NEW ESTIMATES OF THE VALUE OF FEDERAL MINERAL RIGHTS AND LAND

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Michael J. Boskin, Marc S. Robinson,
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ABSTRACT

Michael J. Boskin, Marc S. Robinson,
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We calculate a time series of the value of federal mineral rights for oil and natural gas by using estimates of proven and undiscovered economically recoverable reserves and time series on federal government royalties and bonus payments.

We estimate that the value of federal oil and gas rights exceeded $800 billion in 1981, which was larger than the privately held national debt. The paper also presents confidence bounds on the estimates.

The paper also revises previous estimates of the value of federal land. New data, and attention to the decomposition of federal land, lead to substantially higher estimates. Our estimate in that by 1981, the total value of federal land was $175 billion.

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Michael J. Boskin and Marc Robinson
with the assistance of
Terrance O'Reilly and Praveen Kumar*

The federal government owns a large fraction of the mineral rights and land in the United States. The value of these resources varies substantially over time, both with acquisitions and sales of these assets and with changes in the prices of the minerals and land involved. Whether one is interested in measures of national wealth, land management policy as part of efficient government operations, or (long-run) macroeconomic fiscal policy issues, time series estimates of the value of federal mineral rights and land are potentially valuable information.

At one extreme, consider a country or state which owns substantial mineral rights when the price of those minerals skyrockets. The additional revenues potentially available either for use in the public sector, or to allow tax cuts to provide greater private income, may alter the course of the economy. There are historical precedents. Saudi Arabia was able virtually to abolish taxation due to revenues from the sale of mineral rights, and Alaska actually used oil based revenues to provide cash grants on a per capita basis to its citizens, thereby increasing their private wealth and consumption opportunities.

The microeconomics of sensible resource allocation, within the public sector and between the public and private sector, relies on careful cost-benefit evaluations of the value of public services and the

opportunity costs of providing them. These in turn are only possible with accurate information on actual and potential revenue sources, including the opportunity costs of purchases and sales of assets, as well as traditional flows of income into and out of the public sector. Therefore, the value of federal mineral rights and land is potentially an important piece of information for a host of public policy questions.

This paper provides, for the first time, estimates of the value of federal mineral rights in the post-war period in the United States. It also presents a new time series for the value of federal land and compares the results with previous estimates. We find that the values of federal mineral rights and land are enormous and fluctuate by tens of billions of dollars annually.

In section I, we consider the valuation of federal mineral rights, in particular the revenue which the government is able to obtain from onshore and offshore leases for the extraction of oil and natural gas. We review some recent studies of resource accounting (none of which focuses on the government sector) and present a new methodology for valuing mineral rights. We estimate the value of federal oil and gas mineral rights to be $819 billion in 1981, a number higher than the privately-held federal debt in that year.[1] Our estimates consider economically recoverable undiscovered reserves[2] and therefore would substantially exceed estimates which used the methods of previous studies.

Section II is devoted to the valuation of federal land. We review the work of Goldsmith, Milgram, and Eisner and Pieper on this subject and we present new updated estimates of the value of federal land, taking into account the changing composition of federal land. Our

estimate for 1981 is $175 billion, composed of $112 billion for urban land and $63 billion for rural land.

Section III provides a summary and agenda for research, and an appendix provides the details of Milgram's methodology for estimating government land value and our extension of her estimates.

I. THE VALUE OF FEDERAL MINERAL RIGHTS

A. Previous Studies of Resource Accounting

Though no previous study attempts to value federal mineral rights specifically, a number of recent studies of income accounting for exhaustible resources, such as oil and natural gas, support the inclusion of estimates of the underground reserves of these resources in measures of national income and wealth.[3] The current accounting practice is to exclude such estimates. The National Income and Product Accounts of the Bureau of Economic Analysis consider only production of mineral resources, ignoring the level of reserves. The studies argue for the inclusion of the net value of proven reserves in estimates of national wealth.[4] This value could change through discovery, depletion, and changes in the price of the resource.

The perpetual inventory method provides a means of building on an estimate of the value of proven minerals for a particular year. Determining the annual changes in value is fairly straightforward; the major difficulty arises in determining a base year estimate for the value of proven resources. In an important study, Landefeld and Hines [1982] discuss three methods for estimation: the present value method, the land price method, and the net price method.

The present value method requires forecasting prices, operating costs, production and interest rates over the life of the field after

its discovery. The present value of the stream of net revenues is determined. Soladay [1980] extends this method by trying to take into account the upward revisions in estimates of reserves that typically occur after the discovery; the total quantity produced from a field is greater than the initial discovery. Several ways of guessing future trends in net revenues have been used. Soladay extrapolates future net revenues based on the weighted average of net revenues over the period 1948-1974 and chooses a particular interest rate. Landefeld and Hines report results for three arbitrary choices of growth rate in net revenue and interest rates. The Securities and Exchange Commission (SEC)[5] proposed that companies be required to assume no growth in net revenue and a 10 percent discount rate.

The net price method assumes that net revenues increase at the rate of interest. According to economic theory, this is necessary for equilibrium if the cost of exploration and extraction is the same for all of the exhaustible resource.[6] The advantage of this method is that it does not require any assumptions regarding the time path of production, since any pattern has the same present value.[7]

The third method discussed by Landefeld and Hines, the land price method, assumes that the entire value of the proven reserves is paid to the landowner in the form of bonus payments and royalties. They also assume that royalties are a constant fraction of the net value of the resource, so that annual data on bonuses can be used to estimate the net value of the oil and gas prospects leased that year. One problem with this method is that the value of oil and gas prospects leased in a particular year bears no particular relationship, even in expected value terms, to new proven reserves in that year, because of decision and

drilling lags. This is therefore fundamentally different from either the present value or net price methods. A second difficulty lies in Landefeld and Hines' estimates, since they use 12.5 percent as the fraction of net price which is paid in the form of royalties. Since royalties are at least 12.5 percent of the gross price of oil and gas, this significantly understates the importance of royalties, and their estimates for the value of oil and gas prospects leased is too low. This is confirmed by noting that the estimates using the land price are much smaller than their estimates using other methods.[8]

Each of these methods is inadequate for creating government wealth and capital formation accounts. The most important problem is the neglect of the value of economically recoverable undiscovered reserves. This neglect, as argued below, causes an understatement of wealth and capital gains and an overstatement of government investment.

Earlier studies argued against including economically recoverable undiscovered resources in either national or firm accounts on the grounds that estimates were too uncertain. This problem is much less severe for the U.S. as a whole than for the individual firm, since the sample of prospects is far larger and, therefore, the distribution is tighter (the coefficient of variation is smaller). While the range of estimates of undiscovered resources may be wide, there is no a priori reason for believing an estimate to be biased. By contrast, assuming that undiscovered resources have no value is surely biased and, therefore, estimates of wealth and income will be biased.

B. Methodology for Valuing Mineral Rights

When the government leases the mineral rights in a particular area - rights essentially to as yet undiscovered resources - it has reduced its mineral wealth by transferring claims to part of it to the private

sector. In return, the government receives some payment immediately in the form of a bonus, with the rest of the payments deferred as royalties or rental payments. Bonuses are cash payments which are not conditional on the existence or size of the resource and are, typically, the variable subject to bidding. Royalty payments are fractions, usually fixed in advance, of the gross revenue of the produced output, if any. By the time reserves are proven, their only value to the government is the present value of the royalties they represent.

The base year value to the government of federal mineral rights is the sum of three components: future royalties on proven reserves, future royalties on estimated undiscovered reserves, future bonuses on unleased land.[9] This may be written (choosing 1981 as the base year) as follows:

$$(1) \qquad V_{1981} = PVR_p + PVR_u + PVB$$

where,

PVR_p = Present value of future royalties on proven reserves, both onshore and offshore.

PVR_u = Present value of future royalties on undiscovered reserves, again both onshore and offshore.

PVB = Present value of bonuses on mineral leases.

To obtain the value for any future year, we take the value for the previous year, add capital gains or losses and subtract bonus and royalty payments received. Capital gains and losses are calculated by assuming that the current price is the base from which future prices grow at the interest rate.[10] Since all three components of the base

year value are proportional to the current price, the capital gain is just the change in price times the previous year's value. Using this method, the base year value can be projected backwards as well.

Ignoring undiscovered reserves can cause several problems in the wealth and income accounts of the government. For example, the sale of leases would be treated as an increase in government receipts and wealth rather than an asset sale and future royalty rights would not appear in the accounts until drilling was successful. Further, capital gains and losses associated with price changes would only be counted on proven reserves. Government capital formation, defined as the change in government wealth, would be overstated, since the sale of assets in the form of possible reserves would be ignored.[11]

For all of these reasons, we believe accurate resource accounting for the government sector requires estimating a value for the undiscovered reserves on government land. This only needs to be done for a base year; the perpetual inventory method may then be applied to calculate other years.[12] For the base year calculation, we use Department of the Interior estimates for the expected undiscovered reserves for onshore and offshore federal land.[13] To value the royalties on these undiscovered reserves, an assumption regarding future prices needs to be made. We choose the strong and convenient assumption that future prices are expected to increase at the rate of interest.[14] This assumption means that the time path of production is irrelevant; all production patterns yield the same present value of royalties. Such time independence is especially useful for undiscovered reserves since there is a substantial and uncertain time until the resource will be extracted. The assumption can be justified by noting that the Long-Term Pricing Committee of the Organization of Petroleum Exporting Countries

(OPEC) has recommended a 3 percent real annual increase in oil prices which, given its low cost of production, would be close to that suggested by economic theory. The average annual rate in real oil prices received by U.S. producers was 3.5 percent over the period 1950-1982.[15]

This assumption implies that the value of future royalties on both undiscovered and proven reserves on federal land is the royalty rate times the quantity reserves times the current price for the relevant resource. Thus,

$$(2) \qquad PVR_p = \sum_k P_k \times (r^f \times R_p^{kf} + r^o \times R_p^{ko})$$

where k indexes the mineral, f indexes offshore reserves, o indexes onshore reserves, R is the quantity of reserves and r is the relevant royalty rate.[16]

Similarly,

$$(3) \qquad PVR_u = \sum_k P_k \times (r^f \times R_u^{kf} + r^o \times R_u^{ko}).$$

The present value of future bonus payments on unleased land also needs to be included to obtain the base year estimate for the value of federal mineral rights. To do this, we first find the present value of bonuses paid to the federal government over the period 1954-1979.[17] We divide this by the present value of royalties paid over the period 1956-1981. The difference in the periods covered is designed to account for discovery and production lags. We assume that the present value of future bonuses on undiscovered resources will be the same fracton of

estimated future royalties on these undiscovered resources as occurred in this period.[18]

Thus, we assume,

$$(4) \qquad \frac{PVB^{1981}_{1954-1979}}{PVR_p + PVR^{1981}_{1956-1981}} = \frac{PVB}{PVR_u}$$

where,

$PVB^{1981}_{1954-1979}$ = 1981 present value of bonuses paid to the government on leased land from 1954 to 1979, in 1981 prices.

$PVR^{1981}_{1956-1981}$ = 1981 present value of royalties paid to the government from 1956-1981, in 1981 prices.

Since PVR_p and PVR_u are calculated as in (2) and (3) above, we only need to convert bonuses and royalties actually paid in the period to present value dollars. To do this, we assume an annual real rate of discount of 2 percent and compute

$$(5) \qquad PVB^{1981}_{1954-1979} = \sum_{\tau=1954}^{1979} B_\tau (1.02)^{(1981-\tau)} \cdot \frac{Q_{1981}}{Q_\tau}$$

where

B_τ = Bonuses paid to the Government for year τ.

Q_{1981} = GNP deflator for 1981.

Q_τ = GNP deflator for year τ.

Similarly,

$$(6) \qquad PVR^{1981}_{1956-1981} = \sum_{\tau=1956}^{1981} R_\tau (1 + 0.2)^{(1981-\tau)} \frac{Q_{1981}}{Q_\tau}$$

where,

R_τ = Royalties received by the Government in year τ.

C. Estimates of the Value of Federal Oil and Gas Mineral Rights

Our estimates for the value of federal oil and gas mineral rights in 1981 are presented in Table 1. Two striking facts are apparent. First, the present value of bonuses from offshore mineral leases far exceeds the corresponding figure for onshore leases. The reason for this is that offshore bonuses were much greater than onshore bonuses in the period 1954-1979. For example, since 1971, offshore bonuses have annually exceeded one billion dollars whereas onshore bonuses did not reach twenty million dollars.[19] This difference is reflected in our estimate of the present value of bonuses through equation (4).

Second, the present value of future royalties from economically recoverable undiscovered reserves similarly dominates the corresponding figure for proven reserves. The explanation for this is straightforward: estimates of undiscovered resources are much larger than currently proven reserves.

Table 1

Calculation of the 1981 Value of Federal Mineral Rights for Oil and Natural Gas (V_{1981})

(Billions of 1981 Dollars)

Component	Total	Onshore	Offshore
PVB	221.1	0.9[a]	220.1
PVR_p	88.4	34.5	53.9
PVR_u	509.8	111.0[b]	398.8
TOTAL: V_{1981}[c]	819.3	146.4	672.8

[a] This figure is calculated assuming that the future ratio of onshore and offshore bonuses will remain the same as in the historical period.

[b] This figure is derived assuming that the ration of offshore undiscovered gas reserves in Alaska is the same as in the 48 states.

[c] The present value of bonuses for the period 1954-1979 for offshore and onshore were $50.9 and $0.2 billion respectively. The corresponding figures for the value of royalties for the period 1956-1981 were $20.81 and $8.70 billion respectively.

The detailed time series of the total value of federal oil and gas mineral rights from 1954 to 1982, presented in Table 2, are extremely interesting. The aggregate series began a very rapid growth in 1974, and jumped again in 1979-80. The current value of over $800 billion is the single largest asset in the complete balance sheet of the federal government. It is substantially larger than the value of federal land. In fact, it is approximately the combined value of all federal tangible assets or all federal financial assets.[20] Prior to 1974, the total series was quite stable in nominal dollars, and therefore it exhibited a slight downward decline in real terms. While the dollar value has increased sharply recently, even prior to the increases in energy prices the value for oil and gas were substantial. For example, in 1971 the value was $100 billion (in 1971 dollars) which was much more than the value of federal land. It also was twice as large as the value of federal government gold holdings.

Table 2

Value of Federal Oil and Natural Gas Rights

and Changes in Value, 1954-1982

(Billions of Current Dollars)

Year	Value			Change in Value
	Total[a]	Oil	Gas	
1954	80.6	62.3	18.3	---
1955	80.8	62.0	18.8	0.2
1956	81.9	62.4	19.5	1.1
1957	89.4	69.0	20.4	7.5
1958	88.7	67.2	21.5	-1.7
1959	87.8	64.6	23.2	-0.9
1960	90.0	63.9	25.1	2.2
1961	91.1	64.0	27.1	1.1
1962	91.3	63.7	27.6	0.2
1963	91.5	63.4	28.1	0.2
1964	90.4	63.0	27.4	-1.1
1965	90.1	62.4	27.7	-0.3
1966	90.2	62.5	27.7	0.1
1967	90.9	62.8	28.1	0.7
1968	90.4	62.1	28.3	-0.5
1969	93.6	64.9	28.7	3.2
1970	94.9	65.9	28.7	3.2
1971	100.6	69.8	30.8	5.7
1972	101.5	67.9	30.6	0.9
1973	109.9	75.4	34.5	8.4
1974	176.0	129.2	46.8	66.1
1975	210.8	142.9	67.9	34.8
1976	238.0	150.5	87.5	27.2
1977	273.9	155.8	118.1	35.9
1978	295.7	161.7	134.0	21.8
1979	389.5	222.8	166.7	93.8
1980	598.3	376.4	221.9	208.8
1981	819.3	547.1	272.2	221.0
1982	817.2	486.8	330.4	-2.1

a We have assumed that the present value of gas and oil bonuses are proportional to the present value of gas and oil royalties on undiscovered reserves, i.e.

$$\frac{PVB^{gas}}{PVB^{oil}} = \frac{PVR_u^{gas}}{PVR_u^{oil}}$$

The relative value of oil and gas in the total has changed somewhat over the period. While oil is still the largest component, the share of oil has fallen from over three-fourths in the late 1950s, to two-thirds or less in the last few years. While oil typically receives more attention than natural gas, these figures reveal the importance of natural gas.

Also included in Table 2 is the change in value from year to year. These changes tended to be be small until the total value became large subsequent to the substantial increases in energy prices in 1973-4. The change in the value of these mineral rights in many years in the 1970s and early 1980s exceeded the nominal federal government budget deficit.[21]

Table 3 breaks the change in the value of federal oil and natural gas mineral rights through time into three components: revaluation, bonuses, and royalties. While bonuses and royalties became large in the early 1970s they are still relatively minor compared with the enormous revaluations of this period. The bulk of the change in the value in most years is the revaluation of the rights. The revaluations largely reflect the energy price shocks, but once the total value of oil and gas becomes large, even small price changes can lead to large revaluations. It should be stressed that revaluations would occur even if the price followed the assumed pattern of growing at the interest rate. In recent years, these revaluations are substantial relative to the capital gains on assets held by the household sector of the United States.[22]

Table 3

Components of the Change in Value of Federal Oil and Gas Rights, 1954-1982

(Billions of Current Dollars)

Year	Change in Value	Components:		
		Revaluations	Bonuses	Royalties
1954	---	---	0.1	0.0
1955	0.2	0.3	0.1	0.1
1956	1.1.	1.2	0.0	0.1
1957	7.5	7.6	0.0	0.1
1958	-1.7	-1.6	0.0	0.1
1959	-0.9	-0.7	0.1	0.1
1960	2.2	2.6	0.3	0.1
1961	1.1	1.2	0.0	0.1
1962	0.2	0.8	0.5	0.1
1963	0.2	0.4	0.0	0.2
1964	-1.1	-0.8	0.1	0.2
1965	-0.3	-0.1	0.0	0.2
1966	0.1	0.5	0.2	0.2
1967	0.7	1.4	0.5	0.2
1968	-0.5	1.1	1.3	0.3
1969	3.2	3.6	0.1	0.3
1970	1.3	2.6	0.9	0.4
1971	5.7	6.2	0.1	0.4
1972	0.9	3.7	2.3	0.5
1973	8.4	12.0	3.1	0.5
1974	66.1	71.8	5.0	0.7
1975	34.8	36.7	1.1	0.8
1976	27.2	30.3	2.2	0.9
1977	35.9	38.7	1.6	1.2
1978	21.8	25.0	1.8	1.4
1979	93.8	100.8	5.1	1.9
1980	208.8	215.8	4.2	2.8
1981	221.0	231.9	6.7	4.2
1982	-2.1	6.8	4.1	4.8

The figures in Tables 2 and 3 reveal how important the value of federal government mineral rights can be to measures of national wealth, to measures of changes in that wealth, to mineral leasing policy, and to sensible government budget reporting and policy. The total value of these mineral rights, $819 billion, is enormous. To place this in perspective, in 1981, this value exceeded the value of the privately held national debt ($794 billion). Obviously, the value of other minerals would add to this total. Clearly, ignoring the value of resources in government budgets and in national income and wealth accounts can be quite misleading..

The critical estimates of undiscovered economically recoverable resources of conventional oil and gas on federal land in 1981 were made by the United States Department of the Interior.[23] These are presented in Table 4. Estimating proven reserves in a field where hydrocarbons have been discovered is difficult and results in frequent revisions; the task of estimating undiscovered recoverable resources is much more complex, as the number of dry holes attests. Using a point estimate, however well-founded in expert geological opinion, perhaps suggests more certainty than actually exists. We have therefore calculated the value of federal oil and gas mineral rights for 1981 using the high (5 percent) and low (95 percent) bounds calculated by the United States Geological Survey (USGS).[24] The high estimate is $1134.9 billion, while the low estimate is $582.1 billion. While the range of these estimates is clearly large, even the low estimate shows that federal oil and gas mineral rights have considerable value. Independent studies by other groups have come up with different ranges for the quantities of

undiscovered recoverable oil and gas in the U.S., but at least since 1975, there has been a growing consensus, with overlapping ranges and point estimates for both oil and gas approximately within the range of the United States Geological Survey (USGS) [1981] estimates.[25]

Table 4

Proven and Unproven Oil and Gas Reserves (1981)

(Oil in Billion Barrels/Gas in Trillion Cubic Feet)

	95 percent confidence level[c]		Mean		5 percent confidence level[c]	
	Oil	Gas	Oil	Gas	Oil	Gas
OFFSHORE[a]						
Proven	3.8	41.6	3.8	41.6	3.8	41.6
Undiscovered, Economically recoverable	15.5	82.9	25.5	140.2	39.9	216.25
ONSHORE[b]						
Proven	4.6	24.9	4.6	24.9	4.6	24.9
Undiscovered, Economically recoverable	24.3	61.3	41.61	112.1	66.6	170.1

Sources:

[a]Offshore Figures from tables 53 and 54 of Federal Offshore Statistics, December, 1983, op. cit.

[b]Onshore figures were published only through 1980. The updated USGS mean figures for 1981 which are somewhat lower than the published 1980 figures, were kindly provided by Mr. Dale Zimmerman, United States Department of the Interior, Washington, DC.

[c]Ratios to mean values for onshore reserves are assumed to be the same on federal land as total land. Also, it was assumed that the ratio of unproven offshore and onshore reserves in Alaska is the same as in the 48 states.

Two additional points should be made about undiscovered resources. First, they do not stay undiscovered forever. Annual additions to proven offshore reserves were about 14 percent of the total stock of proven reserves over the period 1977-1981 for both oil and gas.[26] Second, estimates of recoverable undiscovered resources must properly depend upon prices and technology. Technological advances or real price increase should lead to upward revisions in the estimates of undiscovered recoverable resources.

We also tested the sensitivity of our results to alternative assumptions about the rate of price increases. Two considerations suggest that price may not grow at the rate of interest. If costs are non-trivial, as on the outer continental shelf, the scarcity rent, rather than price, should grow at the rate of interest. If the relative costs at the margin are those of major Organization of Petroleum Exporting Countries (OPEC) producers, say Saudi Arabia, costs are indeed trivial, but if monopoly power is continuously exercised, marginal revenue, not price, will grow at the rate of interest. While we believe that for long-run considerations, the competitive, trivial costs result may be most appropriate, we present below estimates of the relative value of mineral rights if price grows less rapidly than the interest rate.

The net present value of proven (R_t) and undiscovered (U_t) reserves at t are given by

$$(7) \quad NPVR_t = R_t P_t \sum_{i=0}^{\infty} (1-y)(ydq)^i = R_t P_t \frac{(1-q)}{1-ydq}$$

$$(8) \quad NPVU_t = U_t P_t \sum_{j=0}^{\infty} (1-c)(cdq)^j \cdot \sum_{i=0}^{\infty} (1-y)(ydq)^i = \frac{U_t P_t (1-y)(1-c)}{(1-cdq)(1-ydq)},$$

where,

R_t: proved reserves at t;

U_t: undiscovered (economically recoverable at current cost) reserves at t;

(1-y): fraction of R_t produced during t (assumed constant);

(1-c): fraction of U_t converted to R_t during t (assumed constant);

P_t: real price per unit at date t;

t: valuation date;

d: discount factor = 1/1+r, where r is real interest rate;

q: price growth factor.

Some sample calculations indicate the potential difference under alternative price path assumptions when price grows at less than the interest rate. Calculations assume r = 0.03; y = 0.10; c = 0.03.

Table 5

Ratio of Value for q < r

Assumed rate of real price increase (percent per annum)	NPVR	NPVU
1.0	0.851	0.552
1.5	0.884	0.680
2.0	0.920	0.761
2.5	0.958	0.864
3.0	1.000	1.000

For example, the present value of royalties with a price increase two-thirds of the assumed real interest rate is $470 billion in 1981 as opposed to our estimate of $598 billion. The present value of bonuses likewise would be somewhat smaller. Our point, however, that the value of federal mineral rights is large relative to other federal assets and liabilities remains unaltered. Further, virtually all of our other assumptions tend to bias the estimated value downward.

II. THE VALUE OF FEDERAL LAND

A. Previous Studies of the Value of Federal Land

A time series for the value of federal land in the post-war period [1945-1981] is provided by the estimates of Goldsmith [1962], and the follow-up studies by Milgram [1973] and Eisner and Pieper [1984]. These studies, as well as the current one, demonstrate how successive refinements of basic data often hang from a very slender thread.

Goldsmith bases his post-war time series on an estimate of the value of government land on December 31, 1946 in the study by Reeve, et al [1950]. The land value estimate of the Reeve study has two main components: military and non-military government land. These estimates are as follows:

Land, non-military:	$4.93 billion
Land, military:	
a) market value	$1.07 billion
b) replacement value	$2.13 billion

The estimate for nonmilitary land is based upon its original acquisition costs, with (casually justified) adjustments to reflect 1946 market values. Separate adjustments were made for each of five categories of land. For most categories, Reeve does not cite any source as the basis for the adjustment factors employed.

For military land, Goldsmith chooses Reeve's replacement value figure, which is an estimate of the cost to the military to replace its holdings with comparable land. For nonmilitary government land, Goldsmith's extension of Reeve's estimates from 1946 through 1958 is based upon two price indices:

FOREST LAND: Reeve's value for forest land in 1946 multiplied by

"index of stumpage prices in national forests."

OTHER CIVILIAN LAND: Value for 1946 (Reeve's total minus forest land) multiplied by "index of grazing land prices in western states."

Goldsmith describes his extension for military land as a "rough estimate."

Grace Milgram estimates the value of government land over the period 1952-1968. Her series is based upon Goldsmith's estimate for 1956. Values for 1952-1955 and 1957-1968 are extrapolated using the following methodology. Increments to the stock of government land are derived from the change in the General Services Administration's (GSA's) annual estimates of the value of government land, from the change in acreage of government urban land and rural land, and from price series developed by Milgram for rural, nonmetropolitan and urban land.

Milgram derives an independent estimate of the value of rural government land in 1956, using rural government acreage and a price for rural public land. The price is based primarily upon an estimate of the market value of the public domain managed by the Bureau of Land Management (BLM). The value of urban government land in 1956 is determined as the difference of Goldsmith's 1956 estimate for total federal land, and her rural land value estimate.

Increments to the rural land stock are determined by the value of the change in government owned rural acreage, using the rural public series. Increments to the urban land stock are estimated by subtracting the incremental rural estimate from the change in the annual General Services Administration (GSA) estimate of the value of total government land. The yearly stock estimates are computed by adding these

increments to the previous year's stock, after the rural component for the prior year has been adjusted by a price index for nonmetropolitan land, and the urban component for the prior year has been adjusted by an urban price index.

Eisner and Pieper [1984] estimate the value of federal land in 1980 as $119.5 billion. They use Milgram's 1968 figure as a base and assume that annual net investment in land is zero. They infer the change in the market value of government land from the Federal Reseve Board's estimate of the market value of private land, and from the ratio of Milgram's 1968 estimate to the 1968 Federal Reserve Board's estimate for private land. Thus,

$$GL_t = PL,\ F_t \cdot \frac{GL,M_{68}}{PL,F_{68}}$$

where

GL_t is the market value of government land at t.

PL,F_t is the Federal Reserve Board's estimate of the market value of private land in year t.

GL,M_{68} is Milgram's estimate of the market value of federal land in 1968.

Table 6 below reproduces the estimates of these authors for selected years.

Table 6

Value of Federal Land in

Billions of (Current) Dollars

Year	Value	Source[a]
1946	7.0	G
1951	13.4	G
1956	13.4	G,M
1961	20.6	M
1966	29.5	M
1971	37.6	E & P
1976	73.3	E & P
1980	119.5	E & P

a) G = Goldsmith

M = Milgram

E & P = Eisner and Pieper

Eisner and Pieper's estimates for the value of federal land are consistent with recent work by Raymond Goldsmith on the national balance sheet (Goldsmith [1982]). Milgram's study provides estimates of the value of land over all sectors, 1952-1968. Goldsmith extrapolates these estimates to 1975, arriving at a figure for the aggregate value of land of $1551 billion. He estimates the share of federal land at 4 percent, which would give an estimate of $62 billion for the value of federal land in 1975, compared with Eisner and Pieper's $63.6 billion.[27]

B. New Estimates of the Value of Federal Land

We have extended Milgram's estimates of the value of federal land to the period 1969-1981, using a variant of her methodology as described in the Appendix. In Table 7, these estimates can be compared with Eisner's extension of the Goldsmith/Milgram estimates.

Table 7

Value of Federal Land in

Billions of (Current) Dollars

	New Extended Estimates			Eisner and Pieper
	Total	Urban	Rural	Estimates
1969	37.3	21.9	15.5	34.9
1970	44.8	29.0	15.8	36.4
1971	53.8	36.2	17.6	37.6
1972	63.4	44.3	19.1	42.6
1973	72.8	53.1	19.7	50.4
1974	76.5	49.9	26.6	57.3
1975	80.4	52.9	27.5	63.6
1976	90.5	57.9	32.6	73.3
1977	105.5	67.6	37.9	82.2
1978	120.3	74.7	45.5	96.9
1979	137.5	86.5	51.0	110.4
1980	174.4	118.3	56.1	119.5
1981	175.1	112.4	62.7	128.0[a]

[a] Updated using Eisner and Pieper's methodology.

We estimate the value of federal land to be $175 billion in 1981, composed of $112 billion urban land and $63 billion rural land. Our new estimates substantially exceed those of Eisner and Pieper. The total is larger in every year, and the rate of growth is significantly higher.

Our estimates are higher because we take into account the change in the composition of federal land holdings. Eisner and Pieper do not consider the composition; their extension simply indexes the value of government land by the change in value of private land in the aggregate. While the total acreage held by the federal government declined by almost 5 percent between 1968 and 1981, its holdings of more valuable urban acreage more than tripled. This is shown in Table 8.

Table 8

Composition of Federal Land Holdings

Selected Years

(Millions of Acres)

Year	Urban	Rural	Total
1968	1406.3	753938.5	755344.8
1972	2326.8	758349.6	760676.4
1976	2936.2	759256.2	762192.4
1980	4768.4	714753.4	719521.6

This total value estimate of $175 billion is approximately the value of all of the equipment (such as machines, trucks, typewriters, computers, etc.) owned by the federal government.[28] It is far less than the value of federal mineral rights as estimated in section I.C.

It may be tempting simply to add the value of federal land to mineral rights. However, there are theoretical reasons to suspect that at least some of the value of federal mineral rights is capitalized into the value of the federal land bearing the minerals. In that case, it would be necessary to discount the value of the land before aggregating the land and the mineral rights. Since we are uncertain of the extent of capitalization, we have focused on the disaggregated components rather than their sum.

We have clearly not captured the full value of federal onshore mineral rights in our land value figures. Our estimate of the value of onshore mineral rights in 1981, $146 billion, greatly exceeds the value of federal rural land, $63 billion. Furthermore, the method of derivation for estimates of federal rural land values makes it unlikely that they will reflect the underlying mineral values.[29] Clearly, to obtain the total value of land and mineral rights, we would have to add some, though not all, of the value of federal land to our estimate of the value of federal mineral rights.

III. SUMMARY AND CONCLUSION

We have presented new and updated estimates of the value of federal land and oil and gas mineral rights. These estimates are $175 billion and $819 billion, respectively, by 1981.

Our results reveal the increasing importance of the value of the federal government's holdings of urban land in the total value of federal land over the period from 1968 to 1981. Over this interval the federal government's holdings of urban land tripled in acreage.

We estimate the value of federal oil and gas mineral rights to be very substantial, particularly following the sharp rise in energy prices in 1974 and 1979. In 1981, for example, the magnitude exceeds the privately held national debt.

This study is unique, as far as we know, in its effort to determine the value of the federal government's mineral rights and in the methodology it uses. We exploit information about undiscovered reserves and royalty and bonus payments to the government. Our methodology can be extended both to other minerals and to the private sector.

There remains room for considerable research on both the value of government land and its mineral rights. A new benchmark estimate for the value of federal land in a particular year is especially important. A more detailed disaggregation of the types of federal land holdings and improved and updated corresponding price information would also be helpful.

Improved estimates of the size of other mineral resources on federal land and estimates of the relationship between the quantity of economically recoverable unproven reserves of oil and gas and their prices would enable us to produce more comprehensive measures of wealth.

Finally, let us reemphasize the potential importance of estimates such as ours to sensible government budgetary decisions. These include land management policy, general cost-benefit analysis incorporating proper measures of the opportunity cost of resources, and perhaps even, in some contexts, fiscal policy.

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Footnotes

*Boskin is Professor of Economics at Stanford University and Research Associate, National Bureau of Economic Research; Robinson is Assistant Professor of Economics at University of California at Los Angeles; and O'Reilly and Kumar are graduate students, Economics Department Stanford University. This paper is part of Boskin's larger project on more comprehensive federal government budgets. We are deeply indebted to Dennis Epple, an anonymous referee, and seminar participants at Stanford University and the National Bureau of Economic Research for helpful comments. We want to thank the Center for Economic Policy Research at Stanford University and the National Bureau of Economic Research for financial support.

1 The total national debt in 1981 was $1,004 billion. Of this, $210 billion was held by government agencies and the Federal Reserve, leaving $794 billion held by private individuals and institutions.

2 Those resources estimated to be recoverable and profitable to extract at current prices technology.

3 Securities and Exchange Commission [1979], United Nations [1979] and [1980], Financial Accounting Standards Board [1980], Soladay [1980], and Landefeld and Hines [1982].

4 They also favor the incorporation of this value in accounting measures of firm wealth.

5 Securities and Exchange Commission [1979], p. 503, quoted in Landefeld and Hines, p. 150.

6 If the resource has an increasing cost of extraction, net price should increase at less than the rate of interest in equilibrium.

Landefeld and Hines neglect to note this in their defense of the net price method.

7 Payments to landowners are only relevant to calculations concerning firms, and not to calculations of national wealth.

8 Landefeld and Hines, p. 159.

9 This is obviously not the total value of the minerals on federal land, nor is it even necessarily the remaining scarcity rent on the mineral (since bonuses and royalties may not capture the full rent). We ignore rental payments, which are quite small compared to bonuses and royalties, as well as additional taxes which might be generated from the production. The extra taxes should only arise from special taxes on the resource (e.g. crude oil windfall profits tax) or the economic surplus captured by the producer rather than the government.

10 Capital gains are in current dollars; they occur even when the prices increase as predicted. We consider alternative price increase assumptions below.

11 All of these distortions occur in the accounts of any landowner if only proven reserves are taken into consideration. The earlier studies, discussed in the previous section, were concerned with valuing the assets and depletion of a producer; they were not concerned as much with the landowner from whom the lease was obtained. In this paper, of course, the government is the focus and in the United States governments generally are not producers of minerals.

12 This does not take into account changes in the estimated recoverable undiscovered reserves. These would be paper gains and losses. We examine alternative estimates of undiscovered resources below.

13 The estimates of offshore undiscovered reserves were obtained from the Federal Offshore Statistics, 1983, United States Department of Interior, Mineral Management Service. The corresponding onshore estimates were obtained by personal correspondence with Mr. D. Zimmerman of the Department of Interior. We discuss the methods used by the Department below.

14 We consider alternative assumptions later.

15 Calculated using price data from the Amercian Petroleum Institute [1983].

16 The royalty rate is assumed to be 12.5 percent for onshore federal land and 16.67 percent for offshore reserves in the case of oil and natural gas. It is calculated using the ratio of minerals produced to royalty payment received from Mineral Management Service [1984]. This source also permits the calculation of royalty rates for other minerals. If the federal government is forced to share royalties with the states, the value of the mineral rights developed later would be divided with them.

17 See United States Department of the Interior, Minerals Management Service,Mineral Revenues, Tables 10 and 13.

18 Changes in development lags would not substantially alter the results. The assumption that the ratio of bonuses to royalties remained constant seem reasonable given that real prices are expected to increase; it is not founded in any particular model.

19 See Mineral Revenues. op.cit.

20 See Eisner and Pieper [1984].

21 See Boskin [1980].

22 See Eisner [1980].

23 The United States Geological Survey (USGS) divided the United States

onshore and offshore areas into 137 provinces. Individual appraisals were made for each of the provinces using geological data and exploration histories as the basis for separate subjective assessments by six geologists. The subjective assessments of high, modal, and low probabilities for undiscovered recoverable resources of oil and gas are average, the aggregated probabilistically across provinces to obtain estimates for the entire United States. A more complete description of the methodology used by the United States Geological Survey (USGS) is given in United States Geological Survey [1981].

24 The procedure for deriving the high and the low figures is as follows. The mean PVR_u figures for gas and oil are multiplied by the ratio of the corresponding 5th and 95th fractile figures (separating out the offshore and onshore components) from United States Geological Survey (USGS) [1981] and the PVR_u^{low} and PVR_u^{high} are obtained. Following the methodology for calculation of PVB, PVB^{low} and PVB^{high} are obtained and the appropriate total values are derived according to equation 1.

25 See United States Geological Survey (USGS) [1981] for a survey of other studies.

26 United States Department of the Interior, Federal Offshore Statistics, op. cit.

27 Based on his estimates of total national assets in 1980 of $21645 billion (Table 89, pg. 200), we can derive his estimate of the value of federal government land in that year. According to Goldsmith, land values constituted 13.7 percent of total national

assets. Assuming that the federal government still holds 4 percent of total land values, the value of federal government land in 1980 would be $118.6 billion. This is again roughly the same magnitude as Eisner and Pieper's corresponding estimate of $124.9 billion and far smaller than our estimate of $174.4 billion. Goldsmith's estimates suggest that he, like Eisner and Pieper, does not take into account the substantial change in composition of federal government land.

28 As estimated by Eisner and Pieper [1984].

29 The magnitude of the rural land value estimates is largely determined by the average estimated price of the public domain managed by the Bureau of Land Management (BLM). (See appendix.) The Bureau of Land Management (BLM) price estimates do not appear to take mineral rights into account.

Appendix on Milgram's Methodology

Milgram's time series estimates for the period 1952-1968 rely on Raymond Goldsmith's estimate of the value of federal land in The National Wealth of the United States in the Postwar Period, p.188. z_{56}

She uses the following price indexes:

A non-metropolitan price index based upon the value of farmland per acre, as estimated by the Department of Agriculture. IR_i

A urban price index based upon three component indexes: FHA site prices, of residential land values in Los Angeles and Philadelphia. IU_i

Average price per acre of rural land held by the federal government. This is a weighted average of two indexes: the value of the public domain in the jurisdiction of the Bureau of Land Management (90 percent), and the value of farmland per acre (10 percent). PR_i

She uses three additional statistics from the Bureau of Land Management:

An estimate of the value of government land LC_i

And acreage held by the federal government, broken down as:

Rural	AR_i
Urban	AU_i

The statistics of the Bureau of Land Management appear in Summary Report of Real Property Owned by the United States Throughout the World, General Services Administration.

Milgram computes three series:

Value of Rural Land	MR_i
Value of Urban Land	MU_i
Total value of Federal Government Land	MA_i

Here is an algebraic expression of Milgram's procedure:

$$MA_t \equiv MR_t + MU_t$$

$$MR_{52} = (PR_{56} \cdot AR_{56})$$

$$MR_t = MR_{t-1} \cdot \frac{IR_t}{IR_{t-1}} + PR_t \cdot \Delta AR_t$$

$$MU_t = MU_{t-1} \cdot \frac{IU_t}{IU_{t-1}} + \Delta LC_t - PR_t \cdot AR_t$$

where $\Delta LC_t = LC_t - LC_{t-1}$

Comments:

(1) Milgram's estimates for 1952-55 and 1967-68 are extrapolations of the series determined by the method above.

(2) PR_t could not be determined for our extension from Milgram's sources. Our extension from 1969 on uses the published farmland series, but a series on the value of the public domain was not available from the BLM. Therefore, the public domain component of the weighted average is based

on an extrapolation of the value of the public domain in 1968. The growth rate for each susequent year was assumed to equal the average annual growth rate of farmland over the period 1969-1981.