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GIVING LAND TITLES IN NORTHEAST BRAZIL-- THE POSSIBLE USE OF AERIAL PHOTOGRAPHY

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Giving Land Titles in Northeast Brazil -- The Possible Use of Aerial Photography

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Recently a road has been completed connecting Brasilia and Belém in northeast Brazil. People have been settling along this road and many more are expected in the area. How can homesteaders be made out of squatters? The ability to give firm title to the land is an important item in this problem.

The use of air photos for giving land title seems a very attractive possibility. A large area is photographed quickly and photos show things as they appear on the ground.

Air photos have been used for establishing land boundaries. Land was purchased for a recent highway through a high cost area of Dallas, Texas, using only aerial photography; accuracy was guaranteed to plus or minus one foot. Photogrammetry was used in 1958 for a land transfer from the federal government to the state of Utah.[1] Relatively small property surveys have made use of air photos.[2] In 1931 Italy did a systematic resurvey using photogrammetric instrumentation and has gone further in producing cadastral maps since then. At the beginning of World War II, aerial photogrammetry was the regular means of producing cadastral maps in Switzerland. France has used these methods for quite some time.[3] Chile is just completing an aerial survey of her agricultural lands which includes tax maps of land ownership boundaries.

What are the limitations of aerial photography for establishing land boundaries? Cost is one factor. Available knowledge is a second.

It is very difficult to get an idea of the costs involved. The following is given with no attempt at making different estimates "jibe". The Chilean survey of approximately 50,000 sq. miles of agricultural lands has a listing of 178 North Americans and 142 Chileans working on various phases;[4] the total cost is in the neighborhood of $6 million.[5] This cost can not be attributed only to the tax maps, but must also be allocated among land use and land capability studies made concurrently. When pressed, a commercial photogrammetrist made a rough estimate for a single strip of photos for 1500 miles in northeast Brazil -- considering no base of operations except at either end of the strip -- to be roughly between $50,000 and $100,000. This strip of photos would be at a scale of 1:24,000 or 1 inch = 2000 feet. Thus with the road in the middle of each 9 inch contact print, about 1.5 miles would be included on either side of the road. This photogrammetrist did not know that there are several air strips between Brasilia and Belém.

In the Madison, Wisconsin, area photogrammetric costs for large area mapping photography are about $25 per square mile and would be with a minimum of ground control. This photography would have a scale of 1 inch = 400 feet.[6] General figures

for highway surveys are:[7]

	Time	Cost per mile	Width of coverage
Aerial photography	1 week	$800	1000 feet
Ground methods	6-8 weeks	$1000-1200	300 feet

Much of the air photo coverage of the continental United States is flown for the U.S. Department of Agriculture, largely in connection with acreage control programs under the supervision of the Agricultural Stabilization Corporation. The state office of the A.S.C. submits their requirement for bid by private companies and generally pays from $235 to $275 per square mile. Eight to ten counties are covered under one contract which calls for the contractor to submit a negative, one contact print, and an uncontrolled photo mosaic as an index, all under specified technical requirements. These are nine inch square prints at a scale of 1:20,000.

Unit costs for the Utah land transfer were $180 per mile for one project and $240 for another.[8]

Unit costs in northeast Brazil might be modified from that of a private contractor if the Brazilian Air Force flew the necessary photography and took charge of maps and measurements. Much of this area has already been photographed;[9] for the area not presently photographed, suitable special purpose photography might be incorporated into present plans for the difference in cost between the anticipated and modified photography.

One of the major factors in the cost of aerial photography is the relatively few days with weather suitable for photography. Infra-red film is commonly used for several special purposes, but has not been used to increase the number of available flying days.

The use of aerial photographs for cadastral surveys has been common in Europe, but is quite new to the United States and Canada. Only about a year ago did the American Society of Photogrammetry establish a committee entitled "The Application of Photogrammetry to Cadastral Surveying." Only a few of the articles in the journal Photogrammetric Engineering refer to cadastral surveying although these are most enthusiastic and advocate the extension of its use. Since metrical photography is a relatively new science in the United States, the courts have not yet taken judicial notice. New York, Pennsylvania and Florida "Minimum Standards" for title insurance policies each contain the following identical paragraph: "The surveyor's field work must be performed with transit and steel tape and its accuracy proved by a closed traverse."10/ Thus there is interest but no great backlog of experience in the use of photogrammetric methods for property survey in the United States.

Most experience with cadastral surveys using air photos is in settled areas. Northeast Brazil is for the most part unsettled without a high incidence of cultural land marks. Much

of the identification of property boundaries in Chile was by such things as fence rows and the edges of fields plus rapid checks on the ground. This is generally true for the establishment of land boundaries.

Let us look at the requirements of a land survey and attempt to see how air photos may fit in.

It is agreed that in issuing land title it is absolutely necessary that the title be tied to something physical on the ground. An air photo is a map in itself. It definitely establishes relationships among identifiable objects on the ground. Can not these attributes of air photos assist in tying land titles to the ground they describe?

First let us consider some of the properties of air photos themselves.

Measurements made on a photo that are intended to represent measurements of the photographed land have varying degrees of accuracy. Scale varies between photos, even those of the same flight, for scale varies with the distance of the camera in the airplane from the ground. Even though the photographing airplane is flown with a professionally constant altitude, the plane's altitude is in relation to sea level, and changes in the elevation of the land surface below will change the scale of the photos of that flight. Scale varies within a single photo. In a vertical photo, scale changes from the center of the photograph, which is directly below the camera, to the edges of the photo,

which are taken at some degree of obliqueness. Elevation differences within a photo also affect the scale.

These and other problems such as are associated with a slight tilt of the plane, are regularly handled in professional map making.

The intended scale of the photography will affect the ability to measure ground distance on the photo. The scale of most of the aerial photography available in the section of northeast Brazil with which we are concerned is at greater than 1:30,000.[11/] Much of the aerial photography of Latin America is of 1:30,000. At such a scale, 1 inch on the photo = 30,000 inches on the ground, or about 2500 feet; a one inch square represents 143.5 acres. The scale of the contact prints used by the Agricultural Stabilization Corporation is 1:20,000 or 1 inch = approximately 1,667 feet. They do not use these contact prints directly but have them enlarged to 1 inch = approximately 660 feet, and 1 inch square equals about 10 acres. Since in Wisconsin tobacco is measured to .01 of an acre, measurements are generally made in the field using a tape. They do use a planimeter in the office and when they are certain of current field boundaries, feel they are correct to .1 acre, and under ideal conditions have found themselves to be only a few .01s off from taped field measurements. Engineers find that results with a planimeter correct to within .5 to 1 per cent can be obtained with careful work.

When enlarging a photo, some detail is lost. Thus most professionals use contact prints and when they want larger scale, have the photographs taken at that scale. The A.S.C. finds enlarged photos helps them when dealing with laymen. Either method increases the cost. A photo purchased by an individual at 1:20,000 scale costs $.85 while the 1 inch = 660 feet cost $2.60. Bulk rates reduce this cost considerably.

Thus measurements on photos, to be very accurate, requires professionally compensated maps and a high degree of skill.

Could a careful technician with less training and with less expensively prepared photos simply locate identifiable points on the ground and not be concerned with measurements? This would seem possible. In passing out land in somewhat undifferentiated areas of an unsettled region, natural land marks would probably be inadequate. Artificial permanent monuments would seem necessary. These permanent monuments could be an iron pipe, a steel pin, or a sunken concrete post. There would be little problem in making their location visible in an air photo: they could be marked by a spot of lime, by panels, by cutting of brush, and so on. There is no problem if the temporary, highly visible markings disappear on the ground, for the spatial relationships can be simply re-established on the ground and in the photo at any time.

Before going further with the application of air photos to the establishment of property boundaries, the common systems of survey used in the United States should be considered.

Permanent reference points, usually artificial monuments, are used as starting points in all boundary surveys. About 72 per cent of the contiguous states of the United States is tied to a public lands grid system. In the older sections of the East and Texas, systems of metes and bounds are used. In subdivisions and in larger cities, properties are often described by a form of block and lot system.

The United States public lands system was set up with the intent of having sections one mile on a side. The primary division of the grid coordinate system is a tract approximately 24 miles square. Tracts are subdivided into 16 townships about 6 miles on a side. Townships are subdivided into 36 sections approximately one mile square. The use here of "approximate" does not provide for a lack of precision in the survey, but is necessitated because meridians converge. The method of further subdivision is specified in the official manuals of instructions, but in practice such subdivision is generally done by a local surveyor rather than the public surveyor.

T. Lynn Smith and Justo Díaz Rodriguez in 1944 proposed a law for the public lands of Columbia based on the United States public lands systems; it was passed by the lower house but not acted on by the senate because of the unsettled political state at the time.12/

The U.S. public lands grid system calls for monuments at the tract, township, and section corners with provision for

monuments at quarter section limits.

A grid coordinate system similar to that of the United States could be done in Brazil. Civil engineers advise this, for any other system will be more expensive in the long run and will incorporate many headaches avoided by the grid system. Such a survey would almost surely be done by photogrammetric methods. In rough country it takes an 8 man crew about a week to run a line a mile, running it both ways as a check. It has been suggested that for the distance involved between Brasilia and Belém, the State of Wisconsin does not have the facilities to make such a survey. Such a job would be the work of the U.S. Coast and Geodetic Survey. The initial cost of a grid coordinate system is high.

In a block and lot system used by many subdivisions and cities, the entire area is surveyed and all the blocks and lot subdivisions identified, described, and recorded. Property descriptions then refer only to the previously recorded parcel descriptions. T. Lynn Smith's Columbian proposal included such a method for issuing parcelas -- which were not to be subdivided but always handled as wholes.

Property descriptions by metes and bounds should include the following. The point of beginning should be identifiable, permanent, well referenced, and near the property. If the coordinates are known, they should be given. The corners should be definite. Lengths and directions of the side of the property

should be given. Names of adjoining property owners should be given. The area is usually given, both as an aid in identification and for valuation for tax purposes.

In most places in the United States, no boundary is truly "legal" until established by a court decision. An exception to this is Massachusetts where there is a land court; land titles are legally established by this court.

A minimally feasible method of writing land titles would presumably follow some form of metes and bounds. Since the road from Belém to Brasilia is both conspicuous and the method of access to the region, it would seem to be a reasonable point of reference for property descriptions. Artificial monuments could be constructed along the road, be carefully identified, and serve as official points of beginning for all property descriptions. It would be best if an official or an official survey team staked out the corners of each parcel as it were claimed, and the property description written while present at the new parcel.

If it were not possible to have good measurements, it would seem to be still possible to describe the properties of small holders so that the intent of the description were reasonably apparent. The less precise the measurements, the closer together should be the road monuments, perhaps every half mile, or less. Without good measurements, only road frontage could be easily described. But if the corners of the parcel were staked with

a long pipe or pin, and descriptions written only by an official doing the staking while present at the site of the description, problems should be substantially reduced over no system at all.

A property description, for example, would include such a statement as that starting from marker X1001, south and on the west side of the road, Joseph O'Rielly's parcel is bounded by stakes numbered x 42 to x 47 inclusive. The east side of Joseph O'Rielly's property is bounded by the road, the south line abuts José Gonzales and the stakes x 42 and x 43 are Joseph O'Rielly's southline and José Gonzales north line; no one owns the property adjacent to the north boundary of Joseph O'Rielly's this 13th day of October, 1964. There would be signatures and seals. Such a description would take the curl from an engineer's hair, but as a minimum above no records, it would suffice. Many problems would occur as soon as anything except road frontage were passed out.

With slight additional cost, the road monuments could be precisely located. This could be done rapidly with such an electronic measuring device as the Tellurometer or Geodometer. These instruments work within the line of sight between two towers: an upper limit of 40 miles is possible, although 25 miles is the practical limit. In the Antarctic with helicopter support a five man team surveyed 1000 miles in four months. Under less vigorous conditions along a road, things would move even more rapidly; the time to put in control points takes 2.5

or 3 times the speed of the travel time of the vehicles; helicopter support along with the available aerial photography would expedite this operation. Intermediate monuments might be located by traditional survey methods in areas where the need for them would first arise. With road monuments at known locations it would be good to survey each parcel as it were staked out. Under this system many potential future problems would be reduced and properties could be easily located short distances from the road. In those areas presently covered by vertical photography, a good part of the work toward making precise measurements has already been done.

Under any circumstances the road monuments should be permanent and positively identified. A post hole digger mounted on a truck would provide a simple and rapid method for constructing such monuments. The hole would probably be six feet deep and either filled with fresh concrete or a prefabricated concrete post.

To facilitate both the passing out of titles and the development of communities and community services, land titles should probably be given out only in specified areas at first, these areas being expanded as the need arose.

Air photos could be introduced into any system. The simplest would be for the official staking out the parcel to attempt to pin-prick a photo to represent the staked corners. He would not use measurements but would attempt to locate the pin-pricks by

identifiable objects in the photo. The numbered photo would be incorporated into the parcel description.

An accurate map is essential to the development of the area. A sufficiently accurate map may be presently available from the available photography. From the photos used to construct the map, can be determined regions of agricultural use -- relating to both size of parcel to be passed out and in the sequential development of the area. Drainage patterns and problems can be learned, health hazard areas, areas of potable water, and sites of road building materials can all be identified.

The farther settlement goes from the road the more important a grid system and a good map become. Since a coordinate grid system would probably be established by photogrammetric methods, a highly accurate map would be a simple derivative. Some map will be essential to a land registration system.

Jerry Masters of the University of Illinois has described the elements of a photogrammetrically controlled cadastral survey. His description can serve as a take-off point when considering the use of air photos in Brazil. The following is taken from that description:[13] The maximum economy for cadastral surveys comes from air photos of a scale of about 1:10,000.[14] The flights should be made in the early spring or when there is a minimum of vegetative cover. For the most accurate photogrammetric results at least five points of known

position per stereomodel or photograph are desirable. Fewer points are clearly marked before photographing. The photographs are enlarged and taken to the field by the surveyor and all details to be measured are identified. All details not visible in the air photo are determined by ground survey. If the identification is executed correctly a very complete map and/or measurements can be produced without additional trips to the field.

In passing out land titles in the unsettled region of northeast Brazil, firm titles will cause the least subsequent problems. The most precise land survey financially -- and thus politically --- possible will cause the lowest long run cost. A minimal, universal, approved system can be of very low cost and is better than an idefinitely postponed more precise system. Air photos can be introduced into any system of distributing land titles; this paper has attempted to draw together some of the factors affecting the decisions for their possible use or uses.

Since this paper was written, a journal article has been published describing the Philippine experience incorporating photogrammetry into their cadastral survey; they use the Torrens system of land registration. At their former rate of survey they would have taken about 100 years to have finished their cadastre; the present photogrammetric project

took almost as long as conventional methods; they expect to be able to finish their cadastre in 15 more years. Accuracy and confidence in results have increased over conventional methods. The cost of the conventional cadastre was approximately $12.00 per hectare, the present photogrammetric project cost is approximately $9.00 per hectare, and the rest of the program is expected to cost less than $6.00 per hectare.[15/]

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FOOTNOTES

1/ Bryner, C.C., "Photogrammetry Used in Land Transfer of an Area that was Transferred from the United States Government to the State of Utah," Photogrammetric Engineering, Vol. 29, No. 1, pp. 862-864.

2/ Warneck, Peter E., "Photogrammetry and Property Surveys," Photogrammetric Engineering, Vol. 29, No. 4, pp. 594-595.

3/ Masters, Jerry R., "Photogrammetry and the American Cadastral Surveyor," Photogrammetric Engineering, Vol. 26, No. 3, pp. 469-474.

4/ It is possible that some of these persons are double-counted and the total number of Americans and Chileans less than this.

5/ Personal letter from Peter Dorner, professor, University of Wisconsin, presently stationed at the University of Chile, Santiago, Chile.

6/ Department of Civil Engineering, University of Wisconsin.

7/ Ibid.

8/ C. C. Bryner, p. 863.

9/ "Status of Vertical Aerial Photography of O.A.S. Member Countries, Northern South America, Inter-American Committee for Agricultural Development," map, preliminary edition based on compilation sources available as of December, 1962, by the Unit of Engineering and Natural Resources, Department of Economic Affairs, Pan American Union, Washington 6, D.C.

10/ Eldridge, Winifield H., "Legal Aspects of Photogrammetry Used in Property Surveys," Photogrammetric Engineering, Vol. 29, No. 5, pp. 864-866.

11/ Map above.

12/ Smith, T. Lynn, "Colonization and Settlement in Columbia," Rural Sociology, Vol. 12, No. 2, pp. 128-139.

13/ Jerry R. Masters, pp. 471-472.

14/ The scale used in the Chilean survey is 1:10,000 and 1:30,000.

15/ Marzan, G.T., G. Umalhay, and T.C. Jimenez, "Philippine -- Numerical Photogrammetric Cadastre," Photogrammetric Engineering, Vol. 30, No. 2, March 1964, pp. 278-282.

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