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Ecology, Resource Redistribution, and Mormon Settlement in Northeastern Arizona

Successful Mormon colonization of the American West has largely been attributed to the adaptive advantage of cooperative Mormon values. This article shows that successful Mormon colonization of the Little Colorado River Basin had an ultimate ecological basis: the redistribution of surplus resources among settlements situated in dispersed and functionally independent local environments. Two systems of resource redistribution among 19th-century Little Colorado Mormon settlements are examined, showing that ecological considerations explain their differential success as adaptive mechanisms contributing to the success of this local colonization effort. The article concludes by suggesting that general ecology provides a useful theoretical framework for explaining successful Mormon colonization in this region and elsewhere.

MORE THAN TWO DOZEN MORMON AGRICULTURAL SETTLEMENTS WERE founded in the Little Colorado River Basin of northeastern Arizona as part of an ambitious 19th-century Mormon effort to colonize the American West. A demanding and highly variable environment threatened the success of this local effort by seriously limiting agricultural productivity and by imposing excessive demands on farming. High costs in the face of low and highly variable agricultural productivity yielded substantial emigration and population instability, and resulted in the failure of some half dozen settlements. The colonization effort succeeded, however, despite the difficulties encountered, and the basin today contains some 20 towns that originated during early Mormon colonization of the region. Significantly, agricultural colonization of the basin was largely a Mormon achievement, with Mormon settlements succeeding where others had failed (see Peterson 1973:1–2).

Historians and social scientists have long been interested in the impressive success of Mormon colonization and have largely explained this success in terms of the social and economic consequences of cooperative Mormon values (cf. Arrington 1958; Leone 1979; O'Dea 1957; Peterson 1973). While recognizing the role that cooperative values played as proximate causes underlying successful Mormon colonization, this article argues that successful Mormon colonization of the Little Colorado River Basin had an ultimate material basis: the judicious redistribution of surplus resources among individual settlements situated in separate and independent local environments. The article also argues that the adaptive advantage of Mormon resource redistribution conforms to expectations derived from general ecological theory.

Although considerable debate exists regarding the relationship between diversity and stability in ecological systems and the extent to which regulation occurs within complex ecological communities (see Abruzzi 1987:317–318; May 1973:37–40), research exists that suggests that complex ecological communities are better able to maintain population and community stability in the face of limited environmental variation (cf. MacArthur 1955; Rogers and Hubbard 1974). The key to maintaining community stability under

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variable environmental conditions lies in the degree to which redundancy exists in the flow of energy/resources through a community. Redundancy results when resource flows through a community originate in several functionally independent channels. Community stability and persistence can only occur if a community's resource flows possess sufficient redundancy to assure local resource availability during periods of increased environmental instability. Where sufficient redundancy exists, the destabilizing impact of environmental fluctuations can be offset by the existence of a complex network of overlapping energy/resource flows. Where sufficient redundancy does not exist, the negative consequences of environmental perturbations are likely to ramify throughout the community and reduce community stability, even among communities containing a high degree of diversity. This article suggests that Mormon values facilitated resource redistribution, and thus successful colonization of the Little Colorado River Basin, only when they underlay a multihabitat resource-flow system that contained sufficient redundancy to effectively counteract local environmental instability.

The relevance of material considerations and general ecological theory for explaining successful Mormon colonization in the Little Colorado River Basin is illustrated by the differential success of two systems of multihabitat resource redistribution developed by early Mormon settlers in the region. The first of the two systems was based on the joint operation of several productive enterprises by early United Order towns located along the lower valley of the Little Colorado River.[1] This initial system failed as a mechanism of environmental regulation despite its collective organization and its manifest ecological orientation because it lacked sufficient redundancy to withstand and offset the destabilizing impact of environmental instability. It depended directly on the surplus labor and productivity of fewer than a half dozen settlements situated in similar, highly unstable habitats. A system of tithing redistribution later emerged that provided the redundancy needed to offset local environmental instability. This later system succeeded because it was based on resource redistribution among nearly 20 settlements located in diverse, independent, and widely separated habitats. Significantly, this later system did not evolve as a conscious adaptation to physical environmental conditions, but largely as a response to competing non-Mormon business interests. In addition, while tithing redistribution emerged as part of the overall cooperative thrust of Mormon colonization, it depended fundamentally on institutions that enabled individual settlers to profit from participation in the system.

By showing that successful Mormon colonization of the Little Colorado River Basin can be explained by explicit reference to general ecological considerations, this article attempts to go beyond merely stressing the importance of environmental factors in the settlement process. Specifically, its goals are (1) to indicate the ultimate material basis for successful Mormon colonization, and (2) to suggest that general ecology provides a meaningful theoretical framework for explaining successful Mormon colonization and, potentially, the evolution of complex human communities.

Mormon Colonization of the Little Colorado River Basin

Mormon colonization of the Little Colorado River Basin began in 1873, when a well-equipped party of more than 100 individuals was dispatched by Church leaders in Salt Lake City to establish a single settlement along the lower valley of the Little Colorado River (see McClintock 1921:135; Tanner and Richards 1977:12). This initial effort failed, and a second attempt was made in 1876. This time, 500 settlers were organized into four companies and instructed to establish four settlements in the general location chosen for the previous expedition. These were Sunset, Brigham City, Obed, and St. Joseph (see Figure 1). Additional colonies were founded along Silver Creek and along the upper Little Colorado River during 1877–80.

Establishing and maintaining viable agricultural communities in this arid and climatically variable region proved exceedingly difficult. Annual precipitation for most of the

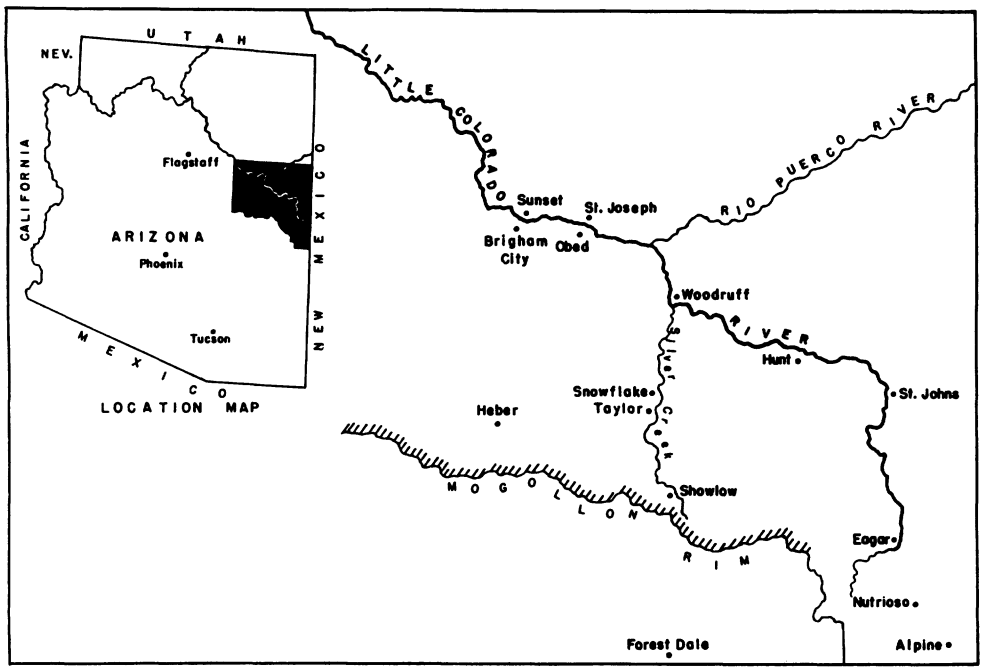

Figure 1
Little Colorado River Basin Mormon settlements. (Reprinted with permission of Plenum Press.)

basin averages less than 400 mm and varies substantially from year to year. Furthermore, little, if any, precipitation occurs during the critical months of April to June. Irrigation was, therefore, essential to successful farming in the region (see Abruzzi 1985). However, because surface water flows largely in direct response to precipitation, streamflow also fluctuates sharply, and most streambeds are dry during April to June, when 45% of annual irrigation requirements must be applied (see Bureau of Reclamation 1947:72). Mormon settlements also had to contend regularly with early frosts, high temperatures, droughts, flooding, hailstorms, insects, and high winds. In addition, two devastating droughts ravaged the basin for nine years between 1892 and 1905, killing thousands of livestock and causing widespread crop failure. Such pervasive environmental variation frequently resulted in individual settlements losing crops to several causes during a single agricultural season.

Hard work and cooperation did not, therefore, guarantee success. Settlements were frequently left with insufficient food to survive the winter, despite a heavy investment of labor and other community resources. For example, while Sunset produced 7,000 bushels of wheat and corn in 1879, this lone productive year was preceded and followed by three years of poor harvests. Likewise, Brigham City suffered continuous crop failures from 1876 to 1881, while St. Joseph sustained near-total crop failures for three of the seven years between 1876 and 1882. In addition, records indicate that generally poor harvests occurred throughout the basin during half the years between 1880 and 1900 (Abruzzi 1981:92–96). Total tithing collected displayed an annual variation of nearly 40% at St. Joseph and Woodruff, more than 30% at Showlow and Alpine, and about 20% among the relatively properous and stable settlements of Snowflake, St. Johns, Taylor, and Eagar (see Table 1).

Substantial variation in agricultural productivity persisted despite continued intensive labor investment. For example, St. Joseph constructed five dams between 1876 and 1884

Table 1
Total tithing by town, 1887–1905 (in dollar values).[a]

Year	St. Joseph	Woodruff	Snowflake	Taylor	St. Johns	Eagar	Showlow	Alpine
1887	611	570	2,334	1,004	—	—	364	—
1888	772	410	2,969	1,299	3,637	1,427	283	288
1889	862	602	2,855	1,573	4,413	1,838	418	425
1890	1,204	797	3,411	1,710	4,328	1,804	651	234
1891	590	681	2,851	1,414	4,479	1,743	489	388
1892	684	971	3,319	1,557	3,447	1,391	522	472
1893	734	581	2,865	1,130	3,029	1,901	263	491
1894	583	581	2,498	1,259	2,347	1,165	572	218
1895	772	655	2,341	995	2,391	2,021	330	470
1896	748	629	2,362	1,192	2,169	1,634	325	442
1897	952	774	2,578	1,147	2,541	1,975	389	454
1898	1,191	894	2,183	1,230	2,861	2,156	226	333
1899	1,543	1,324	2,880	1,479	3,482	2,029	453	594
1900	1,141	1,394	2,945	1,563	3,961	1,371	233	416
1901	1,677	1,246	3,882	1,567	4,200	2,485	—	523
1902	1,497	1,349	3,782	1,817	3,713	1,886	—	391
1903	1,907	1,578	4,142	1,857	4,542	1,863	554	860
1904	1,796	1,364	3,699	2,055	4,186	1,739	585	506
1905	2,094	1,047	3,589	1,847	4,361	2,155	667	583
X[b]	1,124.11	915.42	3,025.53	1,463.47	3,560.50	1,810.17	430.88	449.33
s	489.41	356.43	589.24	318.20	817.39	325.69	144.43	146.96
V	.435	.389	.195	.217	.230	.180	.335	.327

[a]Source: Abruzzi (1987:88).
[b]"X" denotes the mean; "s" denotes standard deviation; "V" denotes coefficient of variation.

for a total cost of nearly 9,000 man-days and 3,000 team-days labor valued together at over $40,000, all of which were destroyed by floods in the Little Colorado River (see Abruzzi 1981:169–177). Settlers at St. Joseph did not achieve a permanent irrigation structure until the construction of their final dam in 1924.

Each dam loss produced a crop failure which resulted inevitably in individuals emigrating from the affected community. Emigration, in turn, forced the remaining inhabitants of a town to recruit new settlers to rebuild the dam, repair ditches, and replant fields. Understandably, population instability was most pronounced among settlements located along the lower valley of the Little Colorado River, as these towns experienced both the greatest variation in agricultural productivity and the highest incidence of dam failures. St. Joseph and Woodruff, the two surviving lower valley settlements, sustained 13 and 10 dam failures, respectively, between 1876 and 1900. By comparison, only three dam failures occurred at Snowflake and Taylor, two at St. Johns, one at Showlow, and none at either Eagar or Alpine during the same years (Abruzzi 1981:191). As a result, the lower valley contained the greatest number of failed settlements. Brigham City was abandoned in 1881 and Sunset in 1883. A later settlement, known eventually as "Old Taylor," was both founded and abandoned in 1878 following the construction and loss of five dams during that single year. Obed was abandoned in 1877 due to persistent illness associated with its location.

Exploiting Environmental Diversity

As the previous discussion clearly indicates, local environmental variability threatened the survival of individual settlements in the Little Colorado River Basin, and thus undermined the entire colonization effort. However, the region's spatial diversity provided an opportunity for early settlers to overcome local environmental limitations. The basin contains numerous widely separated and structurally distinct local habitats which are often differentially affected by the same environmental variation and which offer distinct potentials for agricultural productivity. Consequently, a clear adaptive advantage existed for early Mormon settlements to integrate the productivities of several habitats into a single resource-flow system. A multihabitat exploitative strategy would diversify an individual settlement's resource base and thus increase local community productivity and stability. To the extent that a multihabitat strategy occurred among Mormon settlements in the region, it increased the probable success of their colonization effort.

Individual settlements could reduce their level of dependence on any single highly variable habitat by exploiting several distinct local environments. In this manner, the region's spatial diversity could be used to circumvent its temporal variability. Widely separated habitats generally displayed different schedules of variability. For example, while the particularly wet 1890 agricultural season increased agricultural production at most locations, it caused crops to rot at Alpine and led to the loss of dams at Snowflake, Taylor, Woodruff, and St. Joseph (see Abruzzi 1981:94, 174, 179, 188). Similarly, St. Johns and Alpine reported extensive damage to crops caused by grasshopper infestations between 1884 and 1891, whereas other settlements did not (see McClintock 1921:191).

Broad regional environmental forces also generally produced distinct impacts in different portions of the basin. For example, while abundant rainfall generally increased agricultural productivity at lower elevations, it increased flooding and crop damage at higher elevations and in other local habitats where soil permeability is low, such as in the lower valley of the Little Colorado River. Similarly, intense rainfall or heavy snow melt yielded more frequent dam failures at lower elevations because of the larger surface area drained here. While warm years generally provided more adequate growing seasons at higher elevations, they increased the likelihood of heat stress and higher evapotranspiration rates on crops at lower elevations. Conversely, while cooler temperatures reduced heat stress on crops in the lower valley, they increased the risk of early frosts throughout the southern highlands. Consequently, due to local differences in elevation, precipitation,

temperature, length of growing season, soil quality, and surface water quality and availability, agricultural productivity varied significantly within and between Mormon settlements throughout the 19th century. For this reason, no clear correlation exists in the pattern of annual agricultural productivity achieved among individual towns throughout the region (see also Lightfoot 1980:206–208).

The development of an integrated multihabitat resource-flow system thus offered a clear adaptive advantage for early Mormon settlements in the region. For those towns whose very survival was in perpetual jeopardy, the ability to withstand otherwise devastating crop failures and dam losses frequently meant the difference between extinction and continued survival. However, even the more prosperous settlements benefited from resource redistribution. Between 1887 and 1905, agricultural productivity varied more than 35% above and below its average at Eagar, and 28% above and nearly 40% below its mean at St. Johns. Even Snowflake, the most prosperous settlement in the entire region, experienced 30% variation in agricultural productivity during these years. By actively pursuing a multihabitat exploitative strategy, Church leaders more realistically shifted the focus of self-sufficiency away from individual settlements and onto a regionally coherent adaptive system.

The Little Colorado Mormon settlements developed two distinct multihabitat resource-redistribution systems during the 19th century. The first consisted of a series of productive enterprises jointly operated by the early United Order towns in the lower valley of the Little Colorado River. The second and later system operated through the collection and redistribution of the tithing resources among settlements dispersed throughout the river basin.

Conjoint Enterprises

Early Mormon settlements in the lower valley jointly operated four separate productive enterprises: a sawmill, a dairy, a grist mill, and a tannery. Unfortunately, almost no information exists regarding either the grist mill or the tannery. However, enough information exists for the sawmill and the dairy to indicate (1) that these enterprises provided important resources that supplemented agricultural production along the lower valley, (2) that they frequently provided these resources during the very years when farming along the lower valley failed, and (3) that the per capita productivity of these supplementary activities often exceeded that achieved through irrigated farming along the Little Colorado.

Established during November 1876, the sawmill was located about 60 miles southwest of Sunset. Production at the mill during November and December that year was 51,202 board-feet at a cost of 1,200 man-days labor (Porter 1923:65). By April of 1877, production at the sawmill had totaled 100,000 board-feet (Jensen 1935:4/10/1877), and during November of 1878 about 80,000 board-feet of lumber were produced (Little Colorado Stake 1878–87:11/30/1878). Most of this lumber was used by settlements in the lower valley to construct the initial buildings needed to establish these towns. However, in 1879 nearly 40,000 board-feet of lumber were charged to individuals at Snowflake (Porter 1923:65), and as early as September 1877, a delegation was sent to Prescott, Arizona, to determine the current market price for the sale of lumber (St. Joseph United Order 1887:9/6/1877).

The sawmill produced lumber for five years. However, it became increasingly difficult to maintain sufficient labor at the site. Travel to the sawmill from the Little Colorado settlements took nearly a week round-trip. Consequently, a more or less permanent population had to be stationed there. Following a heavy initial input of labor, the number of permanent residents at the mill steadily declined, and by the close of 1881 the mill was sold.

The most successful of the early conjoint enterprises was the dairy. Established in 1878, the dairy provided both substantial and critical provisions for the early colonies. During the first year, 48 men and 41 women tended 115 cows and produced 5,400 pounds of

cheese and 442 pounds of butter (McClintock 1921:154; Peterson 1973:111; see Little Colorado Stake: 8/31/1878). Production at the dairy during 1881 included 2,000 pounds of cheese, 1,300 pounds of butter, 1,100 pounds of pork, and 340 bushels of potatoes (Warner 1968:10). By 1882, a reported 200 cows were being milked there (Warner 1968:11).

Although the dairy was successful and substantially enhanced the aggregate productivity of the lower valley settlements, its productivity, like that of the sawmill, depended upon surplus labor available from the parent communities. Since the dairy was also located at a considerable distance from the Little Colorado, its efficient operation likewise required a resident population. However, as lower valley settlements suffered continuing hardship trying to maintain their fragile irrigation systems, they were increasingly unable to provide the labor needed to operate the dairy. Furthermore, as population size declined at Sunset and Brigham City, the Mormon dairy suffered. With the demise of these and other towns along the Little Colorado the dairy was abandoned in 1882, less than a year after the close of the sawmill.

Tithing Redistribution

Following the failure of the conjoint enterprises, Little Colorado Mormon settlements evolved a system of tithing redistribution that contributed substantially to the success of their colonization effort. Tithing was collected by individual wards, centralized into regional stake warehouses and then forwarded, less a portion granted for local use, to the General Tithing Office in Salt Lake City.[2] Most tithing collected within the Little Colorado River Basin during the 19th century was paid in kind, as cash was a scarce commodity on this remote frontier. Items were tithed as they became available, and tithing stocks were generally most abundant following the fall harvest.

Only a fraction of the tithing collected among Little Colorado settlements during the 19th century was actually forwarded to Salt Lake City. The majority remained within the region. While considerable tithing resources were exchanged among individual settlements in order to alleviate local shortages of specific commodities (see Leone 1979:74–77), most was used to subsidize specific projects deemed important by local Church leaders to the success of the colonization effort. The irrigation systems upon which agriculture in this arid region depended were the single most important public structures among Little Colorado Mormon settlements. Consequently, it was in subsidizing dam reconstruction that tithing redistribution performed its most critical adaptive function (see Abruzzi 1981:165–196; Leone 1979:43–110).

The destruction of irrigation systems threatened the survival of an entire community. Their immediate reconstruction was, therefore, essential, especially if a dam failure occurred during the agricultural season. However, such undertakings were generally beyond the resources of individual towns, especially the smaller ones. Through tithing redistribution local Church leaders provided produce and supplies that permitted endangered settlements to survive until the next harvest. They also used tithing funds to hire labor to help repair dams, and allowed individuals to offset their tithing obligation to the Church by donating labor on dam reconstruction and on other Church-approved projects. Tithing surpluses were also distributed to needy individuals and families within a town, even during years when the majority of that community prospered. Applied in this manner, tithing redistribution enabled surpluses collected at one spatiotemporal locus to offset production deficiencies at another time and place.

Tithing redistribution thus contributed substantially to the successful colonization of this arid and climatically variable river basin. It is highly unlikely that either St. Joseph or Woodruff would have survived repeated dam failures were it not for access to regional tithing resources. Individual settlements also benefited when losses occurred for reasons other than poor harvests or dam failures. For example, Mormon settlers at St. Johns and Eagar, both relatively prosperous communities, depended critically on tithing redistri-

bution during several years in which they endured intense and costly political harassment by non-Mormons (see Abruzzi 1981:43–49).

The effectiveness of tithing redistribution depended on several supporting institutions, including (1) a regional board of trade that established uniform prices among Mormon settlements in the region and made it economically advantageous for individuals to donate resources to the Church, (2) a network of church-affiliated mercantile institutions that provided the storage, transportation, and credit arrangements needed for effective tithing redistribution, and (3) a system of quarterly stake conferences at which representatives from every settlement exchanged information, assessed local needs, and determined appropriate resource allocations.

The Board of Trade among Little Colorado Mormon settlements was designed to encourage and direct cooperative production, marketing, and purchasing activities among Mormon settlements. This was done in order to regulate wages and prices paid in economic transactions with competing non-Mormon business interests (see Abruzzi 1981:215–217; Arrington 1958:342–349; Leone 1979:82–83; Peterson 1973:131–135). Local boards of trade were established throughout the Mormon settlement area that were administratively united with Zion's Central Board of Trade in Salt Lake City. By establishing specific prices charged to non-Mormons, the Board of Trade necessarily fixed the prices that prevailed among Mormons themselves. In addition, by establishing set prices for all commodities, items in greater abundance at one town might be more profitably converted through deposit in the Church's local marketing apparatus than in sale to non-Mormons. Both individuals and local Church leaders could, therefore, exchange surplus goods on hand for scarce commodities that were abundant elsewhere at prices that were not harshly responsive to market fluctuations. As a result, the Board of Trade's pricing policies facilitated resource redistribution among Mormon settlements and inhibited the expatriation of resources from the redistributive system.

The Arizona Cooperative Mercantile Institution (ACMI), like the Board of Trade, developed as a local component of an encompassing Church institution: Zion's Cooperative Mercantile Institution (ZCMI) (see Abruzzi 1981:217–221; Arrington 1958:298–322; Leone 1979:79–81; Peterson 1973:136–153). The ACMI was founded in 1881 with 11 local church leaders forming its initial Board of Directors. A central ACMI store was established with locally owned affiliates organized in most settlements. The ACMI was originally begun as a wholesaler for Mormon towns in the region, purchasing supplies at prices that individual settlements could not command. However, it quickly assumed an important credit function. Individuals and affiliated cooperative stores could obtain advances from stocks on hand, usually to be repaid following the next harvest. Applying liberal credit arrangements, the ACMI facilitated recurring investment in local agriculture, as it normally carried a heavy load of debtors from one year to the next.

The ACMI also performed a critical role in tithing redistribution. Local bishops could exchange goods from their tithing stocks for cash, and frequently stored tithing produce on credit with the ACMI. Individuals could deposit their tithing obligations to the Church at the local ACMI affiliate and either have the proper amount credited to their tithing account or banked against future need. Labor was also an important commodity that could be exchanged at the ACMI. A substantial number of individuals obtained temporary employment freighting for the ACMI or performing other duties necessary for its operation, and the entire settlement of Woodruff exchanged employment for food and supplies with the ACMI following the destruction of their dam in 1884 (Abruzzi 1981:179).

The effectiveness of the ACMI in resource redistribution was enhanced by its integration with the larger ZCMI. Deposits in local cooperative stores throughout the Mormon West could be credited to individuals and towns within the Little Colorado River Basin. Thus, by its various credit arrangements and through its intimate association with the local Church leadership, the ACMI effectively transformed an otherwise dormant sur-

plus into an active flow of resources that circulated between locations of relative abundance and those of critical need.

The responsiveness of tithing redistribution was assured by a system of quarterly stake conferences attended by representatives from each ward. Although they were ostensibly held for religious communion, the conferences served as a time during which considerable information was exchanged regarding the material circumstances of local settlements. The conferences occurred during critical junctures in both the agricultural and seasonal cycles: prior to the planting season (February–March), after the spring runoff (May–June), following the intense summer rains (August–September), and subsequent to the fall harvest (November–December). They therefore facilitated a rapid exchange of information and enabled a judicious response to local needs at the very times when environmental conditions were most likely to have a negative effect on local agricultural systems.

Discussion

As already indicated, the Little Colorado River Basin presented early Mormon settlers with a diverse yet highly variable environment that imposed severe limitations on agricultural productivity and community stability at the same time that it offered the potential for circumventing local environmental limitations. Early Mormon settlers clearly recognized the adaptive advantage of exploiting regional diversity and employed several specific strategies to integrate the exploitation of diverse habitats into a single resource-flow system. However, of the two multihabitat resource-flow systems that emerged—one based on joint resource exploitation and the other on tithing redistribution—only the latter system functioned as an effective mechanism of environmental regulation by circumventing environmental variability. It is argued here that tithing redistribution succeeded primarily due to the greater redundancy of resource flows it provided compared to the earlier system of conjoint enterprises.

The conjoint enterprises eventually failed because they never achieved functional independence from the lower valley settlements. Most activities performed at the sawmill and the dairy had to be completed during the summer and early fall due to the constraints imposed on these activities by the winter weather at higher elevations. However, agricultural labor was performed primarily during the summer and fall as well. Consequently, the effective operation of the conjoint enterprises competed directly for labor with farming in the lower valley. A record of the labor expended at St. Joseph during 1879 illustrates clearly the problem these early settlers faced (see Table 2). Of the 4,761 man-days of labor credited to 23 men, approximately 4,500 man-days, or 196 man-days per capita, had to be performed concurrently with the growing season.

Little time remained, therefore, to invest in other activities. Competing demands for labor in agriculture, dairying, logging, milling, and the numerous other operations needed to establish and maintain individual settlements strained the limited labor force of these small towns. During periods of critical labor shortages in agriculture, which occurred almost semiannually due to recurring dam failures, the drain of investing in supplementary productive activities far removed from the lower valley was a burden that became increasingly difficult, and eventually impossible, for lower valley settlements to endure. The instability and high cost of agriculture in the lower valley precluded the continued investment of limited resources in potentially productive yet supplementary resource flows.

Labor shortages among lower valley settlements were also aggravated by high dependency ratios (see Table 3). Settlements in the lower valley maintained consumer/producer ratios that reduced their productive capacity below that already imposed by their small size. This increased the already excessive drain on their limited resources. Furthermore, dependency ratios increased with time. At St. Joseph, the proportion of the population under eight years of age increased from 36.5% in 1877 to 49.5% in 1881, a year that witnessed a major dam reconstruction (see Abruzzi 1981:171–172). Signifi-

Table 2
Labor expended at St. Joseph during 1879.[a]

Work performed	Labor expended (in man-days)
Ditch	764.5
Farm	734
Garden	154
Stock	256.5
Herding cows	90
Herding sheep and shearing	326
Dairying	473
Freighting to Utah	128
Choring	234
Carpenter work	303.75
Shoemaking	82
Smith work	95
Building and sundry labor	710.25
Teaching school	95
Sawmill	315
Total	4,761

[a]Source: Porter (1923:375).

Table 3
Percent of the population under eight years of age among settlements in the lower valley of the Little Colorado River, 1877–86.[a]

Year	Sunset	Brigham City	St. Joseph
1877	25.0	34.0	36.5
1878	21.0	36.0	45.0
1879	33.8	40.2	43.0
1880	31.6	38.7	38.8
1881	34.5	—	49.5
1882	43.6	—	45.8
1883	52.4	—	43.6
1884	41.5	—	42.5
1885	42.3	—	23.3
1886	—	—	23.1

[a]Source: Abruzzi (1981:207).

cantly, children under eight years of age still accounted for 42.5% of the population at St. Joseph in 1884, another year requiring a major dam reconstruction (Abruzzi 1981:173). In 1883, the year of its dissolution, Sunset's population contained 52.4% children under eight years of age, the highest proportion of any town throughout the settlement period. In contrast, the proportion of the population under eight years of age in the Eastern Arizona Stake in 1879 was only about 31%, and at its peak reached only 36.7% in 1883, with children under eight years of age comprising only 26.2% of the population of Snowflake in 1880 (Abruzzi 1981:208). In addition, mean family size at St. Joseph between 1892 and 1897 was 7.3 persons, or nearly 30% greater than the mean family size of 5.8 persons recorded at Snowflake during the same years (Abruzzi 1981:209).

Thus, during the critical years when lower valley settlements struggled to establish their productive bases along the Little Colorado River and attempted simultaneously to

establish the institutions upon which a multihabitat resource-flow system could be based, they lacked the manpower needed to accomplish their goal. Lower valley settlements never seemed able to command enough resources to repair dams, clean ditches, or repair fields, let alone expand into new and distant habitats (see Abruzzi 1981:169–177; Tanner and Richards 1977:41–51).

The conjoint enterprises established by the lower valley settlements were not ecologically viable, despite their manifest ethnoecological basis, because they were not compatible with regional environmental conditions. Nor was their viability enhanced by the fact that they were based on the cooperative Mormon values that underlay their communal United Order organization (see Peterson 1973:91–122). The small populations of these communities suffered an intense drain on their meager resources due to the variability of surface water flow in the Little Colorado River. At the same time, chronic labor shortages in the face of frequent dam failures and high dependency ratios limited the ability of lower valley settlements to invest sufficient resources to effectively exploit distant habitats. Thus, despite its cooperative orientation, communal organization, and explicit ethnoecological basis, the system of conjoint enterprises failed as a mechanism of environmental regulation.

By contrast, tithing redistribution succeeded as a mechanism of environmental regulation, despite the fact that its critical supporting institutions were established for nonecological purposes. Although tithing redistribution itself was employed in part to offset the impact of local environmental variation, the Board of Trade and the ACMI were established primarily in response to competing non-Mormon business interests, while the quarterly stake conferences functioned ostensibly to promote religious unity and social separation. However, despite their manifest nonecological origin, the latter institutions provided the foundation for an ecologically viable multihabitat resource-flow system for the very reasons the conjoint enterprises did not. By broadening the organizational and environmental scope of the exchange network and by incorporating within this network a sufficiently large aggregate population permanently occupied within numerous, widely dispersed habitats, the system of tithing redistribution was suitably structured to circumvent local environmental variation within the basin.

By including every Little Colorado Mormon settlement and thus integrating resource flows from every exploited habitat, this later regionally coherent exchange system was able to provide substantial resources (labor, food, and supplies) at those specific times and places where resources were critically needed to offset the destabilizing impact of local environmental variation. In addition, tithing redistribution integrated the productivity and labor of more than 2,000 persons in two dozen independent settlements scattered among widely separated habitats. As a system of environmental regulation, tithing redistribution stood in sharp contrast to the conjoint enterprises that integrated the material resources of only a few hundred persons inhabiting three or four neighboring settlements located in similar highly unstable primary habitats.

The effectiveness of tithing redistribution was also enhanced by the integration of local settlements into a regional, centrally administered religious organization and by the affiliation of local institutions with external parent organizations. While the former increased the responsiveness and reliability of local tithing redistribution, the latter provided access to resources whose availability was independent of regional environmental conditions. Enveloping Church institutions frequently provided critical subsidies to stricken communities which augmented the regional system's ability to respond to local needs. The hierarchical structure of 19th-century Mormon settlements and institutions therefore provided an adaptive organizational framework from which a suitably complex regional resource-flow system could emerge. Furthermore, despite its manifest cooperative orientation, tithing redistribution actually functioned through supporting institutions that made participation in the system individually profitable. As already indicated, by fixing prices on commodities the Board of Trade also enabled individuals to exchange their surpluses more profitably with the local Church marketing apparatus, either as tith-

ing or as credit in the local Church-operated cooperative stores. In addition, during its earliest years, the ACMI paid investors dividends exceeding 25% (see Abruzzi 1981:20), and as late as 1890 the ACMI still declared a dividend of 20% (LeVine 1977:38).

The creation and central redistribution of local surpluses, combined with the availability of additional subsidies from external Mormon sources, contributed substantially to the success of Mormon settlement in this basin. These were the same institutional arrangements that underlay successful Mormon colonization elsewhere (see Arrington 1958), and it is for this reason that successful colonization of the Little Colorado River Basin and much of the American West was largely a Mormon achievement.

Significantly, the differential success of Mormon attempts at multihabitat exploitation in the Little Colorado River Basin conforms to expectations derived from general ecological principles and suggests broader theoretical implications for explaining the success of Mormon colonization. Ecological redundancy was clearly absent in the system of conjoint enterprises established by the early United Order settlements in the lower valley of the Little Colorado River. Although these enterprises exploited resources away from the lower valley, the labor needed to operate them was directly linked to conditions affecting agriculture along the Little Colorado. Consequently, the negative impact of environmental instability upon irrigated farming in the lower valley ramified to the conjoint enterprises. Rather than offsetting environmental instability, as anticipated by ecological theory, the multihabitat exploitative system of the early lower valley settlements succumbed to it.

In contrast, the later system of tithing redistribution integrated settlements throughout the entire basin by uniting the productivity and labor of separate populations concentrated in the intensive and independent exploitation of diverse local habitats. Productive shortfalls at one location were compensated for by surplus productivity elsewhere. Thus, separate and independent resource flows in numerous, distinct habitats provided sufficient redundancy to circumvent local habitat variability. Linking local tithing redistribution to encompassing Church institutions merely enhanced the redundancy that already existed. Consequently, again as anticipated by ecological theory, tithing redistribution operated as an effective mechanism of environmental regulation and contributed substantially to successful Mormon colonization of the region.

In summation, then, this article has shown (1) that successful Mormon colonization of the Little Colorado River Basin resulted largely from the development of a system of resource redistribution that offset the destabilizing impact of local environmental variation, (2) that general ecological theory explains both the role of resource redistribution in successful Mormon colonization and the differential success of Mormon efforts to develop a multihabitat resource-flow system, and (3) that ecological theory combined with a consideration of local material conditions provides a more precise understanding of this colonization effort than do references to cooperative Mormon values. It is, therefore, suggested that general ecology offers a potentially important theoretical framework for explaining both the general success of Mormon colonization and the evolution of complex human communities (see Abruzzi 1989).

Notes

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[1]Mormon settlement along the Little Colorado River began under an organizational arrangement known as the United Order (see Arrington 1958:323–349; Peterson 1973:91–122; Tanner and Richards 1977:51–63 for discussions of the United Order and of the United Order Movement in Mormon history). Within United Order settlements, both property and labor were pooled (see St.

Joseph United Order 1876). In the Little Colorado River Basin, only those towns located within the lower valley of the Little Colorado River were organized as United Order settlements. By the early 1880s, even these settlements had abandoned their United Order organization, the last being St. Joseph, which ceased functioning as a United Order community on November 7, 1882.

[2]The Mormon Church is divided administratively into stakes and wards, which may be compared to diocese and parishes respectively in the Roman Catholic Church. During the 19th century, each settlement contained one ward. Wards in the lower valley of the Little Colorado River were initially organized into the Little Colorado Stake, with the remaining wards included within the Eastern Arizona Stake. In 1887, local wards were reorganized into the Snowflake and St. Johns Stakes, containing the western and eastern settlements respectively.

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