.

Table 3 summarizes the benefits of value added and the cost in lost existence value. I used the six price points mentioned in previous contingent valuation studies and the Census

Bureau's adult population estimates to generate an annual, national price. I discounted the incremental value added by Alaskan oil operations, net of the annual externality cost per American citizen, at the rate of 7% (which is the government's benchmark for evaluating natural resource projects).[41]

Table 3: Summary of Value Added at Varying Oil Prices and Externality Costs

(in Billions of Dollars)

	Estimated Annual Externality (WTP)					
	$1.03	$4.90	$11.41	$38.00	$59.40	$104.85
$10 per Barrel	2.6	-9.5	-30.0	-113.6	-180.8	-324.0
$30 per Barrel	21.8	9.7	-10.8	-94.4	-161.6	-304.5
$60 per Barrel	55.7	43.5	23.1	-60.5	-127.7	-270.6
$100 per Barrel	110.4	98.2	77.8	-5.8	-73.1	-215.9
$200 per Barrel	235.6	223.4	202.9	119.4	52.1	-90.7

As you can see, externalities significantly detract from economic growth. The table above shows the net present value of future (net) benefits of drilling. Not even at the $200 per barrel of crude oil mark does NPV remain positive throughout the entire analysis. Lacking an ANWR-specific contingent valuation study raises questions about the appropriate WTP column to analyze. $38 comes from an ANWR survey. However, it asks how much people are Willing to Accept. At this level, Congress should reject drilling when oil is less than $200 per barrel, in real terms. If externalities are close to $1, it is always wise to open drilling operations. Half of the results produce a positive NPV, implying we should drill. However, even in the very best case-scenario, we add only $235 billion to a GDP. If US GDP does not grow from its 2007 level of

[41] Tietenberg, 2007, p. 48

$13.84 trillion, the net present value of GDP from 2009 to 2058 is $191 trillion. The benefit of drilling in the best case has a less than 0.15% impact.

Scientists generally agree that our dependence on dirty fuel has polluted our air supply and increased carbon dioxide levels in the atmosphere. The longer we drill for oil, the more we prolong our addiction to hydrocarbon energy. Extending North Slope production by 30 years undermines government initiatives to explore green energy sources today. I encourage the reader to apply his own cost of waiting to address climate change. Note, however, the negative impact externalities have on net present value.

Adding climate change cost further reduces the profitability of ANWR drilling. In Table 4, I adjust my previous calculations by Fankhauser's Coefficient of carbon dioxide damage. He contends that every gigaton of carbon dioxide reduces social welfare by $300 million[42]; some environmental scientists recommend multiplying Fankhauser's estimate by five to determine the true impacts of carbon dioxide stocks. Drilling in ANWR will ultimately result in the burning of 10.4 billion barrels of oil. Each of those barrels of oil will produce 363 kg of carbon dioxide when burned.[43] As you can see in the Table, we should drill only if crude oil costs more than $200 per barrel in real terms and externalities cost less than $11.41 per person. Multiplying Fankhauser's estimate by five may be reasonable since our understanding of carbon dioxide damage has improved since he wrote his paper in 1995. Each carbon unit remains in the atmosphere long after the oil serves its purposes. These incremental pollutants pose substantial costs to our society and progeny; they too should reduce the value added of oil.

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[42] Dutta & Radner, 2004, p.5178
[43] Snyder, 2008, p.938

Table 4: Value Added of ANWR, Adjusted for Fankhauser's Estimate of Carbon Costs

(in Billions of Dollars, including Fankhauser Coefficient)

	Estimated Annual Externality (WTP)					
	$1.03	$4.90	$11.41	$38.00	$59.40	$104.85
$10 per Barrel	-22.5	-34.7	-55.1	-138.7	-206.0	-349.1
$30 per Barrel	-3.3	-15.5	-35.9	-119.5	-186.8	-329.6
$60 per Barrel	30.6	18.4	-2.1	-85.6	-152.9	-295.7
$100 per Barrel	85.2	73.1	52.7	-30.9	-98.2	-241.0
$200 per Barrel	210.4	198.3	177.8	94.2	27.0	-115.8

(in Billions of Dollars, including 5 times Fankhauser Coefficient)

	Estimated Annual Externality (WTP)					
	$1.03	$4.90	$11.41	$38.00	$59.40	$104.85
$10 per Barrel	-123.1	-135.2	-155.7	-239.3	-306.5	-449.7
$30 per Barrel	-103.9	-116.1	-136.5	-220.1	-287.3	-430.2
$60 per Barrel	-70.0	-82.2	-102.6	-186.2	-253.5	-396.3
$100 per Barrel	-15.3	-27.5	-47.9	-131.5	-198.8	-341.6
$200 per Barrel	109.9	97.7	77.2	-6.3	-73.6	-216.4

The positive values above reflect an untrue assumption in most value added analyses. Incremental value added models assume that labor and capital resources are idle; oil production gives purpose to resources that would otherwise contribute nothing to U.S. productivity. However, in reality, oil development will have to divert labor and capital away from other industrial sectors. The value added by oil companies will simply decrease value added by industries experiencing the resulting capital and labor shortage. Value added is the upper bound to GDP growth. Please see Table 5 to observe how net present value can change if only 50% of oil's development comes from otherwise idle resources.

Table 5: Value Added of ANWR, Adjusted for Fankhauser's Carbon Cost and 50% Value Added

(in Billions of Dollars, including Fankhauser Coefficient)

	Estimated Annual Externality (WTP)					
	$1.03	$4.90	$11.41	$38.00	$59.40	$104.85
$10 per Barrel	-26.8	-39.0	-59.4	-143.0	-210.2	-353.1
$30 per Barrel	-17.2	-29.4	-49.8	-133.4	-200.6	-343.5
$60 per Barrel	-0.3	-12.4	-32.9	-116.5	-183.7	-326.5
$100 per Barrel	27.1	14.9	-5.5	-89.1	-156.4	-299.2
$200 per Barrel	89.7	77.5	57.0	-26.5	-93.8	-236.6

(in Billions of Dollars, including 5 times Fankhauser Coefficient)

	Estimated Annual Externality (WTP)					
	$1.03	$4.90	$11.41	$38.00	$59.40	$104.85
$10 per Barrel	-127.4	-139.5	-160.0	-243.6	-310.8	-453.6
$30 per Barrel	-117.8	-129.9	-150.4	-234.0	-301.2	-444.1
$60 per Barrel	-100.8	-113.0	-133.5	-217.0	-284.3	-427.1
$100 per Barrel	-73.5	-85.7	-106.1	-189.7	-256.9	-399.8
$200 per Barrel	-10.9	-23.1	-43.5	-127.1	-194.3	-337.2

As you can see, adjusting for reduced value added and carbon costs produces mostly negative net present values. Negative net present values imply that we should not accept the ANWR oil drilling project. The degree of negativity differs dramatically at different existence value estimates. The reader of this paper may hesitate to accept this conclusion given the highly subjective nature of existence value determination. Thus, I include Table 6. This table shows the same analysis as Table 5, but assuming $0 Willingness to Pay (existence value of wilderness).

The effects of climate change and the adjustment for realistic economic growth result in negative net present values even if I ignore the ecological externalities.

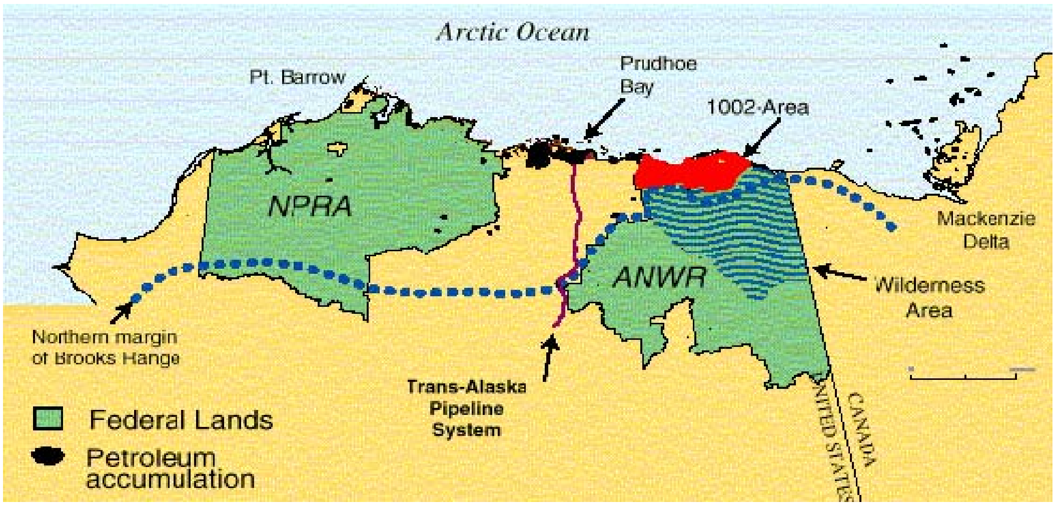
Table 6: Value Added of ANWR, 50% Value Added and No Existence Value

(in Billions of Dollars)

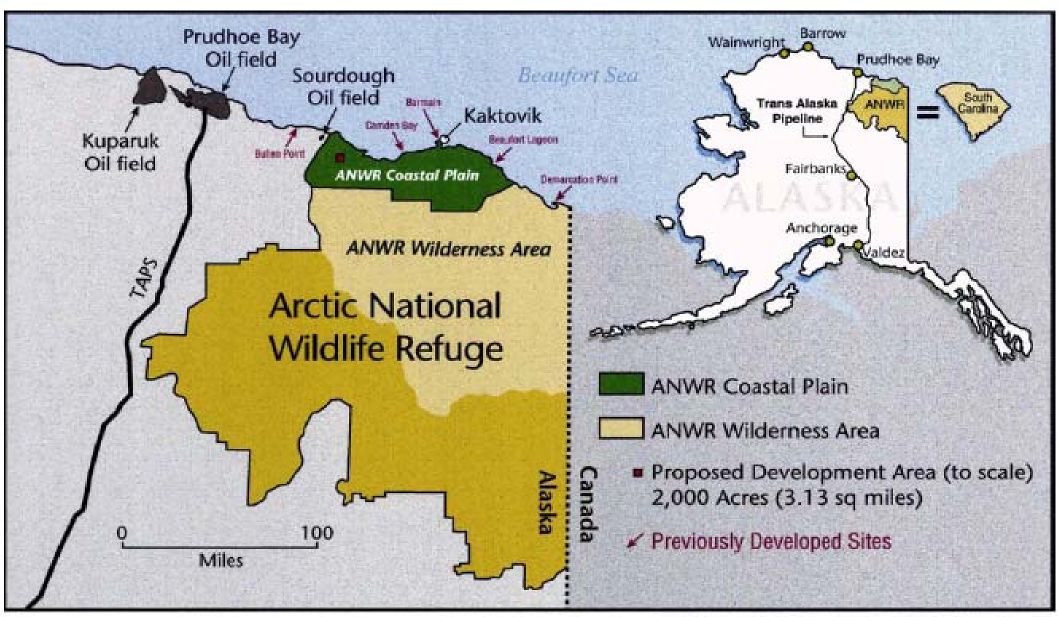
	Fankhauser Coefficient	5x Fankhauser Coefficient
$10 per Barrel	-$15.80	-$116.37
$30 per Barrel	-$13.97	-$114.54
$60 per Barrel	$2.97	-$97.60
$100 per Barrel	$30.31	-$70.26
$200 per Barrel	$92.91	-$7.67

The benefits to oil drilling in ANWR decline with the inclusion of broader environmental costs and economic considerations. Millions of Americans rely on petroleum products in their daily activities. Drilling in the ANWR would provide more oil to an ever-growing energy market. Oil lobbyists have us believe that additional Alaskan drilling will help both U.S. consumers and the economy as a whole. Unfortunately, the size of ANWR operations prevents it from fundamentally benefiting either of those constituents. Prudent policymakers will prohibit ANWR drilling on account of mostly negative net present value results. ANWR oil destroys more value than it creates.

APPENDIX A: REGIONAL MAPS



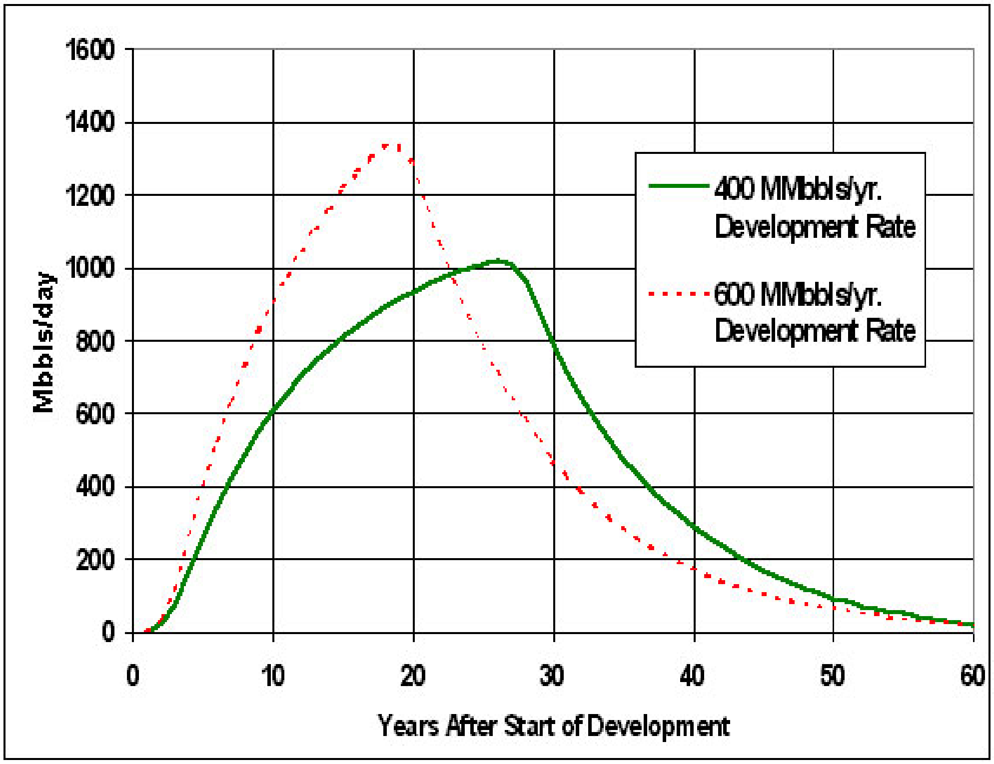
Source: Energy Information Administration, 2000, Figure 1



Source: Conrad & Kontani, 2005, p. 276

APPENDIX B: DEVELOPMENT FORECAST

Projected oil development in the Arctic National Wildlife Refuge and surrounding coastal plain:

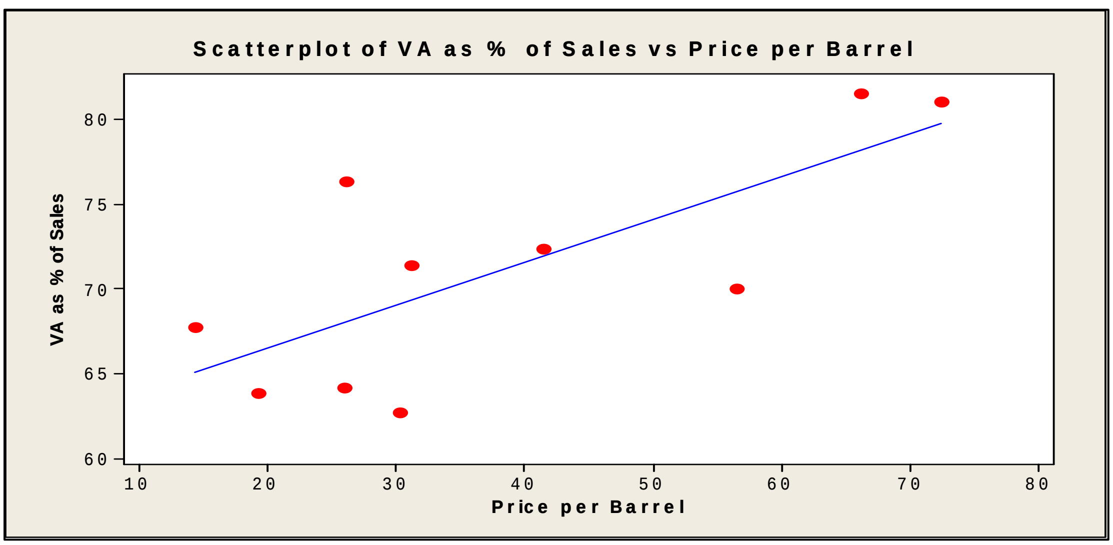


Source: Energy Information Administration, 2000, Figure 3

APPENDIX C: HISTORICAL VALUE ADDED OF ALASKAN PETROLEUM

(in Millions of Current Dollars)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total Alaska Industry	23,165	24,322	27,034	26,609	29,186	31,219	35,102	39,298	43,117	48,326
Oil and Gas Extraction Value-Added	1,995	2,858	4,784	3,394	4,292	5,356	7,188	9,635	10,640	10,869
Pipeline Transportation Value-Added	1,794	1,882	1,882	1,925	2,419	2,070	2,241	1,915	2,370	2,644
Support Activities for Mining Value-Added	567	433	560	714	546	612	823	1,235	2,022	2,081
Petroleum Manufacturing Value-Added	261	127	139	189	197	232	271	236	241	247
Total Alaskan Oil Value Added	4,617	5,300	7,365	6,222	7,454	8,270	10,523	13,021	15,273	15,841
Average Crude Oil Price ($/barrel)	$14.39	$19.25	$30.30	$25.92	$26.10	$31.14	$41.44	$56.47	$66.10	$72.36
Alaskan Production (in Millions of Barrels)	474	431	388	374	374	372	351	329	283	270
Alaskan Sales	$6,818	$8,298	$11,745	$9,691	$9,768	$11,588	$14,542	$18,603	$18,732	$19,541
Alaskan Oil Value Added as % of Sales	67.72%	63.87%	62.71%	64.20%	76.31%	71.37%	72.36%	69.99%	81.53%	81.06%



VA as % of Sales = 61.4 + 0.253 Price per Barrel

Source of Value added Data: Department of Commerce, 2008, Alaska

APPENDIX D: HISTORICAL PERMANENT FUND DIVIDENDS

Dividend Year	Number of Checks	Dividend Amount	Total
2006	3,150	1,106.96	3,486,924.00
2005	220	845.76	186,067.20
2004	97	919.84	89,224.48
2003	38	1,107.56	42,087.28
2002	42	1,540.76	64,711.92
2001	31	1,850.28	57,358.68
2000	23	1,963.86	45,168.78
1999	35	1,769.84	61,944.40
1998	21	1,540.88	32,358.48
1997	21	1,296.54	27,227.34
1996	22	1,130.68	24,874.96
1995	28	990.30	27,728.40
1994	23	983.90	22,629.70
1993	15	949.46	14,241.90
1992	14	915.84	12,821.76
1991	12	931.34	11,176.08
1990	13	952.63	12,384.19
1989	16	873.16	13,970.56
1988	10	826.93	8,269.30
1987	2	708.19	1,416.38
1986	0	556.26	0.00
1985	1	404.00	404.00
1984	0	331.29	0.00
1983	0	386.15	0.00
1982	1	1,000.00	1,000.00
Total	**3,835**		**$4,243,989.79**

Source: State of Alaska Department of Revenue: Permanent Fund Dividend Division, (n.d), p. 9

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