Xeq ².

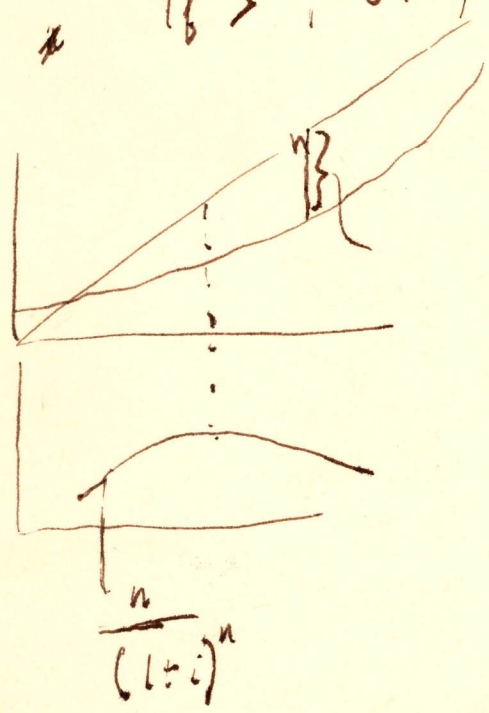
02 i

05 0

01 lst n

$\frac{n}{(1+i)^n}$ $\frac{n-1}{i^{n-1}}$ GTO 99 show max

* If >, GTO, GTO 00, recycle.



Ratio is max when $\frac{d \ln I^n}{dn} = \frac{d \ln n}{dn}$

$\ln I^n = n \ln I \doteq ni$

$\frac{d\,ni}{dn} = i$

$\frac{d \ln n}{dn} = \frac{1}{n}$

Max when $i = \frac{1}{n}$

i	$\frac{1}{i}$	$\frac{i}{\ln I}$
.05	20	20.50
.10	10	

Forest Eng. Course

H.G. Payer

Major Outline.

I. Road dimensions

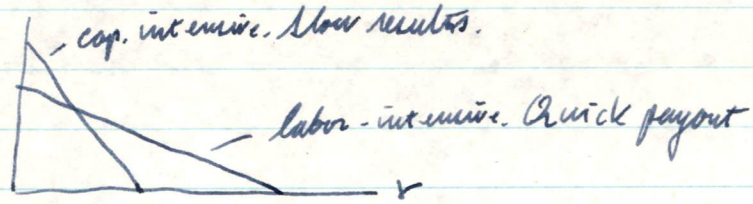
A. Where to locate

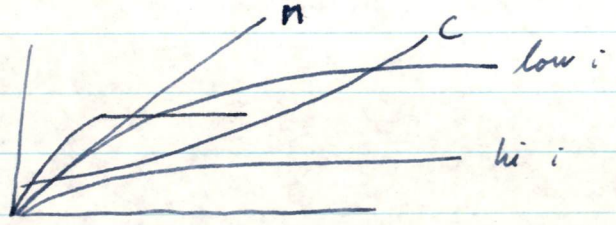
1. Macro.

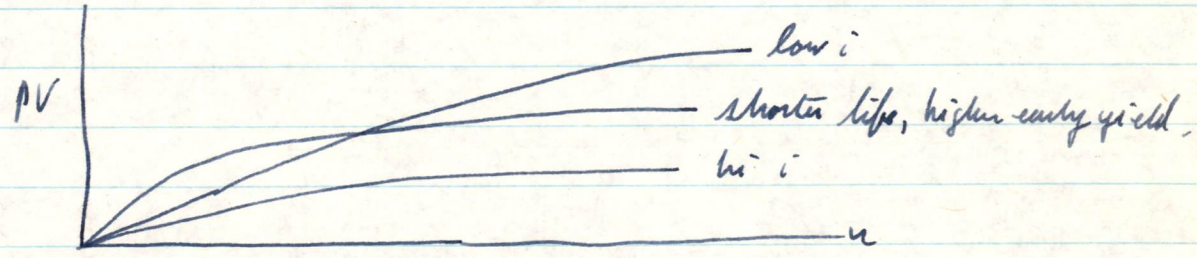
Rank alts.

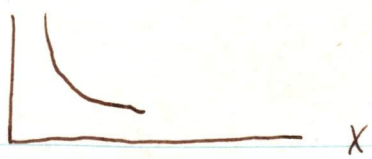
Since land cheap & K scarce. I suggest use internal i. Screen out all projects below some i.

(over)







7. 

~~2. Accro~~

By whichever of 3 criteria, use best-first. Sharply different from S.T. Is rather "Ricardian." Better land yields simple user cost.

a. Land yields it in perpetuity. Better sites ~~yield it~~ shd be worked hard, renewed often.

b. Old-growth as a mine yields it temporarily. Simplex has time value

The costs in gen are not "it's only money". (Money is intangible). Money is symbol of resources that need conserving — energy, materials.

Also, capital, which is increasingly scarce.

Ln approach.

$$S_e = \frac{F}{I^n - 1}$$

$$\ln S = \ln F - \ln(I^n - 1)$$

$$\frac{d \ln S}{di} = 0 - \frac{n I^{n-1}}{I^n - 1} = \frac{-n I^{-1}}{1 - I^{-n}}$$

[Max when $\frac{F'}{F} = \frac{(I^n - 1)'}{I^n - 1} = \frac{i' I^n}{I^n - 1} = \frac{i'}{1 - I^{-n}}$]

$$\frac{S'/S}{i'/i} = \frac{-i n I^{-1}}{1 - I^{-n}} = \frac{-in}{1 - I^{-n}} \frac{1}{I}$$

2. Micro location. Routing; width of r.o.w.

Is gn. of land vs. [capl. ~~cost~~ & labor].

Communicability required. Requires i.r. plus cap. thg.

Distrib. sheet on ~~cap~~ meth. of finance.

Can use either annuity, or PV, as lingua franca.

Here, use PV.

A. L.V.

i) S_e, Eqns. (9) & (10)

S_e not worth much? Not if you haven't planned to max. it, — and you haven't. 120 year rotns? No way.

But forest land can have good values.

ii) Env. Annual flow, cap. in perpetuity. Higher value.

✓ Higher i puts more premium on env. than wood (future wood.)

(over) Thus, hi i argues not vs. forest cover, but vs. future timber, logging.

B. Capl. Is a PV

C. Labor. Comes later, mtce & opn. & repair.

✓ Using hi i results in causing you to prefer more labor.

Env. value: $P = \frac{a}{i}$

$$\frac{dP}{di} = a\left(-i^{-2}\right) = \frac{-a}{i^2}$$

$$\frac{P'}{P} = \frac{-a/a}{i^2/i} = \frac{-1}{i}$$

$$\frac{di}{di} = 1$$

$$\frac{i'}{i} = \frac{1}{i}$$

$$\frac{P'/P}{i'/i} = -1$$

Timber Value: $S_e = \frac{F}{I^n - 1}$

$$\frac{dS}{di} = F\left(-\left(I^n-1\right)^{-2}\right)\left(n I^{(n-1)}\right)(1) = F\frac{-n I^{(n-1)}}{\left(I^n-1\right)^2}$$

$$= \frac{-Fn}{I^{1-n}\left(I^n-1\right)\left(I^n-1\right)} = \frac{-Fn}{\left(I - I^{1-n}\right)\left(I^n-1\right)} = \frac{-Fn}{I^{n+1} - I - I + I^{1-n}}$$

(for ln. approach see next page)

~~Currently~~

Vice versa, low i magnifies future labor costs, encourages big or durable outlays now to reduce future labor.

Can't avoid choosing an i. Have to trade off values w. different dates.

Can decide not to discount? Then $i = 0$. So?

So then PV of land $= \infty$, and you can't use any? ✓

CC = i + a

Can use low i? Then choose capl. intensive bias, vs. labor & land. Seems wrong, when there is world shortage of K.

B. Length of road

1. Prune off subecon. tips. Macro.

Appraisal rpt. on Stein consolidates all, $45/cct, logging & hauling. Consolidation invites X subsidy. Longer hauls cost more.

MNP analysis. Sheet passed out.

Any positive MNP is OK, if there is no road from other side.

F.S. understates road cost? After stumpage offset, F.S. is fuel road. Licensee still gets profit allowance, 18% of gross.

Appraisal enters cost at i = 0.

Does F.S. allocate full extension cost to mgmt. area? I doubt it.

C. Density of road & spur network.

Higher density can be very productive. It subs. lower cost for higher cost xpts. Shrinks blocs.

MNP again. Now, stop at max ANP. [But allocate all road costs to all blocs, so more blocs mean slightly lower ~~NP~~ ANP.]

Just like subdividing urban land. Max unit value

At margin, when adding one more bloc, reason thus:

$$\text{Net Gain} = NP_n - \sum_{1}^{n-1} MNP - [\Delta \text{ trunk road cost}]$$

D. Capacity of road (reach by reach)

Fn. of width, grades, turns, surface, bed, route, etc. "Inputs"

Data are available on cost of 6 classes.

But all ~~(inputs)~~ vary in fixed propns. Need more study, to vary them individually

Data needed on productivity of better road. Product is speed, etc., × traffic. I.e., Δ traffic flow.

This gives key to getting data on input productivity. What do

they add to objective.

E. Durability of road

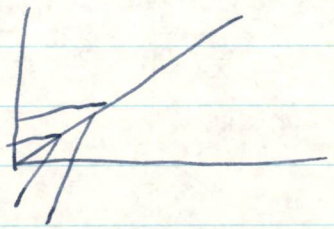
Already partly covered. Depends on relative costs.

Lerch & K make roads durable. If they're cheap, lengthens life. If labor cheap, rebuild every year.

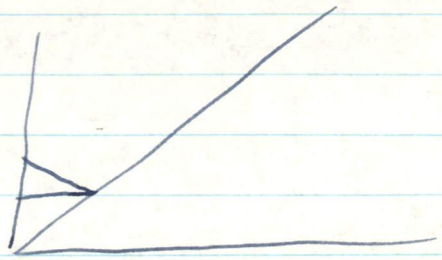
i) Mgmt. year has mgmt. cost, and decision is like planting a tree -- Capl. now for service later, less intervening risks.

ii) But may add durability by ∆ culverts. Notes, 18-21. Same result.

iii) Sensitivity to i.r.



To w.r.



II. Time Factors

A. Period of operation

assuming cap. cost is high, & site specific.
(If neither, why take 40 years? Why take 2?)

ERT, & 16-17.

B. Lead time, staging, & dead time.

Unrecovered IC compounds & becomes more IC. Cash flow avail.

Licensees are aware of IC cost, & squawk. T.S. has free IC, so T.S. ends up picking up all IC costs. If it costs them 15%, is it really free?

When T.S. says $i = 0$, means <u>money</u> rate, not real. The <u>constant</u> is wrong, regardless of real rate.

Patching adds to lead time. Like 15 years of urban sprawl before infitting. Doubles or triples real cost.

C. When to begin.

Having compared lead time & cutting pd., move whole program as a bloc three time. MPV.

See ripening: When to build what.

D. Risk. Already covered

Lender vs. investors risk. X subsidy. Collateral sec.

Risk premium self-justifying, turns receiving into income. Mafia.

E. Reforestn.

Is a qu. of how much. Is always some low fig. that pays.

F. Recompense for road.

S.T. depreciation.

How to make the Stein go.

1. Shorten cutting cycle, ~~redn~~ (hardly any Δ cap. cost involved, and appraisal system shows none, anyway.) Cf. 10.

2. Cheaper road by separately varying elements in road classes.

3. Allow higher grading. (Wood is for sawmill, I bet they apply same closeness regardless!) a) Micro, log by log b) Macro, acre by acre

4. Reforest only for hydrology & game, forget future wood

5. Allow ~~it~~ progressive clear cut. a) Reduce cap. in roads b) Shorten hauls, esply. early hauls, and this may be larger element.

6. Add recrn. & other road benefits, charge to recrn.

7. Find mill w. excess capacity, charge no "profit". (They take this point re logging mach. & eq.)

8. Base profit re roads only on ~~it~~ unrecovered K in roads.

9. Get higher price. Deus ex machina. But we can answer this qu: what price is needed to make Stein go. (distribn. of variable price over time also matters.)

Also, wait for lower-cost logging techniques. See RIMS.

10. Disaggregate, deconsolidate bookkeeping. The way books are kept now, all is slopped together, so no saving seems worth much trouble. Specifically, benefit of quicker cutting

Thus, by ~~cut~~ reducing pd. from 40 to 20 yrs, double annual output while raising crf only maybe 3-5%. This is swamped in consol. accts. but crf × K is $4-8, vs. $45/ccf "logging"; i.e. vble costs. But cash flow is excess over vble. costs, and there the % effect is high.

II. Change layout

a. Establish there are trade-offs

b. Show they are made wrong, can save some

2. Ripening: when to build what

The time to build any given Plant (P_n) we have seen is the first year when current benefits cover variable costs plus the fixed costs correctly assignable to year zero, these covering interest, depreciation, and decay, but not locational obsolescence.

To build sooner would lose net benefits in the first year. Benefits might cover variable costs, but they need also cover fixed costs in year one, that is they must yield interest to warrant committing capital during that year, and warrant losing some of the capital by depreciation. There is in general no compensating gain from Plant One (P_1) to requite any loss taken in premarginal years. The positive rents in after years would be reaped just as well by a plant built later.

This does not mean we altogether abandon the behest to build ahead of demand to achieve scale and lower costs. The criterion still has us build a plant when demand is too small to achieve minimum SAC when built, just as in the static case. SAC then falls over a reach as demand grows. In addition, we will see there is some gain in advancing the second generation Plant by a year, but this will fit into place in the later discussion of future generations. There may also be a stimulus to demand, discussed later: here we assume demand growth is given exogenously.

To build this Plant later would lose a year's rent, again for no later gain. So the optimal Renewal date (R-date) is quite determinate--for any <u>given</u> plant.

Let us begin with the first Plant whose first year yields a positive rent,* and call it P_1. We rule out all prior plants and dates,

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* For simplicity, from here on "rent" means the extra rent of the mass challenger over the CIA defender, except as specified.

even though some of them would yield positive net rents over Life, because it is self evident there is no gain in losing money when you do not have to.

But that means we have already decided P_1 is superior to prior plants of positive net value. Is it not then also possible that P_1 is inferior to a later plant of still higher net value? We would not build P_1 any later; but we might wait to build P_2, a larger plant of lower SAC over most of its Life as demand keeps growing. It is not enough for the Challenger to prevail over the Defender of the past; he must outdo other Challengers from the future.

This is the old doctrine of ripening associated with R. T. Ely. "If I buy land and hold it for appropriate use, I perform social service. A lot suitable for a fine downtown office building may otherwise be improved with a very different, inferior building and hinder permanent improvement . . ."* "It would be in the end a waste to put upon this land inferior buildings which would have to be torn down."**

Ely asked his doctrine to carry more weight than it would bear in the suburban land boom of the 'twenties, and he and Wehrwein finally accepted Simpson and Burton's revised metaphor of "cold storage".*** Touring the suburbs today one gets an urge to take out Simpson and Burton again. Yet there is something to Ely's idea, which has been around at least since Ecclesiastes III, "To everything there is a season, and a time

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* R. T. Ely, "Land Speculation," Journal of Farm Economics 2:121-36 (1920), p.127.
** R. T. Ely, "Outlines of Land Economics," Ann Arbor: Institute for Research in Land Economics, 1922 (mimeograph), p. 104.
*** H. D. Simpson and E. R. Burton, The Valuation of Vacant Land in Suburban Areas, (Evanston: Northwestern University Press, 1931) p. 44.

to every purpose under the heaven." Perhaps he applied it to the wrong sites at the wrong time. It is more compelling apropos our intersite sector, where the future promises not merely a higher use but lower unit costs, too.

Since the larger plant (P_2) has higher costs at first, or requires larger volume to achieve given costs, it is still green when P_1 is ripe. If we want it we are better off to wait for it. The issue therefore resolves itself into defining and balancing the gains and costs of waiting. Many economists at this point advise one to select the future plant "of highest present value". It is a good reflex, yet not good enough, for after each alternative plant there looms a chain of successors. We will presently develop some simple algebraic tools to handle this complication and maximize present value of the series (PVS). We will see that this is consistent with our basic criterion of maximizing rent, whereas maximizing present value of the first generation plant (G_1) alone is not. The mathematics becomes simple, however, only by first defining terms and clarifying issues. Let us itemize and analyze the gains and costs of waiting.

The gains of waiting

The basic gain is the lower SAC_2 curve of a larger plant (P_2), not just at the tangency with LAC but increasingly with time and larger volumes. We have already stressed how the advantage of larger plants gains by dynamic growing of demand.

The lower SMC_2 allows larger volumes, as well, by repetition of the reasoning of Figures 2 and 3.

This is some gain, but mixed, for the marginal volume is at a low

reach of the demand curve, limiting its value. Also the future rents must be discounted, and the discount factor grows geometrically with time whereas demand (by assumption) grows arithmetically, and volume slower than that as SMC rise.

Gain 2, a small one, is that the optimal R-date of all plants (P_n) larger than P_1 (the first marginal one) is slightly left of SAC_N tangent LAC.

The difficulty of this finer point is greater than its importance. I include it to anticipate any confusion it might occasion if left implicit.

The R-date advances because all tangencies to the right of P_1's (i.e. SAC_1 tangent LAC) must yield a surplus. This follows because P_1 breaks even at its tangency. When the demand curve has risen, it lies above LMC all the way to the new intersection which determines the size of P_2, where LMC = SMC_2 and LAC tangent SAC_2. P_2 should therefore be started before the demand curve has risen this far; otherwise it is overripe.

Of course the in-between plant smaller than P_2 whose SAC_n tangent LAC at this earlier time is also overripe then, and so on back to P_1 where the R-dates converge. So there is no ambiguity over what plant is ripe on any given date.

Thus we see a reason why larger plants can spread their FC over more years. As demand grows the plants becoming successively ripe are larger than those whose SAC tangent LAC at the intersection of demand and LMC. And this effect grows as the lifetime rents of plants grow.

Gain 3 is better foresight. As a generality this argument has no value, for it will be equally enervating next year--moreso, perhaps,

because next year's optimal plant requires a longer forecast. There is only a gain if the current rate of clarification is above the future.

line omitted "Uncertainty" is not a good general stall, either. It is valid if you suspect it will grow less, that argues for building earlier--the smaller plant, of course. If you think the fog will lift in 15 to 20 years that gives time to amortize a small interim plant.

Gain 4 is added productivity. This is a normal expectation. It means a later plant enjoys lower costs and gives better service thanks to technological advance as well as scale, and fortifies the advantages of larger plants.

Gain 5 is higher costs of the existing Defender CIA. It may seem odd to call this a gain, but the rents of our alternative Challenger plants are just their advantages over the CIA. The worse the CIA, the greater the gains. It satisfies common sense to think of the gains as another year's use from the old CIA plants.

Gain 6 can be reduced cost of inputs. This might seem far-fetched today, but not at all. When we correct for depreciation of the dollar, most raw materials have fallen secularly for some time, and probably will continue to. The most important input by all odds is borrowed money, and there is always a chance of lower future interest rates, although I do not foresee that now myself. It would be wrong to argue that accelerated future inflation is equivalent to lower future real rates of interest, because money borrowed this year for a long term will enjoy this benefit almost as much as money borrowed in the future.

Gain 7 is that the U.S. may help pay. Socially this is spurious,

of course. It is an effective delayer of many good works, however, and socially quite damaging, especially in conjunction with other federal programs of the reverse twist where works are accelerated to capture matching funds before they run out.

There, then, are the wiles of Scheherazade. One should hear them skeptically, for with these a confirmed temporizer can procrastinate without end. So let us now play the other side of the waiting game.

The costs of waiting

The major loss is deferral of rent or net benefits. Costs, to be sure, are also deferred, but this defers benefits over costs and there is the loss.

The lost rent of P_1's year 0, taken singly, is of little moment for year zero is marginal. But by the time P_2's first year is marginal P_1 would have been postmarginal and rent-yielding. Looking forward and comparing the respective successor plants in the P_1-series the same is true a fortiori because of P_2's longer Life; but I defer this for separate treatment.

On balance then P_1 yields smaller net rents than P_2 but yields them sooner. To sacrifice P_1 for P_2 is an investment. The thing invested is the sacrificed net present value of P_1. The thing gained in return is the net present value of P_2 later when P_2 is ripe. The cost is interest over the period of waiting on the value invested. The investment is good if it yields a competitive rate of return. Let MPV_n be the "Moving Present Value" at the start of year n for Plant n; let i be interest rate. Deferral to m pays if $MPV_m \geq MPV_n(1 + i)^{m-n}$. This is equivalent to the

rule of maximizing present value (from a fixed date of reference) and is all right as far as it goes, which is only into the first generation. We will see that it becomes complete when extended to comprehend all.

Cost 2 is deferral of demand. I have treated hereto only the exogenous aspect of demand, but where the mass system is prerequisite to immigration there must be some lag in attracting demand. It is not enough to proclaim an intent to build. Cement is more credible, and the market responds. The present buildup of future demand, discounted, may be treated as a current revenue. While that may sound fuzzy it has an observable index in the rise of land values before use. This is too parlous and complex a topic to elaborate here, but there is something to it. The Haig-Simons doctrine tells us that capital gains are income at the time they accrue. If so, advanced land values represent benefits at the time they advance. And we must not fail to treat the enhanced capital value of the intersite enterprise the same way, and the advanced treasury equity, too. On the other hand, we must beware of soft land values traded on thin equities with easy credit. We must beware of sheer land bubbles. We must beware of claiming credit for exogenous demand increments. And we must beware of purely redistributive gains.

Cost 3 is future inflation of input prices. "Build before costs rise again:" one hears this rationale constantly and it may sound ignorant because pure inflation is a purely illusory cost of waiting. But financing with long term bonds changes all that. Future inflation means a lower real rate of interest than the specious one. Lower interest rates reduce the disadvantage of incurring costs sooner rather than later.

However, this is double edged. Lower interest rates also reduce the disadvantage of receiving revenues later. Since revenues are greater than costs, and larger plants mature later than smaller ones, the revenue side is stronger. The net effect of lower interest rates is to favor waiting, as summed up under Cost # 1. So this most common of importunings may serve better as a sedative, although there is a good deal of play in the complexities. Cost 3 turns out to be Gain 8.

Cost 4 is that demand may not grow as expected. This is very small, because the lost years of P_1 were close to marginal, and the option has not been lost of building P_1 later.

Cost 5 is the loss of limited Federal matching funds, discussed with Gain 7. It is spurious, from the social viewpoint.

Cost 6 is the loss of, or failure to acquire the site, as by franchise, license, monopoly, etc. This is generally purely acquisitive and therefore spurious, although occasionally an easement might be saved from irreversible loss to a lower use. This is a paramount motive in practise for premature extensions of mass systems into unripe territory. In conjunction with the decentralist bias in rate-making (E. 1 and 2 above), it works mischief too extensive for a few words adequately to damn.

The cost of deferring succession

All the gains and costs of waiting can find sockets now in a simple model where the basic cost is interest on the Moving Present Value (MPV) and the gain is growth of MPV.

It is time to ask, present value of what? Many economists are satisfied to look only to the first generation, believing later values to

Topics

BCA

Trade-offs & multi-use. (Leading sector role. Developmental MC=P.)

Valuation. Forest Land used for roads; for recr.; for parks, grazing, etc.

Project design: Objective fn. – what to max., subject to what (watchout proxies; durability)

Go or no go – or defer. Choose use of max. P.V.

Sizing (length & width) "Standard" of roads.

Timing (beginning & end) (staging)

Market – for whom to build

Avoiding X-subsidy

Recoupment – who pays, & when?

(Opt. life of road depends on this) Period of opn. (Xerox pp. from ERT)

Ec. life vs. a.c. vs. guidelines. Tech. vs. biological decadence, etc.)

Beginning ~~(allow to fill up. lead time)~~ (Use RIMS & ERT)

Lead time – cap'g int. during construc. Cf. analysis's Staging

Best first vs. even-flow.

Locating. a, Macro, priorities among big alts. & b, Micro, routing. land vs. K.

Allowance for risk. (Avalanche, flood) (Risk-avoidance (over)

Layout -- Trade-offs among trunks, ~~&~~ & branches. MVP of land, size of eng. blocs. (coord with opt. life of same, but opt. life may be more based on whole valley.

Protecting "environment" – runoff, streams, game, scenery

~~Reforest. 2 to 5 Ha. 7-10 yrs, allowed for "proper restocking" ≡ 33%.~~

~~Routing -- land vs. capt.~~

Taxation -- treatment in the measmt of benefits & costs.

Extended benefits

Δ l.v.

(net) multipliers

Macro tax bias; micro bias.

Taxn. of roads, prop. tax. Exemption of cap. in timber.

~~Subsidies~~ Inc. tax subsidies to road builder.

Interest rates

Use of -- capt. thy.

Choice of:

Risk & i.r.

How allow for risk. (watchout proxies. Constant right method vs. Δ i.r.)

Invt. risk vs. credit risk

Angle, risk, i.e. risk as perceived by middle mgrs. Conservative bias? Others?

Sensitivity analysis – how critical is i? (Horebeke comment: the more K-intensive, the more important is i.r.)

Renewed forecasting.

by middle managers. Paradoxes of risk -- visible and invisible. Paradox: overinvest in washout capex. reduces washout risk, but ↓s risk that mgrl. invt. may go unused. v. Commodity pepsi, etc. "Low-quality" ↓ to Mfg. invt., e.g.,

✓ Washout risk is a form of longevity. I.e., if road does wash you can rebuild it. So cost insured against is finite.

{ Opt. rotn. age.
Opt. spacing
Type of regn. inv. — to shorten future cycle

Opt. life of road
a) If need is continuous. See (3), p. 7-9. Tie to opt. rotn. age.
b) If need ends w. logging

Recompment for road.
Licensee fences road. Then he charges cost to Crown via stumpage. "Stumpage offset".
a) Guidelines that let him pay no stumpage until full road cost recouped (~~w/o~~ with interest?) At that point Crown is fncg road. Let appraisal system grinds out automatic % for licensee. He gets return w/o investment.
This may be comp. for requiring him to patch cut.
b) Older guidelines. Cost depletion or "Ledger System." Amortize road over several years, ~~as~~ so much per cunit as scaled out.
c) Proper ~~depr~~ amortn. sched. Time depreen., mainly. Sinking fund depreen. -- can explain it.
Ledger system puts spurious MC on road use, slows cut.

"Standard" of roads.

6 "Classes" are too few. And the elements shd. not vary in fixed coeffs.

Road ~~Standard~~ Class has four elements or more. They shd. be separately variable.

- Width (seating capac. vs. higher opg. costs)
- Speed limit, fn. of max. slopes, turn radii, surface, signing, use of radios, homogeneity of use, etc.
- Durability, fn. of route, site, roadbed, mtls., surface, Washout protn., snowslide protn., canopy removal, etc.

  Built-in durability vs. higher repair & maint.
- Environment protn.

Thurs., MG topics

Project Design, Ec. Opt., & F.S. Policies.

Objective fn – what to max., subject to what.
(PV(B – C); B/C; i.

Is it only "go or no go?"
Possibilities of partial use, lower cost
High-grade areas; high-grade timber; low-standard road, ~~etc~~ min. reforestn., short hauls only, ~~etc.~~ ~~more timber~~ independent sub-contractors, lower mill costs, recouping more from providers, elim's x subsidy, bending rigid rules

Road ~~dim~~ dimensions: 1) Where to locate. Macro: micro
2) Length of road
a) How far in to go, an ec. choice. ~~&~~ Prune off subec. tips. (over)
b) Staging -- min. the dead K. (Cap'ze. int. on unrecovered cap.)
c) Road density -- to min. the pre-road, high-cost movement,
i) Parallel & nearby trunks
ii) Spurs, platforms --- points of entry, or "pressure change" — say "mode change" here.
(over)

Capacity of road (fn. of width, grade, surface, turns)
Hauling cost -- how affected by road capac. Trade-off
Routing & width: land vs capital tradeoffs
~~Capital intensity~~ Durability of road: Capital ~~invt.~~ and land vs. labor ~~op. & maint.~~ tradeoffs. (Can achieve capacity either way, so these are separate issues)
a) Simple case, ecs. of longevity
b) Washout protn. as invt. in longevity

MNP of land. Enter road cost & hauling cost. Road cost is understated by: a) Not charging int. b) Cost per mile rises at tips as you get into higher ground c) Longer tips require added capacity all the way there.

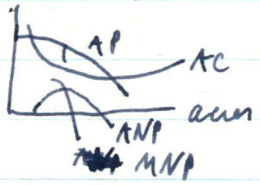
Hauling cost is understated by consolidated accts, as in J-J. memo.

MGP of input acres falls as you climb up valleys, too.

Subdivide valley into blocs to max. unit value. Like subdividing real land, or "Chelseafication". Thus max. total value – subject to, smaller blocs require more roads & spurs, so deduct this added cost.

Max ANP of land. Where ANP = MVP. Spreading overhead vs. longer skids.

Then figure how much road cost save by reducing no. of units, by one. Cost is added internal land, msrd. as $-ANP + \sum_{1}^{n} MVP$ where added.



Give numerical e.g., show sensitivity of MVP

b) cont.

i) Decrg cost of capacity to by pass water

ii) Productivity of capacity to carry ~~var~~ variable load -- "risk"

iii)

c) Sensitivity to i, r.

Road classes — rational standards or rigid ~~standard~~ fixed coefficients?

Time factors:

Period of operation -- optimal economic life of logging operation where capital cost is high and site-specific. (if neither, ~~it~~ can take it all at once. Hence my suspicion of J.J. figures on low cap. costs vs. high logging costs)

(Xerox pp. from ERT)

Opt. ec. life when need continuous. 

Timing operation -- when to begin. (MAV) (RIMS) (Fncl. vs. biol. rigidness.

Staging again

Lead time, construction time. The high cost of premature investment.

Progressive clearing vs. patching

Risk

Reforestn. also a space factor, distn. nets.

Choosing i.

S.f. depreciation. Recoupment for road. Licensee-contractor needs to recover his princ. no faster than road depreciates. He's guaranteed a return on it so long as timber holds out. Locating roads } to timber supply determines life of road.

a) Macro choices. Setting priorities among major alternatives. ~~Economic~~ Best-first principle vs. ~~working circles, S.F.~~ S.F.U. ~~or~~ system, and patch-cutting.

b) Micro choices. Routing, ~~Loads~~ r.o.w. width. Land vs. capital vs. labor in the input mix.
Reducing env. input.

Risk allowance — its many meanings

Risk of washout vs. risk of inverting K with no return. The bias to assume less visible risks. } biased risk perception ~~Costs~~ Right method. Contract si.

Lender's risk vs. invt. risk. Biases in the allocation of loanable funds, the cross-subsidy in large borrowing. Cross-subsidy vs. diversification.

Risk of ~~non-repayment~~ not recovering princ. — inflated by changing risk premiums in rate of return, a spurious risk.

Tax factors

2dry hems. Sl.v. si
ripples, no

Logging period

Instl. constraints

A.C. for whole PSYU, find status of PSYU act re Stein for one TSHL.

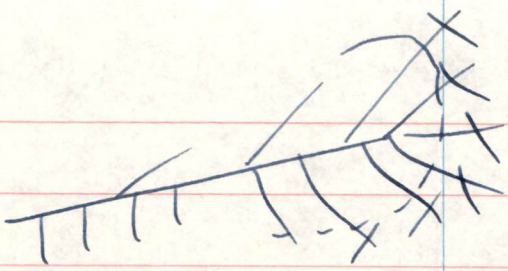
"Guidelines", e.g. 50% on first pass. Find guidelines used in Kamloops Forest Distr. for Stein R.

Restocking pd.

TSHLs began in 1969.

"Proper restocking" is ≡ 33%. You have 7-10 years to do it. (Or else ...?)

TFLs reforest faster, w/in 2 yrs. Cost is taken as a cost in appraisal, i.e. expensed. Also, A.C.E.



Shorten spurs. But I think no, bec. they are low-cost branching

ECONOMIC ANALYSIS FOR FOREST ENGINEERING

A dialogue between economists and Forest Service middle-managers February 17 - 19, 1976, Student Union Building

UNIVERSITY OF VICTORIA

Jointly sponsored by B.C. Forest Service
Engineering Division,

B. C. Institute for Economic Policy Analysis
and

University of Victoria

TUESDAY, FEBRUARY 17

9.00 - 11.45 Professor John Schofield, Department of Economics, University of Victoria

"Basics of Cost-Benefit Analysis"

12.00 - 1.00 French lunch, "Sauve-qui-peut"

1.00 - 2.00 Break into 5 6-person committees to prepare statements on how applying principles to recent, current or future decisions might have changed or change them. It is also fair to suggest how the cases might change the principles.

A. Definition of Benefits and Costs
B. Valuation principles
C. Decision criteria - what to maximize?
D. Priorities - which project comes first?
E. Selecting the class of the road.

2.00 - 3.15 Committee spokespersons report to group
Hold strictly to 15 minutes each.

3.30 - 4.30 Response by Professor Schofield and staff.

WEDNESDAY, FEBRUARY 18

9.00 - 10.15	Professor Gerald Walter, Department of Economics, University of Victoria "The Economic Management of Multiple Use Forests"
10.30 - 11.45	Professor Thomas Lambe, School of Public Administration, University of Victoria "Interest, inflation, and risk".
12.00 - 1.00	English Lunch "On Your Own"
1.00 - 2.00	Break into same committees, same rules

A. Pricing policy for road users: recoupment and allocation.

B. Prices as conversion factors among forest outputs

C. Present worth as a decision criterion

D. Selecting an interest rate

E. Allowing for risk

2.00 - 2.45	Committee C, D, & E spokesmen report to group
2.45 - 3.30	Professor Lambe and staff respond
3.30 - 4.00	Committee A & B spokesmen report
4.00 - 4.30	Professor Walter and staff respond

THURSDAY, FEBRUARY 19

9.00 - 11.45 Dr. Mason Gaffney, Executive Director
B. C. Institute for Economic Policy Analysis
"Project Design, Economic Optimization,
and Forest Service Policies"

12.00 - 1.00 Mexican Lunch, "Sal si puedes"

1.00 - 2.00 Same committees, same rules

A. Could the Stein be viable? How?
B. Economic life vs. Allowable Cut and Guidelines
C. Road standards - are they economically optimal?
D. Washout protection - how much is warranted?
E. Reforestation - can the investment pay?

2.00 - 3.15 Committee spokespersons report to group.
Hold strictly to 15 minutes each.

3.30 - 4.30 Response by Dr. Gaffney and staff.

Forest Engineers Class

1. Consider lenders risk, too

2. Treatment of flood probabilities - disaster prevention. (War, too)

$$PV = \frac{1}{n}\,\frac{1-e^{-in}}{i}$$ "Be prepared".

? n is no. of yrs. before washout flood. $\frac{1}{n}$ is chance it will occur each yr.?

Same formula applies to investing in equal excess capacity for peaks loads of a positive payoff kind. Application here is less common. Few positive gains are so large as disaster losses.
occasional

Some possible e.gs:

Convention capacity
assembly halls, stadiums
Grabbing resource leverage w. armed force, or threat
Cashing in on ~~fads~~, vogues - by stocking Hula hoops, skate boards, etc.

Seizing quotas when they are fluid
Supplying shipping capacity when short
Embargo protection - excess stocks
Famine insurance
Water diversion capacity.

2½. In flipping coins, etc., risk is removed by increasing no. of events. A way of ↓ no. of events is to shorten life, i.e. reduce K-intensity.

Depends on nature of invt. Flood-control capacity, the event is the flood, so long-lived K undergoes many events, pools risk.

3. Assets of variable return

Valuation depends on fungibility. An input supply — water, power, labor — is worth much less if intermittent or interruptible. (Hence the great value of land, relative to productivity)

Money returns, on other hand, investor's need of level flow is much less.

Better than a steady, level supply is one that varies under your control. Control is the key.

4. Knowledge requirement.

"Risk aversion" may in fact be work aversion — the work of investigating. You have to learn and know much more to buy stocks than bonds.

5. Need for level flow.

Everyone needs a level flow to live. Beyond that, no need.

So working people can go for higher ~~rate~~ means in return for less liveliness. So can coupon clippers w. a sense bare.

6. If future yields are uncertain, and this occasions a discount, then reduce all by x%. This reduces PV of all by x%.

But if you raise i by x%, the more remote future are discounted more.

7. Low govt. rate doesn't come from pooling risk so much as mortgaging tax power; and control over money.

Notes by M. G., 19 Feb. '16, Dialogue with Forest Engineering Group

Math. of Finance, compressed

1. P = present value, lump sum
   F = future value, lump sum
   a = level annual payment
   i = interest rate, annual
   n = number of years

2. "Money makes money, and the money money makes makes more money."

$$F = P(1+i)^n$$

3. Shorthand

$$(1+i)^n \equiv e^{in}$$ where e is the base of natural logarithms

4. "Capitalization" in perpetuity.

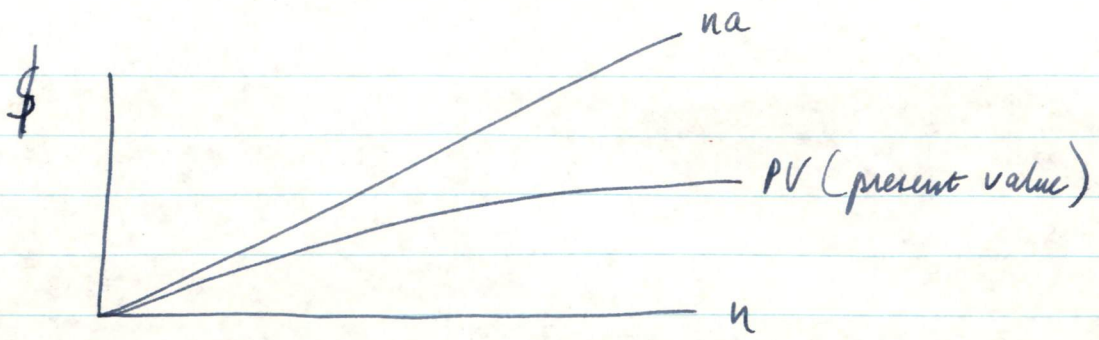
$$P = \frac{a}{i}$$

5. Capitalization over n years. The key operation.

$$P = \frac{a}{i} - \frac{a}{i} \div e^{in} = \frac{a}{i}(1 - e^{-in}) = a\,\frac{1 - e^{-in}}{i}$$

(Note that e^{-in} is a short way of writing $\frac{1}{e^{in}}$)

$$P = a\,\frac{1 - e^{-in}}{i}$$ is the "present value formula"



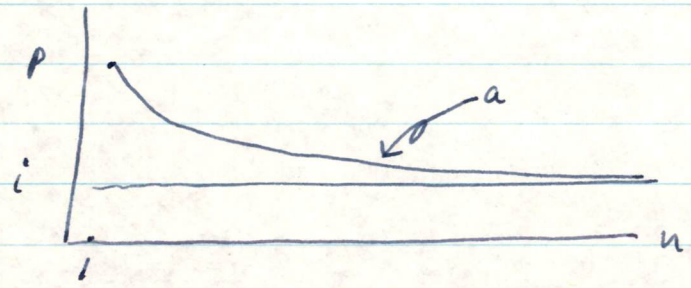
(Fig. 1)

6. The instalment plan formula: annualizing a present lump sum

Solve (5) for a:

$$a = P \frac{i}{1 - e^{-in}}$$

(Fig. 2)



7. Growth of an annuity at compound interest.

$$F = Pe^{in} = a \frac{1 - e^{-in}}{i} \times e^{in} = a \frac{e^{in} - 1}{i}$$

8. Sinking Fund instalment. Solve (7) for a

$$a = F \frac{i}{e^{in} - 1}$$

9. Forest Valuation

(8) is also the way to value forest land which yields ~~that~~ regular periodic harvests. Say it yields $F every $\underline{n}$ years. Costs (C_i) are zero.

Annuity equivalent of one harvest is:

$$a = F\frac{i}{e^{in}-1}$$

Capitalizing in perpetuity:

$$\frac{a}{i} = \frac{F}{e^{in}-1}$$

10. Now let Costs be incurred in year 0. Their future equivalent is found from

$$F = Pe^{in}$$

Here, P is C_0, and future equivalent is $C_0 e^{in}$.

Forest land value, or "Soil Expectation Value" $\equiv S_e$ is:

$$S_e = \frac{F - Ce^{in}}{e^{in}-1} \qquad (10)$$

11. Solving (10) for $(F + S_e)$:

$$F + S_e = (C + S_e) e^{in} \qquad (11)$$

(11) says forestry is an investment whose input is land plus capital and whose output is land plus timber.

12. Growth of investment in timber. Solve (11) for F:

$$F = (C + S_e) e^{in} - S_e \qquad (12)$$

(12) is a modified compound interest curve.

13. Rate of growth of timber investment

Differentiate (12) w.r.t. n.

$$\frac{dF}{dn} = i (C + S_e) e^{in} \qquad (13)$$

Substituting (12)

$$\frac{dF}{dn} = i (F + S_e) \qquad (14)$$

(14) says the investment grows each year by interest on timber plus land value.

14. Financial maturity of timber

As long as the current stumpage value of timber is growing faster than (14), the timber is unripe, and vice versa.

15. Depreciation of forest roads.

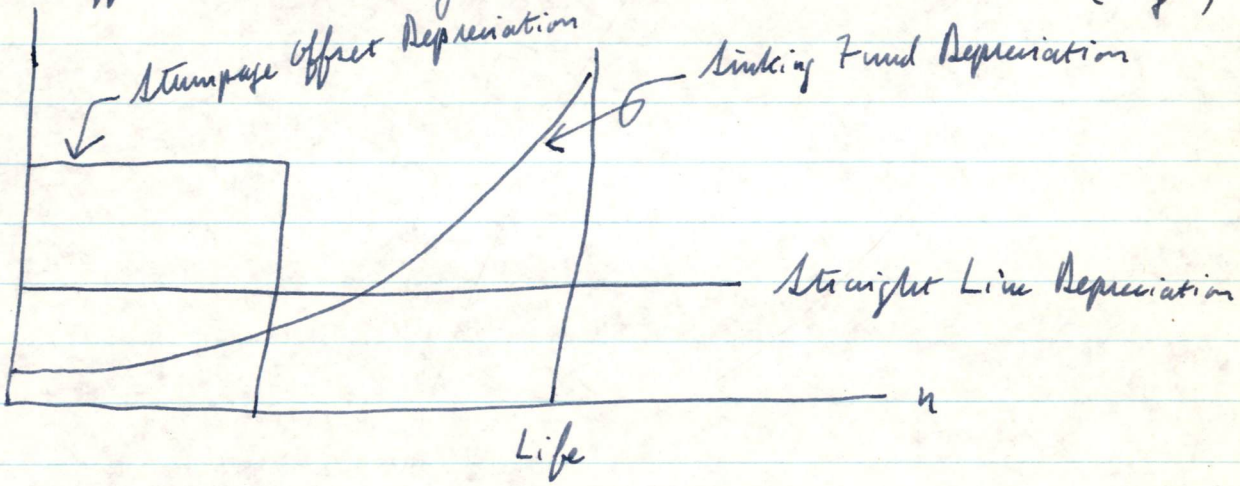
Life of forest roads is determined largely by "locational obsolescence." They are useful so long as there is wood to cut and haul. Under our appraisal system they earn a guaranteed (sort of) income, not decaying over time. Their residual value is approximated i.e. from (5), the Present Value Formula, where n is years of life remaining.

$$P = a\frac{1-e^{-in}}{i}$$

For depreciation, differentiate (5) w.r.t. n:

$$\frac{dP}{dn} = \frac{a}{i}\left(--ie^{-in}\right) = ae^{-in} \qquad (15)$$

This is called "sinking fund depreciation," because the amount of allowable depreciation each year is equal to the growth of a sinking fund, whose accumulated value after n years would equal the capital cost of the road. It is a much slower write-off than normally allowed. (Fig. 3)



16. Valuation of Old Growth

Value depends on rate of cut.

Let A = total stumpage.

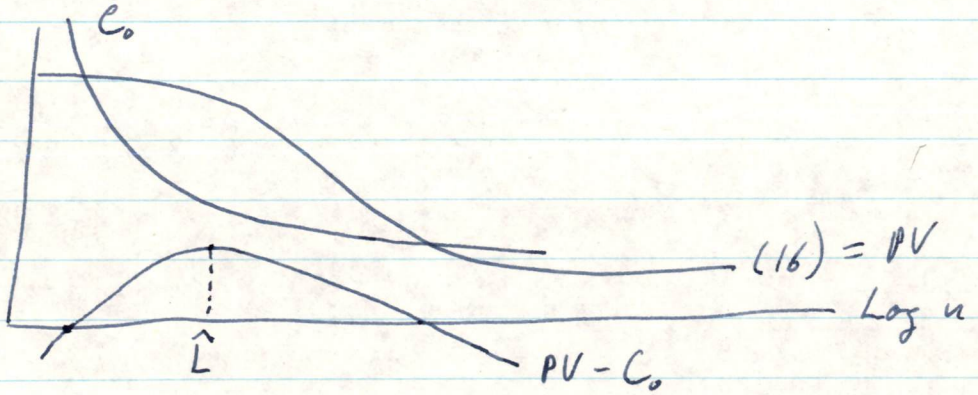
Annual gross income stream = $\frac{A}{n}$

$$PV = \frac{A}{n}\,\frac{1-e^{-in}}{i} = \frac{A}{i}\,\frac{1-e^{-in}}{n} \qquad (16)$$

(16) is a decreasing function of n. To maximize (16) : we always want to cut everything right away. However:

- for small n, (16) decreases very slowly
- capacity costs also decrease with n. For small n, they decrease rapidly.

To maximize net value of old growth removal, maximize the excess of (16) over capacity costs:



(Fig. 4)

$\hat{L}$ is optimal life.

17. Valuation of old growth followed by new growth.

Modify (16) by adding S_e to A. This says that when you cut you get value of timber plus release of site for future growth. This makes the curve steeper and pushes $\hat{L}$ to the left, i.e. speeds the cut.

18. Valuation of peak load capacity.

Let ρ = period between floods of ~~given~~ level, equal to control capacity.

ΔC is added cost of insuring against ρ-year flood. ("added" to some existing background level.)

Expected frequency (or probability) of ρ-year flood is $\frac{1}{\rho}$ each year.

Full cost of washout is D_A (damage) (operating losses plus repairs) (plus p.r. problems)

$$PV = \frac{D}{\rho} \frac{1 - e^{-in}}{i}$$

(PV of $ added peaking capacity)

As you add peaking capacity, marginal cost is below average, and probably declining by the 6/10 rule.

$$C = k Z^{.6}$$

where k = a constant

Z = Capacity

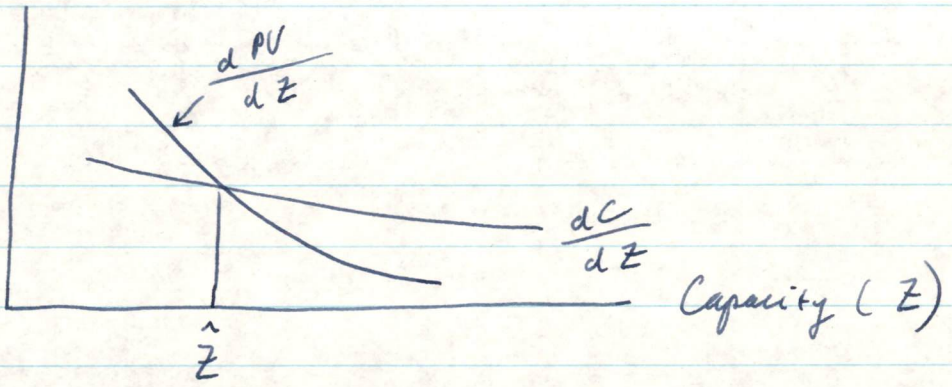
so

$$\frac{dC}{dZ} = k \frac{6}{10} Z^{-\frac{4}{10}}$$

$$AC = \frac{C}{Z} = \frac{k Z^{.6}}{Z} = k Z^{-.4}$$

$$\frac{MC}{AC} = .6$$

But the PV of ΔZ falls faster because ρ rises rapidly.



$\hat{Z}$ is optimal capacity.

Common fallacy: focus on .6 rule + build excess capacity, ignoring rapid rise of ρ. But this is not the only common error!

19. Peaking capacity is an investment in longevity.

Even though probability is involved, so is discounting, and peaking capacity reduces probable future costs by increasing certain present ones.

Thus higher $\underline{i}$ values reduce the PV of ΔZ $\left(\frac{d PV}{d Z}\right)$ and shift $\hat{Z}$, (optimal capacity), to the left.

20. Higher capacity does not reduce risk, but trades risks.

Increasing Z reduces the risk of warrant, but increases the risk of making an unproductive investment in wasted excess capacity. Risk is inherent in the situation. We trade one for another.

Warrant risk is more visible. ("Fire the engineer!") Engineers have an understandable bias in favor of excess capacity, therefore.

To lenders and investors, both risks should be visible. They should however assume responsibility for their decisions, so engineers don't get wrongly blamed.

21. Effect of allowing risk premium in interest rate.

If we adjust for "risk" by raising i, the result is to favor smaller culverts, increasing risk of washout.

I leave you with the paradox — or is it one?