ing the transition period? These cash flow considerations are not only of interest to the rancher, but also to the banker.

E. When all income and expenditures are tallied, it will be necessary to consider a number of important things. First, how long will it take to repay any borrowed capital? Second, the discounted value of the cash in and outflows during the development period and for a set period after completion need to be considered. This is the basic capital budgeting technique that compares the discounted net cash inflows to the initial outlay of equity capital, with the exception (hope) that the discounted cash flows are positive and exceed the amount of invested equity. In capital budgeting, borrowing and debt repayment are considered cash in and outflows that are separate from the equity invested in the project. Thus the effects of inflation, and any other anticipated forces that reduce the spending power of future dollars, are considered. Third, what net income can be expected once the conversion is complete, and is it sufficient to meet the requirements set out in "A" above?

Thus we have a “bare bones” set of analysis guidelines with the final form of the evaluation dependent on the needs and structure of the ranch. A decision of this nature is important. If the rancher has any doubt about his or her ability to do the analysis, expert help should be called in.

The important thing to remember is that one should never eliminate the possibility of moving all inside until a thorough analysis has been done.

The results may be pleasantly surprising.

Literature Cited


Infrared Photo Interpretation of Non-riparian Wetlands

V.J. Anderson and P.J. Hardin

Wetlands have become a focal point in land management in recent years. Policy development and interpretation from Section 404 of the 1972 Clean Air and Water Act has made identification of these wetlands a necessity prior to any kind of development or use that may compromise this resource. Controversy between private landowners who viewed these regulations as lacking scientific support and conservation/preservation groups and agencies who have influenced the creation of these policies have plagued this issue from its inception (Walter 1991). Those who have experienced the restriction of use on their lands have expressed concern that these regulations provide for unconstitutional land seizure by the government (Brookes 1991). Discontentment and resistance to wetland delineations and restrictions were evidenced by the August 17, 1991, passage of the 1992 Energy and Water Development Appropriations Act which negated delineations made under the provisions of the 1989 Federal Manual For Identifying and Delineating Jurisdictional Wetlands.

Efforts to revise the wetland policies have been met with resistance by those concerned with the loss of this resource (Pope 1991, Holloway 1991). Undoubtedly revisions will continue to be made and a wetland policy, guideline or law of some nature will likely be in force continually. The task of identifying these wetlands will be ever present and techniques to increase the ease of this assessment are critically needed.

In the Spring of 1991, a study was initiated to determine the effectiveness of remote sensing for wetland identification using high altitude infrared photography. The study area was sixteen quadrangles (approximately 800 square miles) including and surrounding Strawberry Reservoir in the Uinta National Forest of Utah.

Methodology

Criteria set forth by the 1989 wetlands manual were used to make wetland determinations. The three basic criteria that were required to delineate a wetland area were (1) evidence of wetland hydrology such as standing water, debris drift rings, etc.; (2) hydrophytic vegetation (species confined to or often found on wet sites); and (3) hydric soils (soils formed in the presence of water or periodic inundation evidenced by soil color and presence of mottling and/or gleying).

Off-site methods for wetland determinations were first employed during the months of May and June, 1991. This
involved a review of all available materials (U.S. Geological Survey (USGS) topographic maps, National Wetlands Inventory (NWI) maps, soil survey maps, and aerial resource and infrared photographs) describing soil types, plant communities, and previously determined wetlands included within the 16 quadrangles surrounding Strawberry Reservoir. Infrared photographs were examined stereoscopically to make a first appraisal of possible wetland areas from subtle changes in the color of the land cover.

While our technique for photo interpretation and information transfer from infrared photos to orthophotoquads followed those described in Riparian Area Management: What Can Remote Sensing Contribute?, we initially found detection of non-riparian wetlands on the air photographs to be very difficult for the following reasons:

1. The small scale of the photography (1:40,000) and the small size of wetlands in the study area made them difficult to detect.
2. The late summer (September, 1987) timing of the photographs likely resulted in some of the wetland areas, which would have been visible in early season photography by their bright pink signature or standing water, to go undetected because of late summer desiccation.
3. Tree canopies sometimes masked the understory, making wetlands occurring in the understory of trees difficult to detect.
4. Wetlands tended to grade into non-wetland through a transition area. The mapping required that definite boundary polygons be drawn. This proved difficult and somewhat subjective.

Since the differences between wetland and non-wetland areas on the photographs were subtle, we initially used an interpreter arbitration technique to resolve problems. For example, two team members would independently interpret the same pair of photographs, outlining their own interpreted wetlands on acetate which overlaid the photographs. These separate acetate interpretations were then compared on a light table and a discussion ensued to resolve differences between the two. If a resolution was not realized, a third interpreter made the final determination. This was discontinued for the final few weeks, since the two interpreters found their results consistently converging.

Field truthing a representative number of lab designated wetlands allowed further refinement of the photo interpretations. Delineation of possible wetlands was based on the degree of certainty of the off-site determination and categorized as likely and possible wetlands.

Upon completion of the photo interpretation for the entire study area, field checks of 115 delineated areas of either likely or possible wetlands were made during the months of July and August, 1991. Three levels of on-site wetland determinations were made in various combinations. Sixty-three sites were visually checked with no data being recorded. Thirty-five sites (35) were field checked using the routine method described in the 1989 wetlands manual and the remaining 17 sites were field checked using both the routine and comprehensive methods described in that manual.

The routine on-site determination method required a listing of the dominant plant species, an analysis of the soils and a description of evidence of the hydrology of the area. Upon completion of these steps, the areas that met the three criteria were determined to be wetlands and the boundaries were delineated.

An alternative to the routine method was a comprehensive on-site quadrat sampling technique which required detailed quantitative data for each plant species. A routine check was completed on every site in which the comprehensive method was employed, allowing comparisons between the methodologies.

Following the field checking, the wetland information was copied from the air photographs to the orthophotoquads. Orthophotoquads are similar to controlled air photograph mosaics, except that displacements due to terrain height have been removed and the photographs have been warped to fit mapped features properly. Labels and coordinate grids are also added to the photographic information. Each orthophotoquad is designed to precisely cover the area of one USGS quadrangle.

The transfer of information from the air photographs to the orthophotoquads was completed with relative ease,
since the same vegetation pattern, road pattern and other features could be located on both. After the transfer was completed, the wetland information was digitized from the orthophotoquads into the computer using Intergraph MGE software. Once the digitizing was complete, check-plots of these wetland boundaries were drawn at the precise scale of the corresponding orthophotoquad. The check-plot was placed over the orthophotoquad on a light table and the two were examined for agreement. A cartographer then combined the wetland information with other digitized linework such as roads, trails and streams to create a final map for each quadrangle (Fig. 1).

**Results and Discussion**

There was a 100 percent agreement between the routine and comprehensive methodologies. The comprehensive method yielded more quantitative data on which a decision could be based, but required a far greater investment in time. Of the areas marked as possible wetlands from infrared photo interpretation in the lab, 61 percent were delineated as wetlands after evaluations. Of the areas marked as likely wetlands in the lab, 94.5 percent were delineated as wetlands following field inspection. In the areas where technicians did the ground truthing of potential wetlands mapped from the photos, other wetlands were discovered that had not been mapped in the lab. This represented nearly 19 percent of the wetlands encountered.

After reviewing the possible options available (field analysis only, satellite imagery, infrared, black and white or color photo interpretation, etc.) for completion of a non-riparian wetlands inventory over large areas, infrared photo interpretation seems to be an attractive alternative. After adequate training, a good lab technician could map out as much as one quadrangle per day, depending on the number of potential wetlands in that area. Continuous field checking at much lower intensities than were conducted in this study would be useful to refine the interpretation in the lab. The routine method described above tends to yield the same final delineation as does the more time consuming comprehensive method and would be adequate for most ground truthing.

Many of the areas that were wetlands were relatively obvious on the photos and could be classified as wetlands with a relatively high degree of confidence, as indicated by the 94.5 percent level of confirmation of the definite classification category. A liberal approach to the possible classification category may include many of the wetlands that went undetected from photo interpretation, but were discovered in the field. These could be checked more thoroughly before any wetland conflicting use is implemented or allowed.

Since none of the National Wetlands Inventory maps for this study area were field checked by NWI interpreters, it is not surprising that there were substantial errors of both commission and omission in their maps. Our experience with NWI maps resulted in a very low level of confidence in their designation of non-riparian wetlands. Independent examination of wetlands on more localized levels is recommended.

**Conclusions**

Despite the recent debates, modification of regulations and interpretations of wetlands policies, delineation of