



## EVALUATING CONVERSION OF CROPLAND TO FORESTS

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### ABSTRACT

*Non-additivity of various outputs of multiple use systems is a problem usually met by planners in evaluating alternative land use options. Seven (two single use and five multiple use) production systems were considered in a study of alternative uses for a tract of cropland, owned by the Winnebago Tribe of Nebraska, for conversion to forestry. A client-driven interactive process was used to evaluate competing land use objectives and generate alternatives. A weighting summation method was applied to evaluate and compare alternatives. Four weighting schemes were used to emphasize various view points based on objectives. Evaluation showed two agroforestry systems as the best alternatives.*

*Keywords: Agroforestry, decision making, economics, land use planning, multiple goals.*

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### INTRODUCTION

The sustainability of agricultural land use practices is determined by several factors. These factors may be categorized into three major groups — biological, physical, and socio-economic and legal — and their interaction often constitutes the basis of all production systems (York, 1988). The desirability of a land use system is usually gauged on the same grounds: biological and technical feasibility, economic viability, social acceptability, and political responsibility.

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Decision making concerning land use changes, such as the conversion of forest to agricultural use or agriculture to forest, is neither simple nor easy. According to Wood (1988), such decision making necessitates a thorough study of the problem, an indepth exploration of the desired and possible outcomes, and a good grasp of a range of possible solutions to the problem.

Central to this process is the active participation of the landowner, especially in the early planning stages. The land resource manager presents the final recommendations, but the landowner makes the final decision based on his/her own objectives. Programs have been known to fail simply because of the absence of this direct linkage between program goals and clientele goals.

Landowners often want to realize several goals from the same land. Consequently, the evaluation of land use has to deal with analyzing a mix of objectives and decision criteria within the context of limited resources. Not all criteria can be easily evaluated in monetary terms or quantitative measurements. Examples are the existence of a wildlife species, visual quality, and other environmental goods and services that are called "nonmarket" because they are not sold or traded in a market. Techniques have been developed to evaluate the values of these nonmarket goods, such as the contingent valuation approach (Bowker & Stoll, 1988), willingness to pay approach (Shultz & Lindsay, 1990), valuation of option, existence, and bequest demands (Walsh *et al.*, 1984), travel cost method (Walsh, 1986), and valuation of natural resource service flows (Brookshire *et al.*, 1980). However, a decision has to be made, and nonmarket goods have to be evaluated together with other outputs regardless of the units of measure used. Thus, it may be necessary to add income with the number of potential jobs and recreational opportunities, habitat values, soil loss, and other goods.

The following study illustrates the use of an interactive goal formulation process in combination with a weighting summation method in the evaluation of various land use options, where the landowners (the Winnebago Tribe of Nebraska) explored conversion of a tract of tribal land to native bottomland forest.

## THE STUDY: A SEARCH FOR AND EVALUATION OF FORESTRY LAND USE OPTIONS

A study of various land use alternatives for Big Bear Hollow (BBH), a 1255-acre tract of agricultural land owned by the Winnebago Tribe of Nebraska, was completed in 1992 (Rosacker *et al.*, 1992). Guided by the Tribe's general land use and site specific objectives, the evaluation involved the conversion of the land from its present intensive agricultural production into other uses, including forestry and agriculture and a mix of both (or agroforestry), within a 10-year period. BBH has been rented to a non-native American farmer. It has been producing corn and soybeans for over 20 years. BBH is located on the Missouri River floodplain about seven miles east of Winnebago. It is bounded by the Missouri River to the east and by forested bluffs to the west.

The objectives of the study were: (1) to identify the objectives of the Tribe for BBH, (2) to establish decision criteria used to evaluate the objectives, (3) to assess the capabilities of the Tribe's human and natural resources as related to BBH, (4) to develop alternatives for possible conversion of BBH into forest crops or agroforestry, a combination of forest and agricultural crops, and (5) to evaluate each alternative in terms of the economic, environmental, and social effects. The study was intended to assist the Tribe in fulfilling the resource management goals expressed in their 1989 Land Use Plan. This plan defines and sets goals for the proper management and use of its various resources (such as agricultural lands, forests, water, wildlife, recreation, commercial lands, residential lands, transportation, and other areas) and how the plans for each area would contribute and fit into a comprehensive, integrated management plan for all the lands on the reservation. The Land Use Plan looks at how all these plans relate to the members and how they enhance the Tribe's traditional land stewardship philosophy of being temporary occupants of the land and of being good caretakers of the same. For instance, the Tribe's general land use goal for BBH is "to develop a long-term land use management plan for BBH to attain economic, environmental, and social objectives through the promotion of tribal values" (Johnson-Trussell Co., 1989).

## METHODS

The study was conducted in three phases. The first phase identified all Tribal objectives relating to BBH, identified the decision criteria to evaluate these objectives, and established baseline resource capabilities for the Tribe's human/cultural and natural resources. A nominal group technique (Schomaker & Lime, 1988) was used to develop and rank objectives. The second phase developed a set of alternatives that addressed the mixed set of objectives for BBH. The third phase was the application of a weighting summation method to evaluate the effects for each alternative and compare forestry, agroforestry, and agricultural alternatives using various weighting schemes.

### *Phase 1*

The nominal group technique (NGT) was used to develop and rank the objectives that were identified for BBH. The NGT is a consensus-building procedure often used in identifying critical issues or in assessing information needs. It requires the participant(s) to list items in response to a question posed before the group. The individual lists are pooled, a brief discussion follows to clarify items, and independent ranking by each member is then held. A group ranking for each item is developed by combining the individual ranking (Schomaker & Lime, 1988). The items in this study were the tribal objectives related to BBH. This process has been used in various fields, including planning, policy making, management, and education (Langone, 1990; Schomaker & Lime, 1988; Pokorny et.al., 1988; Mahler, 1987).

The NGT in this study involved a group of Tribal Council members and tribal elders in a meeting. It started with a set of 20 objectives previously identified for the BBH area. This set was obtained from tribal documents, and from informal interviews held with elders and community members. The items were discussed and another objective was added (Table 1). Then the 21 objectives were evaluated by each group member by assigning a value from 0 to 10 to each objective, with 10 being the highest score. For each objective, all values were summed to yield a group ranking. The results were presented to the group for a brief discussion. Individual re-evaluation by the members of their

original valuation followed. Each group member was instructed that they could modify their values if they wished or keep the same values. The final step produced an amended final group ranking, which represented a consensus valuing of each objective by the Tribe.

The NGT is similar to the Delphi technique (not used in this study) which is another consensus valuation process that can be used to obtain the same information on objectives. Except for the group discussion and for being together, the NGT is similar to the Delphi in terms of the individual evaluation, group summary, re-evaluation, and anonymity that are all parts of the process (Linstone & Turoff, 1975; Rule & O'Laughlin, 1989). Anonymity is observed in that the facilitator only shares the summed results and responses could not be traced as to who made them in the NGT.

Scoping activities also developed data on resource capabilities and a set of criteria to evaluate the specified objectives. For instance, to measure the employment objective, criteria dealing with full-time and seasonal employment were used because the Tribe was concerned about both. Some criteria were indices, such as a soil erosion index which was based on site-specific factors. For goals for which no apparent measurement existed, such as the transfer of knowledge from one generation to another, the decision criteria were developed by consensus of the research team members. More detailed description of criteria development is given in Rosacker *et al.* (1992) and is available from the authors. A list of these criteria and the type or unit of measure used for each are presented in the Results Section and also are briefly described in the following paragraphs.

The economic criteria emphasized activities that provide net returns to people, such as jobs and farming income. The criteria used in this study were present net worth (PNW), annual cash flow, and employment. Considering the activities included in each alternative, cashflows for cropping systems involved were determined and opportunities for seasonal and full-time employment were identified.

The environmental criteria measured outputs and impacts for soil, water, habitat, and other environmental indicators. They included well yield, water use for irrigation,

crop water use, soil loss, organic matter, bulk density, nitrogen fertilizer, pesticide danger, species diversity, and game and wildlife habitat. Well yield, irrigation water, and fertilizer were based on actual amounts used in each alternative. The Blaney-Criddle method (Finkel, 1982) was used to estimate crop water use for various land uses. Soil loss, organic matter, and bulk density criteria were relative indices reflecting soil quality. A pesticide danger index was based on type and characteristics of pesticides used. Species richness measured the number of representative species of plants and animals, while a Habitat Evaluation Procedure (U.S. Fish and Wildlife Service, 1980) was used to determine the habitat suitability of each alternative for four representative game animals (white-tailed deer, fox squirrel, eastern wild turkey, and eastern cottontail rabbit).

The social criteria dealt with responses on educational and recreation concerns and internal cultural interactions. They included educational and recreational opportunities, transfer of intergenerational knowledge, hunting activities, tribal control of land use, and complementarity of alternatives with surrounding developments. These were mostly indices that were developed based on the opportunities provided by the various components of each alternative.

The institutional/political criteria dealt with opportunities for outside funding and technical support for the alternatives. The concerns were matching of the Tribe's Land Use Plan with the alternatives and funding opportunities from the Bureau of Indian Affairs and other sources. Indices were developed for all criteria except BIA funding opportunities. One criterion, enhancement of Indian water rights claims, was dropped because it was a complicated legal issue beyond the scope of this study. However, relevant information on how this objective could be possibly facilitated was presented to the Tribe.

### *Phase 2*

A land use alternative consisted of one or more types of land uses called management regimes. Alternatives were developed based on the objectives obtained from the NGT, on the assessed cultural and natural resource capabilities, and on several additional land use guidelines from the Tribal Council and the Bureau of Indian Affairs, Winnebago

Agency. The guidelines included: a 10-year phased-in implementation schedule, retention of an established (in 1991) shelterbelt planting of 55-acres along the Missouri River, the development of a black walnut plantation, consideration of foregone cash rent from the current land use of BBH, impacts of the Food and Agriculture Conservation and Trade Act (1990), state-level policies on agronomic/forestry or agroforestry crops, possible short-rotation woody crop (SRWC) plantation and agroforestry systems, and the impact of the Army Corps of Engineers' management plan for the Missouri River that especially involved Glover's Bend, an important tribal recreational area located to the east of BBH. The number of alternatives developed had to reflect the spectrum of land uses, from the current agricultural use to the complete conversion of the 1255 acres to forestry.

### *Phase 3*

The analysis of alternatives involved determination of magnitudes associated with the decision criteria, the use of a decision matrix, and the application of a weighting summation method. The decision matrix is a useful tool in displaying a summary of interactions or impacts of one set of items (factors or criteria) against another set. The use of the weighting summation method in this evaluation followed Canham's (1990) procedures. This method has been used in studies involving alternative site locations for power plants, solid waste disposal plants, and power line locations ( Leopold, 1969; Zieman, 1971; and Hobbs, 1978, as cited by Canham, 1990). A later study by Cole (1994) employed the matrix approach to assess threats to wilderness. Cole's approach, however, dealt only with ratings and nominal scaling of the impacts of potential threats on wilderness attributes and did not involve any comparison of alternatives.

The comparison of all alternatives involved the simultaneous impacts of all criteria on an alternative. A criterion measured the effect associated with an alternative for a 50-year period, and its impact could be easily compared across alternatives. A 50-year planning period was used based on the long-term views of the Tribe expressed in their Land Use Plan and the production cycles of trees included in some alternatives. But because effects (criteria) were meas-

ured in terms of dollars, number of people employed, tons of soil loss, wildlife habitat value, and so on, it was difficult to sum all effects within an alternative, and to compare alternatives. To solve this comparability problem, data for all criteria and alternatives were scaled using the Z-statistic (Canham, 1990). This allowed all criteria effects for each alternative to be summed, yielding an overall score for that alternative. The Z-statistic is defined as:

$$Z_j = \frac{x_{ij} - x_m}{S_x}$$

for  $j = 1$  to  $n$ , the total number of decision criteria, where

$x_{ij}$  = the raw data value for alternative  $i$ , for all  $i = 1$  to  $k$ , the total number of alternatives,

$x_m$  = mean of all data for a given criterion,

$S_x$  = standard deviation of all data values for a given criterion,

$Z_j$  = a standardized score for the  $j$ th decision criteria.

Four weighting schemes were used to compare these options. These schemes were based on:

- (1) actual criteria weight values as determined by the NGT,
- (2) equal weight for each criterion,
- (3) arbitrary high weight given to environmental criteria only, and
- (4) arbitrary high weight given to economic criteria only.

The NGT weights were derived from the scores attributed to the criteria associated with the tribal objectives for BBH. These scores were provided by Tribal members who participated in the NGT process and who provided a group ranking of these objectives as given in Table 1. For each weighting scheme, the Z-scores were multiplied by the weights assigned to the criteria. For example, in giving priority to economic criteria, it was assumed that all economic criteria were ten times as important as all other criteria. Hence, the Z-scores for economic criteria were multiplied by a weight of 10.0; for all other criteria, their Z-scores were multiplied by 1.0. These numbers were arbitrarily chosen.



In most cases, only one criterion was identified for one objective. However, in cases where two criteria were used to measure an objective, each criterion was given one-half value toward the attainment of that objective. This assumes that each of the two criteria contribute equally toward the attainment of that particular objective. The weighted Z-scores could be summed for an alternative and the total weighted score for each alternative could be directly compared then. For any weighting scheme, the "best" alternative is that with the greatest total weighted score.

## RESULTS AND DISCUSSIONS

Table 1 presents the 21 objectives developed from Phase 1. Note that the NGT did not result in highly polarized opinions regarding the importance of objectives. In the final round, social and political objectives were the highest ranked (health risk and building continuity) and the lowest ranked (recreational opportunities and relationship with the Army Corps of Engineers). The attainment of the Tribe's land use plan goals, its water rights claims, fostering of tribal land use philosophy, and several environmental objectives, such as enhancement of water quality and quantity, species diversity, and wildlife habitat, were highly ranked also.

Seven alternatives were developed, representing feasible alternative uses of BBH, and are shown in Table 2 with the estimated acreages of their various components. All alternatives had the 55-acre shelterbelt component. Alternative 1 (status quo) placed all 1200 acres in irrigated and dry land corn and soybean production. Alternative 2 retained the irrigated cropland (75% of the area) and had the rest in trees (black walnut, cottonwood, and other native bottomland forest species). Alternative 3 had 50% of the area in irrigated agronomic production and 50% in trees (SRWC species, and mixed native bottomland forest). Alternative 4 had irrigated alfalfa production on 25% of the area, 71% in trees (SRWC and bottomland tree species), and about 4% for Indian corn, berries, and a wholesale container nursery operation. Alternative 5 dropped the alfalfa, retained the berry/corn/nursery areas, and put the rest (96%) of the land to forest to produce timber, wildlife, and recreational opportunities. Alternative 6 considered a 40-acre demonstration/research plot in cooperation with the USDA

TABLE 1. GROUP RANKINGS

*Nominal group rankings for the Tribal objectives associated with alternative uses of Big Bear Hollow.*

OBJECTIVES	RANKING <sup>a</sup>	
	1st Group	Final Group
1. To minimize health risks associated with farm chemical use	75	87
2. To build continued tribal support for the project	87	87
3. To enhance the water rights of the Winnebago Tribe of Nebraska	69	79
4. To enhance attainment of goals of the Winnebago Land Use Plan	66	78
5. To enhance quality & quantity of the water coming from the area	64	76
6. To enhance wildlife habitat	63	75
7. To enhance diversity of plants/animals of bottomland ecosystem	62	75
8. To enhance the complementary nature of the project withbGlover's Bend (adjacent forested land on Missouri River)	64	75
9. To foster the tribal philosophy of land use	61	72
10. To reduce soil loss	57	71
11. To enhance soil fertility	57	70
12. To foster long-term support of tribal goals & objectives by the BIA	59	69
13. To minimize loss of income from converting site to other land uses	58	68
14. To maintain about the same cash flow as from leasing BBH	75	68
15. To foster hunting and fishing opportunities for the Tribe	58	66
16. To enhance the transfer of intergenerational tribal knowledge	57	66
17. To promote long-term opportunities for adult employment	54	61
18. To foster educational opportunities for the entire tribal community	50	60
19. To promote opportunities for seasonal youth employment	46	58
20. To foster long-term support of tribal goals and objectives by the Army Corps of Engineers	55	47
21. To develop recreational opportunities for tribal members	43	40

<sup>a</sup> The larger the number the greater the importance of that objective to the Winnebago Tribe of Nebraska.

TABLE 2. DEFINITION OF ALTERNATIVES

*Defining the seven proposed alternatives by management regime with estimated acreages.*

MANAGEMENT REGIMES	ALTERNATIVES						
	1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	4 <sup>d</sup>	5 <sup>e</sup>	6 <sup>f</sup>	7 <sup>g</sup>
Shelterbelts	55	55	55	55	55	55	55
Irrigated corn & soybeans	1040	900	600	0	0	0	0
Dryland corn & soybeans	160	0	0	0	0	0	0
Managed mixed bottomland	0	226	191	325	773	764	0
Managed cottonwood	0	36	20	0	60	46	0
Managed mixed walnut	0	38	4	0	39	67	0
Short rotation woody crops	0	0	385	338	0	0	0
Unmgd. mixed bottomland	0	0	0	171	194	190	965
Unmanaged cottonwood	0	0	0	15	65	65	125
Unmanaged mixed walnut	0	0	0	4	22	28	110
Irrigated alfaalfa	0	0	0	300	0	0	0
Agroforestry demonstr. plot	0	0	0	0	0	40	0
Berry patch	0	0	0	2	2	0	0
Indian corn	0	0	0	40	40	0	0
Nursery	0	0	0	5	5	0	0

<sup>a</sup> Status quo — 100% (1200 acres) of land in irrigated/dryland corn/soybean production; land is cash rented to non-native American farmer.

<sup>b</sup> Less diversified agroforestry system with 75% of area in irrigated croplands and the rest in managed forests.

<sup>c</sup> Agroforestry system with 50% of area in irrigated cropland and 50% in managed forests and SRWC plantation.

<sup>d</sup> Agroforestry system containing alfalfa, managed and unmanaged forests, nursery and small agricultural areas.

<sup>e</sup> Agroforestry system with managed/unmanaged forests, nursery, and small agricultural areas

<sup>f</sup> Less diversified agroforestry system with managed/unmanaged forests and agroforestry research/demonstration area.

<sup>g</sup> Complete conversion to native bottomland forests.

Forest Service National Agroforestry Center (located in Lincoln, Nebraska), and converted the rest to native forest. Alternative 7 considered complete conversion of the 1200 acres to native bottomland forests.

Of the seven alternatives, 2 and 3 contained predominant agricultural activities and some forestry, 4 and 5 were more diversified alternatives, while numbers 6 and 7 provided predominantly non-market (recreational and wildlife) outputs with other market goods.

Table 3 presents the 25 decision criteria, the type or unit of measure used for each criterion, and the raw effects based on each criterion for each alternative over a 50-year planning period. Using raw effects, alternatives could be compared for only one criterion at a time, e.g., annual cash flow is highest for Alternatives 4 and 5. A more meaningful comparison is made by considering all criteria Z-scores for each alternative. Z-scores for selected criteria are presented in Table 4 to illustrate transformation of values of criteria of varying units into comparable unitless values. Simple summation of Z-scores for an alternative yields a valuation that implicitly assumes that all criteria are equally important, which would correspond to those obtained under the equal weighting scheme, one of the four schemes applied in this study.

In each weighting scheme, the Z-scores per criterion were multiplied by a specific assigned weight. Negative values obtained for Alternatives 1 to 3 in all weighting schemes reflected the fact that these three alternatives had predominantly agricultural activities and had low forestry and environment-enhancing opportunities. Hence, one could expect low nominal, equal, and environmental scores for these alternatives. These same alternatives were also low in economic weighting because employment opportunities (full time, seasonal, youth) were zero or minimal. Alternatives 6 and 7 were ranked low under the economics weighting because of limited cash income and few employment opportunities. On the other hand, Alternatives 4 and 5 had agricultural activities that provide for substantial cashflow and employment opportunities, as well as forestry components that offer more educational, recreational, and intergenerational interaction opportunities and greater tribal control of land use as compared to alternatives with

TABLE 3. EFFECTS ACROSS THE ALTERNATIVES

*Matrix of raw effects for all criteria across the seven proposed alternatives.*

CRITERIA AND UNIT OR TYPE OF MEASURE USED	ALTERNATIVES						
	1	2	3	4	5	6	7
Yearly cashflow (\$) (undiscounted)	90,000	67,500	45,000	104,440	104,440	0	0
Present Net Worth (\$) (discounted @6%)	-601,120	-876,030	-900,698	-238,858	-385,864	-1,540,983	-1,604,630
Full-time jobs (no. of job opportunities)	0	0	1	2	2	2	1
Part-time jobs (no. of job opportunities)	0	1	2	10	6	4	2
Jobs for the youth (no. of job opportunities)	0	10	20	67	60	28	28
Well yield (acre-feet per year)	450	450	300	287	0	0	0
Crop water use (acre-feet per year)	2,219	2,334	2,430	2,901	2,601	2,598	2,609
H <sub>2</sub> O from MO River (acre-feet per year)	80	0	0	0	0	0	0
Soil loss (index)	-10,800	-8,400	-6,421	-2,308	-1,012	-1,051	-600
Organic matter (index)	3,000	4,914	5,725	8,497	10,692	10,772	11,875
Bulk density (index)	2,260	4,377	5,477	7,866	10,528	10,625	10,635
N fertilizer (pounds)	72,000	-54,000	-36,000	-4,920	-4,920	-4,493	0
Pesticide danger (index)	-8,871	-6,657	-4,480	-1,094	-15	-496	-17
Species richness (no. rep. plant/animals)	6,000	12,000	12,225	17,947	29,017	29,280	30,000
Game/wildlife habitat (habitat value)	6,992	5,584	5,690	5,830	6,556	6,613	6,771
Educational opportu- nities (index)	0	4	5	10	10	7	8
Complementary developments (index)	0	2	3	8	8	8	8
Intergenerational enhancement (index)	0	1	4	10	10	8	8
Recreational use (no. people participating)	0	352	665	957	1,270	1,265	1,304
Tribal control of and use (index)	2	4	5	10	10	10	10
Hunting activities (index)	290	270	274	157	92	53	14
Match with Tribe's and use plan (index)	2.5	4	5	6	6.5	7	6
Funding, BIA (\$)	0	48,210	184,701	214,581	185,287	186,412	192,840
Funding, others (index)	0	5	6	10	10	10	10
Building continuity (index)	10	9	5	0	2	6	9

primarily agricultural or purely forestry management regimes.

The scaled results in Table 4 also yield important information regarding comparison of alternatives, especially with respect to highly ranked goals. For instance, Alternatives 4 and 5 are closely ranked. However, the achievement of specific goals varies to some degree and should be pointed out. Alternative 5 provides more than Alternative 4 in terms of the achievement of top ranked environmental goals, such as species richness and wildlife habitat, or of the social goal of continued tribal support for the project. In a situation where no specific type of criteria is being preferred, this kind of information should be of help to the decision maker.

For each weighting scheme, the weighted Z-scores were summed for each alternative. These total scores were then compared to determine the ranking for that scheme. Table 5 presents the summary rankings of the seven alternatives using the four different weighting schemes. Using the NGT-scores, Alternative 5 was ranked first and Alternative 4 was second. Using equal weights for all criteria, the rankings

TABLE 4. Z-SCORES

*Matrix of Z-scores for selected criteria.*

CRITERIA	ALTERNATIVES						
	1	2	3	4	5	6	7
Present Net Worth	0.520	0.004	-0.042	1.200	0.930	-1.250	-1.370
Full-time jobs	-1.270	-1.270	-0.160	0.960	0.960	0.960	-0.160
Crop water use	-1.380	-0.870	-0.440	1.670	0.330	0.320	0.370
Soil loss	-1.560	-0.970	-0.500	0.500	0.810	0.800	0.910
N fertilizer	-1.620	-1.000	-0.370	0.700	0.700	0.720	0.870
Species richness	-1.360	-0.760	-0.730	-0.560	0.960	0.990	1.060
Intergenerational enhancement	-1.400	-1.160	-0.440	0.990	0.990	0.510	0.510
Match with Tribe's land use plan	-1.770	-0.820	-0.180	0.450	0.770	1.090	0.450
Game/wildlife habitat	1.220	-1.240	-1.050	-0.800	0.430	0.560	0.840
Building continued support for project	1.090	0.830	-0.220	-1.540	-1.010	0.040	0.830

TABLE 5. RANKING OF ALTERNATIVES

*Ranking of the seven alternatives using four weighting schemes.*

WEIGHTING SCHEMES	RANKING						
	1st	2nd	3rd	4th	5th	6th	7th
Nominal group <sup>a</sup>	Alt. 5	Alt. 4	Alt. 7	Alt. 6	Alt. 3	Alt. 2	Alt. 1
Equal weight <sup>b</sup>	Alt. 5	Alt. 4	Alt. 7	Alt. 6	Alt. 3	Alt. 2	Alt. 1
Environmental weight <sup>c</sup>	Alt. 7	Alt. 5	Alt. 6	Alt. 4	Alt. 3	Alt. 2	Alt. 1
Economic weight <sup>d</sup>	Alt. 4	Alt. 5	Alt. 1	Alt. 3	Alt. 2	Alt. 6	Alt. 7

<sup>a</sup> Tribal weights determined from the NGP are applied.<sup>b</sup> All objectives given equal weight.<sup>c</sup> Environmental objectives given weight of 10.0, all others 1.0.<sup>d</sup> Economic objectives given weight of 10.0, all others 1.0.

were similar to those derived by using the NGT weights. This is somewhat surprising given the variation in Tribal weights from Table 1 relative to the equal weighting scheme. Giving high weight to the environmental criteria, Alternative 7 was first and Alternative 1 was last. Finally, when high priority was given to economic criteria, Alternative 4 ranked first and Alternative 5 was a close second. This was expected because both alternatives provided for more cash flow and employment opportunities from both agricultural and forestry activities.

Based on the four weighting schemes, Alternatives 5 and 4 seemed to be the best land use alternatives. Both alternatives were diverse mixtures of forestry and agricultural (agroforestry) operations, and both addressed most of the tribal objectives that were expressed for BBH.

A note of caution is in order, however. Formal risk consideration was limited to the present net worth criterion using a real discount rate of 6%. Informal risk and uncertainty considerations within each alternative were made by adjusting downward yields and prices for alternatives with risky management regimes. For example, the nursery operation part of Alternatives 4 and 5 was considered a high risk proposition because it required a high level of technical and managerial skills, high capital cost of establishment,

and uncertainty associated with markets for the nursery products. Thus the cash flow and present net worth are diminished by the assumed risk. No sensitivity analysis was applied to the raw effects.

## CONCLUSIONS

The evaluation of various land use alternatives for Big Bear Hollow used a combination of techniques. Crucial to the process is the understanding by the clientele of the importance of their participation in identifying and articulating their own objectives. A consensus of these objectives may be obtained through an interactive process. In this study, objectives were developed and ranked using the NGT.

The seven alternatives that were developed represented a spectrum of land use packages, ranging from the status quo (purely agricultural production) to 100% conversion of the land to forestry (timber, wildlife, recreation) production. Based on 25 decision criteria, the alternatives were evaluated using a weighting summation method. Four weighting schemes were applied to emphasize preferences in objectives. Based on these schemes and transformed effects (Z-scores), the best alternatives seemed to be two agroforestry alternatives involving production of a diverse mixture of forest and agricultural crops.

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