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The "Framework for Determining the Suitability of Undeveloped Land for Use as Cropland" is a decision-making format to assist private and governmental agency decision makers in categorizing undeveloped lands, which have been identified as having potential for conversion to cropland, as to their suitability for use as cropland. The Framework guides the decision maker in a step-by-step process to identify and inventory relevant data, then collate these data into quantified criteria to be used in classifying a site's suitability for cropland. Five classes of suitability, including an "unsuitable class," are identified. At present no such framework exists to guide this process. The research need was identified and the dissertation developed over a period of years in which the author participated in and reviewed several decision processes involving the conversion of undeveloped land to cropland.

The dissertation focuses on the Intermountain West due to its potential to provide new cropland. However, the Framework may have more universal application.

The dissertation includes a review and discussion of existing methodologies relevant to the problem, and of pertinent literature.

An appendix demonstrating the use of the Framework in an actual study of a Desert Land Entry Proposal is included.

A FRAMEWORK FOR THE DETERMINATION OF THE SUITABILITY OF UNDEVELOPED LAND IN THE INTERMOUNTAIN WEST FOR USE AS CROPLAND

by

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CHAPTER I

INTRODUCTION

As the great American age of expansionism is coming to a close and the last remaining sites in the Intermountain West that hold promise for conversion to cropland from their present status as rangeland come under pressure for conversion, some of the earliest evaluation questions still remain. What factors must be considered to determine the suitability of undeveloped land for use as cropland? How do these factors interrelate to create more, or less, suitable situations?

There was a time when a man could walk into the Intermountain West, stake out 160 or 320 acres of land, and file a claim for a new "farm." His criteria for choosing a particular plot were based on his perception of what would make a good farm site. When one reads prospectus published by some of the early promoters of newly opening agricultural areas during the heyday of Intermountain settlement, it is clear that information made available to potential settlers was not based on a close study of those lands. Moreover, even those settlers with agricultural experience seldom gained that experience in the semiarid environment they were entering and farm management techniques of the day were developed in the humid eastern areas of the nation. Consequently, a very high percentage of the new farmers chose lands that were unsuited to cropping with management techniques available at the time and many soon abandon their claims, often even before satisfying the requirements for ownership specified in the legislative policy which they filed under.

Today it is still possible to file for a farm land claim in the Intermountain West, but no longer need the suitability evaluation be based on a lack of knowledge or superficial judgment. Individuals and groups filing for land as well as the agencies that make the decisions have increasing capability for documentation concerning the physical and locational attributes as well as the social and economic criteria necessary for supporting a viable cultivated crop enterprise.

The reality, however, is that despite the availability of a great variety of information, it is not correlated or organized into a framework permitting objective evaluation of land suitable for cropping. This lack of an organized framework for evaluation continues to make the problem of decision making difficult. My experience over the last few years of attending meetings and holding conversations with government planners and resource specialists of all levels, consultants, and private individuals involved in determining the suitability or feasibility of tracts of undeveloped land for use as cropland suggests that a general sense of frustration prevails over the whole issue of rangeland conversion.

The experience that has led up to the writing of this dissertation has extended over a four-year period. As a Community and Resource Development Specialist with the University of Idaho, I became involved in two seemingly separate endeavors which intersected into the development of this dissertation problem.

The first of these experiences came from involvement with comprehensive land use planning efforts. In assisting with the development of "Prime Agriculture" maps to be used in setting agricultural planning goals and objectives, a dissatisfaction with existing methods of land evaluation grew, until, pushed by frustration and clientele requests, I developed my own framework for the designation of suitability of land for use as agricultural land. This system was followed by suitability frameworks for residential use and industrial use. My systems were combined and published as "Designation of Priorities for Land Use."[1] A subsequent interagency effort led to preparation of a framework for the determination of the suitability of land for the grazing of commercial livestock.[2] These publications have been the basis for a number of comprehensive land use plans and land use studies in the Pacific Northwest.

The objective of the preparation of these suitability frameworks was to provide a system where readily available data could be utilized in an organized format to evaluate areas of land as to their site and situation attributes and limitations for specific uses. It was felt that in any given planning area all lands suggested as having potential for the same type of use should be evaluated for that use by using the same criteria and the same evaluational requirements. This would eliminate (or at least limit) the possibility of preferential treatment and inconsistency in planning.

The second experience leading to this dissertation involved working with citizen participation in governmental decision making. It was one of my duties as a Community and Resource Development Specialist to engage in educational efforts to increase the participation and effectiveness of citizen involvement in public policy decision making. Through this task an educational effort developed in working with the Bureau of Land Management (BLM) personnel in complying with their requirement to develop a citizens participation component of their Carey Act and Desert Land Act filing review process.

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[1]Arthur C. Rathburn, "Designation of Priorities for Land Use," A.E Series #166 Cooperative Extension Service, University of Idaho, revised January, 1976.

[2]State of Idaho Rural Development Committee, Subcommittee for Land Use Suitability, Arthur C. Rathburn, chairman. "Determination of Suitability of Land for the Grazing of Livestock," A.E Series #340, University of Idaho Cooperative Extension Service, January 1978.

It was at this point that the two seemingly unrelated tasks became linked. Early assessment of the decision process involved in the evaluation of whether land should be converted from an undeveloped state to cropland revealed that at all levels of decision making from private to federal there was no published work that set a framework or directional guide as to what data should be collected and analyzed so as to arrive at a decision that could be readily documented and reviewed by all concerned. The Bureau of Reclamation does follow a framework, but their framework does not lend itself to any task other than that assigned to the Bureau. There being no framework for evaluation studies, decisions on land allocations, even within the same planning area, were found to be based on different criteria.

It was during discussions with knowledgeable persons that the suggestion was made that I utilize my philosophy of land use suitability to develop an evaluation framework for the determination of suitability of undeveloped land in the Intermountain West for use as cropland. Being that such an endeavor did not fall into the assigned tasks of a Community and Resource Development Specialist, it became the topic for this dissertation.

It is within this region, the Intermountain West, that much of the nation's undeveloped lands with promise of cropland suitability lie. According to one 1974 source, "Estimates as to how much land is suitable for new development ranges from 20 to 40 million acres (8.9 to 16.19 million hectares) in the 17 western states."[3] A recent estimate claims there are 32,117,500 acres (12,997,631 hectares) of potentially irrigable lands in the interior Pacific Northwest alone.[4]

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[3] Ad Hoc Committee of the Western Agricultural Research Council for the Western Governors, "Intensification of Western Agriculture," in Western Agricultural Prospects, Problems and Solutions, U.S. Government Printing Office #35-636, 1974, p. 278.

[4] J. C. Engibous and W. A. Starr, "Additional Lands for Crop Production: Western States," in Land Use: Food and Living, proceedings of the 30th Annual Meeting Soil Conservation Society of America, October 10, 1975, San Antonio, Texas, p. 43.

When one considers the world-wide scale and Charles Kellogg's estimate that there are 4.45 billion new acres (1.8 billion hectares) of potentially arable soil, the western United States loses some significance. However, when compared to the existing volume of agriculture lands in the Intermountain West, the potential lands estimate indicates the importance of the decision-making process that will consider the cropland suitability of these lands. It is hoped that the Framework for Suitability evaluation developed in this dissertation will add to the capability of those individuals involved in making resource decisions to make those decisions in a less frustrating and more organized manner.

The Framework channels the user through a decision-making process which results in an undeveloped site being assigned a set of quantified criteria to use in determining its suitability as cropland. The Framework guides the user in a step-by-step process of collating and quantifying a comprehensive data base.

The Framework as developed as this dissertation is an applied process that reflects the concept of land as a resource. In order to determine the suitability of undeveloped land for use as cropland, it is necessary to determine just what components, in what quality and quantity, must be present to make any site of land a valuable resource. The site must then be evaluated as to its conformity to the combination of social, physical, and economic phenomena that qualify the land as a resource in the eyes of our modern American culture.

OBJECTIVE AND PLAN OF THE DISSERTATION

This dissertation formulates for the first time a comprehensive Framework for an organizing methodology by which relevant criteria can be inventoried, evaluated, and quantified leading to a suitability classification for undeveloped land being considered for conversion to cropland in the Intermountain West. Though the focus is on the Intermountain West, the Framework may have a more universal application. The dissertation also examines existing land and resource evaluation methodologies as to their application to land conversion from rangeland to cropland.

The research involved the interviewing of local, state, regional, and federal agency personnel, as well as a multitude of agricultural experts as to their perception of the problem. All relevant publications that could be located were also reviewed. Though the Framework that was subsequently developed is felt to be of value for use of all levels of decision makers, the framework was mostly developed and tested through analysis of completed and ongoing evaluations of land being considered for conversion to private ownership for use as cropland from the present status of federal rangeland under the custodianship of the Bureau of Land Management.

Following this introduction, Chapter II is an analysis of methodologies and terminology associated with land evaluation as recorded in the literature.

Chapter III considers the influencing factors identified in the research that must be addressed to determine if specific undeveloped lands are suitable for conversion to cropland. The chapter then analyzes various methodologies for evaluation of each criterion.

Chapter IV, the final section of this dissertation, presents and explains an original framework by which decision makers can objectively determine the suitability of specific undeveloped land areas in the Intermountain West for use as cropland.

The Appendix contains an abbreviated analysis of the Black Pine Valley Desert Land Entry proposal using the Framework developed as this dissertation. The Black Pine DLE proposal was reviewed by the District Manager of the Burley BLM District in southern Idaho for his recommendation in 1977. The author was allowed to review all the files and data concerning this proposal, as well as several others in that and other BLM districts, and sit through all of the public and closed meetings concerning the proposal. The Framework devised as this dissertation was under development at that time so was not used in its present form in the actual proceeding on the Black Pine proposal.

CHAPTER II

LAND EVALUATION AND CLASSIFICATION

Before entering into the discussion of the physical, economic and social factors that are important criteria in suitability determination, it is desirable to review land evaluation and land classification systems and how they apply to land use decision making. It is also important to review existing agricultural land classification methodologies and assess their applicability to the problem of undeveloped land conversion to cropland in the Intermountain West.

Land evaluation and classification schemes have grown out of utilitarian needs. Vink states, "Reliable methods of land evaluation are essential tools for solving, by interdisciplinary methods, the present-day problems of land development and environmental management."[5] Land evaluation is the first step in attaining the sought-after concept of highest and best use of our natural resources. In his opening address to the Canberra, Australia, CSIRO Symposium on Land Evaluation, C. S. Christian outlined the task of land evaluation.[6]

> The task of land evaluation is to predict, as well as we can, the alternative uses and their consequences, to indicate what is involved and what effort is required to attain the best use of land. It provides the basis, we hope, for right decisions. With this information nations and communities can formulate plans for land use according to economic conditions and social ambitions, plans that should be the best possible in the light of available scientific and technological information.

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[5] A.P.A. Vink, Land Use in Advancing Agriculture, p. 16.

[6] C. S. Christian, "Opening Address," CSIRO Symposium on Land Evaluation, Canberra, Australia, 1968, in presentation and discussion of papers, T. G. Chapman (ed.), pp. 5-6.

The decision makers involved with the issue of conversion of the undeveloped lands of the Intermountain West to cropland must take as their first step an in-depth and comprehensive evaluation of those lands in question.

LAND EVALUATION VERSUS LAND CLASSIFICATION

Two concepts, land evaluation and land classification are frequently utilized as if they are synonymous. Such is not the case. Land evaluation is a generic term that refers to all of the methodologies used to probe into the value of land resources for man's use, or in Steward's words:[7]

> Land evaluation is the assessment of man's possible use of land for agriculture, forestry, engineering, recreation, etc. Almost invariably a particular possible use of land by man is dependent, not on a single parameter of a natural resource attribute, but on the interaction of a number of parameters of various attributes, man's use of land is also very dependent on the human resources: technology, finance, labor. These are not fixed in space, and are time-variable in a manner that is not predictable with great accuracy. Thus land evaluation is not something that can be done once for all time, but must be repeated when significant changes take place in any of the human resources.

The term land classification denotes a <u>method</u> of land evaluation. Land evaluators include persons concerned with land classification, as well as those who are concerned with performance prediction and economic appraisal.[8] Classification in its strictest sense "is the process of systematically grouping objects and their relationships into a meaningful order so that their character may be clarified and more easily comprehended."[9] Classification has also been used in relation to identification, taxonomy and regionalization. Gerald Olson defines land classification as "the assigning

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[8] <u>Ibid</u>., p. 9.

[9] Richard M. Highsmith, Jr., "Land Classification: A Review," prepared by members of a Land Classification Workshop, Oregon State University Geography Department, July 2-13, 1979, p. 1

of classes, categories or values to areas of the earth surface (generally excluding water surfaces) for immediate or practical use."[10] Whereas land evaluation includes methods which only search for a yes-no conclusion as to a specific use of a specific land area. The confusion between the terms is because land classification has been given much broader meaning in most literature. "In its broadest sense, land classification may deal with land use, land evaluation, land systems, land capability, land inventory and terrain evaluation, it is also concerned with soil survey, soil survey interpretation, and soil capability, suitability or limitations."[11]

LAND CLASSIFICATION

Since land classification is undertaken to address specific needs and purposes, many approaches have been taken to achieve the common goal of organizing and classifying land resources. An Australian geographer, J. A. Malbutt, has placed the various approaches into three types.[12]

1. The Genetic Approach—approaches that arrive at distinctive land units by repeated subdivision on the basis of causal (such as climate and land forms) environmental factors. This approach leads to the classing of large land areas into "natural regions."

2. The Landscape Approach—approaches that arrive at small regions that are identical by use of visible features such as topography, soil or vegetation. This approach is based on quantitative rather than qualitative data.

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[10] Gerald W. Olson, "Land Classifications," in "Search for Agriculture," Vol. 4, no. 7, 1974, p. 4.

[11] Ibid.

[12] J. A. Malbutt, "Review of Concepts of Land Classification," in Land Evaluation papers of a CSIRO Symposium, Canberra, Australia, August 26-31, 1968, G. A. Steward (ed.), 1968, pp. 11-28.

3. The Parametric Approach—approaches that classify land on the basis of selected attribute values such as elevation, surface geometry, and vegetation structure. The approach is highly qualitative and lends itself to electronic methods.

Another method of typing land classification systems was outlined by the Land Committee of the National Resources Planning Board in a 1941 publication.[13]

Type I.	Land Classification in terms of Inherent Characteristics
Type II.	Land Classification in terms of Present Use.
Type III.	Land Classification in terms of Use Capabilities.
Type IV.	Land Classification in terms of Recommended Use.
Type V.	Land Classification in terms of Program Effectuation.

Only Types I, II, and III are used for land resources. The other two are associated with cultural, political and legal influences involving land.

In later discussions various classification systems will be analyzed, though no attempt will be made to type each system because, as Malbutt indicates, the reader must keep in mind that all classifications are not alike. Thus they are, at times, difficult to compare.

Land classifications have proliferated because "classification is important, if not essential, in managing and understanding land resources and land areas. It creates order out of apparent chaos and reduces to a workable small number the total number of objects (i.e.,

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[13]U.S. National Resource Planning Board, "Land Classification in the United States," as found in a Survey and Evaluation of Land Resource Classification Systems in the United States. Master Thesis by Frank Thatcher Aldrich, Oregon State University, June 1967, pp. 13-14.

classes) one must deal with and remember."[14]

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[14]Robert G. Bailey, Robert D. Pfister, and Jan A. Henderson, "Nature of Land and Resource Classification——A Review," in Journal of Forestry, October 1978.

AGRICULTURAL CLASSIFICATION TERMS AND SYSTEMS

A major confusion facing anyone trying to understand agricultural land classification lies in the profusion of terms utilized to describe land that has value for the cultivation of crops. The terms: Class I, Class II, and Class III, prime agricultural land, unique farmlands, arable lands, irrigable lands, agriculturally suitable lands, and agriculturally feasible lands are all utilized. Though each does have its own significance, too often in the literature they are used as if they were synonymous. A closer look at these terms reveals the importance of each and in cases their interdependence.

LAND-CAPABILITY CLASSIFICATION SYSTEM

The land-capability system was adopted in 1949 by the Soil Conservation Service, U.S. Department of Agriculture, as a tool to help farmers and ranchers make conservation plans for their lands.[15] It is based very strongly on the soil features of the land that limit use because of risk or possible damage due to erosion.

An important point to keep clearly in mind is that the system classifies soil areas rather than land areas. "The soils are grouped at three levels: the land capability unit, subclass, and class. All soils that have about the same soil management needs and yields are grouped together and given a local land-capability unit designation and a local definition. Subclasses and classes, however, have

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[15] This system was based on the study "Classification of land according to its capability as a basis for a soil conservation program," Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado, September 7-20, 1948.

nationwide definitions . . ."[16] The subclass designation suggests the kind of limitation. For example:

e - soil susceptible to erosion

w - soils found in normally wet conditions

c - soils found in adverse climates

From these subclasses it is seen that the land-capability system does utilize some criteria other than the actual physiological qualities of the soil.

The class definition which is the most commonly used grouping is designated by a Roman numeral, i.e., Class I, Class II, etc. Each class designation suggests the degree of limitation. The lower the Roman numeral, the fewer the limitations to agricultural use.

"Classes I, II, and III take in the soils that are suited for cultivated crops. Class IV land can also be used for crops, but the user must choose his crops with care or manage the soil with extra care, or both. Classes V, VI, and VII take in soils that, for the most part, are not suited for cultivation but will produce useful pastures, range forage, certain special crops, trees, or wildlife. Class VIII land has limitations that restrict its use mostly to recreation, wildlife, or water supply. Much rough or rocky Class VIII land has scenic value."[17]

The above description of the land-capability classes suggests how and why this system has come to be used as it often is—as an agricultural land-use designation. The land-capability system "is based on the combined effects of soil features and climate on the risk of soil damage, on limitations in safe use, and on the difficulty

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[16] Soil Conservation Service, U.S.D.A., "The Measure of Our Land," PA-128, 1969, p. 2.

[17] <u>Ibid</u>., p. 4.

in applying conservation practices when the land is cultivated."[18] However, this description denotes land use rather than limiting features in regard to cultivation. It also uses the term "suited for." Thus, the land capability system has been utilized as a potential land-use designation. For example, the State of Oregon Land Conservation and Development Commission, which has the responsibility to enforce that state's land-use laws, uses the following definition:[19]

> AGRICULTURAL LAND——in Western Oregon land predominantly Class I, II, III, and IV soils and in Eastern Oregon land of predominantly Class I, II, III, IV, V and VI soils as identified in the Soil Capability Classification system of the United States Soil Conservation Service . . .

This use of the land-capability system (often misnomered as soil capability system) for designation of use for the purpose of governmental land-use planning or control is not at all uncommon.

The problems inherent in setting policies by utilizing a land classification system dependent on the inherent physical characteristics of the land itself were recognized even before the development of the land-capabilities system. At the first National Conference on Land Classification held in 1940 at Columbia, Missouri, "it was pointed out that usually land of identical physical character has many 'best' uses in different economic units. Not only do people use the land in a dynamic political, social, and economic frame of reference, but also in one that is dynamic in respect to physical techniques. New discoveries in scientific agriculture apply unequally to different kinds of land."[20]

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[18] Ibid., p. 19.

[19] Oregon Land Conservation and Development Commission "Statewide Planning Goals and Guidelines," September 1978.

[20] Thomas E. Fenton, "Definitions and Criteria for Identifying Prime and Unique Lands," in "Perspectives on Prime Lands," U.S.D.A., 1975, p. 136.

A warning against using the land-capability classification system alone as an indication of the ability of an area to grow crops was issued in 1977 by Soil Conservation Service Deputy Administrator for Soil Survey, William M. Johnson. In a talk before the Soil Conservation Society of America, Johnson pointed out:[21]

> Others propose to define prime in capability class equivalent—Class I, II, III, for example. The fault of this procedure is that it is based on an interpretive grouping of soils that, in turn, is based on some criteria that are not relevant to primeness and that do not give much weight to potential yields.

It was not the purpose here to discredit the land-capability classification system. It is a highly useful tool for preparing on-farm conservation plans, but one must be careful in using it as the sole guide to judge the ability of a given parcel of land to produce profitable yields of agricultural commodities.

PRIME FARMLANDS

In July 1975, 80 distinguished conservationists gathered to discuss the nation's prime agriculture lands. Their meeting, sponsored by the U.S.D.A. Land Use Committee, resulted in a series of recommendations addressing the issue of the retention of America's prime agricultural land. One of these spawned a new classification system.[22]

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[21] William M. Johnson, "Identifying Prime Food and Fiber Lands," Land Use: Tough Choices in Today's World. The proceedings of a national symposium, March 21-24, 1977, Omaha, Nebraska, C.1977, pp. 109-110.

[22] U.S.D.A., "Recommendations on Prime Lands," prepared at the Seminar of the Retention of Prime Lands, July 16-17, 1975, p. 38.

> U.S.D.A. should broaden its consideration of prime agricultural land to include a more comprehensive set of parameters. For example, productivity, crop adaptability, proximity to market centers, parcel size patterns and urban interface should be considered. A broader information base would facilitate the discussion of policy options.

From this recommendation came a new agricultural land classification system. By October of 1975 the U.S.D.A. had already issued a memorandum "regarding a national program for inventorying prime and unique farmlands."[23] This system introduced the terms Prime Farmland and Unique Farmland, as well as the less definable Farmland of Statewide Importance and Farmland of Local Importance. These are defined as follows:[24]

> Prime Farmland. Prime farmland is land best suited for producing food, feed, forage, fiber and oilseed crops, and also available for these uses (the land could be cropland, pastureland, rangeland, forestland or other land but not urban buildup land or water). It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed, including water management, according to modern farming methods.

> Unique Farmland. Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to produce sustained high quality and/or high yields of a specific crop when treated and managed according to modern farming methods. Examples of such crops are citrus, olives, cranberries, fruits, and vegetables.

> Additional Farmland of Statewide Importance. This is land, in addition to prime and unique farmlands, that is of statewide importance for the production of food, feed, forage, fiber and oilseed crops. Criteria

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[23] Soil Conservation Service, U.S.D.A., "Land Inventory and Monitoring Memorandum 3." October 15, 1975, p. 1.

[24] Ibid., pp. 2-5.

for defining and delineating this land are to be determined by the appropriate state agency or agencies.

Additional Farmland of Local Importance. In some local areas there is concern for certain additional farmlands for the production of food, feed, fiber, forage, and oilseed crops, even though these lands are not identified as having national or statewide importance. Where appropriate, these lands are to be identified by the local agency or agencies concerned.

It is of interest to note that this program falls short of the comprehensiveness recommended by the July 1975 symposium even though it was Deputy Administrator Johnson of the Soil Conservation Service that prepared the background paper on the upcoming SCS program that spurred the recommendation in the first place.[25] It can be noted that of the five parameters mentioned in the recommendation only two can be addressed—productivity and crop adaptation—in relation to the Prime and Unique Farmlands study.

IRRIGABILITY

In the Intermountain West nearly all of the undeveloped lands lie in areas where the average annual precipitation falls below the level necessary to supply the water needs of most crops. Therefore, the physical properties of the land that pertain to its ability to grow crops under irrigation become very important. Land classification systems that only refer to the "potential irrigability" of land have been formulated to identify lands with this important property. "It should be emphasized that the placing of these lands into their respective classes (irrigability) does not reflect their capacities

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[25]William M. Johnson, "Classification and Mapping of Prime and Unique Farmlands," Perspectives on Prime Lands, Background papers for Seminar on the Retention of Prime Lands, July 16-17, 1975, pp. 189-198.

for other PHYSICAL capabilities for irrigated agriculture . . ."[26] Other constraints on the success of potential agricultural endeavors such as climate, distance to market, and availability and costs of water are not considered. A study of the irrigation potential in Washington State described the physical features to be considered in the study of irrigability as such.[27]

> Several physical features of the land affect irrigation development potential. Ideally, the soil should be of medium texture with a high infiltration rate and high moisture-holding capacity so that water can be applied in large amounts but at infrequent intervals during the growing season. The land should be nearly flat to reduce erosion and make farming easier, and it should be well-drained to avoid waterlogging and salination. If the land is in large unbroken tracts, system development costs are less and the land can be farmed in larger, more efficient units. Finally, a warm and sunny climate with a long free growing season and not too much wind is ideal for producing many of the more valuable crops.

Most "potential irrigability" studies are, in fact, soil surveys that place lands into soil classes dependent on their ability to grow crops under controlled irrigation.

One such system divides all soils into four land classes. Classes 1, 2, and 3 have potential for irrigation under the criteria of this system.[28]

> CLASS 1 lands are those lands with little or no particular limitations for irrigated agriculture. Class 1 lands are

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[26] Idaho Water Resource Board, "Potentially Irrigable Lands in Idaho," July, 1970, p. 2.

[27] Norman Whittlesy and Walter Butcher, "Irrigation Development Potential in Washington," College of Agriculture Research Center circular #579, Washington State University, February, 1975, pp. 3-4.

[28] Idaho Water Resource Board, op. cit., p. 1.

> well-adapted to the most appropriate method of irrigation and with a minimum of conservation management should maintain a high level of productivity for climatically adapted crops.
>
> CLASS 2 lands present moderate limitations for irrigated agriculture. These limitations may be in the form of development problems such as stone removal, land smoothing, or drainage. Among the limiting factors placing soils in the Class 2 category may be those of a management nature such as limited soil depth, limited permeability presence of hardpans or alkalinity, and problems of erosion control and equipment management on sloping land. Class 2 lands are generally adapted to row-cropping and to most climatically adapted crops.
>
> CLASS 3 lands have severe limitations for irrigated agriculture. As described for Class 2 lands, these limitations may be problems either of development of management. The majority of Class 3 lands are best suited for small grains and forage production, and with above-average management satisfactory economic returns may be achieved.

The total list of criteria used in this system is found in the section on soils.

Norman Whittlesy and Walter Butcher summed up the shortcoming of potential irrigability studies that have been conducted in the State of Washington (including the Pacific Northwest River Basins Commission study).[29]

> Potentially irrigable lands estimated in the studies cited above include virtually all lands to which water could be applied and a crop produced. Availability of water for irrigation and economic feasibility were not considered. As a result some of the "potentially irrigable" lands would, in fact, require long trans-basin or inter-basin movement of water and/or very high-lift pumping to bring water from the nearest available source to the land. Other "potentially irrigable" lands have poor soils (60% are rated as Class III) or growing seasons that limit the possibilities for high value-high return crops. These lands, although potentially irrigable, are not likely to be irrigated in the foreseeable

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[29] Whittlesy, op. cit., p. 2.

> future because the returns from the irrigation would amount to only a fraction of the costs of supplying the water. Irrigation is not economically feasible.

"Irrigability" is a term that has relevance to the question of identifying those lands that have potential to be converted from rangeland to irrigated cropland, but it can by no means be used as the sole determinant of suitability.

ARABLE LAND AND NONARABLE LAND

The terms arable land and nonarable land are utilized in two ways. First, within the Land-Capability Classification System, Classes I through III and sometimes IV are associated with arable lands. The term takes on a different significance when used in irrigation project reports considering the feasibility of farming semiarid lands. In that case it has an irrigability related component. The following excerpt from such a report clarifies this use of the term.[30]

> The object of the land classification was to segregate those lands which are suitable for sustained profitable production under irrigation at reasonable water costs from those lands which have generally not proven to be suitable, and also to divide the land into several classes representing degree of suitability.
>
> Lands which are suitable are called "arable" and those not suitable are called "nonarable." As the irrigation plan is developed, those arable lands which can be served by the system are called "irrigable lands" and those which cannot be served, whether or not of arable quality, are called "nonirrigable lands."

In this dissertation study, the term arable will be used in this meaning due to the importance of irrigation to most land conversion decisions in the Intermountain West.

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[30] J.U.B. Engineers, B&H Project, revised. Feasibility Report, 1977, p. 11.

SUITABILITY

A fourth term used in agricultural land classification is "suitability." This is an often-used term in the more recent literature. Suitability, such as "prime agricultural land," is most often used to "refer specifically to the physical properties and attributes of soils."[31] D. W. Griffen, whose recent classification guide uses only soils data, defends this restricted criteria base because "although many factors are involved in choosing good sites on which to construct homes, create recreation and conservation areas, or engage in intensive agriculture, an initial consideration should be the physical limitations or restrictions that stand in the way of such development. Soils are the single best measure of these limitations-restrictions."[32] He also adds that soils are the proper basis from which to judge suitability because they "change very little over time."[33] Though the importance of soils cannot be denied such a narrow view of land leaves some serious questions. For example, if small parcel of land with excellent soils is in the center of a city and is surrounded on all sides by housing is it still highly suitable for agriculture? Griffen would undoubtedly say that it is due to the capability of the soil to grow high-value crops. The multitude of problems such as dogs, children, inability to spray chemicals, high economic rent, high taxes, and possible problems in irrigating (especially sprinkler irrigation) are all ignored if in a dry area. In other words, the "soils only" viewpoint considers only the site

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[31] D. W. Griffen, "A Technical Guide for Determining Land Use Suitability," University of Illinois at Urbana-Champaign College of Agriculture, special publication 47, August, 1977, p. 3.

[32] Ibid.

[33] Ibid.

characteristics (and then only a few of the possible criteria) and ignores the situation. The weakness of such a narrow viewpoint has been addressed in other recent systems. A suitability system being developed at the Soils Department at Oregon State University recognizes the question of adjacent use revealed above.[34] The O.S.U. system is very dependent on soils as the determinant of site suitability and utilizes the adjacent land use as the situation determinant of suitability. The small parcel of land in the hypothetical situation posed above would not receive a high suitability rating under the O.S.U. system because the adjacent lands are in relatively noncompatible uses.

Now, one asks the question, "If a parcel of land is in a total non-urban, undeveloped area surrounded on all sides by agriculture or openspace land but has rather steep slopes and somewhat rocky soils, is it suitable for agriculture?" Both the Griffen and the O.S.U. system may not classify it as such. However, an investigation of the parcel's use may reveal that crops have been produced on the land and the farmer has consistently shown a good profit from this parcel. In cases such as this, there may be productivity factors other than the actual capability of the soil to grow crops. John Stockham, in an attempt to establish an agricultural land clsssification system for land-use planning in Jackson County, Oregon, developed as part of his system a "productivity index number."[35] This index number was derived by totalling the net returns per acre for the indicator

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[34]This system is part of an ongoing program of land and soil evaluation being developed by the Oregon State University Department of Soil Science.

[35]John Stockham, "Agricultural Land Classification System for Jackson County," second draft, April, 1975. (This system, to my knowledge, was never adopted. Mr. Stockham left Jackson County for a position in Minnesota shortly after this draft was developed.)

crops: pears, alfalfa, and irrigated pasture. These crops were used not only because of their predominance in the county, but also because they represented three categories of agricultural crops: horticultural, deep-rooted field crops, and shallow-rooted field crops. Stockham recognized that soils were a very important factor in productivity but that other factors had influence. "Indirectly, the productivity index number based on net returns reflects a number of factors aside from soils. Unlike soil capability class, the productivity rating is not an objective index of soil character, but rather the rating is based on actual production occurring in the field. The productivity ratings, therefore, reflect such diverse influences as water availability, climate, soil pattern, and disease and vector problems."[36]

Using an indicator crop to determine if land is suitable for agricultural use has been employed elsewhere with some success. Perhaps the best known rating system is the CSR (corn suitability rating) system developed in the Midwest. "The CSR is an indicator of the relative long-term productivity of the soil mapping units used in soil survey as compared to the most favorable soils in the most favorable crop-growing areas in the state. The CSR for a soil-mapping unit reflects the integrated effect of numerous factors that influence potential yields and the ease with which the soils can be managed."[37]

For the purpose of determining the suitability of land that has never been cultivated for use as cultivated cropland, the CSR and Stockham systems both are inadequate. They depend heavily, if not entirely, on the need to analyze the cropping history of the land, an information base that is naturally non-existent on

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[36] Stockham, op. cit., p. 8.

[37] Janice M. Clark, "Agricultural Zoning in Black Hawk County, Iowa, in Land Use: Tough Choices in Today's World, Soil Conservation Society of America, special publication No. 22, p. 151.

undeveloped lands.

A suitability system that was developed by the author mainly for use in the Intermountain West also fails in its ability to be applied to nondeveloped lands. It does use, however, a much broader criteria base for classification of lands and, therefore, helps to explain the evasive term suitability. This system was developed by the author to assist land-use planners that was unsatisfied with existing classification systems because of their narrow, soils-oriented dependency.[38] The original publication was written to address classification of land as to its suitability for agriculture, residential and industrial use. A companion publication covers suitability for use in grazing land.[39] The Rathburn system, as it applies to agricultural land, is designed to identify and prioritize agricultural land, "as to its conversion availability to non-farm uses." This is not to facilitate a process of conversion but (1) to promote preservation of prime agricultural land and (2) to guide conversion of the least valuable (socially as well as economically) agricultural land to non-farm uses if and when such conversion becomes absolutely necessary."[40] The system considers 11 criteria as having varied impact on the suitability of land for agricultural use.

1. U.S.D.A. Soils Conservation Service, Land-Capability Classification

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[38]Arthur C. Rathburn, "Designation of Priorities for Land Use," A. E. Series #166, Cooperative Extension Service, University of Idaho, revised January, 1976.

[39]State of Idaho Rural Development Committee, Subcommittee for Land Use Suitability, Arthur C. Rathburn, chairman, "Determination of Suitability of Land for the Grazing of Livestock," A. E. series #340, University of Idaho Cooperative Extension Service, January, 1978.

[40]Rathburn, "Designations of Priorities for Land Use," p. 3.

2. Size of Area (contiguous cultivated area not ownership pattern)

3. Production History

4. Availability of Irrigation Water

5. Market Locality

6. Availability of Necessary Transportation

7. Climate (including number of frost-free days, average precipitation, average summer-high and winter-low temperature)

8. Proximity to nearest Urban Concentration

9. Unique qualities (including ability to grow specialty crops, unique climate zone, and highly productive land due to existing technology)

10. Productivity (determined by average dollar return for predetermined primary and secondary crops)

11. Portion of area in non-farm use (excluding land devoted to irrigation, power or transportation delivery)

Some important features of the Rathburn system are numbers 8 and 9. The system recognizes that even if the site's physical properties (soil, water, and climate) are good, the land may be situated near noncompatible land uses that can create externalities that negatively affect the suitability of the land for farming.

It is also recognized that there is the possibility that even though the soils do not qualify the land for classification as "Prime Agricultural Land," some lands are highly productive. Some crops which are grown in the area may prefer steep, rocky or highly acidic soils. Also, new technology may make formally low-productive areas into highly productive areas. In the Intermountain West there are many areas that, due to poor soil and terrain features, were not very productive until overhead sprinkler technology became available. An example of this is to be seen in the Central Snake River Plains of

Idaho. Much of the land is in capability Class VI soils because of their extreme sandy condition. In an area of less than nine inches annual rainfall it was difficult to provide the water requirements of most agricultural commodities, but with the development of overhead sprinklers the sandy areas have become some of the most productive in South-Central Idaho. The system also recognizes that microclimate areas may exist. The canyon bottom lands and river benches along the Snake River allow a horticultural industry that could not exist above the canyon rim because of early and late frosts.

The Rathburn system of determing the suitability of agricultural land, like the suitability systems earlier discussed, cannot be utilized to determine suitability of non-developed lands for cultivated cropland because of its reliance on existing crop history. Because it was developed only as a guide to planning committees, it also falls short of the goal of this study to prepare a detailed framework for the determination of the suitability of under-developed land to be converted to cultivated agricultural land.

In the preceding discussion, the term suitability remains to be defined. It has been shown to be the "catch-all" term associated with land evaluation and classification. It has, however, been most often used in connection with classification systems that go beyond the description of soil characteristics. The term suitability will be used here to describe the combined site and situation criteria that allow for the use of land for a specified purpose without having undue negative impact on the longevity of that land for its desired use or its cultural setting.

In the case of agricultural suitability a parcel of land classified as suitable for agriculture should have the necessary physical attributes (site) to produce good crop yields in perpetuity and the locational attributes (situation) to not create social or economic hardship on the stewards of the land or on other affected individuals.

FEASIBILITY

Another term that is used interchangeably with suitability in agricultural classification is "feasibility." Undeveloped land is often classified as to its agricultural feasibility. Most often, however, the term is used to mean economic feasibility. In this sense agricultural feasibility refers to the ability of a specific land area to grow commodities in a quantity and quality that will allow a reasonable profit to the individual or individuals investing time and capital in farming it. Feasibility using this definition depends on the land possessing all of the properties necessary to be prime agricultural land, irrigable land (if in a semi-arid area), and land suitable for agriculture. In addition to these, it must be developed in an area and time period when markets for candidate commodities are available at a price that is above the average cost of production. This production and market aspect of feasibility is difficult to put into a classification system because it is an analysis that is time-oriented. Markets have the opposite quality that Griffen attributed to soils for use as a land evaluation criteria. Whereas Griffen said that soils "change very little over time," markets are constantly shifting over time. A complete feasibility study must not only be time-specific but must be more site-specific than is the purpose of this study.

The decision-making process for a farmer considering whether an area is feasible to farm was neatly diagrammed in Melczer's study on agricultural land classification[41] (see Figure 1). The answers to the questions he must ask are to a great extent answered by the data needed to arrive at the classification terms that have been discussed here.

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[41] Andrew H. Melczer, "Criteria for Classifying Land for Agricultural Use," September, 1976, p. 56.

DECISION-MAKING PROCESS——THE FARMER

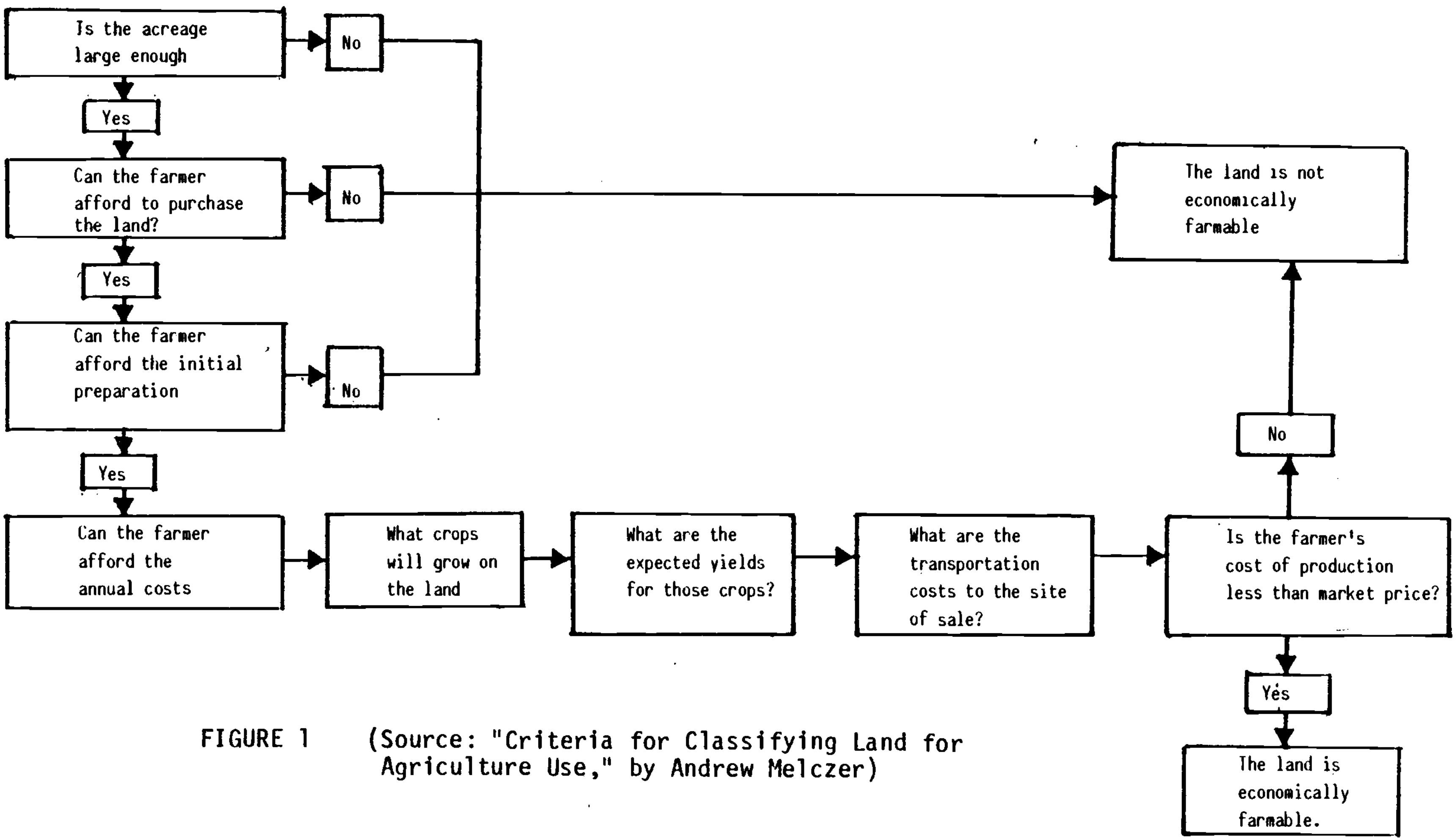

FIGURE 1 (Source: "Criteria for Classifying Land for Agriculture Use," by Andrew Melczer)

RELATIONSHIP BETWEEN AGRICULTURAL LAND
CLASSIFICATION TERMS

The terms that have been discussed so far differ mostly in the comprehensiveness of the factors involved in their determination. All are terms to describe a capability quality of the land to be used as cultivated cropland. Figure 2 shows the relationship between the terms in regard to the site's ability to return a profit to the farmer.

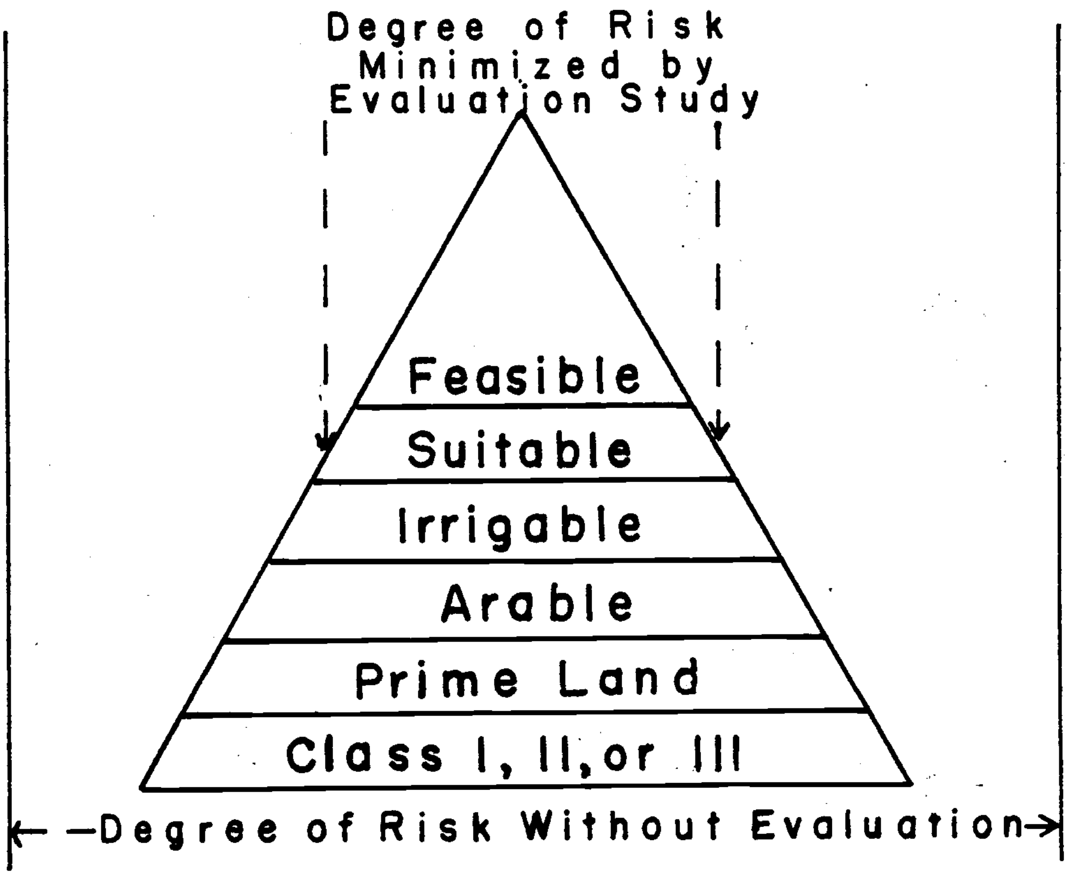

FIGURE 2. Relationship of Common
Land Classification Terms

At the bottom one finds class designations from the land-capability classification system. The term above it—prime land—though also a soils classification term, better describes the site's ability to support crops at a profit level. Thus, feasible is a term that gives the best indication that the land can support a crop management system that will allow economic benefit to exceed the cost.

To further confuse the issue of land classification, another whole set of determinant criteria must be considered before a land parcel can be elevated from the designation of potential cultivated cropland to available potential cropland. These are the best and somewhat baffling category of criteria known as governmental regulations.

If these criteria must be placed into the pyramidal diagram of land classification, it would be as seen in Figure 3.

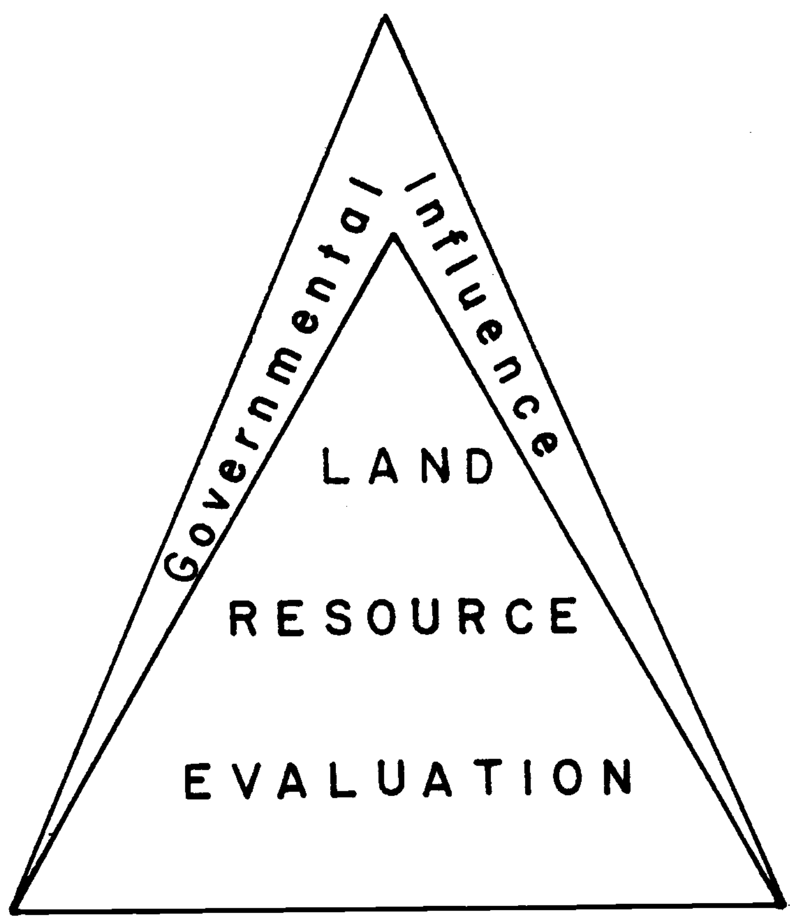

FIGURE 3. The Degree of Governmental Influence in Land Use Classification

Governmental influence permeates to all levels of the classification pyramid. The influence at the lowest level may be small, but nevertheless there. The land-capability classification of an area is determined in part by the level of detail of the soil survey. The interest level expressed by government entities or quasi-government entities (such as Soil Conservation District) determines the detail of the survey. Many large nondeveloped tracts of land are classified Class VI or VII, but when detailed surveys are conducted they are found to contain Class I, II or III soil areas.

Even if a study determines that it is economically feasible to farm an area there is no guarantee that it will be classified as such. The area may never be classified as feasible for cropland because some governmental agency has declared that the land is not socially feasible to develop. "The final decision concerning classifying lands for agricultural use must include both the economic costs to the farmer and the social costs to society. If the land is not economically feasible to farm from the farmer's perspective, it might be feasible to farm from society's viewpoint. The opposite is also true."[42] The role of governmental influence will be discussed in more detail later.

There are naturally many terms and classification methods that have not been discussed here. The intent was not to entirely explore the literature pertaining to land evaluation and classification, but rather to lay a ground work from which to launch a more detailed discussion of the criteria needed to determine the suitability of undeveloped lands in the Intermountain West for conversion to cultivated cropland.

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[42] Ibid., p. 76.

CHAPTER III

EVALUATION CRITERIA

In this chapter the physical, economic and social factors that affect the suitability of an area of undeveloped land for use as cropland are discussed as an essential basis for the Suitability Framework devised as the problem of this dissertation. A decision-making process is only as good as the data used. If the data fail to depict the factors needed to comprehensively study a site, the study will be of less value. In some of the studies concerning the suitability of new lands for conversion to cropland analyzed by the author the data base was quite narrow in its scope. The effectiveness of the Framework for Determination of Suitability depends on a comprehensive understanding of the data needed. Therefore, the following review of factors of land-suitability has been included as basic evaluation for use of the Framework.

For the purpose of discussion, the criteria have been divided into two groupings: site evaluation criteria and situation evaluation criteria. Site evaluation criteria are those criteria that affect the production of food, fiber, or oil seed plants on a given area of land. Situation evaluation criteria are those criteria that affect the suitability of the land due to its location in a spatially interrelated environment.

Included in the discussion of the criteria are some methodologies used to classify or evaluate the factors analyzed. Some of these methodologies have direct application within the suitability decision-making Framework presented in Chapter IV as the dissertation objective. The decision on which factors actually affect land-use suitability is an important step in building a framework for suitability study. Other factors were considered, but were rejected as being of little or no value in determining whether an area of undeveloped land is suitable for use as cropland.

SITE EVALUATION CRITERIA

The need for a satisfactory site cannot be overlooked. Agriculture is an economic process, but it is a process that is dependent on there being a favorable site in which soil, water, and solar conditions are found in a combination that favors plant growth. The Framework considers the physical factors that effect agriculture. Each factor must be analyzed in the process of studying the suitability of prospective new cropland. It is only when each is understood in its own right that the combined values of all can be appraised.

WATER RESOURCES

Most discussion on the criteria of agricultural land evaluation or classification starts with soils. However, the focus of this dissertation is on the Intermountain West, an area where life centers around the need for water. "Water in the West is more valuable than gold. It is literally the lifeblood of the West, because where it does not exist or has not been routed by man, little change has occurred over the centuries."[43] The demarcation between areas with and without water are so sharply in contrast that they are readily identified. Padfield and Smith refer to this phenomenon as "waterspace."[44]

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[43]John Stencel, Statement before the Committee on Agriculture and Forestry, United States Senate, Salt Lake City, Utah, April 19, 1974, as found in "Western Agriculture—Prospects, Problems, and Solutions," U.S. Government Printing Office, 1974, p. 54.

[44]Harland Padfield and Courtland Smith, "Water and Culture: New Decision Rules for Old Institutions," in the Rocky Mountain Social Science Journal, Vol. V, no. 2, 1968, p. 29.

> . . . irrigation projects in arid lands have sharp spatial limitations. These spatial limits, imposed originally by natural conditions and reinforced later by legal conditions, are the boundaries between abundant water and no water. This might be referred to as "waterspace."

Within this waterspace evolves a complex of interacting physical and cultural factors. The importance of an adequate and dependable water supply within any one waterspace is expounded (if not glorified) in the following excerpt from a reclamation project annual report:[45]

> In the great arid central valley of Arizona where men and beasts have died of thirst, water has produced and created every dollar of assessed valuation, every penny of income, every doctor's patient and lawyer's client, every storekeeper's customer from the ragged urchin peering wistfully over the counter of the Five-and-Dime to the languid lovely shopping for mink in the luxury of Goldwater's Park Central Salon.

The undeveloped lands of the Intermountain West that are the focus of attention here normally fall outside of any definable waterspace. Though new technology in irrigation is now allowing the conversion of land that was once thought to possess soil or relief components that were too restrictive to allow cultivation, most of the good lands within these spaces have been developed. The undeveloped lands are most often lands that were overlooked during the heyday of western expansion because of the lack or undependability of a water source. Due mostly to the lack of water, these lands have remained under federal ownership in the western states. "Because of the long process of selective disposition of federal lands, by means of which individuals and corporations acquired the best lands as they saw them

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[45] Steven C. Shadegg, "The Phoenix Story, An Adventure in Reclamation," Phoenix: Salt River Project Annual Report, 1958, as found in The Salt River Project by Courtland L. Smith, p. 19.

at the time, the land left in federal ownership has been that which was the least valuable at the time it was reserved for permanent federal ownership."[46]

Because of its importance, water has remained under the legal jurisdiction of state, regional and federal agencies. The question of water availability must be viewed both from a physical and societal perspective. The following paragraphs consider only the physical realities that are deemed as essential for prospective cropland suitability evaluation. The Framework does consider societal factors, but they are not evaluated in the same criteria analysis as the physical factors.

Need to Irrigate

The first question involving water availability that needs to be addressed is rather obvious: Is there sufficient natural precipitation to allow for the cultivation of crops? Most of the land in the West is deficient in precipitation. "Only one of the Westside (Western) States, Washington, receives more average annual precipitation than the national average of 30 inches."[47] A good indication of conditions within the Intermountain West is the fact that the average precipitation of the four states that are entirely within the Intermountain West (Arizona, Nevada, Utah and Idaho) is only 13.5 inches.[48] Combined with a summer dry-climate pattern, the low precipitation severely limits farming.

The actual minimum of precipitation necessary for nonirrigated farming will vary with soil type, elevation, aspect, wind, and

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[46]Marion Clawson, "Economic Aspects of Public Lands, in America's Public Lands Politics, Economics, and Administration, Harriet Nathan (ed.), p. 43.

[47]Bureau of Reclamation, "Critical Water Problems Facing the Eleven Western States," United States Department of the Interior, April, 1975, p. 42.

[48]*Ibid.*, p. 43.

temperature conditions. In land suitability studies conducted by the author in the Pacific Northwest, local agricultural experts most often used the figure of 12 inches annual precipitation as the minimum necessary for farming without supplementing the water supply with irrigation. More precise measurements are available. The use of annual precipitation, whether the 12 inches "guestimate" or the often used 10 inches isohyet for the limit of agriculture is not very reliable. "We cannot tell whether a climate is moist or dry by knowing precipitation alone; we must know whether precipitation is greater or lesser than potential evapotranspiration."[49]

One of the best known equations for use in the Western United States for estimating evapotranspiration is the equation developed by H. F. Blaney and W. D. Criddle in the late-'50s. The Blaney-Criddle System is dependent, as are nearly all other such systems, on a plant factor. "The factor varies with crop as well as season of the year. Since the equation is empirical, the factor also depends on the location where it was determined."[50]

The inclusion of a plant factor may not be necessary, as Clark reports:[51]

> Quite recently, much to the surprise of irrigation engineers and farmers accustomed to thinking in terms of each crop having its own 'water requirement,' Penman (of the Rothamstead Laboratory of Physics) has established the theorem based on the simple laws of physics that water requirements for all crops must be the same if they are grown on the same soil and for the same growing season.

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[49] C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," in "Geographical Review," January, 1948, p. 73.

[50] David M. Gates and R. J. Hanks, "Plant Factors Affecting Evapotranspiration," in Irrigation of Agricultural Lands, Robert Hagan (ed.), 1976, p. 518.

[51] Colin Clark, The Economics of Irrigation, p. 4.

Clark equates the water requirements of plants with "thermal balance." He also cites the validity of the Thornthwaite system (devised in the late-'40s) of predicting evaporation from climatic data.[52] Thornthwaite on finding that the ". . . rate of evapotranspiration depends on four things: climate, soil-moisture supply, plant cover, and land management," developed a system dependent on temperature and latitude (an indicator of day length) to predict potential evapotranspiration. This potential evapotranspiration can be compared to precipitation to arrive at an estimate of when water surplus or deficiencies exist, thus giving an indication of when irrigation is necessary to maintain plant growth. The role of soil in storing and acting as a reservoir for plant needs was treated as a constant by Thornthwaite.[53]

> The part of this water that is within reach of roots is used before the plants begin to suffer; therefore drought does not begin immediately when rainfall drops below water need. The amount of water in the root zone available to plants varies with soil structure and distribution of roots. It is, accordingly, not a constant. However, except in areas of shallow soil the water storage capacity available to mature plants with fully developed root systems varies around a mean that is the equivalent of about 10 centimeters or four inches of rainfall.

Thornthwaite checked his system against irrigation data in 12 American irrigated areas. The only area that varied more than 4% from his theoretical evaporation was West Tule Lake, California.[54] His system not only demonstrated that the factors determining evaporation are independent of the nature of the crop grown, but also that the question of when to irrigate and when not to is perhaps not

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52 *Ibid.*, pp. 4-5.

53 Thornthwaite, *op. cit.*, p. 65.

54 Clark, *op. cit.*, p. 5.

as difficult as many have inferred.

Groundwater

When investigating the physical availability of water, one must consider both groundwater and surface water. Groundwater makes up the bulk of the available irrigation water in the world. Its abundance is somewhat astounding as the following description of it reveals:[55]

> Groundwater is by far the most abundant freshwater resource in the habitable parts of the earth. The aggregate amounts of groundwater within depths < 0.5 mile below the land surface is more than 30 times the total water in all freshwater lakes, more than 60 times the total soil and other unsaturated rock materials, more than 300 times the water vapor in the atmosphere, and more than 3000 times the average volume in all the rivers and rivulets in the world.

The Framework utilized the depth to and volume of groundwater as a factor in determining the degree of water availability. Fortunately the study of the amount of, and depth to, groundwater in most of the Intermountain West has been determined; saving the decision maker the necessity to determine this himself (or herself). Information on groundwater can be obtained from studies by Thomas and McGuiness or from state agencies responsible for groundwater studies, the Water Resource Division of the U.S. Geological Survey and local well drillers.[56,57] In determining the site characteristics one does

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[55] Harold E. Thomas and Dean Peterson, Jr., "Groundwater Supply and Development," in Irrigation of Agricultural Lands, Robert Hagen et al. (ed.), p. 70.

[56] H. E. Thomas, "Groundwater regions of the United States——their storage facilities," in "Physical and economic foundations of natural resources," U.S. Congress, House of Representatives, Interior Insolar Affairs Committee, Vol. 3, 1952.

[57] C. L. McGuinness, "Role of groundwater in the national water situation," Water Supply Paper No. 1800, U.S. Geological Survey, 1963, pp. 1-118.

not need to be concerned with the cost of pumping but only the overall availability. The feasible pumping lift is an economic determination that cannot be derived until all of the site and situation criteria are amassed and the overall suitability determined. An index can be prepared that will serve as a method of comparing groundwater availability to surface water availability and comparing the suitability on one site in comparison to another. A possible index will be appraised in the discussion of the suitability Framework developed later in this study.

Surface Water

Studies suggest that 60 to 65% (depending on which study one reads) of the presently irrigated lands in the Western United States are irrigated from groundwater, but that an increasing dependence on surface waters is necessary. This trend has been spurred by economic considerations and the increased knowledge of the deleterious nature of groundwater mining.

The availability of surface water is mostly an economic and political question. If the political and economic climate allow, water can be transported over long distances. The possibility of interbasin transfers opens areas of extreme water deficiency to designation as new cropland candidates. What needs to be documented for purposes of site evaluation is the physical availability of surface water on or adjacent to the site. If surface water is available the relative cost expressed in terms of vertical and horizontal distance compared to groundwater must be established.

Water Quality

"The quality of irrigation water depends on the materials in suspension and in solution, respectively."[58] The material in suspension is most often silt. High volumes of silt in water can be

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[58] A.P.A. Vink, Land Use in Advancing Agriculture, p. 114.

either beneficial or detrimental to its use for irrigation. "The accumulation of natural silt on cultivated soils has often been considered very beneficial for soil fertility. In some cases, where easily weatherable minerals (e.g., of volcanic origin) are deposited in not too large quantities, this may certainly be the case."[59] In more cases than not, a high volume of silt is detrimental to irrigated agriculture.[60]

> A continuous sedimentation of silt on irrigated lands may also be deleterious to land productivity. The measure of this effect depends strongly on the kinds of original soils on the kind and quantity of the silt and on the conditions under which the silt is deposited. The latter in particular may provide difficulties. If silt is deposited under saline or alkaline conditions and with little or no vegetation, the structure of sediment after drying may become very dense and not very porous. As a result the drainability of the land may become greatly reduced, thus increasing the danger of salination. The translocation of carbonates may further increase this danger, because the few existing pores may be filled with poorly soluable carbonates.

Besides the negative effect of silt on the surface structure of the soil, irrigation systems utilizing silt-laden water must either install insystem or front and sedimentation basins, or suffer high-maintenance costs. Few systems can be planned with sufficient gradient so steep the silt is in suspension until it is released on the field (if such is desired). However, the existence of silt in the water should not deem an area unsuitable since it is a correctable factor. It must be noted though, because the treatment necessary to remove it may be an important ractor for economic feasibility.

As with materials in suspension, materials in solution in irrigation water may be either beneficial or detrimental. "The

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[59] Ibid.

[60] Ibid., p. 115.

materials in solution in irrigation water may to some extent provide extra nutrients to plants and this may be beneficial to land use."[61] Though Vink deemphasizes the importance of salinization or alkalinization, most works on irrigation water emphasize the importance.[62] According to Wilcox and Duram, "There are four principal hazards related to the chemical character of the water: total concentration, sodium, bicarbonate, and boron or other phytotoxic substances."[63] Of these four, Wilcox and Duram found total concentration to be the most important.[64]

> The importance derived from the fact that the salinity of the soil solution is usually related to, and often determined by, the salinity of the irrigating water. Thus, plant growth may be impaired or prevented, depending on the salt content of the water.

Many classification systems have been devised to categorize irrigation water. Below are the classes used by the U.S. Salinization Laboratory:[65]

1. Salinity Classification

   C1—LOW SALINITY WATER can be used for irrigation with most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability.

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[61] *Ibid.*

[62] *Ibid.*

[63] L. V. Wilcox and W. H. Duram, "Quality of Irrigation Water," in *Irrigation of Agricultural Lands*, Robert Hagan *et al.* (eds.), p. 108.

[64] *Ibid.*, p. 109.

[65] *Ibid.*, p. 113.

C2—MEDIUM SALINITY WATER can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.

C3—HIGH SALINITY WATER cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

C4—VERY HIGH SALINITY WATER is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

2. Sodium Classification

S1—LOW SODIUM WATER can be used for irrigation on almost all soils, with little danger of the development of a sodium problem. However, sodium-sensitive crops such as stone-fruit trees and avocados, may accumulate injurious amounts of sodium in the leaves.

S2—MEDIUM SODIUM WATER may present a moderate sodium problem in fine-textured (clay) soils unless there is gypsum in the soil. This water can be used on coarse-textured (sandy) or organic soils that take water well.

S3—HIGH SODIUM WATER may produce troublesome sodium problems in most soils and will require special management: good drainage, high leaching and additions of organic matter. If there is plenty of gypsum in the soil, a serious problem may not develop for some time. If gypsum is not present, it, or some similar material, may have to be added.

S4—VERY HIGH SODIUM WATER is generally unsatisfactory for irrigation except at low- or medium-salinity levels where the use of gypsum or some other amendment makes it possible to use such water.

Potable Water

The water availability criteria in the Framework considers the potability of the water source. Though this is a social-necessitated criteria rather than a physical requirement for agriculture the suitability of the land is affected by it.

SOILS

The importance of soils to land-use evaluation is emphasized in the Framework. Next to water the quality and quantity of soil are viewed as having the most effect on cost of cultivation. It is possible to grow many crops totally free of soil, however the cost of doing so is prohibitive in all but a few special circumstances. As was earlier discussed in the section on definition of some common terms associated with agricultural land evaluation, soils have often been used in classification systems as the sole or nearly sole determinant of agricultural suitability. By use of the term "soil suitability," Vink distinguishes the role of soils in what he terms "actual land suitability." He defines soil suitability as,[66]

> physical suitability of soil and climate for production of a specific crop or group or sequence of crops, or for other defined uses or benefits, within a specified socio-economic context, but not considering economic factors not specified to areas of land. Soil suitability is concerned with the direct usefulness of soils for a particular purpose, under specified socio-economic conditions and with certain assumptions as to the generalized, over-all land conditions.

The placing of too much emphasis on soils comes from the use of the term "soils" to mean land. These two must be differentiated. Soil is only one of the land resources, or, as Brinkman and Smyth define it:[67]

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[66] Vink, op. cit., p. 249.

[67] R. Brinkman and A. J. Smyth (eds.), "Land evaluation by rural purposes," Pub. 17 Wageningen Institute, 1973, as found in Land Use in Advancing Agriculture, by A.P.A. Vink, p. 91.

> A soil is a three-dimensional body occupying the uppermost part of the earth's crust and having properties differing from the underlying rock material as a result of interactions between climate, living organisms (including human activity), parent material and relief over periods of time, and which is distinguished from other "soils" in terms of differences in internal characteristics and/or in terms of gradient, slope-complexity, microtopography, stoniness and rockiness of its surface.

Land, on the other hand, is a more inclusive concept. Vink utilizes the geographical concept of "a tract of land" to define land.[68]

> A tract of land is defined geographically as a specific area of the earth's surface; its characteristics embrace all reasonably stable, or predictably cyclic attributes of the biosphere vertically above or below this area, including those of the atmosphere, the soil and underlying rocks, the topography, the water, the plants and animal activities and results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man.

Physical Properties of Soil

In the process of evaluating or classifying land soils are usually grouped according to similarities in physical properties. These properties largely determine the ways in which the land can be used. For irrigated agriculture the soil should provide for good root and water penetration, have a reasonable water-holding capacity and a chemical makeup conducive to plant growth. To measure these properties, several characteristics of a soil must be known.

Texture

The size and arrangement of soil particles are what determines most of the important performance qualities as permeability, water-holding capacity, and erodability. It also affects the supply of

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[68] Vink, op. cit., p. 2.

nutrients and intra-soil air flow. Figure 4 is a common illustration used to summarize the percentage of clay, silt, and sand found in the common texture classes.[69] Those texture classes that fall the farthest from all three corners are often considered to have the most desirable characteristics. However, texture is only one function and it must be considered with the other soil characteristics plus climate and farming methods. Therefore, there is no such thing as the most desirable texture. Desirability depends on the site and purpose of the evaluation.

When considering texture for irrigated agriculture the type of irrigation will determine the best texture class and vice-versa. For flood and rill irrigation, heavier soils such as clay loam are preferred, whereas under sprinkler irrigation, especially circulars or side-roll sprinklers, heavy soils tend to surface seal which prevents proper infiltration and leads to erosion. Difficulties are also experienced due to the wheels bogging down. The sandier soils which may produce well under sprinklers create excessive demand for large volumes of water under rill irrigation. They may also demand special management practices to prevent serious wind erosion. Textural modifiers that may inhibit cultivation such as gravel and surface stoniness must also be considered.

Depth of Soil

The soil depth to an impermeable barrier such as hardpans or bedrock must be sufficient to allow for good root development and to provide adequate storage for moisture and plant nutrients. Soils that are shallow may also have a drainage problem. This can be serious in semi-arid or arid areas because soils under dry climatic conditions often have high salt and alkali concentrations near the surface which must be leached. This is an especially critical problem under irrigation.

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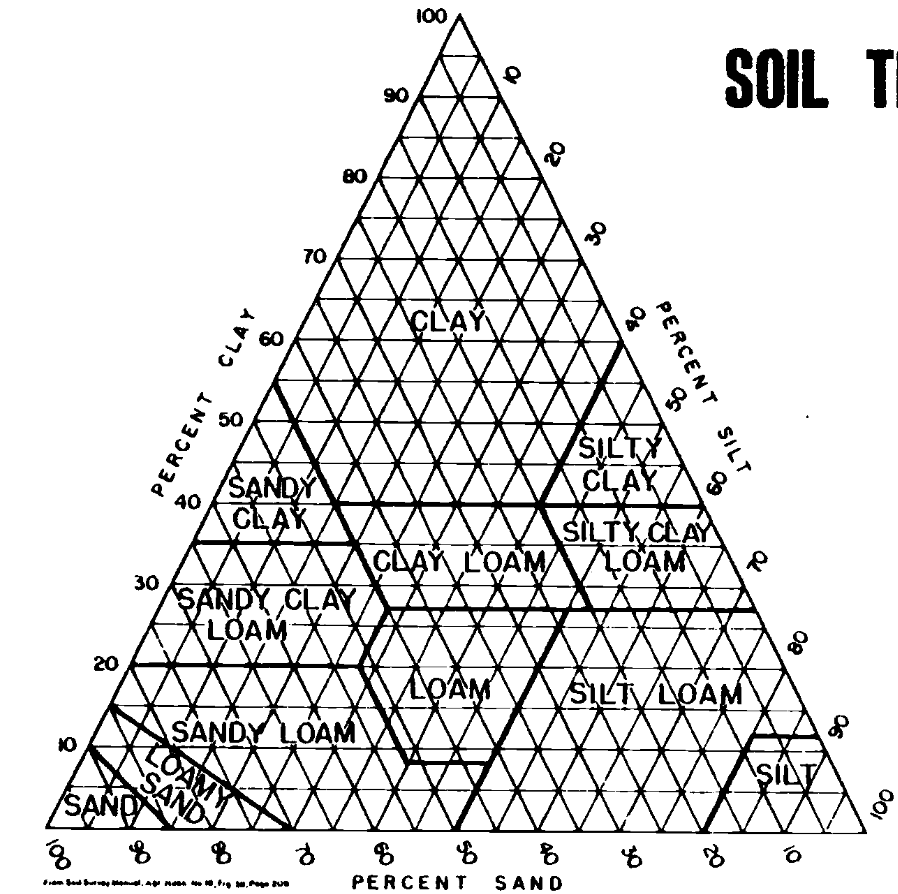
[69] M. B. Russell, "Physical Properties in Soil, Yearbook of Agriculture, 1957, U.S.D.A., p. 32.

SOIL TEXTURAL CLASSES



U.S. DEPARTMENT OF AGRICULTURE . SOIL CONSERVATION SERVICE

FIGURE 4

SIZE LIMITS OF SOIL SEPARATES	
NAME OF SEPARATE	DIAMETER (range)
	MILLIMETERS
Very coarse sand	2.0 - 1.0
Coarse sand	1.0 - .5
Medium sand	.5 - .25
Fine sand	.25 - .10
Very fine sand	.10 - .05
Silt	.05 - .002
Clay	Below .002

Soil Chemistry

The limitations to fertility created by the chemical property of soils is a subject far more complicated than could be discussed here. It is imperative, however, that certain questions concerning the chemical properties of the soil be answered in evaluating soil suitability. Premier among these is the question of soil pH. "When crop plants do not grow well, one of the first questions the soil scientist usually asks is, 'What is the pH of the soil?' or, 'Is the soil acid, neutral or alkaline?'"[70] The occurrence of highly acidic soils is not a problem in semi-arid or arid areas, but "slick spots" due to saline-alkali conditions are not uncommon. The other common chemical problem is the occurrence of sodium in the soil. Over- or under-abundance of minerals and trace elements should be noted, however these are normally correctable by simple management practices.

Drainage

There are three factors that must be considered in relation to drainage: water table, overflow, and depth to impermeable barrier. The importance of a sufficient depth to impermeable barrier to allow proper leaching of salts and alkali concentrations associated with semi-arid or arid soils has been mentioned.

A shallow soil under irrigation can also easily develop a ponding condition which can flood out the root system of many crops. Sub-surface soil saturation from having the water table too close to the surface can result in the same thing. A shallow water table can, however, be beneficial under special circumstances. Some areas are able to support deep-rooted crops, such as alfalfa without irrigation because of their shallow water table. Such an area is the Little Camas Prairie in Camas County Idaho where recent drilling

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[70] W. H. Allaway, "pH Soil Acidity and Plant Growth," in Soil, Yearbook of Agriculture, 1957, U.S.D.A., p. 67.

for sprinkler irrigation has caused problems for dryland farmers because of a lowered water table.

Overflow, or flooding, can naturally be a hazard to crops. In semi-arid areas the danger comes from high-intensity storms which create sheet flooding.

Topography

The two factors of topography that are considered in the Framework to have impact on site suitability are slope and relief. These factors not only affect erosion and drainage but are important for determining the method of irrigation, land development needs, crop adaptability and selection of management systems. Topographic figures are usually covered in soil surveys because they must be correlated with soil and drainage conditions.

Slope

Slope can determine management practices or even prohibit cultivation of areas that otherwise are suitable. Runoff increases with slope, and that, in turn, increases the erosion hazard. Steep slopes are limited to cover crops or minimum cultivation crops such as grain.

Slope can also be a detriment as to the type of irrigation that can be used. Rill irrigation is normally limited to slopes of 2% or less, whereas some types of sprinkler irrigation can be used on up to 12% slopes. When classifying slopes different terms of severity are often used for dry cropland and irrigated cropland. The following designations are used for purposes of land judging in Idaho.[71]

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[71]Wayne L. Thiessen, "Land Judging in Idaho," University of Idaho Cooperative Extension Service, p. 5.

		Dry Cropland	Irrigated Cropland
1.	Nearly level	0 to 3%	0 to 1%
2.	Gently sloping	3 to 8%	1 to 3%
3.	Moderately sloping	8 to 12%	3 to 5%
4.	Strongly sloping	12 to 20%	5 to 8%
5.	Steep	20 to 45%	8 to 12%
6.	Very steep	over 45%	over 12%

Relief

Relief can have major positive and negative impact on agriculture. It is an important factor in climate, soil formation and degradation and in hydrology. Though relief is often considered in three magnitudes, macrorelief, mesorelief, and microrelief, suitability studies normally only concern the latter. Vink categorizes microrelief as having relief forms with height differences of less than approximately 10 meters.[72] Extreme hilly areas can limit the type of irrigation or create high land development costs for land leveling. Vink points out that:[73]

> Relief shows many differences in shape, which in general has both a horizontal and a vertical component. Relief patterns include both hill patterns and drainage patterns, . . . Hill forms and slope forms may have many different shapes all of which have a vertical and horizontal component . . .
>
> All of these factors have a direct impact on land management and may have a considerable significance for land improvement.

Although differences in the shape and size of hills, valleys and drainages normally enter into impact discussions of management, that must be considered in determination of economic feasibility, some differences can have impact on the site analysis. For instance,

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[72]Vink, op. cit., p. 89.

[73]Ibid.

sharp drainages through otherwise flat or nearly flat areas could disrupt irrigation flows. On steeper sloped areas it could prevent necessary contour cultivation patterns.

Microrelief enters into site evaluation in two ways: severity and aspect. Severity addresses the surface condition; for example, is it smooth or very rough due to sharp hills or eroded rills? In areas where irrigation is necessary this becomes important. Surface conditions not only can determine the type of irrigation, but may also prevent irrigation. The management practices of leveling may need to be considered to negate problems of severity. Land can be leveled with up to about five feet of cut and fill if the depth of topsoil allows. In some cases the subsoil quality is such that it can by the application of proper management practices be improved to the same quality as the topsoil.[74] Other relief factors which affect plant growth or management options include aspect, size, and shape of slope.

Considerations of macrorelief (more than 50m.) and mesorelief (10 to 50m.) may also come into play in site analysis when considering climatic conditions such as wind and frost patterns.

CLIMATE

The Framework for determining the suitability of prospective new agriculture land utilizes several factors of climate. "Nowhere in the United States has climate influenced the patterns of settlement and culture more definitively than in the arid regions of the West."[75] If one were to construct a map showing population density, the map would also show the area of most favorable climate for the

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[74]Wayne D. Criddle and Howard R. Haise, "Irrigation in Arid Regions," in Soil, Yearbook of Agriculture, 1957, U.S.D.A., p. 361.

[75]Reed W. Bailey, "Climate and Settlement of the Arid Region," in Climate and Man, Yearbook of Agriculture, 1941, U.S.D.A., p. 189.

cultivation of crops. Of all the physical phenomena that affect agriculture, climate is the most uncontrollable and unpredictable. Soil can be altered and water moved from basin to basin, but rain cannot be ordered at the proper intervals, or a long frost-free growing season guaranteed. Climate is the element agriculturists gamble on the most and can afford to the least. Bailey summed it up in the 1941 U.S.D.A. Handbook of Agriculture:[76]

> Gambling on climate may be possible in semi-arid regions, but the dweller in arid regions has to play it safe or perish. He learns to know where the water is, to husband it, to use just the right amount when it is needed, to protect his water sheds; and by his skill, knowledge, and discipline, he makes rich gardens in the desert. Theoretically; but theory and the practice do not always dovetail, and no type of agriculture has stricter requirements than irrigation farming.

Agriculture is most impacted by the climate factors of temperature, precipitation, wind velocity and insolation. Insolation is one factor that will not be drastically altered by conversion of undeveloped land to cultivated cropland. Therefore, it cannot be used very effectively as a criteria in evaluating undeveloped land for conversion. There are other extreme conditions such as hail storms and tornadoes that can destroy agricultural areas, but all that can be done is to note a degree of possibility for these conditions. The most critical climatic factor is temperature.

Temperature

The need for a sufficient growing season is an important factor used by the Framework. Growing season is a universal term, but not everyone agrees as to its definition. In the United States, "the length of the growing season is generally defined as the interval in

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[76] Ibid., p. 188.

days between the last killing frost in spring and the first killing frost in fall.[77] Some experts tend to question the definition by saying, "What is meant by a 'killing frost'?"[78] Rather than using 0°C (32°F) as a base temperature, the base of 6° (42.8°F) is often employed. It is at this minimum temperature that most crops are supposed to 'grow.' However, as Taylor points out: "Clearly, different species and different environments will exhibit different responses and threshold values occurring above and below as well as at the conventional 42°-43°F (5.6°-6°C) will operate."[79] Kalges recognized the problem of using the killing frost concept, but supports its use because it is "of definite value in that it shows high degrees of correlation with the more complex and theoretically better fortified method of temperature evaluations. It serves very well for the general comparison of temperature conditions of widely separated regions."[90] Data on first and last frost is also generally available which is a definite plus in any land evaluation scheme. The minimum length of growing season will, of course, vary with crop selection. It is also important to note that growing season data are usually site-specific as they are influenced by microrelief.

Temperature is also a key factor in evapotranspiration, which is utilized in the Framework to determine water balance. For purposes of site evaluation the day-to-day fluctuation of temperature and its impact on water availability is a management problem and need not be investigated.

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[77] Karl H. Klages, Ecological Crop Geography, 1941, p. 213.

[78] James Taylor, "Growing Season as Affected by Land Aspect and Soil Texture," in Weather and Agriculture, James A. Taylor (ed.), p. 15.

[79] Ibid., p. 16.

[80] Klages, op. cit., p. 239.

Precipitation

Precipitation is utilized with temperature in the Framework to determine the water balance of the site. Without adequate water balance the farmer must find another source and apply it to his land through irrigation. In collecting data for land evaluation the decision maker must determine both amount and seasonal intensity of precipitation to use in deciding if irrigation is needed, what crops to grow and what erosion-prevention practices must be undertaken.

Wind Velocity

Evapotranspiration is affected by wind, however the Framework utilizes a formula not dependent on it. Wind velocity is considered a climatic hazard. Many areas of the Intermountain West are subject to frequent high-velocity winds, which can cause severe erosion and crop damage. These areas, especially those with unstable sandy soils, must be identified and kept in land uses that help stabilize the soils. This principle has not always been adhered to in new land development. Consequently, some areas have been denuded of valuable topsoil.

SITE EVALUATION METHODOLOGIES

The site evaluation of land under consideration for conversion of undeveloped land to cropland has been the phase most comprehensively covered by existing evaluation methods. These methods were analyzed in the development of this dissertation.

The Bureau of Reclamation does an extensive evaluation on lands being proposed for conversion in a Bureau project. The studies more or less follow the format of a draft instruction paper written to replace part 115 of Reclamation Instructions Series 110 Planning. The Bureau's land resource investigations "are conducted primarily to define land areas capable of sustained, profitable agriculture production under an irrigation economy."[81] A major part of the process is to prepare an irrigation suitability land classification. This classification system is site-specific and related to a specified economic setting. The criteria used are discussed in general, but are not quantified in a manner that standardizes the process. Whereas such an evaluation may be a valuable tool in the Bureau's charge of duties, it does not lend itself to resource decision processes that must compare the value of one area against another in order to best utilize resources. The following paragraph taken from the Reclamation Instruction (draft) demonstrates why a Bureau of Reclamation study cannot be used as a land evaluation guide.[82]

> Land classification cannot and should not be directly applied by following a set of general land class determining factors. Each potential project setting presents its particular land classification requirement. Feasibility land classification surveys should therefore be designed and land classes defined to meet specific development goals and economic requirements relevant to each project.

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[81]Bureau of Reclamation, "Land Resource Investigations," Reclamation Instructions, Series 110 Planning, Part 115, ch. 1, para. 1.

[82]*Ibid.*, Part 115, ch. 4, para. 2b(1).

A useful land classification scheme for irrigation potential of semi-arid lands was devised by the Pacific Northwest River Basins Commission. This system divides potential irrigable land into three classes, and is used by the member states in their studies. The Idaho Water Resource Board defines the three classes as such:[83]

> CLASS 1 lands are those lands with little or no particular limitations for irrigated agriculture. Class 1 lands are well-adapted to the most appropriate method of irrigation and with a minimum of conservation management should retain a high level of productivity for climatically adapted crops.
>
> CLASS 2 lands present moderate limitations for irrigated agriculture. These limitations may be in the form of development problems, such as stone removal, land smoothing or drainage. Among the limiting factors placing soils in the Class 2 category may be those of a management nature, such as limited soil depth, limited permeability, presence of hardpans or alkalinity, and problems of erosion control and equipment management on sloping land. Class 2 lands are generally adapted to row-cropping and to most climatically adapted crops.
>
> CLASS 3 lands have severe limitations for irrigated agriculture. As described for Class 2 lands, these limitations may be problems either of development or management. The majority of Class 3 lands are best-suited for small grains and forage production, and with above-average management satisfactory economic returns may be achieved.

The Water Board clarified that these classes only refer to the evaluation of part of the criteria needed for study.[84]

> It should be emphasized that the placing of these lands into their respective classes does not reflect their capabilities for other agricultural uses, but only rates

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[83] Idaho Water Resource Board, "Potential Irrigable Lands in Idaho," summary Report Number One 1970, p. 1.

[84] Ibid.

> these lands as to their physical capabilities for irrigated agriculture under the criteria developed for the Columbia-North Pacific Framework Studies. The constraints of climate, distance to market and availability and cost of water were not considered in this study.

The land classification specification for the three classes identified by the Columbia River Basin Commission is seen on Table 1.

The Rathburn suitability system, discussed in Chapter I, has also been used to evaluate undeveloped lands. Elmore County, Idaho, Soil Conversation District and Planning Department with the author's assistance evaluated all of the land suggested in a BLM study as being potential croplands. The same criteria were used to evaluate undeveloped lands as were used to classify the existing cropland in the county. Ada County, Idaho, also used the criteria given in the Rathburn System to describe potential cropland in a comprehensive plan. The criteria they used were:[85]

1. It has available water (irrigation or natural);
2. it has Soil Classification Service Class 6 [sic] soils or better, or . . . it has unique conditions which contribute to its productivity;
3. it has access to needed transportation;
4. it is outside any city's area of impact.

This system, though comprehensive in nature, is too general for the purposes of decision making. It was intended as a land-use planning informational aid and educational vehicle for classifying the suitability of existing agricultural land for that use within a system of developed land.

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[85]Ada County Planning, "Ada County Comprehensive Plan," 1977.

TABLE 1
LAND CLASSIFICATION SPECIFICATIONS
Columbia-North Pacific Region
Comprehensive Framework Study

Soil or Land Characteristics	Class 1 Only Slight Limitations	Class 2 Moderate Limitations	Class 3 Severe Limitations
SOILS			
Texture of root zone	Fine sandy loam to friable clay loam	Loamy sand and permeable clay	Loamy sand and clay (sands with sufficient water-holding capacity can be included)
Depth to: Clean sand, gravel, and cobble; impermeable sediments, or hard rock; hardpan or cliche	40"	20"-40"	10"-20"
	Note: If hardpan can be modified by deep tillage, it should be rated less severely.		
Textural Modifiers (Vol.) of tillage layer: Gravel (3") Cobble (3-10")	No problem in tillage	15-50% 10-25%	50-70% 25-50%
Stoniness of surface and tillage layer	No problem in tillage	Cultivation not practical (class 1-Soil Survey Manual p. 217)	Cultivation impractical unless cleared (class 2-Soil Survey Manual p. 217)
Rockiness (small outcrops within soil type)	No problem in tillage	= 2% of surface	2-10% of surface (class 1-S.S. Manual)
	In areas where use has demonstrated suitability more severe modifiers can be rated irrigable for special uses not requiring tillage.		
Available water-holding capacity (to a maximum depth of 4 feet)	6"	$4\frac{1}{2}$"	3"
Permeability	Moderately slow to moderately rapid	Slow and rapid	Very slow and very rapid
Sodium and alkalinity	10% slick spots in complex	10-25% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%	25-50% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%
TOPOGRAPHY			
Slope	Generally 4%	Generally 12%	Generally 20%
DRAINAGE			
Water table	Easily maintained below major rooting depth during growing	Practical to maintain below rooting depth most of the time in growing season (requires drainage)	Can maintain below 18" most of growing season
Overflow	No overflow	Free of overflow in growing season	Overflow may be hazard to crops in some years (2 or 3 in 10)
Depth to impermeable barrier	> 8 feet	> 6 feet	> 6 feet
	Note: Applies in physiographic positions with problem potential, i.e., basins, fans, pediment slopes, etc.		

SITUATION EVALUATION

The Framework emphasizes the need to extend the evaluation process for undeveloped land conversion beyond the study of the physical character of the site. Decision makers must add to their decision-making process embedded in physical criteria an assessment of the social and economic setting in which the project must take place. For a project to survive it must not only have the site qualities necessary to support cultivation, but also be favorably situated, physically, socially, and economically in the total environment in which it must interact.

This sentiment, though long espoused by many involved in land and resource evaluation, did not officially creep into the federal decision-making process until 1970 when the Water Resource Council created the term multi-objective planning. Fitzsimmons et al. claims the concept [86]

> evolved as a logical response to shifts in public values on the role of increasingly scarce water resources and their relationship to environmental, social, and economic concerns. Citizens became increasingly concerned that people and their communities should not be viewed solely in economic and material terms, i.e., that it was necessary for government and other major institutions of society to consider the quality of life of the individual, the social well-being of communities and equity among people. A general feeling emerged that there was a disproportionate emphasis on economic considerations which instead of improving family and community life, left man more at the mercy of technology and government. As part of this change in values, there was concern about exploitation of the environment and of man's natural resources.

To meet this change the Water Resource Council came out in their "Principles and Standards," with the four account system of:

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[86] Stephen J. Fitzsimmons et al., Social Assessment Manual, p. 5.

(1) National Economic Development (NED) Account; (2) Regional Development (RD) Account; (3) Environmental Quality (EQ) Account; and (4) the Social Well-Being (SWB) Account.[87] These four accounts have application to the land conversion problem. However, the general nature of the system with the exception of the EQ evaluation system, as developed by the Bureau of Reclamation, makes it difficult to use in a comparative manner. The Bureau of Reclamation's EQ evaluation system is useful for this in its employment of arbitrary 0-10 ratings for both environmental quality and human influence factors. A comprehensive method of preparing a SWB account has been developed by Fitzsimmons, Stuart and Wolff.[88] Their process does not lend itself totally to the decision involving new lands, but can serve as a reference to the scope of social impacts created by new development.

The criteria that influence the situation evaluation can be divided into several categories: isolation influences, economic influences, environmental impact influences, and social impact influences. As was done with the factors of site evaluation, each of these will be discussed so as to set the foundation for the building of a suitability framework.

ISOLATION INFLUENCES

Isolation influences can be defined as those factors that place restraints on the use of an area for cropland because of its spatial and visual location and size. Isolation may be created by physical barriers or by economic disadvantage related to location and size. Many areas in the West are cut off from markets, potential

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[87] U.S. Water Resources Council, "Proposed Principles and Standards for Planning Water and Related Land Resources," in the Federal Register, U.S. Government Printing Office, 1973.

[88] Fitzsimmons *et al.*, *op. cit.*

water supplies, or service centers by deep canyons or mountain passes that are blocked by early storms or late snowpacks. Such phenomena must be accounted for as decreasing the suitability of the areas.

The elevational relationships between an agricultural area, its water source, and its waste water return system are important for later cost considerations. The availability of water must be considered in terms of lift as well as distance.

Recent studies on two irrigation return systems in South-central Idaho demonstrated the problem that can be associated with the gradient of the return. In one case the elevation of the system is gradual and the water is returned less silt-laden than it was upon entrance to the system. On the other system, the tail-end grade is steep because of the elevation differences between the end of the system and the return flow. On that system the accumulated pollutants do not settle. With enforcement of 208 planning expensive prevention measures may need to be installed. Elevational differences can also create saline problems on lower lands. Saline-alkaline materials leached out of new agriculture land can be transported away to the aquifer and reappear in the springs or wells at a lower elevation. Some of the low areas in Eastern Montana and along the Snake River in Idaho have experienced this problem.

ECONOMIC INFLUENCE

Though the actual study of economic costs and benefits takes place as part of the economic feasibility study usually after the suitability is completed, there are general economic influences that can be considered to determine the degree of suitability of a site because of its situation in an existing physical, social, and economic environment. The common factors of economic influence are transportation, size of area, distance to market, market capacity, and availability of electricity. If the proposed lands were located in a Von Thünen isolated state the analysis of economic influences would be rather simple. It obviously may be difficult to find such a developable site. Some of the same factors still apply, however. The distance to market still can inhibit the production of certain crops, even though the distance factor has been greatly modified by modern transportation methods and networks. The factor now is a combination of distance, volume of commodity, and type of transportation. The question now may be how far to a transportation breaking point rather than a market. This point may be a sugar beet dump on a railroad siding, granery, inland seaport or a processing plant. The "Whiskey Rebellion" concept of processing at the raw material site rather than at the market place is the foundation of Intermountain West agriculture. The Framework uses the term "destination point" to refer to the market, processing site, or transportation breaking-point.

Size and Relationship to Other Agricultural Land

The relationship of agriculture land to its market and other land use is included often in land classification systems. Most systems use it as Rogers does, to determine compatibility.[89] This aspect, as discussed later, is of importance but, being located totally away from non-compatible land uses, does not necessarily infer an ideal situation. A size that is isolated from other agricultural areas will experience degrees of disadvantages that affect its suitability in relation to the size of the area.

Dhillon and Derr found that there is a "critical size" which agricultural areas must maintain to be able to have an associated

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[89] William R. Rogers, "Agricultural Land Evaluation Scheme," unpublished paper Department of Soil Science, Oregon State University, 1979.

supporting agri-business.[90]

> The critical size of an area refers to the minimum volume of agriculture output and associated land area which is necessary to exhaust the economics of size in the supporting agribusiness firms so that they operate at or close to the minimum point on their long-run average cost curves. It further implies that agriculture within the area should be concentrated so that distribution and assembly costs are minimized.

Unfortunately, no simple formula exists that gives us a minimal size of critical mass. It can be assumed, however, that new agriculture locating near an established agricultural area is more likely to enjoy the benefits created by critical mass factors.

The relation to other agricultural lands factor of situation analysis was employed in an initial survey for a study of potential irrigable state lands in the State of Washington. In a fly-over survey by helicopter the surveyor upon not being able to see any other agriculture from a set altitude eliminated the parcel from those to be immediately studied in more detail.[91]

The size of the site will tend to offset many problems created by isolation. The area's size has a varying influence on suitability dependent on topography, site quality and degree of isolation. In suitability studies on existing agriculture land which the author participated in as a process consultant, the size has been set at anywhere between one section (640 acres—256 hectares) and four sections.

Transportation

The Framework considers improvement in the transportation system which has had a major impact on America's agriculture. This

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[90]Pritam S. Dhillon and Donn Derr, "Critical Mass of Agriculture and the Maintenance of Open Space," in Journal of the Northeastern Agricultural Economics Council, Vol. 111, no. 1, June, 1974.

[91]Personal conversation with staff members of the Department of Natural Resources, State of Washington.

improvement has allowed rather isolated areas such as the Imperial Valley to top the Eastern fresh vegetable market and for Idaho to become the "famous potato" state.

More recently the opening of the Lewiston, Idaho, seaport has caused an economic windfall for the Montana hard red wheat farmers. The role of transportation is easy to see at regional and national level. At a more local level, according to a National Cooperative Highway Research report, the existence of a paved road over dirt or gravel makes a tract of land much more suitable for farming than if it were only served by a dirt or gravel road.[92] In fact, according to the report, "The upgrading of a road from dirt to pavement appears to cause almost double the increase (in land being brought into production) that results from going from dirt to gravel."[93] Among the many attributes to agriculture that Winfrey and Zeller documented as being linked to better roads were:

1. Increase in real estate value;
2. decreases in vehicle operating costs;
3. greater ease in obtaining farm supplies;
4. higher weight loads are possible, meaning more tonnage to market and supplies obtained in larger bulk with discount savings possible;
5. increased accessibility to public facilities and utilities, including schools and to trade centers and social activities;
6. higher crop yields possible, with correlated increase in farm income;
7. lower costs of farm production through mechanization and economy in transportation;
8. increase market area;
9. greater latitude in crop type and rotation.

Though Winfrey and Zeller do report some disadvantages, such as higher taxes and more hunters, the evidence strongly supports the fact that

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[92]Robley Winfrey and Carl Zeller, "Summary and Evaluation of Economic Consequences of Highway Improvements," National Cooperative Highway Research Program Report 122, National Research Board, 1971.

[93]Ibid., p. 237.

a good all-weather road system does make an area much more suitable for farming.

Distance to Destination Point

Though relationship of distance to market and type of agriculture has been modified by modern transportation and decentralized processing it still is a factor to be considered in situation evaluation. Many commodities do not transport well and are tied to destination point proximity. Sweet corn is normally grown no more than 10 or 15 miles from a cannery or freezing process industry because the sugars break down swiftly when transported in hot weather. Horticultural crops are also normally tied to a processing or fresh-pack distribution company. Though studies do not seem to be available that give a guide to the maximum hauling distance, in discussions with processors of various types the mention of one-half hour, two hours, and one day were most often used; one-half hour for highly perishable commodities, two hours for less perishable commodities, and one day for perishable commodities that can be handled in bulk but are tied to a fresh market. Surprisingly milk and non-red meat (rabbits and poultry), two textbook examples of commodities most affected by the distance to market factor, are in the last long-haul category in the Intermountain West. Idaho and Utah are perhaps the fastest-growing dairy states. This is due partly to cheese processing, but some fresh milk goes as far as Arizona and California. For such commodities the quantity concept is very important. In order for a load of rabbits to travel the maximum distance, there must be a full load. Milk that is being transported by long distance goes in tandem tanks in order to be profitable, hence large volume is imperative.

Market Capacity

One of the most often heard comments against developing any more land in the Intermountain West is, it has a "potential for serious impact on existing farmers and ranchers. . .through market competition. . ."[94] The Framework only considers this factor in requiring that the user records destination points that are not at capacity. If the potential market is already being supplied and surplus exists, it may be difficult to establish any market for crops from new lands. Schermerhorn found this to be a major problem confronting new land in the Snake River Plains.[95] Schermerhorn pointed to the need to grow export crops most of which (such as potatoes and sugar beets) are hampered by being negatively elastic. As production costs go up, with increased energy and other costs, the price the farmers receive for that production declines at a faster rate. Schermerhorn made the assumption that the same commodity mix would be grown on new lands as on the existing lands. The emergence of oil seed and special crops for ethanol production may change that. However, Schermerhorn is correct in that the decision must be made on existing destination points within the equitable hauling distance of the new lands. The fact that a destination point is now being supplied does not necessarily mean it is closed. However, at the suitability step in land classification, destination points considered should definitely be able to increase their intake.

Availability of Electricity

The availability of electricity has become a large hurdle in the development of new land and consequently is a suitability factor considered in the Framework. Most new lands in the Intermountain West must depend on pumping and/or sprinkler irrigation. These are

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[94] Lonnie Rosenwald, "Pros and Cons of Farm Development Argued," Times News, Twin Falls, Idaho, April 22, 1979, p. B-4.

[95] Richard Schermerhorn, as quoted in "Desert Development Studied at Agricultural Lands Conference," The Idaho Conservation League Newsletter, Vol. 4, no. 3, March, 1977.

both high volume users of electrical energy. This once abundant energy source is no longer in surplus in the West. The supply of electricity is related to political policy. The availability of electricity is treated in a more site-specific manner in the Framework. It only questions: "Can ample electricity be supplied to the site to begin production?" The assumption must be made that any increases, brown-outs, or black-outs will affect all irrigators on the system. It was once assumed that a new user need only request that service be extended and it would be. However, this is no longer the case. Power companies and other utilities are becoming reluctant to extend their services.

ENVIRONMENTAL INFLUENCES

The Framework utilizes several factors of influence to relate how the prospective use of the site as cropland will impact the environment, "the environment" in this case being a physical condition as determined by social values. The factors of impact on or by conflicting adjacent or nearby land uses, conflicts with existing use, and environmental pollution are all physical phenomena measured by social values. Those who agree with the set values see the existence of conflict and pollution as fact. Those who don't find constraints based on such values to be mythical whims with no physical reality. What must be done is to base the criteria measuring environmental impact on the best substantiation available.

Relation to Conflicting Land Use

The Framework considers the presence of land-use conflicts as limitations to the suitability of a site for use as cropland. The noncompatibility of some land uses is a rather new concept in America. At least the attempt to do something about it is new. The multitude of battles over comprehensive land-use planning and zoning are ample evidence that the concept is not universally accepted. What is and is not compatible with cultivation agriculture is not necessarily universally accepted either. In many situations the answer to whether the use of a site for agriculture is compatible with land values is made for the decision maker by the government agency with jurisdiction. When it is not, the decision becomes more difficult. One guide of land-use compatibility that might be used is the development by Ian McHarg.[96] In his now famous work, Design with Nature, McHarg spoke to the "degree of compatibility" of various land uses. McHarg found the compatibility of row-crop agriculture to be:[97]

incompatible	low compatibility	medium compatibility	full compatibility
urban	fresh water recreational	suburban residential	other row-crop agriculture
active strip-mining	general recreational	industrial	arable agriculture
coal mining spoils	cultural recreational	shaft mining	livestock agriculture
quarrying			
sand & gravel pits			
vacation settlement			
forestry			
wilderness			
water shed management			

Source: Interpreted from Design with Nature.

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[96] Ian L. McHarg, Design with Nature, paperback edition, p. 144.

[97] Ibid.

Though this author does not necessarily agree with McHarg's segregation, the use of the four categories provides a useful tool.

After land uses are categorized as compatible or incompatible, the question of distance arises. How far away must an incompatible use be before it becomes tolerable? Let us look at urban as an incompatible use to cultivation agriculture. In the Rathburn suitability system, the suggested distance from priority I agriculture land and urban boundaries is one mile, or outside a city's area of influence (area of growth, area of impact, growth boundary, etc.).[98] In an agricultural land study in Oregon using the Rathburn system, this was set at two miles during the first phase of the study, because it was felt that the wind carried sprinkler irrigation drift and its insystem chemicals that far.[99] Later it was set back to one mile because of political considerations.

<u>Conflict with Existing On-Site Use</u>

One land-use compatibility factor considered by the Framework is the possibility of conflict with uses already established on the site.

To be concerned with whether a proposed use will impair or preclude the site from another use is somewhat contradictory to suitability analysis in the pure theoretical sense. However, in the Framework a site is analyzed as to its compatibility with the existing on-site uses. The variance from this theory is based on the premises that if society has already placed a high value on that area for another use, it should be considered early in any study

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[98]Arthur C. Rathburn, "Designation of Priorities for Land Use," Agricultural Economics series #166, University of Idaho Cooperative Extension Service, 1976.

[99]Bob Perry, "Agricultural Land Classification System for the West County Planning Unit Umatilla County, Oregon," Technical Staff Report No. 1, January 1978. Umatilla County Planning Department.

that would change that use. Also some uses are, as Hollingshead terms them, irreversible uses that cannot be returned to biotic productivity.[100] McHarg's compatibility list gives some idea as to which uses are incompatible with agriculture. Some of the uses seen in the list under incompatibility, such as wilderness, may be compatible if found as adjacent use but cannot share the same site.

The Framework considers a category of land-use impacts of "scientific" sites which includes such phenomena as archeology sites, and historic sites.

The Framework also considers critical and important wildlife habitat. This use may appear often in land evaluation studies in the Intermountain West. Those areas still in native vegetation that have sufficient soil to support good vegetative growth are becoming relatively limited. Large game animals depend on such areas for winter habitat and some endangered species, such as the golden eagle and prairie falcon, may lose their last foothold in entire regions if certain of these areas are brought under plow. Since our society has of late (perhaps too late) given value to such things, the presence of critical wildlife habitat may totally preclude use of the land at present for any other use.

Environmental Pollution

Agriculture normally does not appear on lists of land uses that cause pollution. However, it can be included in the list. McHarg lists water pollution, stream sedimentation and soil erosion as three serious consequences to using land for row-crop agriculture.[101] These consequences are preventable (or nearly preventable since some slight soil erosion will take place under

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[100] Anne H. Hollingshead, "A System Analysis Model for Minimizing the Flow of Biotically Productive Land into Irreversible Uses," unpublished Ph.D. Thesis, Oregon State University Geography Department, 1971.

[101] McHarg, op. cit.

intense agriculture no matter what preventive measures are taken), but are more difficult to prevent on some lands. These factors were mentioned in the section on site analysis, but are also listed here because agriculture may be suitable as far as site criteria indicate but due to the presence of an adjoining culturally valued phenomena even the slightest erosion cannot be tolerated. An example would be the headwaters of Silver Creek in Idaho. This stream's unique condition that brought it to fame as a fishing stream was being threatened by dry-land farming. Farming still takes place, but under management restrictions that affect its suitability as an agricultural area.[102] Some areas that may be subject to winds that would carry field dust causing safety hazards to highways or airports may be another example.

SOCIETAL INFLUENCES

This difficult to assess but important group of influences is most often ignored by land evaluators. As Fitzsimmons and Salama so aptly put it: "Too often in the past man's role has been restricted by the planner to that of a 'homo economicus,' that is, a producer and consumer of goods and services with prespecified objectives of utility and profit maximization."[103] Fitzsimmons with others has attempted to rectify this situation by producing several studies and manuals on social assessment. The most comprehensive of these is the "Social Assessment Manual" prepared for the Bureau of Reclamation which was referred to in the introduction of this chapter.

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[102]The author participated in several studies that concerned land use and its consequences on Silver Creek. Very wide stream bank buffer strips are now being used. Thus, otherwise usable land is not in production.

[103]Stephen J. Fitzsimmons and Ovadia Solana, Man and Water: A Social Report, p. iii.

This manual lists 361 social factors that should be analyzed as to how they will be impacted by water development plans. Whereas large water development projects may demand such a comprehensive study, this author is not prepared to suggest that the question of new lands needs such a study. One may ask, What would be the social impact of analyzing 361 social impact analyses?

The comprehensiveness of the social influences analysis is determined by the size of the project. The addition of one of two farms may prompt no more than an investigation as to the presence of the minimum health, safety and educational services for those families. A multi-section development may involve the inclusion of analysis of the impact on the community services and facilities by the increased loads created by the new development.

One of the more important of the social influences is the availability of labor. Being isolated from a labor source does not preclude farming, but it does place increased management problems which, in turn, can make farming that site less suitable.

GOVERNMENTAL INFLUENCES

In addition to the social impacts the Framework considers societal desires and governmental restraints as they affect the suitability of a site for use as cropland. Public desire is difficult to assess but has profound impact on the decisions concerning resources.

The Framework includes four levels of government in analyzing governmental restrictions. Each level has certain jurisdiction and/or influence on every land resource decision made whether it be by one of the other levels of government or by private citizens. The purpose here is to identify at each of the four levels of government that the Framework considers in the proposed decision-making process.

Local Government

Land is the only major resource in most western states that has been left to local government jurisdiction. Even with land-use jurisdiction, legislative trends have increased the role of state government. Nearly every county and city in the West either has a comprehensive land-use plan, or is working on one. None of the plans that this author has read or helped formulate as a consultant has a component that would directly prevent nondeveloped land from being converted to cropland. There may be, however, indirect impacts on the suitability of such land for conversion. This may be in the form of suggested transportation improvements or in suggested development plans that may create incompatible uses.

The private decision makers should consider these secondary impacts but need not find an area unsuitable for cropland conversion because of them. The state and federal agency person faced with the evaluation problem may be more constrained. The regulations by which he or she must abide may force compliance to local desire (legally described or only expressed by the legally constituted body).

The major body of influence factors that are dependent on or closely related to local government policy are situation influences such as availability of transportation facilities and social services and facilities. Local government, including its hidden component special districts, determine most of the policy that allows or prevents extension and improvement of social services. These factors were discussed in the chapter on situational criteria.

State Government

State governmental influence enters into the decision-making process in several areas. The most prominent of these is in the availability of water. States have the legally constituted right over water resources allocation and planning. This places their influence in a high priority at all levels of decision making, private through federal. In the case of decisions on federal lands, their role may be increased if the lands are to be converted to cropland through action in accordance with the Carey Act of 1894 (to be discussed in the role of the federal government).

State governments also may enter into the process, because of their jurisdictional responsibility over wildlife management. Critical and important wildlife habitat are most often identified by a state agency.

Some of the health, safety, and social services are provided for or regulated by state government. Groundwater contamination regulations are enforced by state health departments. The residential occupation conditions specified under the Carey Act may cause conflict with state health regulations or policy.

Regional Compacts and Interstate Agencies

The existence of a level of government between the federal and state level is a subject of much debate. However, since many resource decisions are made at that level the Framework includes it. The creation of river basin commissions, power authorities, and other multistate compacts and their subsequent activities has created an initial move toward extra-state resource regulation. As the intricate interdependencies of resource use become identified, the need for extrastate regulation becomes more plausible.

Whether the existence of this level, and regulations by it, is or is becoming fact, the regional viewpoint must be taken into account by decision makers, especially by federal agency persons. For example, it has been recently documented that an acre foot of water withdrawn upstream in the Columbia-Snake River complex will result in up to 200 dollars in energy costs, most of which is not borne by the farmer. Hamilton, after investigating this interdependence between water and power concluded:[104]

> The expansion of irrigated agriculture may involve a rather large social cost because of the actions of the average cost-pricing system used in setting electrical power rates. The water diverted for irrigation use reduces the power generation potential of the hydroelectric power plants. The water pumping and sprinkler pressurization also consumes large amounts of electricity. The cost of building thermal power plants to replace the energy used and that foregone is borne by all users of electricity in the region. The total energy cost due to typical development in Southern Idaho may be as much as 200 dollars per acre. Of that energy cost, some is paid by the new farmer, but the largest part of the cost is spread over all other users of electricity in the region.

Such impacts may not enter into the decision-making process on private projects, but governmental, especially federal, agencies cannot ignore it.

Federal Government

The federal government will play the lead role in the decision-making process of converting nondeveloped land to cropland because of jurisdictional responsibility over the largest acreage of the remaining nondeveloped land. The key federal agencies have been, and will most likely continue to be, the Bureau of Land Management (BLM) and the Bureau of Reclamation, both of the Departments of Interior. The BLM and its predecessor the General Land Office were created to administer the public lands not in national parks or forests until such time as they were ceded to state or local government jurisdiction, or to private ownership for use as cropland. The Bureau of Reclamation

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[104] Joel R. Hamilton, "Energy and the Growth of Irrigated Agriculture in Southern Idaho," unpublished paper presented at Idaho Conservation League Agricultural Conference, Twin Falls, Idaho, February 25-26, 1977, p. 12.

was established to give federal help on the provision of the necessary water delivery system for irrigation. The process of disposition of federal land to private ownership in the West has taken place largely under the legislative restrictions of the Homestead Act of 1862, The Desert Land Act of 1877, the Carey Act of 1889, and the Reclamation Act of 1902. To these were added a number of modifications; restrictive and supportive such as the Fact Finders Act, Timber Act, and Stone Act.

BLM's role has recently been altered by the so-called Organic Act (Public Lands Act) of 1978 that left in tact the earlier acts with exception of the elimination of the Homestead Act, but converted the Bureau's role from temporary to permanent manager of federal lands not under the jurisdiction of another federal agency. The implication of changing the BLM lands from being in temporary federal receivership to permanent federal management has not yet been assessed. The status of pending Carey Act and Desert Land Entry applications has not yet been determined in light of the changed federal land policy fostered by the Organic Act.

The policy waters have been recently more muddied by an Idaho State Supreme Court ruling. The Carey Act originally called for the deeding to the states of Arizona, California, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, and Washington 1,000,000 acres; to Colorado, Nevada, and Wyoming 2,000,000 acres; and to Idaho 3,000,000 acres of desert land to be disposed of to private citizens in 20 to 160-acre parcels for the purpose of irrigated agriculture.[105] Though by far the most successful state in terms of acres patented, Idaho has less than 700,000 acres actually patented.[106]

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[105] Bureau of Land Management, "Proposed Regulations for Segregating and Patenting Public Lands," 43 CFR part 2610.0-7, Federal Register, Vol. 42, no. 65, April 5, 1977.

[106] Roy E. Huffman, Irrigation Development and Water Policy, 1953, p. 23.

The alleged reluctance of the BLM to release more land was challenged by the State of Idaho. This challenge was upheld by the Idaho courts. This decision may force BLM to release over 2,000,000 acres of additional land.

Besides the BLM and Bureau of Reclamation several other agencies such as the Environmental Protection Agency, Bureau of Fish and Wildlife, the Forest Service, and the National Park Service may become involved in land conversion questions.

Of all the restrictions that exist in the federal land policy, perhaps the most controversial and influencial on the decision process involving disposition of federal lands are those placing acreage restrictions on patent parcels and the delivery of water. Lands that might otherwise be suitable for cropland might be restricted from conversion because of their questionable feasibility as "family farms" when held to only 160 acres in the case of Cary Act and Reclamation Act lands and 320 acres under the Desert Land Entry. These restrictions should not enter into the suitability analysis, however.

Acreage restrictions are a managerial problem that may or may not affect the economic feasibility. They do not make lands less suitable to farm. For example, nowhere in either act is the use of cooperatives that would eliminate most of the feasibility problems of small acreage prohibited.

SUITABILITY EVALUATION METHODOLOGIES

As has often been mentioned when one looks for evaluation systems that go beyond the physical evaluation of the site and the economic cost and benefit of the proposed uses, the search becomes long and the findings small. The draft Bureau of Reclamation instructions mentioned in the site evaluation discussion goes no further than to mention environmental and social relationships as being two of the relationships needed "for classification of the land for economic purposes."[107] It must be mentioned that the stated purpose of these instructions does not include social analysis. They do, however, emphatically stress the importance of environmental concerns. These concerns seem to be only expressed in the "homo economicus" syndrome terms mentioned by Fitzsimmons.

A method of "Evaluating the Social Benefit and Social Costs of Irrigation Development" was developed by Frederick Obermiller.[108] Obermiller relies heavily on Eckstein's 'with or without' principle, which utilizes the term 'benefit' in the concept of market value and alternative cost. Again, we have man as "homo economicus" and all impacts are on maximization of profit rather than minimization of negative impact. Obermiller's method is valid in economic impact analysis which is necessary in large projects, but it is misnomered.

A relatively new tool in analyzing the impact of any proposed action on the environment is the matrix prepared by Leopold <u>et al</u>.

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[107] Bureau of Reclamation, Reclamation Instructions series 110 Planning, Part 115, "Land Resources Investigations," Ch. 3, 2, A. (draft).

[108] Frederick W. Obermiller, "Evaluating the Social Benefits and Social Costs of Irrigation Development, unpublished paper presented to the Water Policy Advisory Committee, State of Oregon Legislature Committee on Trade and Economics Development, February 28, 1975.

as part of their procedure for evaluating environmental impact.[109] The matrix is far more comprehensive than the need for evaluating undeveloped land's suitability for cropland requires, but is a good check list of possible factors to be considered.

As mentioned, the most comprehensive check list of possible social factors is that of Fitzsimmons. It may be difficult to relate to land evaluation, but it does list in one table all social factors that may be impacted by new development.[110]

Between the various sources of information a very comprehensive list of all the situation evaluation influences can be assembled to meet the needs of and scope of any new development evaluation study.

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[109] Luna B. Leopold and Frank Clark *et al*., "A Procedure for Evaluating Environmental Impact," *Geological Survey* Circular #645, USGS.

[110] Fitzsimmons, Stuart and Wolff, *op. cit.*, Table 1, pp. 205-240.

CHAPTER IV

A FRAMEWORK FOR DETERMINING THE SUITABILITY OF UNDEVELOPED LAND FOR CROPLAND

This dissertation research was designed to develop a decision-making framework to identify and inventory all relevant data that impact the suitability of an undeveloped site for its use as cropland, to correlate these data into criteria indices, and to classify the land as to its suitability for conversion to cropland using these indices. At present no other such framework exists. As has been demonstrated in the preceding background material, there is at present not even a clear identification as to the data that need be considered in the new cropland development question. The preliminary research revealed that the lack of an acceptable decision-making framework that directs the decision process through a retraceable quantifying methodology has led to a general sense of frustration among the individuals that are involved in the process of determining whether specific parcels of undeveloped land are suitable for use as cropland.

This dissertation is concerned only with the undeveloped lands of the Intermountain West. The undeveloped lands with potential for use as cropland in this region are mostly in federal ownership and need irrigation. However, the Framework is designed for application to all undeveloped land regardless of ownership or irrigation need.

In developing this Framework several objectives were established:

1. The Framework needed to depend on data which were readily available to all levels of decision makers;
2. The Framework needed to utilize a set of simplified forms to standardize the process of inventory, analysis, and categorization of potential sites;

3. An allowance for the classification of sites into more than one degree of suitability needed to be included;
4. The Framework needed also to channel the study into a step-by-step process that not only guides the user, but allows the process to be retraced for the purpose of auditing.

These objectives were set to help guide this dissertation into a format that led to a research process dedicated to the advancement of land evaluation technique in a mode that might bridge the gap between applied and theoretical land resource study.

FRAMEWORK OUTLINE

The decision-making process devised for this dissertation for evaluating the suitability of an undeveloped site for use as cropland involves five steps as illustrated on Figure 5.

An important step in determining suitability is the identification of relevant data. In Chapter III, each of the factors established in the research as being necessary in the evaluation were identified and discussed.

Data Inventory

In order to guide the decision maker in the inventorying of data concerning each of these factors, an inventory check list-type format was developed. This form is found in the Appendix, where its use is demonstrated in a suitability study. The concept of inventorying needed data is not new, however the use of a form that allows all of the data by which the decision criteria can be analyzed to be presented in a standardized format was not found to exist in any of the studies reviewed, nor was the use of a form known to any of the resource specialists interviewed.

PROCESS FOR EVALUATING AGRICULTURAL SUITABILITY
OF UNDEVELOPED LANDS IN THE INTERMOUNTAIN WEST

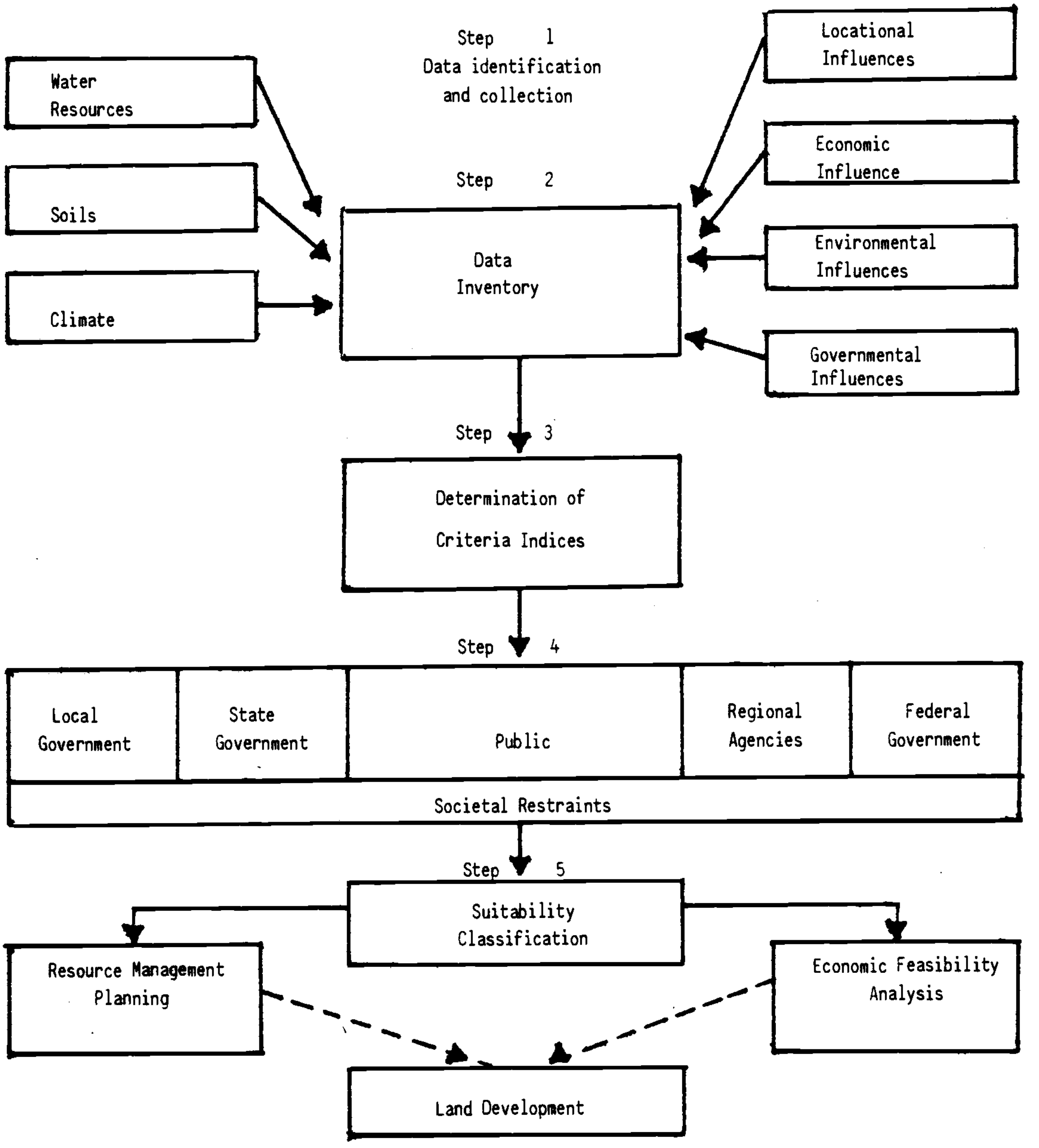

FIGURE 5

Determination Criteria Indices

In documents studied during the research, it seemed evident that the data inventoried in the suitability decision-making process were not standardized. In order to create an organized decision-making process that could be applied to all sites, criteria evaluation indices were devised. These indices are designed to collate the inventory data into objective, quantified criteria that can be used in the classification process. Each index quantifies relevant data into four degrees of value.

1. A value of one (1) indicates that a site has all of the factors needed to totally satisfy that suitability criteria.
2. A value of two (2) indicates that the site has some factor or factors that cause it to fall slightly short of totally satisfying that suitability criteria.
3. A value of three (3) indicates that the site has some factor or factors that moderately fail to totally satisfy that suitability criteria.
4. A value of four (4) indicates that the site has some factor or factors that severely fail to satisfy that suitability criteria.

Societal Restraints Evaluation

The decision-making Framework takes into consideration the part societal desires and regulation play in determining the suitability of a site for use as cropland. If the decision is being made at the private level, the decision maker must consider what restraints to conversion exist within governmental regulations. He or she must consider the local, state, regional, and federal governmental levels. If the decision is by a governmental agency the desires of the general public must be added to the need to assess governmental restrictions. The Framework quantified the general public and governmental response to a proposed conversion into four response levels (Figure 6).

SOCIETAL RESTRAINTS VALUE LEVELS

Response Levels				
General Public	Public in favor of conversion	Some interest group opposition expressed	Strong interest group opposition expressed	Public generally opposed
Local Government	No opposition	Some agency reservations expressed	Elected Officials opposed	Conversion legally restricted
State Government	No opposition	Some agency reservations expressed	Elected officials opposed	Conversion legally restricted
Regional Compacts Agencies	No opposition	Some agency reservations expressed	Conversion not in accord with resource plans	Conversion violates interstate agreement
Federal Government	No opposition	Some agency reservations expressed	Elected officials opposed	Conversion legally restricted

FIGURE 6

The higher the response level value the less suitable a site is for conversion to cropland. A response level of all ones (1's) indicates that conversion of the site to cropland is generally desired by the public and is in compliance with all levels of government regulation.

Suitability Classification

The final step in the decision-making framework is the provision of a methodology by which to classify a site as to its degree of suitability. Five suitability classes, including a nonsuitable class, are specified. Each class is designated by a Roman numeral preceded by the land-use code "PA" to designate "Proposed Agriculture." The suitability evaluation requirements are designed so that sites are classified at the suitability level at which all of the criteria meet or exceed the specified requirements. If any criteria fail to meet the requirement, the site is relegated to a lower suitability level.

Figure 7 is a visual interpretation of the evaluation process as dictated by the Framework for suitability evaluation. The remainder of the chapter is devoted to presenting the particulars of the Framework. The decision steps taken after the site has been classified as suitable are dependent on the situation. If the land is determined to be suitable the prospective user will then proceed to conduct an economic feasibility study. This is a difficult and expensive step which is one important reason for having preceded it with a suitability study. If the suitability study were carried out to provide some alternative data, the next step would then be to include it into the resource management planning process.

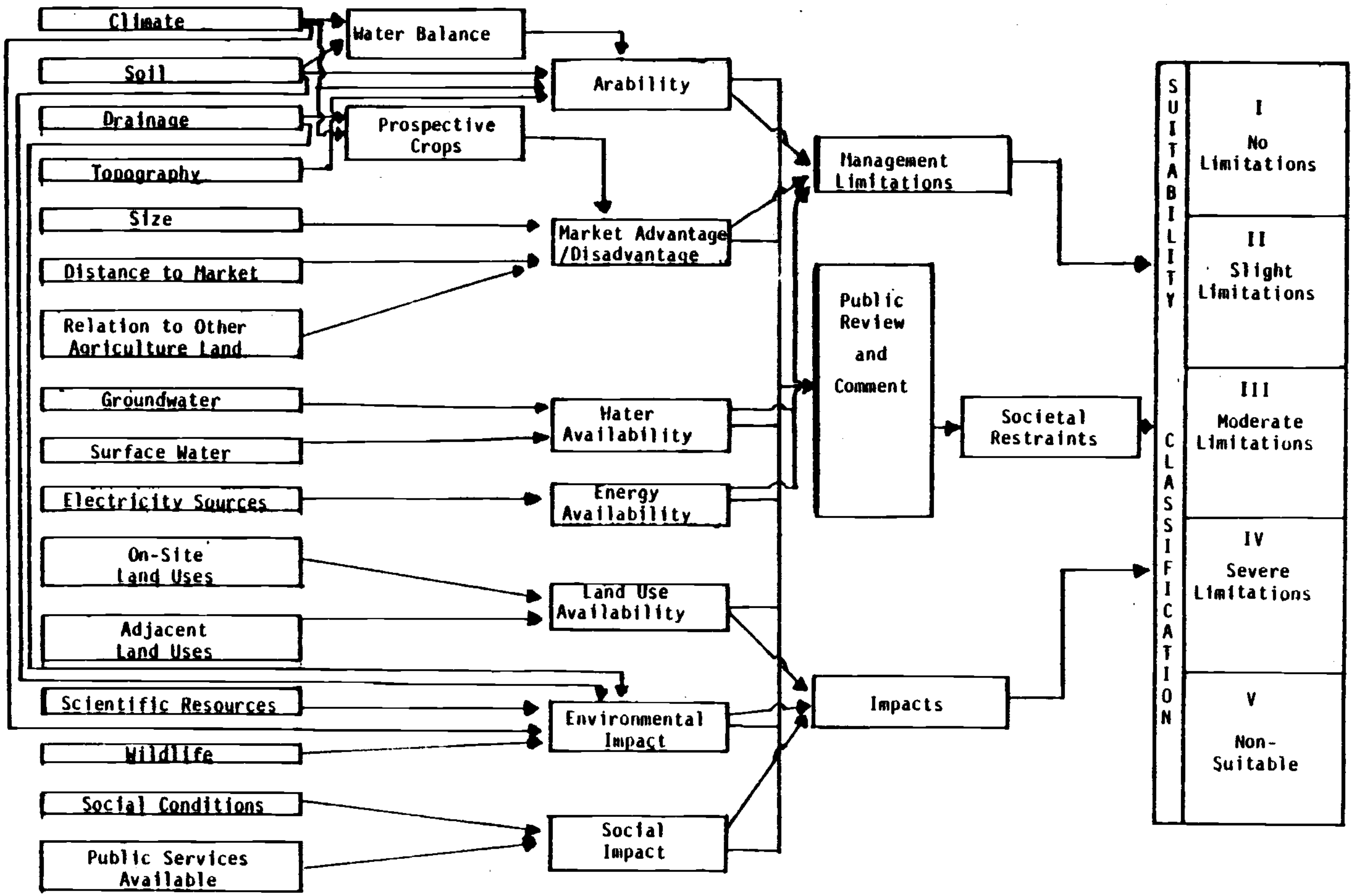

FIGURE 7: Schematic for Classification of Lands for Conversion to Cropland

CRITERIA INDICES AND SUPPORTING DATA

Seven criteria indices are required by the Framework in order to analyze an undeveloped site's level of suitability for use as cropland.

Criteria Indices and Their Code Letters

1. Arability (A)
2. Market Advantage/Disadvantage (M)
3. Availability of Water (W)
4. Availability of Electricity (P)
5. Environmental Impact (E)
6. Land-Use Compatibility (L)
7. Social Impact (S)
8. Societal Restraints (R)

Each index will be explained separately with a listing of the data needed to determine it. A completed data inventory of a case study is found in the Appendix, together with the forms for determining each index.

ARABILITY (A)[111]

The data considered needed to determine the level of arability of a site are:

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[111] The use of the arability index as suggested here can be hopefully soon replaced by a "productivity rating" system being developed by Dr. Herbert Huddleston, soil scientist at Oregon State University. Dr. Huddleston is just completing his productivity ratings for Willamette Valley, Oregon soils. His system was not used here because even though it appears to be a far superior index of productivity potential than the arability index it has not been completed and tested for arid soils.

1. Average precipitation in centimeters by month;
2. Average temperature in °C by month;
3. Water-holding capacity of soil;
4. Drainage ability of soil;
5. Soil texture;
6. Soil depth;
7. Percent of gravel and cobble in soil;
8. Surface stoniness;
9. Percent of surface covered with rock outcropping;
10. Permeability of soil;
11. Alkalinity and sodium conditions present in the soil.

The arability of an area is determined by a combination of these soil, drainage, and topographic conditions. There are five degrees of arability:

A1 Area has almost no limitations to cultivation
A2 Area has slight limitations
A3 Area has moderate limitations
A4 Area has severe limitations
A5 Area nonarable

The arability index is determined by the criteria combination in the following Tables 2, 3, and 4. There are three tables, one for non-irrigation land, one for gravity irrigation, and one for sprinkler irrigation. The table to be utilized is determined in part by the water balance present in the area. A positive water balance throughout the growing season indicates that no irrigation is needed. In such a case, Table 2 is utilized to determine arability. If a negative water balance occurs during the growing season, Table 3 or 4 is utilized and the highest index value is used in the classification process.

ARABILITY TABLE 2 IRRIGATION NOT NECESSARY

Soil or Land Criteria	A1	A2	A3	A4
Texture of root zone	Fine sandy loam to friable clay loam	Fine sandy loam to friable clay loam	Loamy sand and permeable clay	Sand with sufficient water holding capacity
Depth	40"	40" may include tillable hardpan or cliche	20"-40"	10"-20"
% Gravel or cobble	No problem to tillage	No problem to tillage	Slight problem to tillage	Cultivation not practical
Stoniness	Soil survey manual class 0	Soil survey manual class 1 w/v large stones scattered widely	Soil survey manual class 1	Soil survey manual class 2
Rockiness	0-2%	2-3%	not over 25%	Not over 25% if under 160 acres not over 50% if over 160 acres
Permeability	Moderately slow to moderately rapid	Moderately slow to moderately rapid	Slow and rapid	Rapid
Sodium and Alkalinity	don't exist	10% slick spots in complex	10-15% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%	25-50% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%

ARABILITY TABLE 3 IRRIGATION (GRAVITY)

Soil or Land Criteria	A1 g	A2 g	A3 g	A4 g
Texture of root zone	Fine sandy loam to friable clay loam	Fine sandy loam to friable clay loam	Loamy sand and permeable clay	Sand with sufficient water holding capacity
Depth	40"	40" may include tillable hardpan or cliche	20"-40"	10"-20"
% Gravel or cobble	No problem to tillage	No problem to tillage	Slight problem to tillage	Cultivation not practical
Stoniness	Soil survey manual class 0	Soil survey manual class 1 w/v large stones scattered widely	Soil survey manual class 1	Soil survey manual class 2
Rockiness	None	0-2%	2-3%	3-10%
Permeability	Moderately slow to moderately rapid	Moderately slow to moderately rapid	slow and rapid	rapid
Sodium and Alkalinity	don't exist	10% slick spots in complex	10-15% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%	25-50% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%
Slope	0-1%	1-2%	2-3%	3-5%
Relief	Nearly flat	Nearly flat	Gently rolling	Gently rolling
Drainage	Very good	Good	Poor	Marginal
Depth to sterile or impermeable layer	> 8 feet	> 6 feet	6 feet	4 feet

ARABILITY TABLE 4 IRRIGATION (SPRINKLER)

Soil or Land Criteria	$A1_s$	$A2_s$	$A3_s$	$A4_s$
Texture	Loamy sand	Sandy or fine sandv loam	Friable clay loam	Permeable clay
Depth	40"	20"-40"	20"-40" may include tillable hardpan or cliche	10"-20"
% Gravel or cobble	No problem to tillage	No problem to tillage	Slight problem to tillage	Cultivation not practical
Stoniness	Soil Survey manual class 0	Soil survey Manual Class 1 w/v large stones scattered widely	Soil survey manual class 1	Soil survey manual class 2
Rockiness	0-2%	3-5%	6-10%	Not over 25% if under 160 acres not over 50% if over 160 acres
Permeability	Rapid	Very rapid or moderately rapid	Moderately slow	Slow
Sodium and Alkalinity	Don't appear	10% slick spots in complex	10-15% slick spots in complex or exch. sodium up to 15%	25-50% slick spots in complex or exchange sodium up to 15%
Slope	0-2%	3-5%	6-10%	12-20%
Relief	Nearly flat	Gently rolling	Rolling	Rolling
Drainage	Very good	Good	Good	Poor
Depth to sterile or impermeable layer	>8 ft.	>8 ft.	8 ft.	4 ft.

Water Balance

To determine the water balance, a water balance table must be calculated. Water balance is determined by the formula

$$B = (P + 1/2h) - E$$

B = water balance
P = precipitation
h = water-holding capacity
E = potential evapotranspiration

To maintain a positive water balance, necessary for plant growth, the monthly precipitation plus one-half of the water-holding capacity (that portion of the soil water readily available to plants), must be in excess of the volume of moisture lost through evapotranspiration during the growing season.

Evapotranspiration is calculated using Thornthwaite's formula of

$$E = 1.6\ (10T/I)^{a}$$

where E is the monthly potential evapotranspiration in centimeters, T is the mean monthly temperature in degrees centigrade, a is a constant that varies from place to place, and I is the annual heat index.

The annual heat index or I is the sum of twelve monthly heat indices i, and:

$$i - (T/5)^{1.514}$$

To evaluate a, the following equation is used:[112]

$$a = 0.000000675\ I^{3} - 0.0000771\ I^{2} + 0.01792\ I + 0.4239$$

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[112] Jen-Hu Chang, Climate and Agriculture: an ecological study, p. 149.

After precipitation and evapotranspiration are established for each month of the growing season the first month when evapotranspiration exceeds precipitation is determined. The excess evapotranspiration not being replaced by incoming precipitation is subtracted from the readily available soil water (1/2 water-holding capacity of the soil). This process is continued month-by-month until all of the readily available soil water is used up or precipitation again exceeds evapotranspiration. When readily available water reaches zero for further plant growth irrigation is assumed to be required. In other words, when the water balance becomes negative, irrigation is necessary.

MARKET ADVANTAGE/DISADVANTAGE (M)

The market advantage/disadvantage is a relative indicator of economic advantage or disadvantage as created by the combination of size and distance from crop destination points. The data considered necessary to determine whether an area has a market advantage or disadvantage are:

1. The size of the area,
2. The traveling time for a round trip by truck (loaded one way) to:
    a. nearest existing cropland,
    b. nearest major agricultural area,
    c. destination points for the crops most likely to be grown on the site.
3. Possible crop rotations.

The market advantage/disadvantage is based on the assumption that a large-size agricultural area close to the crop destination points for enough crops to maintain a crop rotation that is beneficial to the condition of the soil will have a market advantage on sites that do not possess all of these qualities. It is also assumed that size and distances are off-setting factors.

There are five market advantage/disadvantage indices:

M1 Either

A. If under 640 acres (256 ha):

1. area must be adjacent to a major agriculture area;
2. area must be within one hour of crop destination points for every crop in a good rotation.

B. If over 640 acres:

1. area must be within one hour of crop destination points for every crop in a good rotation;
2. area must be within half-hour of a major agricultural area.

M2 Either

A. If over 1280 acres (512 ha):

1. area must be within one hour of a major agricultural area;
2. area must be within two hours of crop destination points for every crop in a good rotation.

B. If between 640 and 1280 acres:

1. area must be adjacent to existing cropland of at least 640 acres or within one hour of major agricultural area;
2. area must be within two hours of crop destination points for all crops in the rotation.

C. If under 640 acres:

1. must be adjacent to major agricultural area;
2. must be within one hour of at least one crop destination point for a crop in a good management rotation.

M3 Either

A. If over 2560 acres (four sections, 1024 ha):

1. area not over two hours from a major agricultural area;

2. not over two hours from at least one crop destination point for one crop in rotation.

B. If between 1280 and 2560 acres:

1. area not over half-day from a major agricultural area;

2. area must be within half-day of crop destination points for all crops in rotation.

C. If between 640 and 1280 acres:

1. area must be within two hours of major crop destination point for a crop in a good management rotation;

2. area must be within two hours of crop destination points for at least one crop in rotation.

D. If under 640 acres:

1. area must be within one hour of major agricultural area.

M4 Either

A. Area must be over 2560 acres.

B. If between 1280 and 2560 acres, area must not be over half-day from a major agricultural area.

C. If between 640 and 1280 acres, area must not be over two hours from a major crop area.

D. If 640 acres or less, area must not be over two hours from a major crop area.

M5 Area fails to reach requirements of M1-4.

WATER INDEX (W)

The water index is a relative indication of the availability and quality of the prospective water supply. The data considered needed to determine a water index value are:

1. depth to water table;

2. vertical and horizontal distance to surface water source;

and 3. water quality.

The water index is not a statement of actual availability because that is dependent on political and legal status. It also is not an indicator of economic feasibility. It is only a relative indicator of the difficulty of providing water of a satisfactory quality to a given site of land. Water index is directly related to pumping lift and mile transport. For groundwater the water availability is expressed in feet of lift. For surface water, the water availability factor is to be determined by the formula:

$$a = 1 + (d.8.3)$$

a = availability
1 = lift
d = distance
8.3 = a constant to be used to indicate a transport cost

The average cost of surface system installation need not be calculated to determine suitability. However, a recent study cited a typical cost for a foot of lift to be 12% of the cost to build a mile of surface transport system for the same volume of water.[113] Thus, for surface water the constant of 8.3 is utilized to indicate the added burden on needing to import water.

Once the groundwater availability and the surface water availability are established the lower of the two values will be compared to the average pumping lift in the region. Is the projected cost above average, average, or below average? Using this comparison and the water quality values, a water index can be set in the following manner:

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[113] Norman R. Whittlesy and Walter R. Butcher, "Irrigation Development Potential in Washington," College of Agriculture Research Center Circular #579, Washington State University, February 1975, p.4.

W1 Must meet all requirements:

1. water availability must be below regional average lift;
2. salinity classification of no higher than C-1;
3. sodium classification of no higher than S-1;
4. water must be potable if area must accommodate a dwelling.

W2 Must meet minimum requirements:

1. water availability must be approximately regional average lift;
2. salinity classification of no higher than C-2;
3. sodium classification of no higher than S-2;
4. water must be potable if area must accommodate a dwelling.

W3 Must meet minimum requirements:

1. salinity classification of no higher than C-3;
2. sodium classification of no higher than C-3;
3. water must be potable if area must accommodate a dwelling.

W4 Any one of below:

1. salinity classification of C-4;
2. sodium classification of S-4;
3. water not potable if area must accommodate a dwelling.

ELECTRICITY AVAILABILITY INDEX (P)

The significance of the physical availability of electrical power to a site varies as to whether that site is to be irrigated or not and as to the type of irrigation to be used. The electrical index (indicated with a "P" for power) is dependent on data indicating whether three-stage electrical power lines able to add the load are present on the site, near to the site, or if neither, whether it is even available in the region without construction of new power facilities.

The electrical availability index consists of four value levels that are relative indicators of the physical relation between the site and an electrical power transport system. The levels are:

P1 Three-stage electricity power lines with adequate reserve to carry an average per-acre irrigation demand load for a site of that size are present at the site.

P2 Three-stage electricity power lines with adequate reserve to carry an average per-acre irrigation demand load for a site of that size can be readily extended to the site.

P3 Three-stage electricity power lines are not readily available, but excess power is available in the region.

P4 Until new generating facilities are constructed, no electrical power is available in the region to new large demand load users.

ENVIRONMENTAL IMPACT INDEX (E)

The environmental impact index is a relative indicator of negative environmental impact which might result from conversion to cropland, this affects the suitability of the land for use as cropland. The Framework quantifies these impacts in order to compare and collate the various types of impact and arrive at one environmental impact index. It has been assumed that environmental quality is degraded by impacts on socially valued phenomena such as wildlife resources and scenic quality as well as by soil erosion and water pollution. The Framework contains five impact factors:

1. Erosion potential
2. Climate hazard
3. Impact on aquifer
4. Impact on wildlife
5. Impact on scenic value

Erosional Potential

The erosional potential is assessed from soils data and is given ratings in the standard soil survey report. These ratings assess the potential for erosion to take place if the native vegetation is removed. The values established in the Framework for erosion hazard ratings are:

0 - Extreme hazard potential
1 - Very severe hazard potential
2 - Severe hazard potential
3 - Moderate hazard potential
4 - Slight or no hazard potential

Climate Hazard

The climate factors that are utilized in the determination of the criteria measuring the impact of climate on suitability go beyond the normal fluctuations in the climatic conditions. The climatic factors are determined by an analysis of the frequency of the probable occurrence of tornadoes, very high winds, unseasonal snows, hailstorms, and floods. Climate hazard values are expressed for each of the above phenomena as:

0 - Extreme phenomena expected on the average of once every two years.
1 - Very severe phenomena expected on the average of once every four years.
2 - Severe phenomena expected on the average of once every six years.
3 - Moderate phenomena expected on the average of once every ten years.
4 - Rare - chances are this phenomena will not occur the next twenty years.

Impact on Aquifer

The environmental impact index is affected by any probable degradation that might occur to the aquifer due to conversion to cropland. A value is given to the factor of impact on the aquifer as:

0 - Very negative - The data indicates that use of the land as cropland will cause total disruption to some of the existing uses of the aquifer.

1 - Negative - The data indicates that use of the land as cropland will cause some of the existing uses to receive a decreased benefit from the aquifer.

2 - Possible negative - Though no conclusive evidence exists, the data suggest that an unacceptable impact will occur to the aquifer because of use of the land for cropland.

3 - Possible local impact - Data indicates pumping may cause local drawdown that could affect adjacent users.

4 - No impact - No data exists that indicates any significant impact will occur to the aquifer due to the land being converted to cropland.

Wildlife Value

The possible impact of the use of the site for cropland on the wildlife that utilizes the area is considered in the Framework in the determination of the environmental relations criteria value. The impact level given to the factor depends on data that indicate the possible loss of habitat, the relative importance of that habitat, and the population of the species whose habitat might be destroyed. The impact levels are determined as follows:

0 - Extreme - Habitat that is important to the survival of the local population of an endangered species would be destroyed.

1 - Very severe - Habitat that is important to the survival of the local population of a threatened species would be destroyed.

2 - Severe - The conversion would have a possible negative impact on a local population of an endangered or threatened species.

3 - Moderate - Important habitat for the survival of a regionally valued common species would be destroyed (i.e., sage grouse, drumming grounds, mule deer wintering area).

4 - Slight - None of the above.

Scenic Value

The importance of the site as to its scenic value that would be altered upon conversion has an impact on the environmental value of the site and is therefore considered in the Framework as a factor in determination of the criteria for conversion which addressed environmental impacts. The value placed on the scenic quality of the area depends on the perception of the uniqueness of the site's visual qualities. The factor value scale is determined in the Framework as such:

0 - Regionally unique - Site has a scenic quality that is significantly different from any other site in the region.

1 - Regionally rare - Site has a scenic quality that is only found in a few places in the region.

2 - Locally unique - Site has a scenic quality that is significantly different from any other site in the local area.

3 - Uncommon - There are not many sites in the region with the scenic qualities of the site.

4 - Common - The site has no special scenic qualities that attract local or regional interest.

Determination of Environmental Impact Index

The Framework utilized the values given above for the five impact factors to determine the site degree of satisfying the suitability requirement dependent on the possible environmental impacts that might result from use of the land for cropland. The impact levels for this criteria are determined by the index below:

E1 - No more than one factor valued at level 3.

E2 - Not over one impact factor valued at level 2.

E3 - At least one impact factor valued at level 1 or three factors valued at level 2.

E4 - At least one impact factor valued at level 0 or three or more factors valued at level 1.

LAND USE IMPACT INDEX (L)

The decision-making Framework to determine the suitability of undeveloped land for use as cropland utilizes a value index to indicate the degree to which an undeveloped site, if converted to cropland, would be compatible to existing on site and adjacent land uses.

In order to assess the compatibility of cropland to the present land-use situation data on the present land use and adjacent uses must be inventoried. The data needed are:

1. A list of all adjacent land uses and the compatibility of cropland as a neighbor to these uses.
2. A list of on-site land uses, not including recreation, and their compatibility to cropland.
3. Assessment of the uniqueness of the site for recreation.
4. List of any scientific value the site may have and their size.
5. List of any known mineral rights that are held in the area and the size of any area that could be removed from cropland for mineral extractions.

Land-Use Compatibility

Land-use compatibility is for the most part a local perception. The decision maker must develop a compatibility list to fit the societal environment the land is in. McHarg's work that was mentioned during the discussion on evaluative criteria could be used as a guide but only as that. Local interpretation is necessary. In data collection adjacent land as used in the Framework can be interpreted as being within a distance that could create or receive specific negative impact. The Framework sets a value on adjacent land-use compatibility as follows:

0 - Incompatible - uses cannot co-exist.

1 - Low compatibility - uses can co-exist but at least one if not both uses would lose significant quality.

2 - Medium compatibility - uses can co-exist but not at same quality level.

3 - Full compatibility - uses can co-exist without declining in quality.

The Framework sets a value on on-site land use as follows:

0 - Severely incompatible - conversion to cropland would cause the loss of a use that is critical to local economy.

1 - Moderately incompatible - conversion to cropland would cause the irreversible loss of an important use to the local economy.

2 - Slightly incompatible - conversion to cropland would create hardships to individuals in the community because of loss of the area for another use.

3 - Full compatibility - no present use would be lost due to conversion to cropland.

Recreational Use Value

The Framework separates the recreational use of the site from other land use because of the difficulty to place values that depend on economic loss of recreational land use. Instead of a factor value scale based on economic loss a scale based on uniqueness is utilized.

0 - Unique - site provides recreational possibilities that is not found anywhere else in the region.

1 - Rare - Site provides recreational possibilities found only in a few places in the region.

2 - Uncommon - Site provides recreational possibilities found only in a few places in the area.

3 - Common - The site does not provide any recreational possibilities that are not possible in many places in the area and region.

Scientific Value

The criteria measuring the function of land-use impact in determining suitability of undeveloped land for use as cropland is partly dependent on the percentage of land that can be farmed. In the arability index the loss of cultivatable land to rock outcroppings and stoniness were considered. Land can also be denied use as cropland because of the presence of scientific valued phenomena such as an archeological site or a unique vegetational cover. The decision Framework treats these phenomena in the same manner as physical barriers to cultivation. Factor values for these phenomena depend on the percent of land lost to potential cultivation.

0 - Extreme limitation - 50% or more of the land is not able to be cultivated.

1 - Severe limitation - 25 to 50% of the land is not able to be cultivated.

2 - Moderate limitation - 10 to 25% of the land is not able to be cultivated.

3 - Slight limitation - less than 10% of the land is not able to be cultivated.

Mineral Value

In the Intermountain West conflicts between agricultural land uses and mineral extraction are not uncommon. The Framework treats potential mineral extraction the same as scientific values. The same factor values are utilized (i.e., 0 - Extreme limitation - 50% or more of the land is not able to be cultivated).

Determination of Land-Use Conflict Index

The land-use impact index consists of five criteria levels that depend on the values given the factors of land use.

L-1 No negative impact - all factor values of 3.

L-2 Slight negative impact - at least one factor value of 2.

L-3 Moderately negative impact - at least one factor value of 1 or three factors valued at level 2.

L-4 Severe negative impact - at least one value of 0 or two factor values of 1.

SOCIAL IMPACT INDEX (S)

The Framework for Determining the Suitability of Undeveloped Land for Cropland considers the social effects of converting new land to cropland. The social effects are to be recorded in the data inventory by means of the +/- basis discussed in Chapter III. The factors of local service, local economic base, local government revenue and regional impacts are rated as to their relative impact as defined below:

++ very positive
\+ positive
0 neutral
\- negative
-- very negative

This rating system expresses the direction of the impact as well as the magnitude of the impact. The criteria values placed on social impact are determined by the comparison of negative to positive values:

S1 Positive impact - No minus minus (--) values and pluses outnumber or equal minuses (++ counts as two ++'s).

S2 Slight impact - No minus minus values or minus values slightly outnumber plus values.

S3 Moderate impact - Not more than one minus minus value or minus strongly outnumber pluses.

S4 Severe impact - more than two minus minus values that are not balanced by plus plus values.

SOCIETAL RESTRAINTS INDEX (R)

The decision-making Framework adds a dimension to the conversion process that was found to be missing from the processes that were analyzed during the dissertation research. In land resource decisions societal desires and restraints play an important role. This role, however, is seldom or never clearly spelled out as to how it fits with the data analysis portion of land resource devision-making processes. This dissertation presents within the Framework a value determinant index that provides criterial levels for assessing societal restraints that can be used in classifying the suitability of undeveloped land for use as cropland. The societal index enters into the process as carried out at the governmental decision process. However, the private developer who is deciding whether to develop lands need only consider that portion of the societal restraints index concerned with governmental response. Public opinion may be channeled through governmental expression, but until it is, it may not affect the decisions made at the private level.

The Framework provides a means for the decision maker to place numerical values on public desire and governmental restraint. These values are then utilized as criterial determinants in arriving at the suitability classification. For societal restraints there are four value levels:

1. Positive response - Public is in favor of the area becoming cropland and there is no opposition to the proposition from any government level.
2. Slightly negative response - Some interest group expresses some opposition or a governmental agency expresses reservations about the land being used as cropland.
3. Moderately negative response - A large interest group expresses opposition or a body of elected officials express opposition.
4. Severely negative response - The public is generally opposed to the land being used as cropland or the conversion violates legislated regulations.

INDEX	CODE	1	2	3	4
Arability	A	no limitations	slight limitations	moderate limitations	severe limitations
Market Advantage/Disadvantage	M	advantage	slight disadvantage	moderate disadvantage	severe disadvantage
Water	W	excellent quality readily available	good quality available	medium quality available with difficulty	poor quality available with great difficulty
Electricity Availability	P	available on site	available near site	possibly available	not available
Environmental Impact	E	no negative impact	slight negative impact	moderate negative impact	severe negative impact
Land Use	L	full compatibility	medium compatibility	low compatibility	very low compatibility
Social Impact	S	positive impact	no impact	moderate negative impact	severe negative impact
Societal Restraints	R	positive response	slightly negative response	moderately negative response	severe negative response

FIGURE 8 CRITERIAL VALUES FOR RESOURCE, IMPACT SOCIETAL RESTRAINTS INDICES

SUITABILITY CLASSIFICATION

An important objective of this dissertation was to allow for the classification of sites into more than one degree of suitability. The Framework determining the suitability of undeveloped land for cropland therefore provides five levels of classification. Each suitability class is determined by a set of three requirements based on the criteria values determined in the data correlation phase of the Framework. It must be reiterated here that the suitability classification is not a determinant of highest and best use, but rather only an indicator of the suitability of that given site of undeveloped land for use as cultivated cropland. Any site may have high suitability for several uses and the determination of suitability does not guarantee economic feasibility. It does, however, give a relative indication of a site's ability to, under proper management, compete with lands of equal suitability.

In the Framework, each of the five suitability classes is designated by a Roman numeral, with suitability I lands being the highest category. In order to distinguish potential use as cultivated agricultural land from other suitability designations the code PA is utilized.

PAI - Highly suitable - The sites classified as PAI have very slight, if any, limitations on their being converted from their present undeveloped state to cropland.

PAII - Very suitable - The sites classified as PAII have only a few limitations on their being converted to cropland.

PAIII - Suitable - The sites classified as PAIII are suitable for cropland, but have significant limitations that must be negated by above-average management applications.

PAIV - Moderately suitable - The sites that are clasified PAIV are what may be termed marginal land. They are suitable, but very strong limitations to their use as cropland exist.

PAV - A site having a classification of PAV has been found to possess such strong limitations due to physical lack of societal restrictions that it must at present be considered not suitable for use as cropland.

Requirements

For any site to be classified at any of the suitability levels the Framework sets the following minimum requirements:

PAI - must have received all criteria level 1 designations on the resource and impact indices including societal restrictions.

- PAI = A1 + M1 + W1 + P1 + E1 + L1 + S1 + R1

PAII - the Arability critieria value plus the Market Advantage/Disadvantage criteria value equal not higher than 3.

- A + M = <4

- The Water criteria value plus Electricity criteria value equal not higher than 3.

- W + P = <4

- The criteria values from the indices for Environmental Impact. Land Use and Social Impact added together equal no higher than 4.

- E + L + S = <5

- The Societal restrictions index criteria value no higher than R2.

PAIII - the Arability criteria value plus the Market Advantage/Disadvantage criterial value must not exceed a total of 4.

- A + M = <5

- the Water criteria value and the Electricity criteria value must not total more than 4.

• W + P = <5

- the criterial values from the indices for Environmental Impact, Land Use, and Social Impact must total no higher than 6.

• E + L + S = <7

- the Societal restriction criteria value must not exceed R2.

PAIV - the Arability criteria value plus the Market Advantage/Disadvantage criteria value must not total more than 5.

• A + M = <6

- the Water criteria value plus the Electricity value total no higher than 5.

• W + P = <6

- the Societal restrictions criteria value does exceed R3.

PAV - the site fails to qualify for any of the classifications PAI through PAIV.

CONCLUSION

The Framework for Determining the Suitability of Undeveloped Land for Cropland is a decision-making process which identifies, organizes and quantifies relevant data to allow an undeveloped site to be categorized as to its suitability for conversion to cropland into five standardized classes. It was developed to fill a void in the resource decision-making process identified during the author's work with Bureau of Land Management personnel. The focus of this dissertation is on the Intermountain West region of the United States. The Framework meets the predetermined objectives of:

1. The Framework needed to depend on data which were readily available to all levels of decision makers.
2. The Framework needed to utilize a set of simplified forms to standardize the process of inventory, analyzation, and categorization of potential sites.
3. An allowance for the classification of sites into more than one degree of suitability needed to be included.
4. The Framework needed also to channel the study into a step-by-step process that not only guides the user but allows the process to be retraced for the purpose of auditing.

The Framework has been used to classify several areas being considered for transfer to private ownership for use as cropland from its present status as federal rangeland. Appendix A is an abbreviated example of one study.

The Framework serves to condense into a practical applied tool a large body of technical data. It allows nonspecialists to comprehensively analyze and classify undeveloped land as a resource suitable to support use as cropland.

Though organized to utilize data that are readily available in the Intermountain West, it is designed to be flexible enough to allow inclusion of new better resource data when it becomes available.

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APPENDIX

APPENDIX A

The Framework for determining suitability of undeveloped land in the Intermountain West for use as cropland was developed over a period of years in which I was able to participate in several decision-making processes involving the conversion of undeveloped lands to cropland. Most of the processes involved a proposed transfer of federal land to private ownership by means of the Carey Act or the Desert Land Act. My role, other than as observer, was the training of BLM personnel in methods which would increase the effectiveness of the citizen participation portion of the process.

To illustrate use of the dissertation, Framework for the Determination of the Suitability of Undeveloped Land for Use as Cropland, this Appendix is an actual evaluation using the Black Pine Valley Desert Land Entry Proposal. The Black Pine proposal was submitted to the Bureau of Land Management and was reviewed in 1977 by the District Manager of the Burley District. I was allowed to review all of the files and data concerning this proposal, and to sit as an observer through all of the public and closed meetings concerning it.

The dissertation Framework was not developed until after the Black Pine Review was completed. Therefore, the following study is a simulation of the process dependent on the data collected during the original study. Where data were incomplete, I used my judgment based on knowledge of the area and my interpretation of the public and governmental comments received during the review process to estimate the missing information.

The evaluation presented here depicts the inventory and inventory collation indices as revised after the public and governmental review process. None of the public hearings or written comments are included as such information is for the most part available in the "Black Pine Desert Land Entry Environmental Assessment Record," August 1977, available from the BLM District Office, Burley, Idaho.

BLACK PINE VALLEY
DESERT LAND ENTRY PROPOSAL

(A simulation applying the Framework for Suitability Determination)

The proposed action is to classify approximately 5,148 acres of Public Land in Black Pine Valley, Idaho, as to its suitability to be converted from its present status as rangeland to private ownership for use as cropland. The proposed land has been filed on under the provisions of the Desert Land Act. Though several separate filings are involved, this analysis will consider the total proposed project to give a more realistic analysis of the entire development on the Black Pine Valley environment in comparison to individual analysis of each 320-acre entry.

GENERAL INFORMATION

"Twenty applicants have filed desert land entries on approximately 5,148 acres of Public Land in Black Pine Valley. The applications lay within portions of 4 townships: T. 15 S., R. 30 E., T. 16 S., R. 30 E., T. 15 S., R. 31 E., and T. 16 S., R. 30 E., Boise Meridian. All of the applications were filed during the period of May 1975 through October 1975. One of the parcels has been filed on by three different applicants making a total of twenty applications filed on 18 different entries. Figure 5 shows the general location, Figure 6 the scattered nature of the entries. This pattern resulted from the fact that the parcels filed on are Public Land that is classified for multiple-use management but is not, as are most multiple-use classifications, segregated against the filing of desert land entry applications. The surrounding Public Lands are not subject to disposition except by exchange as they are LU or Bankhead Jones lands." (This section is taken verbatum from the BLM Black Pine Desert Entry Environmental Assessment Record.)

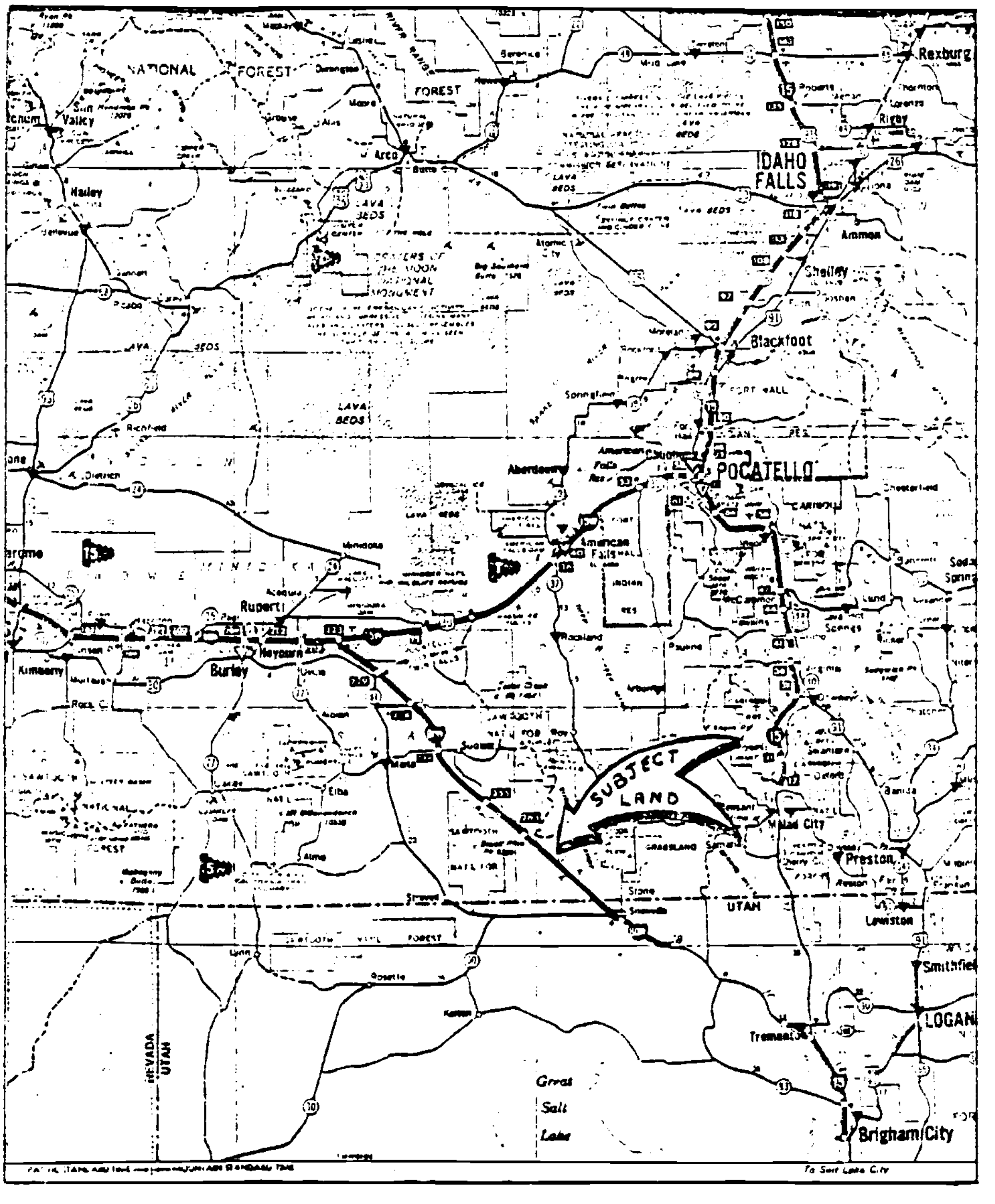


FIGURE 5

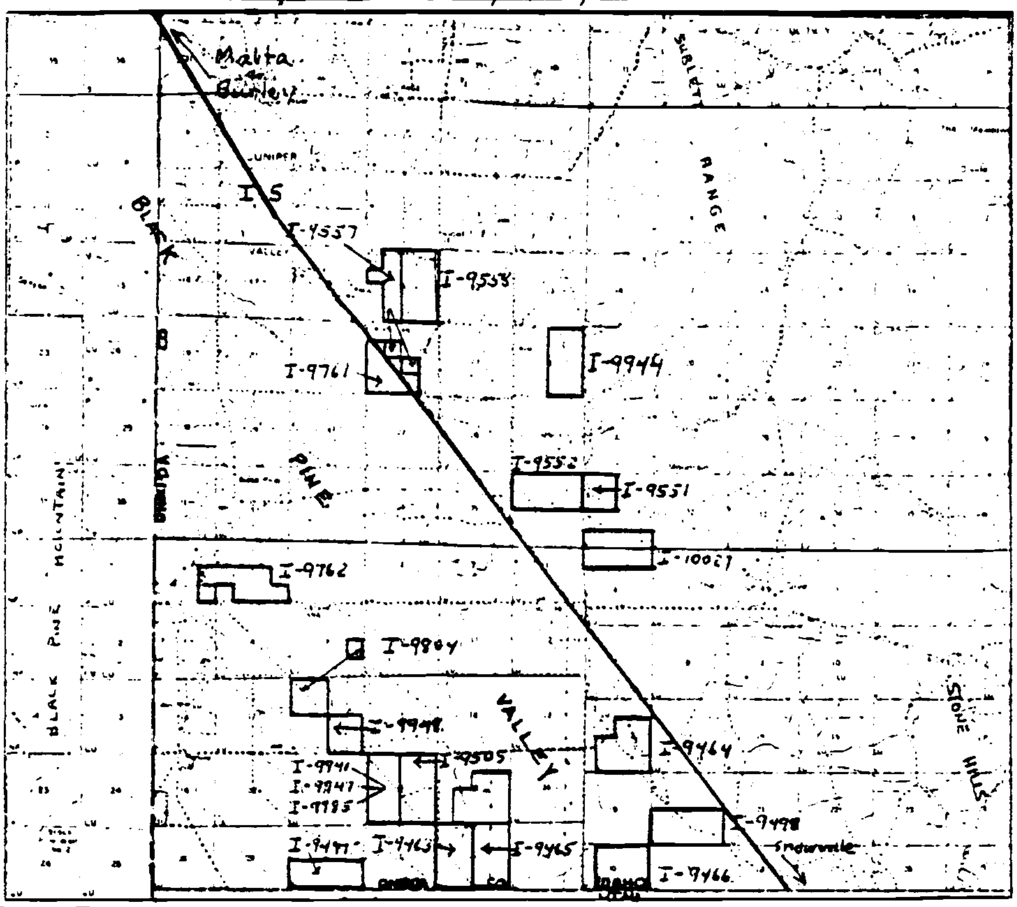
General Location, Black Pine Valley

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

SITE PLOT

Serial Number

Township 15/16 S, Range 30/31 E, Boise Meridian



LAND OWNERSHIP KEY AND ADDITIONAL TOPOGRAPHIC SYMBOLS		Scale: 1" = 2 Miles
Public Land		OTHER DATA
Public Land (Bankhead-Jones)		
Private Land		
Forest Service		
Subject Desert Land Entry Applications		

SITE PLOT

Form 2060-2 (January 1975)

FIGURE 6

Location of the Applied-For DLE Tracts in Black Pine Valley

FRAMEWORK FOR DETERMINING THE SUITABILITY OF UNDEVELOPED LAND FOR USE AS CROPLAND

CRITERIA INVENTORY

Fill in the following criteria inventory. The inventory contains all of the data needed to complete the Framework. The data needs are divided into the categories of climate, water, soils, topography, economic, land use, and social. Use the most current data available. Where current data is not available consult knowledgeable agencies or individuals.

Accompanying the form must be the justification, clarification, or reference for the data recorded on the form. Refer this information to the number under which the datum referred to appears on the form.

EVALUATION CRITERIA INVENTORY

CLIMATE

	J	F	M	A	M	J	J	A	S	O	N	D
1. Ave. precipitation in centimeters	2.8	2.1	2.9	3.1	4.0	2.4	1.2	1.4	1.8	2.4	2.5	2.7
2. Ave. temperature in degrees centigrade	-5.6	-2.8	1.6	6.6	11.1	15.1	15.1	20.6	20.0	7.8	1.6	-4.5

3. Ave. number of days between killing frosts 122

4. Ave. number of growing days 100

5. Probability of climate hazards

	extreme	very severe	severe	moderate	rare
a. tornado					X
b. very high winds			X		
c. unseasonal snow			X		
d. hailstorms				X	
e. flood			X		
f. other (specify) Air Pollution				X	

WATER RESOURCES

6. Depth to water table

a. annual	max.	86 feet	min.	72 feet
	month	September	month	May
b. growing season	max.	86 feet	min.	72 feet
	month	September	month	May

7. Estimated recharge volume of aquifer 23,000 - 24,000 acre ft./yr.

sources		time of year	
	East side Black Pine Mountain		Spring
	West side Sublet Mountain		Spring

8. Potential surface water sources

		distance to	source return	elevation difference	intervening topography
a.	None				
b.					
c.					
d.					

9. Quality of water resources

	C1	C2	C3	C4	S1	S2	S3	S4	Potable Yes	Potable No
groundwater			X			X			X	
surface water										
a. None										
b.										
c.										

DRAINAGE

10. Is the underlying strata condusive to good drainage?

very poor	poor	good	very good
X			

SOILS

11. Texture of root zone Sandy Loam

12. Depth to:
   a. sterile layer (clean sand, gravel, etc.) _>8 feet_
   b. tillable hardpan or cliche _8 to 10 inches_
   c. untillable hardpan or cliche _None_
   d. bed rock _≅ 4000 feet_

13. Percentage of tillage layer consisting of:
   a. gravel _<1_ %
   b. cobble _<1_ %

14. Problem to tillage caused by surface stoniness

no problem	slight problem	cultivation not impractical	cultivation impossible unless cleared
X			

15. Rockiness (outcropping) 0-2% _X_ 2-3%____ 2-10%____ over 10%____

16. Available water-holding capacity of root zone _10 inches_

17. Permeability _Slow to Moderate_

18. Percentage of slick spots due to alkalinity _= 10%_

19. Percent exchange sodium present _unknown assumed low_

20. Erosion hazard

very severe	severe	moderate	slight
	X		

TOPOGRAPHY

21. Average slope _>1%_

22. Microrelief

nearly flat	gently rolling	rolling	sharp hills and drainages
X			

23. Possible restraints due to regional topography

very severe	severe	moderate	slight
			X

ECONOMIC

24. Travel time (round-trip)

	1/2 hr.	1 hr.	2 hr.	1/2 day	1 day	over 1 day
a. nearest cropland	X					
b. major agriculture area			X			
c. small town		X				
d. elementary school			X			
e. high school			X			

25. Travel time to destination point for each prospective crop

Crop	1/2 hr.	1 hr.	2 hr.	1/2 day	1 day	over 1 day
Alfalfa			X			
Barley	X					
Spring Wheat	X					
Sunflowers				X		

26. Prospective rotations

A. ______, Alfalfa, Barley & Spring Wheat

B. ______, Alfalfa, Sunflowers & Spring Wheat

C. ______, ______, ______ & ______

D. ______, ______, ______ & ______

27. Size of area 5,148

28. Availability of electricity

available on site	available	possibly available	not available
	X		

LAND USE

29. Adjacent land uses

use	compatible	slightly incompatible	moderately incompatible	incompatible
Rangeland	X			
Hunting	X			
O.R.V	X			
Cropland	X			

30. Existing on-site land uses

use	compatible	slightly incompatible	moderately incompatible	incompatible
Range				X
Hunting		X		
O.R.V.			X	

31. Wildlife that will be replaced

	critical habitat	important habitat	population designation
Mule Deer		X	Common
Pronghorn		X	Common
Golden Eagle		X	Threatened
Ferruginous Hawk		X	Threatened
Long Billed Curlew		X	Sensitive
Sage Grouse			Sensitive
Sage Sparrow			Sensitive
Greentailed Towee			Common
Vesper Sparrow			Common

32. Impact on present users of aquifer

very negative impact	negative impact	possible negative impact	possible local impact	no impact
	X			

33. Recreational value

very unique	unique	rare	uncommon	common
				X

34. Scenic quality

regionally unique	regionally rare	locally unique	uncommon	common
				X

35. Scientific sites

27 small Archeology sites	≅ 27 acres

<u>SOCIAL</u>

36. Impact on services

	++	+	0	-	--
a. emergency medical			X		
b. police				X	
c. fire			X		
d. elementary school			X		
e. high school			X		
f. school bus service					X
g. snow removal				X	
h. road maintenance				X	
i. number of inpatient beds of 1000 persons			X		
j. postal service			X		
k. recreational services			X		

	++	+	0	-	--
37. Local economic base					
a. agriculture		X			
b. industry			X		
c. commerce		X			
d. change in number of employed		X			
e. number of unemployed			X		
38. Local government revenue					
a. tax base		X			
b. other revenue				X	
39. Regional impacts					
a. change in water transportation routes for industrial dispersion			X		
b. changes in water availability for energy production			X		
c. regional economic impact		X			

INVENTORY DISCUSSION

1. Data from Snowville, Utah, is used here. This station is in the same basin just to the south of Black Pine Valley.

2. Same as above.

3. Same as above.

4. This is an estimate due to the lack of exact data.

5. High winds are a common occurrence in the area. I-80 Freeway, which transects the valley, is often closed due to high winds and blowing dust. Wind erosion could pose a serious problem.

   Late summer hailstorms are often experienced through the entire region.

   Spring runoff has caused shallow gullying. In June of 1977, a wall of water to four feet high and 100 feet wide flowed through tract I-9761.

6. These figures were recorded at Black Pine well #1 located in the area. The lowest figure is after late-summer pumping at only 100 gallons per minute in 1968.

   Wells just to the south on the Victor land have a static water level of about 180-220 feet.

7. The annual recharge to the Juniper Black Pine system was estimated to be about 22,000 acre feet by Claud Baker, Jr., 1974, and 23,000 acre feet by Chapman and Young, 1972. Water moves toward the center of the valley and then flows southward across the Utah border.

8. The nearest possible source would be the Snake River which is 65 miles north over extremely rough terrain. Black Pine Valley, at approximately 4,500 feet elevation, is approximately 700 feet; the Snake River, the highest lift to clear the intervening mountains, would be approximately 2,000 feet.

9. Salt content in the soils in some cases is high enough to reduce the water availability for plants to a depth of about five feet to about three to eight inches.

10. The valley floor is underlain by unconsolidated valley fill and interbedded volcanic rocks of quaternary and tertiary age. The fill extends to a maximum thickness of 4,000 feet. The excellence of the drainage precludes any chance of a leaching problem.

11. Surface layer is a pale brown to brownish gray silt loam, sandy loam, or silty clay of six to 20 inches in depth. Substratum over 60 inches of sandy or clay loam.

12. The extent of the hardpan is not known, but it did show up in the valley. It was found at its shallowest point in tract I-9497.

13. No problem.

14. No stones present.

15. No rock outcroppings present.

16. Generally the available water-holding capacity is eight inches to a depth of five feet, but when reclaimed this should increase to 10 to 12 inches.

17. Mostly moderate.

18. The soils are moderately to strongly alkaline to a depth of about 20 inches and are very strongly alkaline between depths of 20 and 60 inches.

19. Unknown.

20. Wind erosion is a problem throughout the valley. Windblown hummocks were observed on tracts I-9761, I-9558, and I-9557.

21. Area is extremely flat except for being all lake fill from ancient Lake Bonneville.

22. Same as above.

23. No topographic hazard features.

24. a. Cropland exists directly across Utah-Idaho stateline. This is adjacent to tracts I-9497, I-9463, I-9465, and I-9466.
    b. Tremonton, Utah area, approximately 40 miles south.
    c. Snowville, Utah, approximately 10 miles.
    d. Children must attend school in Malta, Idaho, 35 miles
    & e. north.

25. Short-growing season prevents most crops. Present existing agricultural areas utilize an alfalfa, barley, spring wheat rotation. Sunflowers should do well since the area is much the same as areas in Southern Idaho where the crop is being tested and doing well.

26. See above.

27. Includes all 18 tracts.

28. Adequate three-stage lines presently serving crop areas directly south.

29. There should be no negative impacts on or by uses of adjacent lands.

30. The area is now supporting 1,237 AUM's for domestic grazing which is about 13.7% of the total forage utilized in Black Pine Valley annually. This forage would be lost upon conversion to domestic crops. The AUM's can be for the most part transferred.

    The area is now being used by bird hunters, occasional big-game hunters, and ORV enthusiasts. Bird hunting would continue being only slightly changed. The other activities would cease.

31. The area is an important winter habitat area for mule deer. The herd which uses the area has already been severely impacted by the construction of I-80, which cut it off from one-half of the winter range.

The pronghorn herd that utilizes Black Pine Valley is the last remaining herd on the Utah-Idaho stateline. Because of agricultural development in Northern Utah, it is a distinct possibility that this small remnant herd is already doomed. The area provides important habitat to ferruginous hawks and golden eagles, both listed as rare in the handbook on rare and endangered species.

Long-billed curlews nest in the area. A present court case is under litigation in Idaho, Boise BLM district, concerning DLE filing and long-billed curlew habitat.

32. The Utah Department of Water Resources reports that 26,000 acre feet are now being pumped from the aquifer on the existing agriculture land. This indicates that the aquifer is already being mined and any further pumping would no doubt cause a negative impact.

    The Locomotive Springs Wildlife area depends on this aquifer and further removal of water could have a negative impact on the springs.

33. Many areas of higher quality are available in the area.

34. The area has no special scenic quality.

35. Twenty-seven archeological sites were located; this is felt to represent about 10% of the sites in the valley. Since no record of size was kept, it will be assumed that each site is approximately one acre.

36. Some negative impact due to increased demand will be placed on emergency medical, police, snow removal, and road maintenance services. At present there is very little demand in the area on these services. Though some students may move on to the DLE's, the number should be too small to negatively impact Malta School District costs with exception of bus services. The area is not

at present served by a school bus. The addition of a bus to cover the area would add approximately $3,312 to annual school district expenses.

37. The economic base of the area will be positively impacted by the addition of more farm product dollars. The area should increase the dollar output per acre by well over $200 per acre.

38. Due to confusion caused by Idaho's new tax initiative, it's difficult to predict what the tax revenue would be in the area were converted to cropland. The resulting tax base increase would be in part negated by the loss of federal in-lu payments. These payments are made to the county to lessen the economic burden of having non-tax base federal lands in the county.

39. The area will slightly add to the regional economy.

BLACK PINE VALLEY

IRRIGATION (GRAVITY)

Soil or Land Criteria	A1 g	A2 g	A3 g	A4 g
Texture of root zone	Fine sandy loam to friable clay loam	Fine sandy loam to friable clay loam	Loamy sand and permeable clay	Sand with sufficient water holding capacity
Depth	40"	40" may include tillable hardpan or cliche	20"–40"	10"–20"
% Gravel or cobble	No problem to tillage	No problem to tillage	Slight problem to tillage	Cultivation not practical
Stoniness	Soil survey manual class 0	Soil survey manual class 1 w/v large stones scattered widely	Soil survey manual class 1	Soil survey manual class 2
Rockiness	none	0–2%	2–3%	3–10%
Permeability	Moderately slow to moderately rapid	Moderately slow to moderately rapid	slow and rapid	rapid
Sodium and Alkalinity	don't exist	10% slick spots in complex	10–15% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%	25–50% slick spots in complex or saline-alkali conditions with exch. sodium up to 15%
Slope	0–1%	1–2%	2–3%	3–5%
Relief	Nearly flat	Nearly flat	Gently rolling	Gently rolling
Drainage	Very good	good	poor	Marginal
Depth to sterile or impermeable layer	>8 ft.	>6 ft.	6 ft.	4 ft.

SITE RATED AT A2 g

BLACK PINE VALLEY

IRRIGATION (SPRINKLER)

Soil or Land Criteria	A1 s	A2 s	A3 s	A4 s
Texture	Loamy sand	Sandy or fine sandy loam	Friable clay loam	Permeable clay
Depth	40"	20"-40"	20"-40" may include tillable hardpan or cliche	10"-20"
% gravel or cobble	No problem to tillage	No problem to tillage	Slight problem to tillage	Cultivation not practical
Stoniness	Soil survey manual class 0	Soil survey manual class 1 w/v large stones scattered widely	Soil survey manual class 1	Soil survey manual class 2
Rockiness	0-2%	2-3%	not over 25%	Not over 25% if under 160 acres not over 50% if over 160 acres
Permeability	Rapid	Very rapid or moderately rapid	Moderately slow	Slow
Sodium and Alkalinity	Don't appear	10% slick spots in complex	10-15% slick spots in complex or exch. sodium up to 15%	25-50% slick spots in complex or exchange sodium up to 15%
Slope	0-2%	3-5%	6-10%	12-20%
Relief	Nearly flat	Gently rolling	Rolling	Rolling
Drainage	Very good	Good	Good	Poor
Depth to sterile or impermeable layer	>8 ft.	>6 ft.	6 ft.	4 ft.

SITE RATED AT $A3_s$ DUE TO DEPTH TO HARDPAN

WATER BALANCE CALCULATION

$$i = (T/5)^{1.514}$$

Month	Temp. (°C)	i
Jan.	- 5.6	- 1.7
Feb.	- 2.8	- 0.8
Mar.	1.6	0.5
Apr.	6.6	2.0
May	11.1	3.4
June	15.6	4.7
July	20.6	6.2
Aug.	20.0	6.1
Sept.	13.9	4.2
Oct.	7.8	2.4
Nov.	1.6	0.5
Dec.	- 4.5	- 1.4

$I = 26.1$

$I^2 = 681.21$

$I^3 = 17779.58$

$a = 0.000000675\ I^3 - 0.0000771\ I^2 + 0.01792\ I + 0.49239$

$a = .01 - .05 + .47 + .49$

$a = .92$

April Evapotranspiration:

$E = 1.6\ (10T/I)^a$

$E = 1.6\ (20 \div 26.1)^{.92}$

$E = 3.7$

WATER BALANCE TABLE FOR SITE NEAR SNOWVILLE, UTAH

Month	Ave. temp °C	P Prec. cm	E Evapotrans.	P-E	½h - (P-E) remaining soil water*
Jan.	- 5.6	2.8	0		
Feb.	- 2.8	2.1	0		
Mar.	1.6	2.9	.9		
Apr.	6.6	3.1	3.7	- .6	11.9
May	11.1	4.0	6.3	- 2.3	9.6
June	15.1	2.4	8.8	- 6.2	3.4
July	15.6	1.2	11.6	-10.4	0
Aug.	20.6	1.4	11.3		
Sept.	20.0	1.8	7.8		
Oct.	7.8	2.4	4.4		
Nov.	1.6	2.5	.9		
Dec.	- 4.5	2.7	0		
	(Annual) 7.2	29.3			

*Water-holding capacity 25 cm determined from soil survey data from the area

The above table indicates that to grow crops irrigation is necessary at the site of the soil survey.

MARKET ADVANTAGE/DISADVANTAGE (M)

Size: 5,148 acres

Distance to Major Crop Area - 2 hours

Distance to Crop Destination Points:

Alfalfa	-	2 hours,	Tremonton
Spring Wheat	-	½ hour,	Snowville
Barley	-	½ hour,	Snowville

Meets requirements of

M3 ....

A. If over 2,560 acres

1. area not over two hours from a major agricultural area
2. not over two hours from at least one crop destination point for crop in rotation

SITE RATES CRITERIA VALUE M3

WATER INDEX (W)

The pumping lift is projected to be below the average lift for the region. The Black Pine Valley has a moderate problem with water supply due to quality. The groundwater qualifies only as a C-3, S-2 salinity/sodium rating. The high salinity is due to the presence of salt lenses throughout the valley fill, deposited there when the area was inundated by ancient Lake Bonneville.

The site rates as a W3.

ELECTRICITY AVAILABILITY (P)

The site is considered to have available electrical power.

The presence of adequate three-stage electricity on the adjacent cropland qualifies the site for a P2 rating.

Determinant Factors for use in Preparation of an Environmental Impact Index

VALUES

Criteria	0	1	2	3	4
Erosion Potential	Extreme	very severe	severe	moderate	slight or none
Climate Hazard	Extreme	very severe	severe	moderate	rare
Impact on Aquifer	Very negative impact	negative impact	possible negative impact	possible local negative impact	positive impact
Wildlife Value	Extreme	very severe	severe	moderate	slight
Scenic Value	Regionally unique	regionally rare	locally unique	uncommon	common

SITE RATING E 3

LAND USE IMPACT INDEX

VALUES

	0	1	2	3
Adjacent use compatibility	incompatible	low compatibility	medium compatibility	full compatibility
Recreational	unique	rare	uncommon	common
Scientific	50% of area	25 to 50% of area	10 to 25% of area	10% of area
Minerals	50% of area	25 to 50% of area	10 to 25% of area	10 % of area
On site use compatibility	severely incompatible	moderately incompatible	slightly incompatible	full compatibility

SITE RATED L2

SOCIAL IMPACT (S)

Number of factors rated as	-	4
Number of factors rated as	--	1
Number of factors rated as	+	5
Number of factors rated as	++	

Site rating S3

Explanation: Development of area would create need for a new school bus route with approximate cost to school district of $3,312 annually.

SOCIETAL RESTRAINTS VALUE LEVELS

Response Levels	Value 1	Value 2	Value 3	Value 4
General Public	Public in favor of conversion	Some interest group opposition expressed	Strong interest group opposition expressed	Public generally opposed
Local Government	No opposition	Some agency reservations expressed	Elected officials opposed	Conversion legally restricted
State Government	No opposition	Some agency reservations expressed	Elected officials opposed	Conversion legally restricted
Regional Compacts Agencies	No opposition	Some agency reservations expressed	Conversion not in accord with resource plans	Conversion violated interstate agreement
Federal Government	No opposition	Some agency reservations expressed	Elected officials opposed	Conversion legally restricted

SITE RATING R3

(low rating due to the opposition to conversion by the Oneida County Commissioners. They are opposed because of the need to extend services to the area that are not now available)

INDEX	CODE	1	2	3	4
Arability	A	no limitations	slight limitations	moderate limitations	severe limitations
Market Advantage/Disadvantage	M	advantage	slight disadvantage	moderate disadvantage	severe disadvantage
Water	W	excellent quality readily available	good quality available	medium quality available with difficulty	poor quality available with great difficulty
Electricity Availability	P	available on site	available near site	possibly available	not available
Environmental Impact	E	no negative impact	slight negative impact	moderate negative impact	severe negative impact
Land Use	L	full compatibility	medium compatibility	low compatibility	very low compatibility
Social Impact	S	positive impact	no impact	moderate negative impact	severe negative impact
Societal Restraints	R	positive response	slightly negative response	moderately negative response	severe negative response

CRITERIAL VALUES FOR RESOURCE, IMPACT
SOCIETAL RESTRAINTS INDICES

SUMMARY

The Black Pine Valley Desert Land Entry site is rated as a moderately suitable site (PAIV). It fails to be rated higher because of four limitations:

1. The site is isolated from a major agricultural area and from a good destination point for all the proposed crops.
2. The aquifer is seen to be totally allocated.
3. No school bus route now comes near enough to the area to be diverted to pick up new children.
4. The Onieda County Commissioners are opposed to the land being used as cropland.

NOTE: The Black Pine Valley Proposal was given a "do not recommend" designation by the Burley BLM office. This designation was given on the strength of the condition of the aquifer. It is significant to note that even with a good water supply, the Framework would not have rated the site higher.