NON-TRADITIONAL AGRICULTURAL ALTERNATIVES TO MAXIMIZE POST-MINING RETURN AND MEET BOND RELEASE CONDITIONS[1]

by

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Abstract. P. L. 95-87 has limited crop alternatives due to several bond release conditions, including short time frames for cover or productivity compliance, excessive costs of replicating conditions needed for row crop production, and restrictions on cultural practices to enhance production. Hay, pasture, and row crops have limited financial returns, and the payback period for silviculture is very long. Incorporation of small fruit and berry crops in reclamation planning can increase post-mining returns. Edaphic requirement, cultural practice, yield, and production cost analysis indicate that raspberries, strawberries, grapes, and blueberries may be viable alternatives to traditional agricultural uses. Several of these fruits tolerate the low soil pH, moisture, and fertility found in many reclaimed sites. Standard cultural practices for berries are intensive and are similar to those normally required to maximize productivity in mined soils. Augmented practices are thus compatible with bond release. The less mechanized cultivation practices are better suited to the small tracts and uneven ground in many problem reclamation areas. Positive cash flow is reached within 3 to 5 years. Net returns may be 50 times greater than those of conventional crops. Net annual returns of up to $4,000 per acre per year make this an attractive reclamation option for many sites.

Additional Key Words: Reclamation Planning, Berries, Fruits, Cultural Practices, Economic Analysis

Introduction

Although many reclamation advances have occurred in the last few years, most reclamation is still based on grass-legume combinations for hay, pasture, and land stabilization, due to numerous factors including the risk-reward ratios, the bond release conditions imposed by PL 95-87, the technical feasibility levels, and low costs. Tree reclamation research has progressed in spite of increased difficulties, such as increased cost and management levels, greater difficulties of establishment and short-term success, difficulties of meeting bond release conditions, longer time periods required for bond release and commercial harvest, and the lack of initial cash flow.

New topsoil replacement guidelines have increased some sites' suitability for standard row crops such as corn and soybeans. However mined soils are generally an inferior medium for intensively cultivated row crops. Overproduction and declines in farm prices in recent years also have led to a situation where additional row crop land from reclamation is an expensive and redundant commodity that is not competitive with native soils.

[1]Paper presented at the 1986 National Meeting of the American Society for Surface Mining and Reclamation, Jackson, Mississippi, March 17-20, 1986.

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Proceedings America Society of Mining and Reclamation, 1986 pp 33-40
DOI: 10.21000/JASMR86010033

https://doi.org/10.21000/JASMR86010033

Many reports are available on this reclamation with grasses, legumes, trees, and even row crops. However, any review of mining literature for berry production will uncover only a few references to small fruits and berries. This scant literature base includes experimental citrus plantings on Florida phosphate lands, and a few references to use of fruits in United States coal lands reclamation and reclaimed land in eastern Europe.

In light of current regulations and this lack of research interest, is there then a place in mine land reclamation for additional land uses or crops such as fruits? Several recent developments indicate that small fruits and berries do have potential as important aspects of reclamation and post-mining land use planning.

Historical Status and Current Trends

Historical Status

Fruit production historically has not figured in reclamation planning for a number of reasons, including:

1. Fruit production is a minor land use component in most mining regions, so loss of suitable land to mining has not been a significant local issue,

2. Fruit production is perceived as requiring large capital investment, high management skill, specialized knowledge, and exacting soil and climate needs. In the past, fruits have required unacceptable risks in comparison to potential rewards,

3. Fruit plants have had high susceptibility to disease and insect damage. The longevity of the bearing period often was limited to one or two years,

4. No viable markets existed in most of the mining regions due to centralization in production, transportation, and marketing systems,

5. The cost of reclamation to fruits is high, particularly in relation to risks of losing entire plantings prior to the pay-back stage.

From 1950 to 1980, a national shift toward centralization and mechanization in production, transportation, and marketing developed a system specialized to types and varieties adaptable to early harvest, rough handling in shipment, and long storage life. Local and regional producers did not fit into this format, especially in the less densely populated areas where the mining industry is centered.

Local markets, especially in rural areas, had no capacity to support commercial growers. National retailers required volumes and dependability not sustainable by local growers. Consequently, the fresh berry market diminished, and retail outlets became restricted to the bulk quality national chains and local fruitstands.

This lack of a profitable market made rewards from fruit production too low to justify risks. Small fruits and berries were very susceptible to diseases. Raspberries in particular were susceptible to virus diseases transmitted by aphids. Virtually all stock coming from nurseries was infected to some degree, even at planting. Diseases would be rapidly transmitted throughout a field within one to two years. Fruit quality and yield suffered well before plants succumbed.

Strawberries also were susceptible to viral, bacterial, and fungus diseases. The longevity of strawberry plantings on a commercial scale was often limited to two years in one location because of diseases such as virticillium wilt, red stele, leaf spot, grey mold, and leather rot. Control of fungus diseases was limited: no control was available for the viral diseases.

Current Developments

Re-examination of small fruits and berry potential in reclamation planning is due because a number of favorable factors are coinciding at this point in time. These factors include economic, marketing, and regulatory developments as well as technical factors which overcome many past difficulties.

The primary developments favoring small fruits and berries include;

1. Fundamental changes in the marketing system, re-opening the retail market to regional producers,

2. Revisions to PL 95-87 and state mining regulations allowing greater flexibility in experimental procedures and in topsoil substitution and contouring,

3. The current depressed state of the mining industry and the need for higher return/cost ratios and faster cash flow from reclaimed lands, and

4. Improvements in nursery stock and cultural methods for many fruits and berries.

Market Trends. National grocery chains have recently reached sizes where economy of scale has been overshadowed by wage scales and management problems, opening the door to competition from regional and local chains. These retailers have large supply requirements, but lower than for national chains. Purchasing is often done on a local level on a "spot" basis rather than on long-term contracts. In the past five years, this has opened a new niche for small and medium regional growers. Increased popularity of "pick your own" and roadside fruitstands has expanded the market. Consumer response to quality and freshness has firmed prices.

Regulatory Environment. OSM first moved to revise PL 97-85 in 1981 in response to problems in implementation, technical need, and feasibility. The process has led to evaluation and revision of state programs and to a more open discussion and evaluation of reclamation alternatives.

Among the regulatory features which affect the feasibility of berry production are provisions of the Approximate Original Contour (AOC) requirements. Small fruit production requires less mechanization and consequently less level ground than rowcrops. Compromises in contouring allow more leeway in site-contouring to make maximum advantage of growing conditions. Berry production also may represent a compromise position between original contour and level lands required for other "higher and better" land uses.

On prime farmland, the requirements for soil creation are essentially inviolate. The performance standards for small fruits would presumably be similar to those for corn or beans, in that yield would be judged against a reference area or a regional standard. However, in non-prime farmland situations, perhaps different standards could be imposed which would allow for greater range in experimentation. One mechanism would be a multiple land-use designation within a permit boundary. Reclamation standards for the permit area as a whole may be upheld as an average for the total area, such as meeting cover criteria for grazing land. However, subunits within the area may vary from the standards in some extent sufficient to allow establishment of fruit production without productivity standards. For example, a one-acre strawberry planting may be included within a 10-acre herbaceous rangeland. The performance criteria could be interpreted as average cover within the total 10 acre unit, rather than as separate criteria for the 9 acres of grass and the one acre of strawberries. Such a departure would not significantly affect the environmental stability of the reclaimed area, but it would allow inovative techniques and reduce the risk-reward ratio for the operator.

Economic Environment. The inclusion of small areas of successful berry production within a reclamation plan also can be of timely importance in the financial position of the operator or land owner. Richards and Graves (1984) point out the cost imbalances of reclaiming to hayland-pasture at an average cost of $97.94 per acre versus forest at $414.94 per acre. They point out the fact that few operators can afford the luxury of the additional $317 per acre to plant trees.

Their analysis does not indicate further effects of future return on this assessment. Reforestation, if done for harvest, does not provide a cash return for perhaps 20 years. Hayland-pasture may provide an early return, but net income per acre is rarely over $100 per year. Many operators, especially small operators, work on such a small margin that any significant increase in return (either as direct return or as increased land values) may result in a significant increase in cash flow and margin.

Technical Developments. Risks involved with small fruit production outweighed benefits as few as five years ago. The risks were due largely to the high labor expenses of operation and the effects of disease. The last ten years have seen tremendous advances in breeding of superior strains of almost every small fruit variety. Increases in yield, frost and heat resistance, and drought tolerance have been documented for many varieties. Major improvements in disease and insect resistance have resulted in raspberry and strawberry varieties. Raspberry varieties resistent to the virus-transmitting aphids have been developed, and many new strawberry varieties have been released with multiple resistance to most major viral and fungal diseases.

A second major advance in the quality of plants in the last five years is the advent of certified virus-free planting stock. Many states operate control and inspection programs in which plants are propagated under sterile conditions, and grown under strict programs to prevent viral infection. An additional improvement is the introduction of tissue cultured stock, in which each plant is propagated as a cell from sterile laboratory stock. These plants are raised in sterile greenhouses and shipped directly to the field without transplanting from nursery beds. These plants are healthy and suffer less transplant shock, so initial growth is greater and they come into production sooner.

These two advances in plant breeding and production have revolutionized berry production. The production of berries is now far less risky and the economics are greatly improved. New methods of cultivation and production have been tested which make the production of berries cost-effective and profitable.

Edaphic Suitability and Cultural Practices

Table 1 shows some edaphic requirements of selected fruits in comparison to requirements for several commonly used reclamation crops. This table indicates that the fruits have similar nutrient and pH requirements to the more common crops. Soil texture preferences are also similar, although most berries do best on slightly lighter soils such as sandy loams.

Fruit or berry types may be adapted to soil pH ranges from 4.5 to 8.0. Blueberries and strawberries yield best at pH values below 6.0. Blueberries are restricted to pH ranges below 5.5 and do well at pH values of 4.5.

An important factor in selection of berries as a reclamation alternative is the drainage conditions and the soil depths. Table 2 indicates that most berry crops are shallow rooted, with the bulk of the root zone at depths of less than 8 in. This can be both a problem and a benefit. It is a problem in that the plants are extremely susceptible to drought and low soil moisture. Availability of irrigation is a necessity for successful crop production in berries.

Shallow rooting depth may be a advantage in many problem reclamation areas in which topsoil is lacking or in which toxic, infertile, or impenetrable layers are close to the surface, if adequate moisture is made available in the surficial layers. Deeply rooted types such as alfalfa and most trees may be subject to high mortality at an age in which the root systems make contact with the buried zones.

Table 1. Edaphic and Nutrient Requirements of Selected Crops.

Crop	pH Range	Nutrient Level N	P	K
Raspberry	5.5-7.5	Med	Med	Med
Blueberry	4.5-5.3	Med	Med	Med
Strawberry	5.5-6.5	High	High	High
Grape	>5.0	Low	Med	Med
Corn	6.0-7.5	Med	Med	Med
Soybean	5.5-7.0	Med	Med	High
Tall Fescue	4.5-8.0	Med	Low	Med
Bermuda Gr.	4.0-7.5	Low	Med	Low
Alfalfa	5.5-8.0	Low	Med	High
Alsike	5.0-7.5	Low	Med	Med
Loblolly Pine	4.0-7.5	Med	Med	Med
Hybrid Poplar	5.0-7.0	Low	Med	Med

Sources: Courter, et. al., 1984.

Table 2. Edaphic Requirements and Rooting Zones of Selected Crops.

Crop	Rooting Depth (in)	Soil Drainage
Raspberry	1-5	Well-drained
Blueberry	1-5	Well-drained
Strawberry	5-8	Well-drained
Grape	> 60	Well-drained
Corn	6-15	Mod.-drained
Soybean	3-60	Mod.-drained
Tall Fescue	8-36	Mod.-Well drained
Bermuda Gr.	4- 8	Well-drained
Alfalfa	to 250	Mod.-Well-drained
Alsike	12-36	Mod.-Poor-drained
Loblolly Pine	24-72	Mod.-Poor-drained
Hybrid Poplar	24-72	Mod.-Well-drained

Sources: Courter, et. al., 1984.

Edaphic and nutrient characteristics of reclaimed lands throughout the United States range from the neutral to alkaline loams or clays of the ILlinois mine overburdens and topsoils, to the sandstone and siltstone spoils and acidic pyrite spoils of the Appalachian coal fields, to the sterile, acidic sand tailings of the Florida phosphate region. In each of these cases, at least one of the small fruit and berry types may be adaptable to the local soil conditions.

Successful and dependable production of all berry crops depends on available moisture. Irrigation is the only means of assuring this availability on non-mined soils as well as on reclaimed soils. Thus, one advantage of berry crops on mined soils over traditional rowcrops (corn, soybeans) or hay crops (alfalfa) is that irrigation can be employed on reclaimed lands without a competitive disadvantage to non-mined lands and without conflicting with requirements for standard cultural practices for reference areas. In fact, mined lands may offer competitive advantages over unmined lands for some crops, especially in those sites where topsoil substitutes are employed.

Subsoils and previously buried spoils often have reduced viable weed seed concentrations. When used as topsoil substitutes, these soils may have reduced weed problems for several years after reclamation, reducing needs for chemical herbicides and cultivation. In the case of blueberries, naturally acidic conditions reduce the need for soil acidification that is required on unmined lands.

Reclaimed lands offer possibilities for tailoring soils to specific crops. Slope, soil texture, and depth of zones may be controlled to derive optimal drainage and soil moisture conditions.

Site aspect, soil color, and albedo may also be tailored for specific locations. For example, a south facing slope with good cold air drainage coupled with dark, heat retaining soils may be created to allow crop production in regions where spring temperatures are usually too cold for sucessful production.

Economic Assessment of Berry Production

The cost of preparing land for berries is similar to that experienced with hayland-pasture, silviculture, or wildlife habitat. Since traditional rowcrop production has been consistent only upon reclaimed prime farmland, costs of berry site preparation on non-prime sites is less.

Like forestland and wildlife habitat, the cost imbalances in reclamation occur in the subsequent stages of planting, establishment, and long-term maintenance, costs which generally rule out forestry or habitat as economic and productive reclamation alternatives under current regulations.

The economics of berry crops may be substantially more favorable than for forestry. Cash returns from berries are several times higher than for forest crops, and the return period several times shorter. Thus, increased costs of establishment and maintenance do not create the cost imbalances which exist in other crops.

Tables 3 and 4 show cash flow budgets for typical hay crops as well as for raspberries. The costs in these tables are for non-mined lands or sites in which topsoil restoration has resulted in typical soil profiles and fertilities. Establishment costs on mined soils with topsoil substitutes or on less optimal soils may require somewhat greater expenditures for higher liming and fertilizing rates and greater use of mulches for plant establishment. In some cases (such as soil acidification for blueberries or herbicides for weed control), cost savings occur for the berry crops.

The cash flow budgets include all costs directly associated with planting, production, and harvesting of the crop, including costs of plants and materials, labor costs (including labor for harvesting), operating allowances for machinery, and containers necessary for moving crops from fields. Costs do not include indirect costs of land, capital equipment and machinery purchase, storage facilities and transportation, and management and marketing expenses. Due to the reduced needs for annual planting and

Table 3. Cash Flow Budget for Traditional Culture Raspberry production.

Input parameter	Year								Total
	1	2	3	4	5	6	7	8	
YIELD (qt)	0	0	2,574	5,148	5,148	5,148	5,148	5,148	28,314
RETURN ($2.25/qt)									
GROSS RETURN ($)	0	0	5,791	11,583	11,583	11,583	11,583	11,583	63,706
CUMULATIVE GROSS ($)	0	0	5,791	17,374	28,957	40,540	52,123	63,706	63,706
DIRECT COSTS OF PRODUCTION ($)									
Lime	40	5	5	5	5	5	5	5	75
Fertilizer	190	45	45	45	45	45	45	45	505
Seed/Plants	976	168	---	---	---	---	---	---	1,144
Pesticide/Herbicide	---	48	48	48	48	48	48	48	342
Machine Operation	44	22	22	22	22	22	22	22	198
Labor	1,672	537	1,270	2,104	2,104	2,104	2,104	2,104	14,002
Fencing/Trellis	777	38	38	38	38	38	38	38	1,049
Irrigation	5,500	250	250	250	250	250	250	250	7,250
Mulch	516	516	516	516	516	516	516	516	4,128
Containers	---	---	205	411	411	411	411	411	2,265
Total Direct Costs	9,716	1,630	2,401	3,442	3,442	3,442	3,442	3,442	30,961
Cumulative Costs	9,716	11,347	13,749	17,191	20,634	24,076	27,518	30,961	30,961
ANNUAL NET RETURN	(9,716)	(1,630)	3,389	8,140	8,140	8,140	8,140	8,140	32,745
CUMULATIVE RETURN	(9,716)	(11,347)	(7,957)	182	8,323	16,463	24,604	32,745	32,745

Mean Annual Return: $ 7,963
Mean Annual Costs: 3,870
Mean Annual Net: 4,093

First Year of Positive Cash Flow

Year 4

Table 4. Cash Flow Budget for Alfalfa-Grass Hay production.

Input parameter	Year								Total
	1	2	3	4	5	6	7	8	
YIELD (tons)	4	4	4	4	4	4	4	4	32
RETURN ($80/ton)									
GROSS RETURN ($)	320	320	320	320	320	320	320	320	2,560
FERTILIZER CREDIT ($)	12	12	12	12	12	12	12	12	100
CUMULATIVE GROSS ($)	332	665	997	1,330	1,662	1,995	2,327	2,660	2,660
DIRECT COSTS OF PRODUCTION ($)									
Lime	5	---	5	---	5	---	5	---	20
Fertilizer	29	29	29	29	29	29	29	29	232
Seed/Plants	41	---	41	---	41	---	41	---	162
Pesticide/Herbicide	---	4	---	4	---	4	---	4	16
Machine Operation	64	44	64	44	64	44	64	44	435
Labor	43	21	43	21	43	21	43	21	258
Fencing/Trellis	---	---	---	---	---	---	---	---	0
Irrigation	---	---	---	---	---	---	---	---	0
Mulch	---	---	---	---	---	---	---	---	0
Containers	---	---	---	---	---	---	---	---	0
Total Direct Costs	182	99	182	99	182	99	182	99	1,124
Cumulative Costs	182	281	463	562	744	843	1,025	1,124	1,124
ANNUAL NET RETURN	150	234	150	234	150	234	150	234	1,536
CUMULATIVE RETURN	150	384	534	768	919	1,152	1,303	1,536	1,536

Mean Annual Return: $ 333
Mean Annual Costs: 140
Mean Annual Net: 192

First Year of Positive Cash Flow

Year 1

the reduced equipment needs, it is estimated that these expenses would be similar or lower for berries than for other crops.

Table 5 summarizes the cash flow analysis for several crops. Berries have a potential net return of from $1,000 to $5,000 per acre per year, in contrast to the potential returns of $50 to $300 per acre per year for conventional reclamation alternatives. The time period required to generate a positive cash flow is somewhat longer (3 to 5 years) than the one year required for row crops, but is substantially shorter than required for silviculture (15 to 25 years).

Table 5. Summary of Net Returns for Alternative Crops.

Crop	Mean Annual Gross Income $	Mean Annual Direct Expenses $	Mean Annual Net Income $	First Year of Positive Cash Flow
Tall Grass Meadow	139	61	77	Year 3
Alfalfa-Grass Hay	332	140	192	Year 1
Corn	350	146	203	Year 1
Soybean	240	102	137	Year 1
Raspberry	7,963	3,870	4,093	Year 4
Blueberry	3,913	2,443	1,470	Year 5
Strawberry	6,046	4,025	2,021	Year 3
Grape	3,550	2,350	1,200	Year 5

Variations in costs associated with reclaimed sites will not significantly affect the outcome of the economic analysis or the conclusions. Many of the costs associated with reclaimed lands are already factored in for the berries. For example, fertilization costs for strawberries and raspberries include the sowing of a green manure crop prior to planting. Irrigation and mulching costs are also included. Increased costs for liming and fertilizing on reclaimed soils is generally insignificant in relation to the total budget for the berries.

This cost analysis for berry crops also assumes that no existing irrigation equipment or water sources are available. The cost includes a new well and pump. It also assumes that the cost of the well and pump are absorbed only by a one acre field. If existing water sources are available, first year costs for irrigation may be reduced to as little as $1,000 per acre. In many cases, water supplies may be more plentiful and conveniently located in reclaimed lands than in unmined lands.

Effects of Innovative Cultural Practices on Net Return

Assessments of the effect on the cash flow budget if newer cultural practices were used indicate increased returns. For everbearing raspberries which normally produce a summer crop and a fall crop, research has shown that if these plants are mowed to the ground in fall after fruiting,they will produce a single fall crop whose yield equals the usual summer and fall combined crops. Mowing can be done from a tractor in a fraction of the time required by hand, and the need for trellising is removed. Using this system, labor costs are reduced by $3,016 over an eight year period, and the cost of the trellis is eliminated. This translates to a savings of $4,066 over eight years or $508 per year, an increase in net income of over 12% to $4,601 per acre per year.

The return for strawberries also may be increased by innovative cultural practices which reduce labor and material costs. However, most techniques for strawberries have not been as well tested, and results have been more variable.

Summary and Conclusions

Analysis of four potential fruit and berry crops for reclamation planning indicates that these crops do provide viable alternatives to conventional crops for several reasons.

The fruits have a range of tolerance to pH values from 4.5 to 8.0; therefore at least one type of fruit should be viable for most of the pH ranges of reclaimed soils. Shallow root systems of the berries may enhance adaptability to those sites where surface soil layers are thin or where toxic materials or compacted soils are close to the surface.

The economic analysis indicates that the berry crops can yield net returns from five to over thirty times those of conventional reclamation crops, removeing the cost imbalances which have made uses such as forestry and row crops economically unfeasible for reclamation planning. Many steps and costs associated with reclaimed land are identical or similar to those necessary to grow berries on unmined land. Thus many of the additional secondary costs of reclamation have already been factored into the costs of production. The implication of this is that berries on mined land will not be at the competitive cost disadvantage of other crops which do not normally require mulching or irrigating on unmined land.

Since many berry crops do best under specific soil and slope conditions that can be controlled during reclamation, mined land may be used to create favorable sites not otherwise available in a region. Coupled with their increased availability of irrigation water, mined lands may represent a valuable resource for the highest possible agricultural land use for a region.

These crops provide significant benefits in specific cases. Among these are small sites, especially those representing poor cost-return ratios under normal reclamation or those which represent an expenditure of funds which are not covered by coal income. These types of sites may include Abandoned Mine Lands and sites covered by Small Operator Assistance Programs. Other conditions in which irrigated berry crops may be useful include sites with poor surface spoil conditions characterized by topsoil substitution, shallow or droughty soil, soil underlain by toxic materials, slopes, or locations difficult to farm with conventional machinery and techniques.

Inclusion of small areas of high return reclamation within larger units may be a useful alternative means of generating an average land use level for a permit area. Such relationships may be used for trade-offs in cases in which sufficient high quality materials are available to cover only a small portion of the reclaimed land. The added return for these areas may be used to finance the additional costs of reclaiming more areas to wildlife use. Small fruits and berries may add flexibility in obtaining an average land use and return value for a larger area, or they may enhance the value of specific areas.

The time is appropriate to evaluate the use of small fruits and berries in specific reclamation plans and to advance to experimental plantings and demonstration projects. On a long term basis, planning for these crops will require pre-planning for optimal site conditions, and evaluation of landholder or lease agreements to ensure that operators will participate in the added values of these plantings.

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