Conservation leasing and pricing

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How should conservation leases be priced? This working paper provides additional details and technical considers for the PERC Policy Brief "Pricing Conservation Leases: Insights from economics." In particular, it derives pricing rules that allow for "apples-to-apples" comparisons between conservation and other land uses in an auction setting.

Introduction

There is growing recognition that conservation interests ought to be able to compete with extractive interests for public lands usage, and this has led to several unsuccessful (and a few successful) efforts by conservation groups to procure *conservation leases* from regulatory agencies. In some cases, conservation groups (willing and able to pay for conservation) were stymied by regulatory prohibitions on "non-use" leases (Leonard et al 2021), frustrating both conservation interests and those who believe markets are useful allocative tools. Even in cases where conservation leasing is allowed in theory, in practice, a number of economic policy choices related to conservation lease pricing need to be addressed by regulating agencies (contract duration, royalties, lease terms). This paper aims to provide some economic guidance on conservation leasing and pricing, and in the process potentially lower barriers for agencies to allow for conservation leasing.

In particular, this paper asks: How should agencies with a revenue-maximization mandate consider competing use-based and non-use-based bids? Essentially, what "price" should conservation groups pay for conservation leases? This analysis will be most relevant for the tens of millions of acres of state trust lands (primarily in western states) that are managed under revenue-maximization principles, though insights may also carry over to conservation leasing in the context of e.g. BLM lands with more complex regulatory objectives. These state land trusts manage many different "use-types" for their lands (timber, oil and gas, grazing, agriculture, mining, recreation, etc) all with an eye towards revenue maximization for the state.

This discussion takes as a given that there exist conservation interests that would be able to competitively bid for conservation leases against extractive uses. As others have frequently noted, due to standard free-riding and collective action incentives, bids by conservation interests may be lower than the social value provided by conservation. This is likely true in the broad sense, and as a consequence, the total quantity of conserved land will almost certainly be less than the social optimum in aggregate (e.g. total share of land allocated to conservation). However, as noted in Leonard and Regan (2019), for any individual parcel of land, as long as conservation interests are able to outbid the next best use, conservation can win out. This is most likely to be true for parcels with particularly high place-based conservation values (specific recreational amenities, wildlife considerations, aesthetics, etc), where the conservation demand may be very inelastic while extractive demand may be much more elastic. In any case, the fact remains that conservation groups are at the table, cash in hand, and regulatory agencies require guidance in how to respond.

Several key points emerge. First, revenues from public lands must ultimately derive from the underlying private value of land use, and if public lands were to be sold off in perpetuity, then it is clear an auction would be the ideal revenue-raising approach. After all, this is precisely how private markets function to allocate land and reveal opportunity costs. Second, the finite nature of leasing substantially complicates the pricing/auction approach. This complication arises because of the dynamic nature of how the land is used for different use-types (e.g timber vs grazing), and correspondingly the future, or "salvage", value and thus future revenue of the land, at the end of leasing.

The complications that arise due to the finite time horizon of leasing interacting with the dynamic use profiles of different resources imply that different pricing strategies must be employed for different use-types.[1] Thus, the third key point is that premium/refund pricing adjustments to account for the (discounted) future revenue value of the land post-lease should be considered by state-land trusts when conservation interests are competing against other uses. Resource-specific pricing strategies are described in more detail below for grazing, timber, and oil and gas, which represent common uses of state land trust use (by acreage and by dollar), but the common general principle is that they provide a way for agencies to address competing uses with different dynamic usage. These pricing adjustment strategies are referred to as "premium/refund" strategies because, while they can be set to generate equivalent economic incentives, they can either be applied at the initial auction process (premium) by adding a premium to conservation bids that preserve the future value of the land, or at the end of the lease (refund) where the conservation bidder is refunded for preserving that future value.[2] When employed, these pricing strategies would allow for "apples-to-apples" comparisons of upfront bids in an auction between the competing uses.

Next, classic resource use models for oil and gas, timber, grazing, and conservation are briefly reviewed, with a focus on the dynamic resource use profile and future value that they provide. Following that, resource-specific pricing strategies are described for how conservation leases should be considered when competing with other resource uses.

Dynamic natural resource usage

In order for the revenue maximizing agency to actually collect revenue, private interests must find it sufficiently worthwhile to effectively pay to use the land to extract oil and gas, cut down

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[1] This is consistent with current state land practice where it is uncommon to have; rather within-resource auction processes are typically employed to allocate the parcel to the highest bidder (e.g. several different oil and gas interests bidding for the same parcel designated for oil and gas extraction).

[2] For example, suppose a ten-year conservation lease would improve ecosystem health of an auctioned section of land such that it raised the discounted future value of that land by $400. Then a conservation bidder who bid $800 for the land would be given that as "premium" in the bidding process, whereby they would win over a grazing bidder at $1000. Alternatively, the conservation bidder could initially bid and compete with the grazing interest on a dollar-for-dollar basis, but would be "refunded" the $400 (in present value) at the end of the conservation lease. In theory, agencies could also distribute an annualized refund of equivalent present value over time instead of the upfront refund or end-of-lease refund.

timber, etc. Thus, in order to understand the potential state revenue that could be obtained from state trust lands, one must first understand the private values of different uses of those lands. The following models of natural resource use are intended as a brief survey of the classic dynamic optimization models (e.g. Conrad and Clark, 1987), and a myriad of more detailed treatments can be found in the academic literature. The core idea is that forward-looking private interests are able to account for the discounted stream of value provided by a certain use i, and thus determine the value of the property for that use V_i, whether it is oil and gas, grazing, housing, conservation, etc. To begin, the focus is on ownership in perpetuity (i.e. as if the property was sold off as in a private market). The dynamic flow of (undiscounted) returns from each land use type over time $\pi(t)$ are summarized in figure 1.

Oil and gas

For non-renewable resources such as oil and gas extraction, the core economic problem is the dynamic extraction path q given a finite resource stock R. The present value of using the land for oil and gas extraction V_O can then be written as:

$$V_O = \left[\max_q \int_0^T [pq - c(q)]e^{-rt}dt\right]\rho - c_E$$

$$s.t. \int_0^T q dt = R$$

where (suppressing time notation) p is the price, q is quantity extracted, $c(q)$ is the cost of extraction, r is the discount rate, and T is the time to exhaustion of the resource stock. In addition, because of the inherent uncertainty in oil and gas extraction, there is a cost of exploration c_E to determine whether oil and gas extraction is economically worthwhile from a section of land, which occurs with probability ρ.

The time-path of extraction (and profit to the extractor) will depend on economic and geological particulars (Hotelling 1931, Anderson et al 2018), but in general, once extraction begins, the quantity of extraction is initially high before tapering off as the well ages, until the time of exhaustion T (see Figure 1). After that point, the value of the land for further oil and gas use is essentially gone, though there are typically environmental remediation requirements to restore the land.

Timber

For renewable resources with long regrowth cycles such as timber, the core economic problem is one of choosing the timing of harvest cycles of length T. If $f(t)$ is biological function that determines the quantity of harvestable timber as a function of forest age (since last harvest) of t, then the present value of using the land for timber harvest V_T can be written as:

$$V_T = \max_T \int_0^\infty [(p - c_H)f(T) - c_P]e^{-ri}di$$

where i indexes harvest rotations of length T, p is the price per unit of timber, c_H is the harvest cost per unit of timber (paid at the time of harvest), c_P is the (assumed fixed) replanting cost, and r is the discount rate.

Again, solutions will vary with the economic and biological particulars, but the classic Faustmann solution is a series of harvest cycles of optimized length T that accounts for the growth rate of the forest $f'(t)$ relative to the discount rate r, as well as the opportunity costs of future (discounted) harvests.[3] Profits for timber harvesters will be very lumpy, with large sums of money earned in the harvest years at the end of the harvest cycle T, and nothing earned in the long interim years between harvests as the forest regrows.

Grazing

For renewable resources with relatively fast, annual renewal cycles such as grazing (or fisheries), the core economic problem is a question of how intensively to use the resource, e.g. number of cattle to graze each year f. If x is the stock of forage and $g(x)$ is a convex function (e.g. logistic) describing the biological growth of the stock of forage, then the present value of using the land for grazing V_G can be written as:

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[3] Note that per Reed (1984), the annual risk of a forest fire can be added in as an additional premium on the discount rate (e.g. increasing it from 5% to 7% if there's a 2% annual probability of fire with total loss).

$$V_G = \max_f \int_0^\infty [pf - c(f,x)]e^{-rt}dt$$
$$s.t.\ \dot{x} = g(x) - nf$$

where p is the price per unit of cattle, $c(f,x)$ is the cost of raising cattle as function of the number of cattle f and the stock of forage x, n is the forage consumption per unit of cattle, and r is the discount rate.

Dynamic grazing models are less ubiquitous in the literature than the other models discussed here and are often highly detailed to the particulars of the economic or ecological conditions (Finnoff et al 2008). That said, a basic intuition emerges whereby there is a steady-state level of forage that balances the growth rate of the stock of forage with the consumption of forage such that $\dot{x} = 0$. Transition dynamics would lead initially high stock areas to be drawn down to the steady-state level, while initially depleted, low stock areas may be allowed to recover to the steady-state. Once that steady-state is reached, returns for ranchers will be much more consistent year over year than the oil and gas or timber cases above. In further contrast with the oil and gas and timber cases above, at any point in time (e.g. at the end of a grazing lease), the land still remains immediately valuable (and thus can generate revenue) for grazing purposes.

Conservation

Finally, conservationists also derive value from conserving land, though not necessarily in a profit-maximizing way as laid out above for the other use-types. Instead, value accrues to conservation groups via the non-use utility value $U(x,A)$ that the land provides, which may depend on the ecological state x of the site, but in many cases depends on the intrinsic, location-specific features of the site A (e.g. its aesthetic qualities, or wildlife habitat/corridor, etc). For simplicity, suppose that utility can be expressed in dollar-equivalent terms (e.g. the maximum aggregate WTP for conserving a particular location), then the present value of using the land for conservation V_C can be written as:

$$V_C = \max_m \int_0^\infty [U(x,A) - c(m)]e^{-rt}dt$$

$$s.t.\ \dot{x} = g(x) + m$$

where m represents mitigation efforts to improve the ecological state x, $g(x)$ represents any natural restoration of the ecological state, $c(m)$ is the cost of mitigation, and r is the discount rate.

Solutions to the conservationist problem will look somewhat similar to the grazing problem, with conservationists potentially investing in mitigation efforts to improve the underlying ecosystem, if the marginal utility from better ecosystem health $\left(\frac{\partial U}{dx}\right)$ warrants it. A steady-state may emerge, with corresponding transition dynamics depending on whether the site is initially depleted or pristine. Over time, the land may become even more valuable for future revenue, if the ecosystem has recovered or been restored by the conservationist.

Auctions

Given the above values, if state trust lands were to be sold in perpetuity, an auction process that allowed bids from any potential type of user would be well-suited to maximizing revenue. Just as in private land markets, the highest bidder would win the bid and the land would be allocated based on $\max\{V_C, V_O, V_G, V_T\}$. In practice however, most state trust lands are managed via finite term leases, which turns out to introduce substantial complications to the simple auction process described above.

One other caveat worth noting is the traditional environmental economics concern that free-riding incentives will make it difficult for conservation interests to successfully outbid extractive uses. This would lead to too-little land being allocated to conservation relative to a hypothetical social optimum that fully reflected all conservation values in aggregate. As noted in Leonard and Regan (2019), for any individual parcel of land, as long as conservation interests are able to outbid the next best use, conservation can win out. For parcels with particularly high place-based conservation values (specific recreational amenities, wildlife considerations, aesthetics, etc), the conservation demand may be very inelastic while extractive demand may be much more elastic, which would allow for those very high-value conservation parcels to be conserved.[4]

Conservation leasing and pricing considerations

As noted above, if state trust lands were to be sold off indefinitely, an auction process is clearly the preferred approach. However, the more common management approach for state trust lands is to lease the lands for a finite period of time (or in the case of timber, to hold an auction over the right to harvest a certain stand of timber). This finite-horizon leasing introduces complications such that a simple auction approach is no longer appropriate.

Consider for example, a timber sale auction with a logging company and conservation group both bidding. If the timber company wins the bid and the land is logged, the state trust receives the revenue from the auction, but the land generates no revenue until the forest recovers (potentially many years in the future). By contrast, if the conservation group wins the bid and is awarded a 5-year conservation lease, the land can still generate revenue because the trees are still standing – in effect the opportunity cost of the conservation lease (in terms of foregone state revenue) is the delayed auction revenues from the timber sale. Clearly, a $300,000 bid by a conservation group for a finite-term conservation lease and a $300,000 bid from a logging company are not equivalent in terms of the present value of revenues collected by the state – the future salvage value of the land needs to be "priced" in. The particulars of pricing will vary with the resource, as discussed further below, but the general principle is that with appropriate pricing adjustments, an auction mechanism can be employed to generate apples-to-apples bids.

Grazing and conservation leases

Grazing provides the simplest context for considering conservation pricing, as the dynamics for grazing use and conservation use are similar (per Figure 1 above). In principle, transitioning between a grazing lease to a conservation lease, and vice versa, would be relatively

[4] Ultimately, this is an empirical matter beyond the scope of this exercise, but private land sales might provide some insight into how "close" to social optimum (e.g. conservation easements) one might get from an auction process. There are also interesting welfare outcomes that could be considered – for example, the allocative efficiency gains of getting the "right" high-conservation value parcels conserved may be more valuable than getting the "right" aggregate total area conserved.

straightforward, with the conservation group effectively "buying out" the rancher from their grazing lease (Regan et al, 2023). The only dynamic wrinkle emerges if conservation leases improve the quality of the land at the end of the conservation lease, either through natural regeneration or active restoration/mitigation. In that sense, the (discounted) future revenue value of the land is increased by the conservation lease and should be reflected in pricing.

Two options are available – first, the regulatory agency could add a "premium" on top of the conservation lease bid, which can then be compared to any grazing bids. If a ten-year conservation lease would raise the discounted future revenue potential by $400 (in present value terms), then a conservation bidder who bid $800 for the land would win over a grazing bidder at $1000 ($1200 versus $1000). Alternatively, the agency could provide a "refund" at the end of the conservation lease of equivalent present value (i.e $660 in 10 years assuming a 5% discount rate). Knowing they will receive the future refund (worth $400 in present value terms), the conservation group would be able to bid $1200 upfront, which would beat the grazing bid of $1000.

While both pricing approaches can achieve the same revenue-maximizing outcome, there are two things to note. First, from an "optics" perspective, under the upfront premium approach, the agency is awarding the lease to conservation group, even though they bid less upfront. While there are sound economic reasons for this approach that are consistent with the agency's revenue-maximizing mandate, it may still appear to unduly be putting a thumb on the scale in favor of conservation interests. Second, under the premium approach, the regulatory agency pays at the start of the lease and bears the risk of the conservation group actually executing the land improvements, while the refund approach transfers that risk to the conservation group as they would need to improve the land to receive the refund.[5] In order to fund the upfront bid, conservation groups may consider "conservation bonds" or other financial instruments that would pay off at the end of the lease and the receipt of the refund.

[5] In theory, nothing would preclude a grazing lease holder from also taking advantage of a "refund" for improving the land, if the future revenue potential of the land was increased. As noted in Costello and Kaffine (2008), regulatory incentives at the end of finite term leases can induce efficient stewardship incentives for extractors.

Timber sales and conservation leases

As alluded to above, timber sales are a more complex case to consider than grazing, due to the dynamics of timber harvest cycles. Nonetheless, the same basic principles are in place, whereby conservation lease pricing should account for differences in future revenue streams of conservation versus logging. The key distinction with grazing is that, while grazing leaves future revenue potential for the land, once the trees are cut, there is essentially zero revenue potential for many years (or even many decades in some cases). By contrast, under a conservation lease, the timber can still be cut when the lease expires, but the delayed revenue collection by the state needs to be accounted for.

Thus, with timber sales, conservation groups can either receive an upfront premium payment for the discounted revenue value of the future timber (essentially some fraction of the discounted forest value $[(p - c_H)f(T) - c_P]e^{-rt}$), or a present-value equivalent refund at the end of the lease (if the timber remains). For example, a $300,000 harvest revenue value of timber today is worth $182,000 in present value if harvested in 10 years at a 5% discount rate. A conservation group bidding $135,000 today would then win a bid against a timber bid of $300,000 today, since $135,000 + $182,000 = $317,000 is greater than $300,000.[6] Alternatively, the conservation group could receive a refund for the revenue value of the timber of $300,000 in ten years at the end of the lease, and would then bid $317,000 accordingly upfront, knowing that refund is down the road.

Two things to note with timber and conservation pricing. First, the "optics" problem of upfront premiums becomes very extreme in this case – much smaller conservation bids will "win" against larger timber bids, particularly for shorter duration leases, even though again the underlying economic principles are sound. Second, a non-trivial concern is that the forest may burn down during the conservation lease, and the state would lose out on that potential future revenue. This risk of fire can either be priced into the discount rate used to calculate the upfront premium (Reed, 1984), or alternatively the refund approach would in theory provide incentives

[6] Essentially the $135,000 is like a rental payment for using the land to not harvest, which accounts for the opportunity cost of the land.

for conservation groups to engage in fire-reducing management practices in order to protect their "investment."

Oil and gas and conservation leases

Oil and gas presents the most complex set of concerns when considering conservation leasing. This is due to both the dynamic non-renewable extraction and salvage value issue, as well as the particulars of how state trust lands typically generate revenue from oil and gas. In addition to a competitive upfront bid (the "bonus" bid), oil and gas extractors also pay a known royalty rate from any future extraction along with an annual (small) rental fee. In general, the revenue from the royalties is several times larger than the revenue from the upfront bids and annual rentals (Culp et al 2006).[7] As such, there are two tensions at play in thinking about pricing conservation leases. On the one hand, similar to the timber case, a conservation lease still preserves the future revenue value of the oil and gas under the ground at the end of the lease. On the other hand, because the conservation lease does not generate royalties, the state is delayed in receiving a flow of revenue from extraction royalties. Simply put, an upfront $4,000 bid from a conservation group and a $4,000 bid from an oil and gas company will have very different present value revenue implications for the state.

Given the complications, a little extra formalism is helpful for keeping things straight. Let B represent the upfront bid at auction, f is the annual rental fee, and τ is the royalty rate. Then under oil and gas extraction, the present value of expected revenue for the state assuming an optimal extraction path q^* is:

$$ER_O = B + \int_0^T f e^{-rt} dt + \rho \int_0^T \tau p q^* e^{-rt} dt$$

Under a conservation lease with an upfront bid and annual rental fee, the present value of expected revenue is:

[7] While the upfront bonus bids do provide some revenue, perhaps the main benefit to the state is ensuring that the lease is allocated to firms that expect to be able to profitably produce substantial future quantities of oil and gas and thus future royalty checks.

$$ER_C = B + \int_0^T f e^{-rt} dt + ER_O e^{-rT}$$

Intuitively, the conservation lease forgoes the near-term collection of expected royalties $\rho \int_0^T \tau p q^* e^{-rt} dt$ but preserves the future expected revenue stream from later oil and gas extraction.[8] Comparing equations and with a little algebra, the pricing adjustment that would equate expected revenue (and ensure an apples-to-apples comparison between upfront conservation versus oil and bad bids) is:

$$\Delta = \underbrace{\rho\tau \int_0^T p q^* e^{-rt} dt}_{Forgone\ Royalties} - \underbrace{\left[B + \frac{f(1 - e^{-rT})}{r} + \rho\tau \int_0^T p q^* e^{-rt} dt\right] e^{-rT}}_{Discounted\ Future\ Revenues}$$

In theory, the sign of this pricing adjustment is likely to be positive (unless the bonus bid and fee are very large relative to the royalty rate), implying that the conservation group would need to agree to *pay*, either up front or at the end of the lease, the adjustment above. In essence, the conservation group is paying for the opportunity cost of the delayed royalties $(\rho\tau \int_0^T p q^* e^{-rt} dt)(1 - e^{-rT})$ adjusted for the future bonus bid and rental payments $\left[B + \frac{f(1-e^{-rT})}{r}\right] e^{-rT}$.

To put that in context, suppose that the regulatory agency leasing a large track of land to oil and gas would collect $50,000 in upfront bonus bids, $10,000 in present value of annual rental fees, and $1,000,000 in present value expected royalties. The present value to the agency is thus $1,060,000. In order for the agency to find a conservation bid of $50,000 to be equally valuable for a 10 year conservation lease (along with the $10,000 annual rental fees), the conservation group would have to agree to pay $357,077 (assuming a 5% discount rate) to cover the adjusted opportunity cost of delaying the $1,060,000 in expected royalties, bonus bid and rental fees by

[8] Recall that ρ is probability that oil and gas can be economically extracted, so the regulatory agency would need some expectation over that probability.

10 years (the present value of which is $642,922).[9] With that adjustment in place, an upfront auction would yield apples-to-apples bids in terms of state revenue.

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[9] The present value to the agency is again $1,060,000, as the agency would collect the bonus bid of $50,000, the rental fee of $10,000, and the $357,077 adjustment from the conservation group, and then the remaining revenues from oil and gas development ten years down the road.

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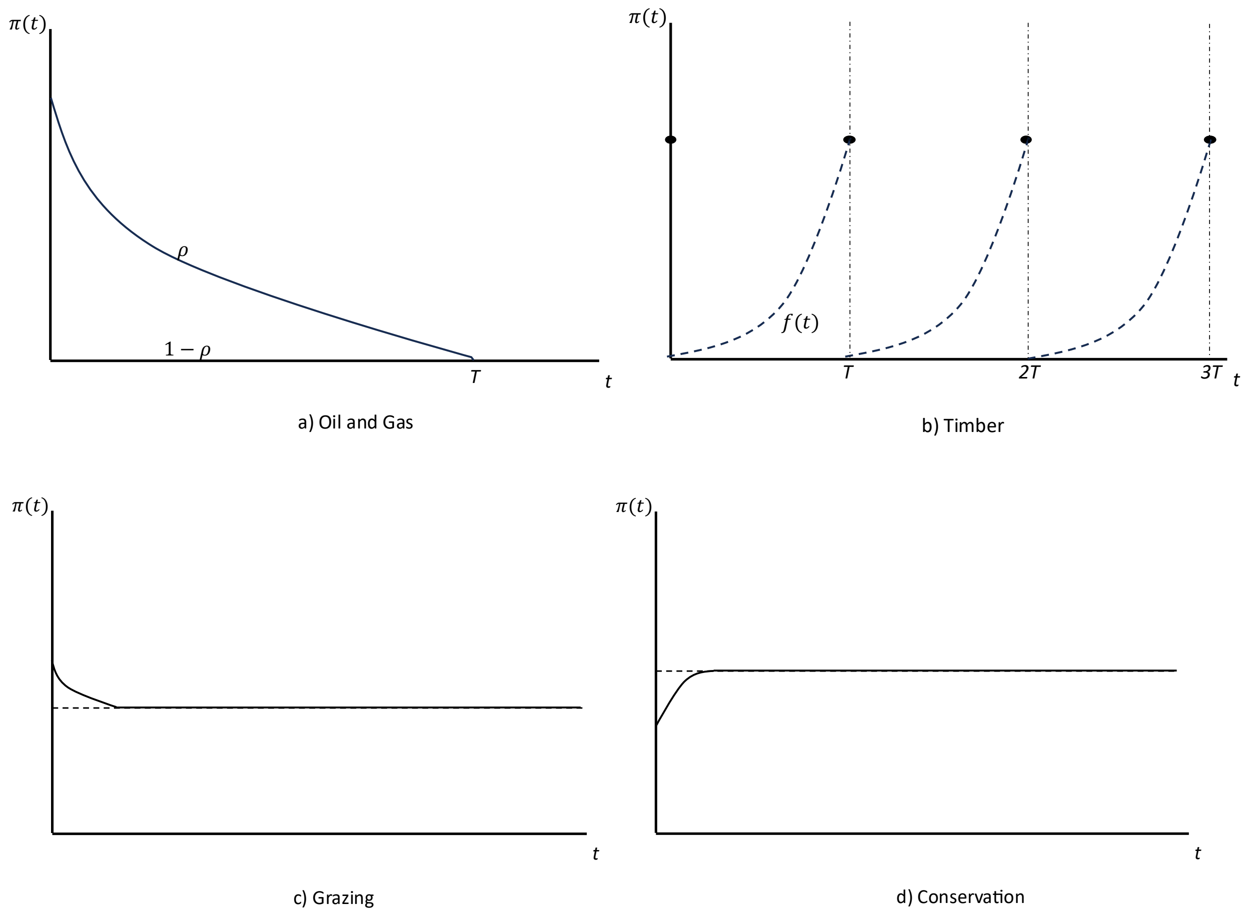

Figure 1: Hypothetical private returns over time from different resource uses from a parcel of land. Panel a) represents oil and gas extraction, where ρ is the probability that it is economical to extract. Panel b) represents timbering with the underlying forest growth ($f(t)$) in dashed lines. Panel c) represents grazing, where a pristine ecosystem is initially drawn down to a steady-state over time. Panel d) represents the monetized value of conservation, whereby an initially degraded ecosystem is remediated by costly mitigation efforts up to a steady-state.