# *The California Geographer*

Volume XXXI
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CALIFORNIA GEOGRAPHICAL SOCIETY

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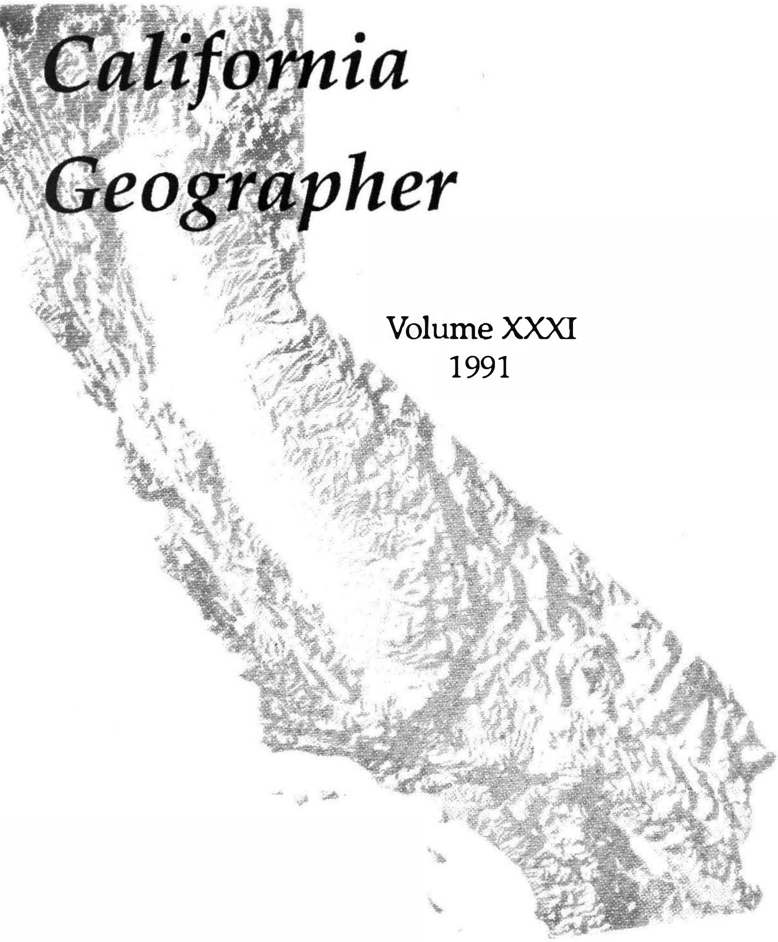

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The California Geographical Society welcomes manuscripts reflecting research into spatial/geographic phenomena relating to the state of California as well as on principles or case studies of geographic education. Manuscripts on other themes by California authors are also welcome. There is no strict maximum length for manuscripts, but very few articles which run longer than twenty printed pages are published.

Submit four copies of manuscripts, type-written and double-spaced. Manuscripts also submitted on disk are preferred, either as an ASCII file, or in most commonly used word processing programs. Manuscripts should conform to the general guidelines published each year in the March issue of the *Annals of the Association of American Geographers,* although no abstract is necessary. All photographs, diagrams, and maps should be numbered as figures and must be camera-ready. Graphics should be no wider than seven inches. Submission of a manuscript without supporting graphical materials will delay the reviewing process.

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California Geographical Society
Vol. XXXI, 1991

# Passing the Mantle: The California State University, Chico Geography Department

*Bruce E. Bechtol*

The following four papers are presented as a special tribute to a team of geographers and a Geography Department that functioned effectively together without any significant personnel changes until 1985. The "old" Chico tradition focused on teaching and especially mentoring bright students into academic geography, public service, and a broad variety of private sector careers. Ultimately new hires starting in the mid-80s brought new talents, insights, and interests into the faculty mix at California State University, Chico. By 1991 there had been a 50 percent personnel turnover in the Chico Geography Department and "The Chico geographers" as they were perceived for years by members of the California academic community in general and practitioners of geography in particular were no more. Now, the question remains: what will be the focus of the "new" Chico Department? Where to from here?

In the fall of 1991 there are fourteen permanent faculty in the Department of Geography at California State University, Chico. Seven of the 1991 faculty are replacements for those

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who retired between 1985 and 1991; Emeriti Rolland Berger, Ladd Johnson, Arthur Karinen, David Lantis, Louis Mihalyi, Frank Seawall, and Margaret Trussell. The first of the Chico Geographers who came and stayed was Dave Lantis. Dave was hired at Chico State College in 1957 as the sole geographer in the Social Science Division. By 1959 Art Karinen joined the staff and the nucleus was created for what eventually would become a "real" department of geography. Time and chance cast Art and Dave in the role of builders. The passage of time and additions of staff in the late 50s through the early 70s and their work with literally thousands of students demonstrates that they had the required desire, insight, and will for the task. Art and Dave envisioned a teaching department of geography; the emphasis was on caring, and effective teaching was the primary mandate. Reflecting back now, most of us who were brought in to assist in the process of program development at Chico recognize that Art and Dave did what was required to bring together the necessary mix of potential talent to do the job.

Geography at Chico State expanded in the 1960s with the addition of Ladd Johnson and Margaret Trussell (1966), Louis Mihalyi (1967), Bruce Bechtol (1968), and Frank Seawall and Jerry Williams (1969). The 1970s brought Ralph Meuter (1970), Bill Collins and Ed Myles (1972), Rolland Berger and Gene Martin (1973), and Dick Haiman (1974). After 1974 the Chico Department was forced into a "steady state" personnel situation. Restrictions on university growth and administrative constraints on new position allocations resulted in no new permanent faculty hires in the Chico Geography Department until the mid-1980s.

The cycle of retirements from the Chico Department began in 1983 with Rolland Berger and Dave Lantis; unfortunately, the University allowed no new permanent faculty to be hired to fill the position vacancies. When Margaret Trussell retired in 1985 the Department was given the authority to hire its first new fulltime probationary faculty member in over a decade and Paul Melcon joined the Chico faculty. Art Karinen retired in 1986 and his position was subsequently filled by Susan Hardwick. Two years later three new fulltime faculty, Don Holtgrieve, Guy King, and Susan Place were added to the staff following the retirement of Ladd Johnson (1987) and Louis Mihalyi (1988). Finally the recruitment of two more women geographers, Christine Rodrigue (1989) and Eugenie Rovai (1991) foreshadowed the most recent retirement of Frank Seawall (1991).

What the personnel changes in the Chico Department portend for the future is anybody's guess, but it appears certain that the infusion of new faculty ideas and talent will steer the department along a different course. As a former "young Turk" who somehow became the senior professor in the department, it is my fervent hope that as we change directions we retain our sense of place and mission. Those of us who remain clearly owe much to those who went before; our tradition of service is strong. If the best of that tradition is maintained, Chico will continue to be a very special environment for geographers.

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# MUSIC AND LANDSCAPE APPRECIATION: A COMPARISON OF THE EXPERIENCE

*David R. Lee*

Through the ages, an appreciation of landscape has stimulated composers to write music which stirs the listener's imagination. Numerous pieces have endured as careful and insightful descriptions of the physical and cultural landscape. On the one hand, then, musical literature has been enriched by composers' understanding of the beauty of forms of the land.

Less obvious, however, is the notion that the structural forms and musical ideas which composers have developed and used in their compositions to heighten the enjoyment of listening can provide a framework for geographers and their students to understand and enjoy the form of the landscape. Both issues are the subject of this essay.

## Landscape Experience as a Linear Experience

### Time Art and Space Art

Works of art are sometimes classified into time arts (music, literature) and space arts (paintings, sculpture, architecture). Space art can essentially be comprehended all at

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once. A painting, for example, can be viewed for a second or two, and its overall composition and subject matter are remembered. Architecture and sculpture also reveal much of their total message in an instant. Such art is not linear, in the temporal sense. Of course the full enjoyment of these pieces requires the viewer to attend to details of the work through time, moving the eye from the details then back again to the whole. The two-second view reveals a basic message of the work but not its full richness.

Time art is linear; its comprehension is revealed through time. In music and literature, for example, a two-second exposure tells virtually nothing about the whole. With time art, one is expected to remember elements which were revealed early in the piece so as to compare them with what transpires later. Repetition of, or allusion to earlier elements helps insure that the listener will remember earlier material and thus adds enjoyment to the artistic experience.

Landscape is not an art form; it is not intentionally created to provide beauty for human enjoyment. Nonetheless, perception of landscape certainly can be a source of aesthetic enjoyment. Like perception of art, perception of landscape can be spatial or temporal. As a spatial experience, landscape can be viewed in the same way as a landscape painting, that is, from a single vantage point where the viewer sees immediately the nature of the whole, but may then attend to the specifics by focusing upon details in the view. The viewer alternately focuses on the details and then on the gestalt of the landscape. This notion of landscape, i.e., that of a vista viewed from a single point, is perhaps the most common use of the term.

More subtle, and for geographers more difficult to explain, is the notion of landscape as a flow of experiences through time and space. An obvious example would be an automobile trip along a road with the observer attending alternately to the view in front, then looking right and left to ever-changing details. This is the experience of landscape which is closest to the musical experience. To gather full meaning from the landscape experience, one must remember what has passed by earlier in order to relate those items to whatever is in the present view.

### Smetana's "Moldau"

To illustrate the concept of landscape and music as temporal flow, let me use the example of "The Moldau," by Bedrich Smetana. The 1874 symphonic poem is conceptualized as a journey down the river Moldau (Vltava) from its beginnings to the city of Prague. The piece begins as two simple flute melodies which signify springs emerging from the mountain slopes of Bohemia. Pizzicato notes of plucked violin strings are drops of dew or rain feeding the springs.

Soon the full strings of the orchestra join these melodies to present the first statement of the Moldau theme, haunting, tenuous, played in the minor key. After the initial statement of this theme, the full orchestra provides the musical development. New images are introduced: a peasant wedding, horses and riders in a hunt, tranquil meadows and lowlands, and for excitement, a dramatic plunge through white-water rapids. Ultimately the traveler emerges at Prague, its ancient citadel instilling a sense of grandeur, pride, and nationalism. The music is dramatic, played in the major key, bold, noble, fulfilling. The trip was successful.

### The Form of the Symphony and the Form of the Landscape

Most introductory music appreciation classes and associated texts examine the form of the classical symphony, well exemplified in Mozart and Haydn, modified somewhat by Beethoven and later 19th Century composers, then more or less abandoned in this century. The forms of the classical symphony can be studied for the lessons they might provide the landscape observer.

Typically the symphony had four movements with the following forms and tempos: a sonata allegro first movement, a slow second movement (andante or adagio), a dance-like third movement (minuet and trio or scherzo), and a finale in a rondo or theme-and-variation form. These movements now will be described as they relate to landscape analogies.

**Sonata Allegro**

The first movement of the symphony is almost always a sonata allegro. Allegro is a tempo designation meaning bouncy, fast but not excessively so. In the landscape, one can imagine here that a traveler is moving down a highway, smartly but not at a frantic pace. Objects in the landscape move past steadily. There is rich variety in what is passing by.

The term sonata here refers to a type of form wherein distinct themes are played one against the another, contrasting in tonality and feeling. Their interaction provides the basis of the tension within the movement. Usually two themes are developed, sometimes more. First comes an introduction and initial exposition of the themes. After this exposition there is development, wherein the themes are altered somehow, played softly or loudly, played in the high or low octaves, or otherwise modified from the original statement, thus imparting an interesting and agreeable sense of complexity. The themes interact: now one is played, now the other; one appears to dominate only to be superseded by the second. Finally comes recapitulation. The conflict is resolved as the dominant theme emerges most strongly, played dramatically in its original form.

A comparison of this form can be made with the comprehension of visual "themes" in the landscape. We may imagine driving down a road, noticing that among the multitude of objects which catch our eye, two classes of phenomena emerge in our consciousness. For example, we may attend alternately to objects of the physical landscape and those of the cultural landscape, beginning with a domination of physical-environment items. As we proceed in our journey, we see one, then the other set of landscape phenomena interacting visually. In places the physical dominate, elsewhere culture does. Here the rocks and soil command the view, only to become shrouded with a mantel of buildings and fields, but later still the buildings give way to rock outcroppings. Physical and cultural continue to intermingle until finally we round a bend and see only a physical landscape.

**Andante or Adagio**

The second movement is moderate in tempo (andante) or slow (adagio). Its feeling is contemplative, reflective. Changes in the musical ideas are presented but they are subtle and gradual. They provide a break from the very involved, up-tempo first movement and the dance-like third movement, and often they contain the composer's most profound thoughts. For example, the second movement of Beethoven's 3rd Symphony, "Eroica", is intended to evoke images of a funeral march associated with Napoleon's campaigns.

The second movement of a symphony is analogous to driving in a landscape which lacks great variation. The unappreciative or uninitiated might describe such a locale as monotonous. The desert landscape, for example may be viewed thus. The general form of the desert landscape may be one of simplicity and homogeneity: light-colored earth, a sprinkling of gray shrubs, virtually flat relief.

But like a symphony's second movement, the desert landscapes are far from boring to those who know their secrets. The changes, though subtle and gradual, are profound. The light-colored earth, upon close scrutiny even from the moving car, reveals intricate changes from white to brown to gray to nearly black. The shrubs show linear or areal patterns, greater or lesser densities, taller or smaller heights. The topography likewise shows highs and lows, flats and arroyos, outcroppings and bare soil.

## Minuet and Trio

The minuet and trio (scherzo in the 19th Century) is a balanced movement with a dance rhythm. Essentially the first third of the movement (minuet) has an AA-BB form (theme "A" played twice, followed by theme "B" played twice). The middle part (trio) is a bridge between the two minuets with two new melodies presented. The final third is more or less a repeat of the first, though somewhat shorter. The movement is intended to be light and happy, balanced both literally and symbolically. It provides a pleasant break from the somewhat ponderous second movement and the profound finale.

A simple landscape comparison to this movement might be the drive through a small town which lies in the midst of agricultural land. One enters the town to encounter residential land (the first third of the experience). There are variations from block to block, but basically the district is homogeneous. Then the driver encounters the central business district, a distinct change from the residential land, a new landscape experience. After transecting the CBD, the driver again reaches the residential district on the far side of town, which is virtually identical to the district first encountered. Finally, the driver leaves the town altogether.

**Rondo and Theme-and-Variation**

The last movement of the classical symphony may be sonata allegro again, but commonly rondo or theme-and-variation forms were employed. In a rondo, which literally means "round," a theme is played, call it theme "A." This is followed by a second theme, "B." Then there is a return to theme "A." Then a new theme "C" is introduced. The music again returns to "A," to be followed by a new theme "D," and so forth. The dominant theme ("A") provides a returning point, as if we are home, then we go out, come home again, then go out somewhere else, return home, and so forth. "The Moldau" is a rondo, with the basic Moldau theme as the "A" theme and other images providing "B," "C," and so forth.

In the landscape, we may imagine driving in California's Sacramento Valley where there is a juxtaposition of orchard and field crops. The orchard crops — olives, for example — will be evident for a few moments of the drive, then they end, and sugar beats appear. After the fields of sugar beats, olives again dominate the landscape, then bright yellow safflower sparkles on the land. Olives again dominate, followed by deep-green hay crops, and so forth. The olives, theme "A," provide a visual constant against which the other crops can be compared.

The theme-and-variation form is well revealed by the name. A musical idea is presented in its elemental form. The theme is then reproduced, but changed somehow, then changed again, and yet again. The alteration may be in the instruments used to play the theme, the register (high or low), or perhaps the tempo. Or the actual melody may be disguised, as other melodies become incorporated into the basic one. Occasionally the music returns to the original statement, so that like the rondo, we have a place to return to.

The second movement of Haydn's Symphony No. 94, the "Surprise" Symphony, is a famous example of theme-and-variation. The simple theme is played first with quick, graceful notes, then repeated with a bold and dramatic addition (the "surprise"). In all, four variations make up the movement.

In terms of landscape, imagine a corn landscape typical of Iowa. The basic theme might be stated thus: fields of corn, soy beans, and fallow. In the background a farmstead: silos, barns, ornamental trees and the farmhouse. Mile after mile the landscape does not change in its general appearance, but close inspection reveals that there are variations which appear in each farm. The corn/bean/fallow ratio varies from farm to farm. The farm houses may be two-story or one-story. Silos may appear in sets of two, singly, or missing totally, and so forth.

## Program Music and Environmental Description; The Continuum of Precision

The form of music may provide a framework to experience and enjoy landscape. By attending to the form of the land, just as by paying attention to the form of music, one is able to heighten one's enjoyment.

We might also gain insight into the role of environment and music by investigating how environmental images are communicated musically. Environment is presented in various forms of program music. Program music is music that is inspired by or that suggests something other than a purely musical idea. The inspiration for the program may be a great battle (e.g., Tchaikovsky's "1812 Overture"), a literary piece (Mendelssohn's "A Midsummer Night's Dream") or a landscape. Program music is contrasted with absolute music, in which the music is independent of the objective suggestion of title, text, or program, and dependent on structure and musical ideas for its power and comprehension.

The distinction between program and absolute music sometimes is not as crisp as these definitions suggest. Much music with apparently very explicit programs will examine the program subject rather briefly, then will become involved in musical development which no longer has the program nuances clearly explicated. The intent of the composer is not to describe a program but to create beautiful music.

Notwithstanding such intricacies, it is to program music based on landscape description that we turn our attention. It is my position here that one can identify a continuum of precision in landscape program music which would identify the explicitness of the description of landscape in the music.

**Actual Sounds**

At the most explicit extreme, one can imagine musical scores in which the actual sounds of landscape phenomena are presented to the audience. For example, in Verdi's "Anvil Chorus," an actual blacksmith's anvil is struck rhythmically. The sound is unique, exact. It conjures images of a smith pounding the anvil in his shop.

A grandiose use of actual noise-makers is the "1812 Overture," properly presented. The program of this piece is Napoleon's defeat at Moscow, and the score calls for actual cannon to be fired at the end of the piece. When played indoors, drums suffice, but correctly the piece is to be played out of doors with actual cannon blasted on cue.

In the modern repertoire, composers have the advantage of using electronic recordings in the score, actual recordings of environmental sounds. With modern sound reproduction, the sound of waterfalls, superhighways, battles and birds can all be quite explicit.

**In the Style of**

Musical themes and melodies may relate directly to some recognizable national or ethnic group — gypsies, Spaniards, or Irish, for example. When these melodies are incorporated into larger pieces, they provide "accents," or suggestive references to the group alluded to. For example, in "The Nutcracker Suite," we are asked to imagine vignettes from far parts of the globe: Spain, Arabia, China. Characteristic stylistic elements which can be identified with these places are woven into the more general piece. In "The Moldau," the river journey passes a village where a peasant wedding is taking place; we know this because we hear the dance music which is taken from Czech folk music. Likewise, Beethoven borrowed freely from German dances, and Tchaikovsky's "1812 Overture" has unmistakable snippets from "La Marseillaise," suggestive of the French soldiers. Music "in the style of" is less precise than the actual sounds and requires that the listener be familiar with the reference. Listeners to the "1812 Overture" who are not familiar with the French National Anthem will miss the nationalistic reference.

**Onomatopoeia**

In language onomatopoeia identifies a word whose sound suggests its meaning, such as buzz and hiss. In music, onomatopoeia is the use of an instrument to represent an actual environmental sound. The flute, for example, is commonly played to sound like a bird, as in Beethoven's 6th Symphony, "Pastoral." In Prokofiev's "Peter and the Wolf," a number of "characters" are represented by instruments, flute for the bird, oboe for the duck, horns for the wolf, and so forth. In Gershwin's "American in Paris," trumpets make taxi-horn sounds, conveying a feeling of a Paris where taxis hooted constantly.

Some of these sounds may be rather explicit — a taxi horn is, after all, a sort of trumpet — but most are really rather abstract. Whereas one may say that a flute can sound something like a bird, it is hard to believe that an oboe sounds much like a duck, and harder yet to hear a wolf in a set of horns.

**Capture the Feeling of**

Less precise yet is music which is intended to capture the feeling of some environmental experience. For example, Debussy's "Clair de Lune" (Moonlight) is intended to impart the feeling of tranquility and introverted reflection which one may experience on a bright moonlit night. "The Grand Canyon Suite," by Ferde Grofé, presents movements in which a desert thunderstorm is described, as are sunrise and sunset over the Grand Canyon, and a mule trip, with the hee-haw and clip-clop of the mules introduced onomatopoetically.

**Absolute Music**

Finally, the other end of the precision continuum is reached with absolute music. The music is not intended to convey any environmental image, or program of any kind. If the listener should entertain thoughts of landscape, such notions do not originate from the music itself.

Music which is intended to evoke a landscape image may be successful or not depending on how environmentally-precise the sounds are. Overall, we must admit that music is not an efficient means to transmit environmental ideas. Music appreciation professors frequently play selections and explain the program. The students will readily agree that in "Peter and the Wolf," yes, the flute reminded them of a bird and the oboe indeed became a convincing duck. However, if the experiment is reversed the music fails to communicate these explicit images. That is, if program music is played to novice students who are asked to provide the program, it is most unlikely that they will deduce the content of the program. For example, most who listen to vivid pieces such as "The Moldau" or "1812 Overture" will not once think of a river or a battle. Only the most explicit musical onomatopoeias or stylistic references will evoke the proper environmental images.

Environmental program music certainly does not fail if the subject matter is unknown to the listener. It then can be appreciated as one does absolute music, for structure and musical ideas alone. However, knowing the environmental subject of the program does heighten the total experience. Moreover, first-hand experience of the environmental stimulus heightens even further the pleasure of the music. To properly enjoy "The Moldau's" ride through the rapids, one should experience white-water rafting personally, feel the swirl of the twisting boat, recoil from water splashed in the face, sense the exhilaration and fear of negotiating a boat through waves and rocks. To appreciate Grofé's Grand Canyon sunrise, one should see it for one's self: first the dark calm of the desert air in the pre-dawn cold, then dim light and the first orange rays lighting the sky. Ever brighter these become, ever more vivid, until finally the blinding disk of the sun explodes on the horizon above the canyon wall.

* * *

The enjoyment of music and the enjoyment of landscape, therefore, are in many ways similar. They both can be appreciated as time art, linear in nature. The musical forms of the classical symphony may be universal and quite applicable to landscape appreciation. Universal, that is, in the sense that the formal arrangement of elements may be the same in music as in other art forms. For example, theme and variation of elements is commonly employed in painting and in literature, and in other art forms as well. The careful balance of the sections of the minuet and trio of a symphony has its counterpart in the architectural balance of the classical temple. Logically, therefore, we can suppose that persons with artistic training and disposition are likely to seek to discover artistic arrangements in landscape elements, and thereby detect beauty in the environment.

On the other hand, landscape appreciation has provided the stimulus for the creation of musical compositions which have survived well. Smetana, Grofé, and hundreds of other composers experienced the beauty of landscape and preserved that beauty in their music. It would be well for geographers to seek out and convey to others the similarities in environmental structures and those of allied disciplines, such as music. The enjoyment of both music and landscape may be enhanced substantially.

Landscape, as discussed above, is not art per se, any more than an interesting piece of driftwood can be labeled a work of art. Notwithstanding, individuals with training in art appreciation retain the ability to recognize order in formal elements in the objects encountered in everyday living, such as landscapes. Their ability to apply principles of art appreciation to natural elements equips them to perceive a richness of beauty which might otherwise go unnoticed.

## Acknowledgment

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# THE IMPACT OF RELIGION ON ETHNIC SURVIVAL: RUSSIAN OLD BELIEVERS IN ALASKA

*Susan W. Hardwick*

Historical and cultural geographers have long been interested in the processes of immigrant settlement and subsequent cultural change (Joerg, 1932; Jordan, 1966; Mannion, 1974, 1977; McQuillan, 1978; Ostergren, 1988; Swrerenga, 1985). However, except for limited studies of ethnicity in the central United States, very little has been accomplished to date on the significant relationship between religion and ethnic retention and sense of place (Jordan, 1980; Ostergren, 1981; Legreid and Ward, 1982). Russian Old Believers in North America offer a particularly fascinating case study for an investigation of the role of religion as a key variable in culture change. For over three hundred years, in Russia, China, South America, and the United States, Old Believers have maintained their Russian language, their religious beliefs, and their traditional lifestyle while living within very different, dominant majority cultures (Colfer, 1985; Smithson, 1976). Will they continue to

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maintain their distinctive cultural and religious identity in Alaska in the 1990s?

## Regional Setting

The tip of the Kenai Peninsula can barely be seen in the thick coastal fog. Glaciated peaks, fiorded coasts, and roaring mountain streams dominate first impressions of this rolling, spruce-covered landscape. Old Believer settlements in Alaska are located in isolated, inaccessible places in three regions of the state of Alaska including Kenai forests, the Matanuska Valley, and islands just north of Kodiak (Figure 1). The largest community, Nikolaevsk, with approximately sixty families, is near the southernmost tip of the Kenai Peninsula and is connected to the small towns of Anchor Point and Homer by challenging dirt roads. Other Kenai villages, also on dirt and gravel roads barely accessible even by hardy four wheel drive vehicles, lie "up Kachemak Bay" on a narrow coastal strip atop a steep bayside escarpment. Old Believers have also begun to settle remote islands just north of Kodiak, accessible only be sea plane or boat. These villages offer the cultural geographer an opportunity to study Russian culture and religion in an isolated, real life setting and thus provide an excellent opportunity to observe the processes of religious and cultural change firsthand. Four aspects of Old Believer culture are considered here: religious origins, migration patterns, lifestyle and cultural retention, and the religious landscape.

## Origin of the Old Believers

Before an analysis of the Alaskan Old Believer landscape is possible, it is necessary to understand their origin and diffusion from their homeland. Russia, long a loose conglom-


Figure 1.

erate of diverse principalities, accepted Christianity in 988 when Prince Vladimir of Kiev forced people into the Dnepr River for mass baptism (Steeves, 1989). The Russian people were instructed to give up their "pagan ways" and become part of the Eastern Christian Church of Byzantium. Over time, the Russian clergy assumed more and more authority over the masses. After 1453, Moslems conquered the city of Constantinople and Greek and Russian monks realized Moscow was their only hope for maintaining the pure Orthodox faith. Thereafter, the Orthodox Church controlled education, religion, and almost all aspects of the lives of the Russian people. Education and book copying was confined to monasteries.

In 1551, the Council of the Stoglav met to discuss church translations and doctrine. Their decisions ultimately were published as law. This Council decided that numerous church books were faulty and people should only use corrected versions. Their decisions became a large scale problem after the printing press was introduced in 1552 to print religious books. Wider distribution of printed material meant that variations and discrepancies in texts became more obvious to more people.

But the real debate began when Nikon, an extremely conservative parish priest, was appointed patriarch by Tsar Alexis in 1651. Nikon wanted certain reforms to realign the Russian Orthodox Church more closely to the original precepts of the Greek Church. He insisted on the revised church books, he had new ideas on the number of hallelujahs sung during worship services, and he changed the number of fingers used to make the sign of the cross. On top of these radical changes in church doctrine, Nikon was an offensively arrogant person. In the end, his insistence on a revised sign of the cross most angered the Russian people. Since they made the symbolic sign many times every day, this became Nikon's most offensive change. In addition, he insisted on changing the spelling of the name Christ. Public outrage resulted in another significant meeting of the official Church Council in 1666 (Conybeare, 1962; Kolarz, 1961; Miliukov, 1943; Zenkovsky, 1957). Rumors circulated wildly. Some said this was the coming of the anti-Christ, the end of the world. Eventually the Council stripped Nikon of his powers, but it did make his reforms law. Since the government punished those who did not comply with changes, thousands of people were persecuted and arrested. Mass movements against changes came to be known as *stary obrian* and *staraya vera* (old belief). Many dissenters, now called "Old Ritualists" (Staroobriadtsy) and "Old Believers" (Starovery), chose to become martyrs rather then surrender to soldiers. Thousands of Old Believers were killed and their homes and churches burned. By the end of the seventeenth century, one group migrated to Romania. Some eventually went to Turkey where they fished and farmed and built small communities. Many thousands fled to Siberia.

Again, in 1917, the Russian Civil War disrupted the lives of Old Believers. Small groups of them emigrated wherever they could. Those in the Asian region of Altai fled across the border into the Sinjiang Province of China. Those in Siberia and the Far East resettled in Harbin, Manchuria. By the end of World War II, Soviet forces had moved into the border lands of China. Many Old Believers were forced into trucks and driven back across the border into the Soviet Union. In 1949, the Communist revolution in China resulted in the collectivization of thousands of Old Believers into villages. Their plight drew the attention of the World Council of Churches who secured visas and funds to help them emigrate. Old Believers from both Sinjiang and Manchuria came together in Hong Kong and prepared to resettle in Australia, New Zealand, Brazil, Argentina, and Uruguay. The majority went to Brazil and resettled on land donated by the Brazilian government. But these were hard years for the emigres. They could not supplement their farm income with handcrafts because of local economic restrictions, it was too hot for traditional Russian crops, and fears of the spread of communism from nearby Chile worried them. In 1964, the Tolstoy Foundation arranged for the Old Believers to resettle in the United States. At the same time, Old Believers from Turkey also migrated to North America. Most went to a region of rich farmland in the Willamette Valley of Oregon, near the town of Woodburn, a place they had heard of from Russian Molokans when they stopped in the Los Angeles harbor on their way to Brazil many years before.

Oregon's semi-rural environment also soon proved difficult for many of the Old Believers as American culture began to dominate their children's values and lifestyles. As a result of these fears, five families left Oregon for Canada and Alaska in 1968, settling along the Plat River in northern Alberta and on the Kenai Peninsula in Alaska in 1968 (Figure 2).

## Alaskan Migration and Settlement

The difficult trip from Oregon to Alaska was nothing new for the Old Believers. As described above, for over three hundred years, they victims of religious persecution had been seeking resettlement sites where they could maintain their traditional way of life and practice their religion in peace. Five Russian families originally left Woodburn, Oregon in heavily laden pickup trucks bound for yet another new life on the Kenai Peninsula. By 1990, at least ninety families resided in the area with over 1000 Old Believers living in six small settlements. Nikolaevsk, their original settlement, remains the largest and most "liberal" by local definitions (Moore, 1990). Due to a religious schism in the village, Old Believers founded four other villages nearby: Dolina, Rozdolna, Voznesenko, and Kachemak Selo. They have also expanded to the Matanuska Valley north of Anchorage as well as south on Raspberry Island near Kodiak.

With a loan from the Tolstoy Foundation in New York, Old Believers in Alaska originally purchased 640 acres of government-owned spruce forests on the Kenai Peninsula. Nikolaevsk, named for the important Orthodox saint Nicholas, grew and prospered for fifteen years as more families migrated from Oregon. Homes, roads, fences, and even a new state-funded school were built (Figure 3). Early settlers worked in nearby Homer fish canneries, the marina at Kachemak Bay, and in small construction crews in the area. However, fishing soon became the primary economic support for the new emigres. Today, at least ninety per cent of

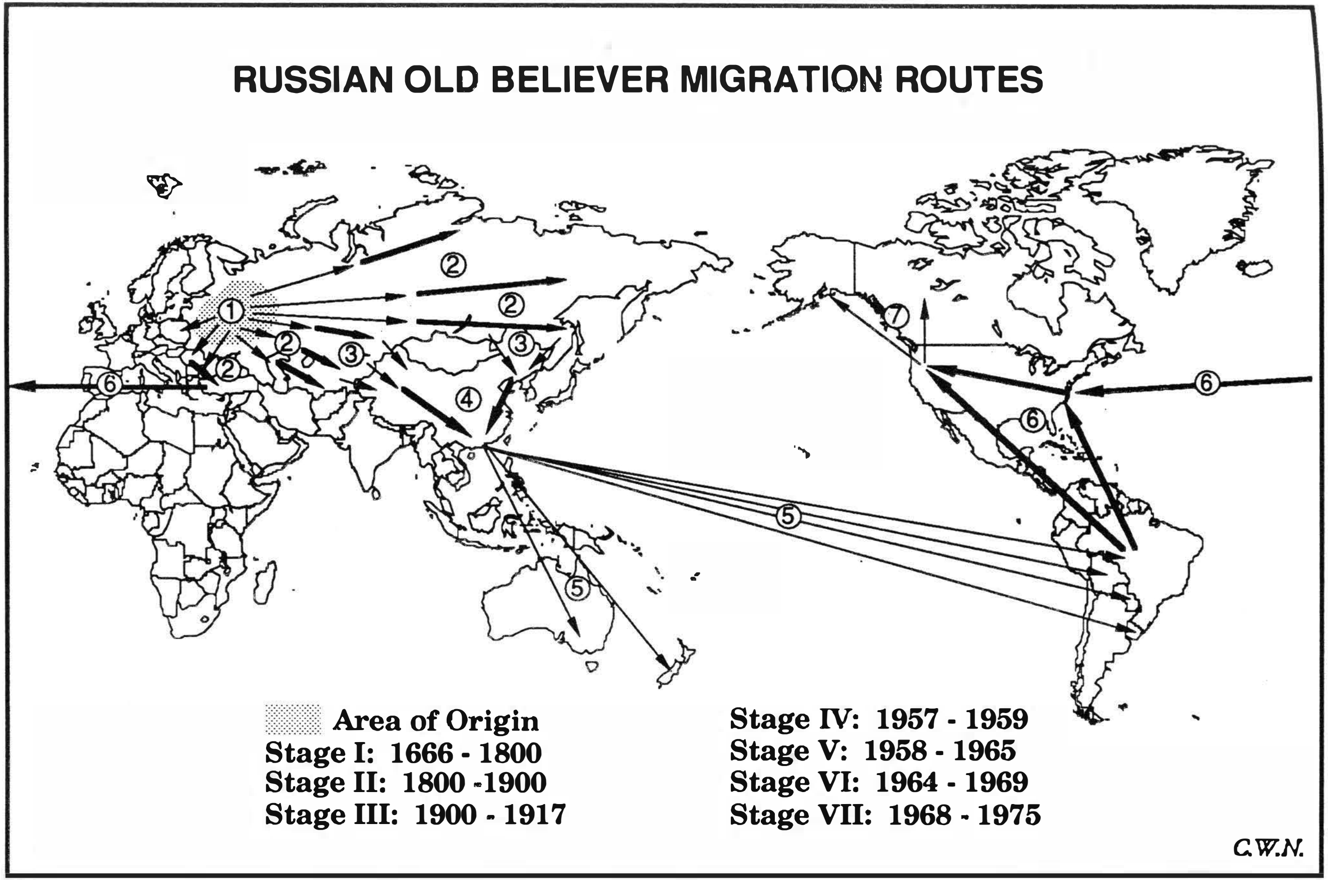
RUSSIAN OLD BELIEVER MIGRATION ROUTES
Area of Origin
Stage I: 1666 - 1800
Stage II: 1800 -1900
Stage III: 1900 - 1917
Stage IV: 1957 - 1959
Stage V: 1958 - 1965
Stage VI: 1964 - 1969
Stage VII: 1968 - 1975
C.W.N.

Figure 2.

Figure 3. Nikolaevsk School

Alaskan Old Believer men fish for a living (Gay, 1988). Most are drift gillnetters in Cook Inlet, Bristol Bay, or Prince William Sound. Some fish for halibut in the Gulf of Alaska. Many learned carpentry skills in the lumbering industry in Oregon, and build and maintain their own boats (Figure 4). Harbors like this one at Ninilchik are filled with boats named the *Zion*, and the *Amur*. Russian settlers in Alaska prefer employment in the fishing industry because it offers them the opportunity to be their own bosses, work independently, and have the option of not working on the numerous religious holidays each year.

## Lifestyle and Cultural Retention

Russian Old Believers in Alaska continue to maintain their traditional lifestyle within the larger context of American life. Although Nikolaevsk and other villages lie

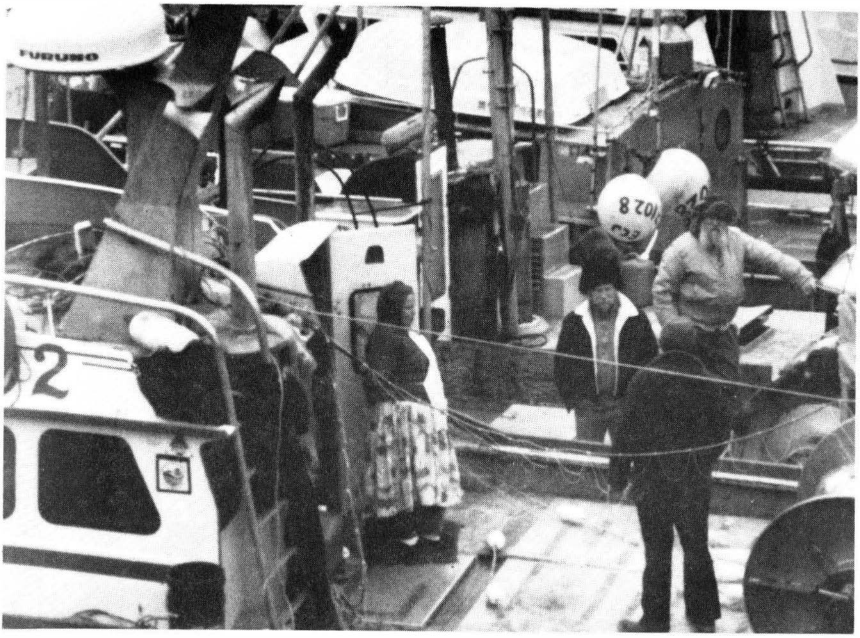

Figure 4. Old Believer Boats in the Ninilchik Harbor

far away from American mainstream culture, nearby towns are within driving distance and public school dominates the children's daily lives. Traditional Russian peasant clothing continues to be worn by all village residents, although young people may be seen with American T-shirts and Levi jackets pulled down over their embroidered Russian shirts and woven belts. The Russian language is spoken by children playing on village streets, in homes, and at church services (Figure 5).

Automobiles and the educational system are now the most potent agents of change among Russian Old Believers in Alaska. Bad weather limits the seasonal use of pickups, although high powered, fancy trucks are used regularly to drive to nearby fishing boats. The Nikolaevsk School is new and modern, housing grades K-12. Classroom teachers and counselors do not openly contest the religious ideas of Old Believer children, but exposure to new ideologies and "for-

Figure 5. Children Playing on the Streets of Nikolaevsk

eign" concepts, as well as daily training in the English language are reasonably expected to have a long term effect on cultural and religious retention among the Starovery. Interviews with the principal and staff at Nikolaevsk School in 1990 revealed that two students from their school were currently attending the University of Oregon, a first for the Old Believers. This exposure to higher education will likewise serve as a potential agent of change in the community.

While these social and cultural forces act against preservation of Russian culture in Old Believer enclaves, religion acts as an integrating counterforce. During the centuries of Starovery migration and resettlement, spiritual beliefs have held Old Believer culture together. Today's cultural landscape reflects the importance of religion in their everyday lifestyle.

## Russian Religious Expression in the Cultural Landscape

Old Believers are fundamental Christians who believe in a literal translation of the Bible. They also maintain strict lifestyle prohibitions based on their religious beliefs. Men cannot shave and women must always cover their heads in public (Figure 6). A handmade, woven belt is tied around every childs' waist at their baptism which must be worn for the rest of their lives. Believers do not eat meat, dairy products, or any animal product on religious holidays and for a prescribed number of weeks before Christmas and Easter. Outsiders are viewed as "unclean" and may not share a meal or common dishes with Starovery. These day to day practices along with numerous other lifestyle requirements

Figure 6. Russian Woman at Nikolaevsk

dictated by their religion clearly set Old Believer culture apart from mainstream American culture.

But not all Starovey in Alaska agree on all lifestyle issues. The old adage, "Two Russians, ten opinions" describes recent events in Nikolaevsk. As in other Russian communities in other places, the Alaskan Old Believers disagree frequently during decision-making. As in any community, some members of the faith are more conservative than others. Some see education as a dangerous force, others support the expansion of Nikolaevsk School. There have also been major disagreements about religious doctrine in recent years.

One of the most critical issues within Alaskan Old Believer congregations has concerned the leadership of trained clergy. After the great schism of 1666, no monasteries existed to train priests, so the Starovery have been practicing their religion with lay leaders for several centuries. However, in the 1970s, several of the residents of Nikolaevsk decided to send one of their young men to a recently discovered monastery in Romania. Upon his return to the village, a division occurred between residents who wanted to follow the priest and those who did not. In 1983, opinions became so extreme that violence caused Alaskan State Troopers to come to Nikolaevsk and a local judge ordered the Old Believer church closed until a resolution could be found. Today, after fires, threats, and the rebuilding of two churches across the street from each other, village residents seem to have reached a truce (Figure 7). However, this religious schism was the primary reason for the founding of four new settlements near Kachemak Bay. Interviews with local residents of Nikolaevsk, Dolina, and Voznesenko revealed that a strained relationship continues to exist between families in the various communities.

Because of this spiritual and cultural division among Old Believers in Alaska, the potential long term potency of reli-

Figure 7. Russian Orthodox Church at Nikolaevsk

gion as a unifying force is being minimized. The overall strength of Starovery culture has long depended on the unity of their religious ideals. Although strict observance of religious beliefs and church doctrine continue to dominate their daily lives, divisions within the group have already created new rifts between and among villages. All culture groups continually are effected by both centripetal and centrifugal forces that tend to separate or unify their members. Such is the case among rural Old Believers in Alaska.

## Conclusions

But internal issues such as religious practices, the increased mobility caused by trucks and automobiles, and the educational system are not the only active forces for change among Old Believers. Several external forces have also been at work. Much of the overall physical and human environment has changed since the late 1960s when Russian migrants first arrived on the Kenai Peninsula. When the settlement of Nikolaevsk was founded in 1968, the nearest towns of Anchor Point and Homer were tiny villages of less than 1000 people each. The tsunami triggered by the Alaskan earthquake of 1964 had caused significant damage to the Homer Spit and retarded overall coastal development in the region. When the Old Believers first saw the site of their new home, it was a much less developed place than it is today. In the two and a half decades since the earthquake the area has witnessed increased development of the tourist economy, an expansion of its importance as a sport and commercial fishing center, and a significant increase in its total population. In addition, Old Believers began to subdivide their land in the 1970s as the petroleum industry improved the Alaskan economy. Now, modern new non-Starovery homes line both sides of Nikolaevsk Road on the way into the village. Old Believers may soon find themselves once again surrounded by the culture they tried to escape when they left Oregon.

In the midst of social and economic development on the Kenai Peninsula, increased mobility due to increased vehicle ownership and improved roads, and fragmentation caused by religious dissension, future cohesion of Old Believer culture is in doubt. For three hundred years the Starovery have been migrating to new lands in search of religious freedom and an isolated lifestyle. Their culture and beliefs have thus far survived war, poverty, dislocation, and numerous other socioeconomic challenges. Longitudinal studies of this fascinating group of Russians need to be conducted at regular intervals in the near future to document the process of cultural change. Whatever the future holds for this ethno-religious group, the complex patterns of the migration, resettlement, and cultural retention of Russian Old Believers in Alaska thus far can only be viewed as remarkable.

**Acknowledgements**

My master's thesis chair, Dr. Margaret Trussell, expanded her interest in historical settlement in the American West in graduate school at Berkeley and later refined it at the University of Oregon. Dr. Trussell, along with Dr. Ladd Johnson and Dr. Louis Mihalyi, shaped my early thinking in cultural/historical geography while I was a graduate student at California State University, Chico in the 1970s. My fascination with ethnic settlement, religion as a cultural variable, and the regional geography of the American West first bloomed at Chico under their guidance. My graduate committee taught me to dive enthusiastically into archival material, tabulate historic census data carefully but suspiciously, and conduct sensitive structured and unstructured ethnographic interviews. This broad background in the methodologies of historical geography was complemented by Dr. David Lantis's insistence on the importance of "good field geography" and Dr. Art Karinen's cartographic expertise. My interest in ethnic settlement patterns in California was encouraged at Chico during a time of decidedly non-ethnic consciousness in academia and my dreams of a teaching position in higher education were supported and nurtured during a time of high unemployment in the educational field.

Dr. Trussell's research on pioneer settlement in particular, was the origin of my long term fascination with immigrant settlement patterns. This paper is a Trussell-inspired study

of settlement and culture change within a little studied and often misunderstood ethno-religious group in the American West, the Russian Old Believers.

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# IN SEARCH OF UPLAND RICE FOR THE THAILAND OPIUM ZONE: A CLIMATE-BASED APPROACH

*Richard A. Crooker*

## Introduction

The mountains of northern Thailand are a *cul-de-sac* for hill tribes migrating from China, Laos, and Myanmar, because bordering lowlands to the south and east are already inhabited by Thai people. The hill tribes practice swidden agriculture and rely on illicit cultivation of the opium poppy (*Papaver somniferum*) for their only important source of cash income. They grow opium to purchase rice and other basic subsistence items, but land shortages are forcing them to seek replacement crops and to consider permanent settlement. Moreover, recent international pressures on the Thai government to eradicate opium production are acting to destroy their marginally productive economic system (Crooker, 1988).

The identification and extension of alternative cash crops for the hill tribes is fundamental to the amelioration of current and future economic hardships in the region. There are several factors associated with successful agricultural inno-

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vations in developing countries: tradition, information dissemination, government policies, international development agencies, and environmental and ecological considerations. In a previous publication I summarized how these factors are related to the opium economy and crop substitution efforts in Thailand (Crooker, 1988). This study concerns a corollary of the crop substitution problem: the development of more dependable upland rice yields in order to lessen the need for growing and selling opium to replace shortfalls in this principal food crop. If rice yields can be improved, there should be an attendant reduction in the economic risk of switching from opium to other cash crops.

My research focuses on atmospheric temperature, which is the most important climatic constraint to the production of upland rice in northern Thailand (Somrith and Promman, 1986). Precipitation is also important, but it is less limiting than temperature because monsoon rains in the areas of opium production are adequate and fairly dependable. Conditions for growing upland rice are considered marginal between 1000 and 1300 mm and at 1600 mm the amount of rainfall ceases to be a constraint. The opium zone receives 1200 to 2200 mm, so only a small portion of its area receives marginal levels (Moorman and van Breemen, 1978). There are several research projects concerned with crossing indigenous and imported cold-tolerant upland rice strains, but none has been successful. In addition, Thai and United Nations agricultural experts have had no success in locating adaptable rice cultivars or experimental germplasm during brief expeditions to Brazil, Nepal, India, New Guinea and Hong Kong (Mann, 1986). These efforts were hampered because investigators did not have a method of adequately examining the adaptation of upland rice varieties to their indigenous climates.

This study uses a general climate model to derive a set of sites with similar temperature regimes around the world.

This cluster of places could be targeted for visits by agronomists to see if better-yielding strains of highly adapted rice could then be found for eventual use in northern Thailand. The methodology used to identify this cluster of places relies on monthly averages of climatic data. A more complex interregional comparative model is not possible because other kinds of climatic data are not typically available for Thailand's opium-producing areas or for most other areas where upland rice is produced. The results are tentative, but part of this paper's rationale is to demonstrate the need for greater interchange of information between geographers and plant scientists so that research on narcotic crop replacement problems can be more effective.

This article makes a contribution to the specialized field of applied geography in two ways. Firstly, it makes regional climatic comparisons with the goal of changing an area's agricultural production. Secondly, it substantiates the need for more effective crop replacement research through the integration of institutional components in the international scientific and academic community.

## Upland Rice and the Constraint of Temperature

Opium-producing villages in northern Thailand are located in an elevational zone between 700 and 1500 meters, which will be referred to hereafter as the opium zone. This zone accounts for nearly all of the mountainous area above 700 meters, since few elevations exceed 1500 meters. As a result of its mountainous topography, the opium zone is fragmented into isolated areas located on mountainsides or straddling ridge crests. Due to the effect of elevation on temperature, the opium poppy flourishes best above 1000 meters within this zone; whereas, upland rice performs better at lower elevations. Consequently, the vast majority of poppy growing villages are located within the optimum elevational range of 900 to 1100 meters so that both crops can be produced as efficiently as possible (Office of Narcotics Control Board, 1981).

Rice (*Oryza sativa*) is cultivated using dryland techniques, which means the fields are not bunded, are prepared and seeded under dry conditions, and depend on rainfall for moisture. When rice is grown in this manner, it is termed upland rice to distinguish it from rainfed wetland and irrigated wetland rice, which involve cultivation in fields with standing water. Population pressure in the opium zone has resulted in overcrowding, a shortening of fallow periods, and a thirty percent decline in yields per acre of this upland rice in the last twenty years. Current upland rice yields of the opium zone are among the lowest in the world, averaging less than 1000 kg per hectare (Crooker, 1988).

Rice is planted in May and June at the onset of the summer monsoon rains, but the growing season extends into the cool, dry monsoon period. The lower temperatures of the opium zone's mountain elevations combine with the cooling effects of Asia's winter continental air mass to limit rice yields significantly by lengthening the vegetative period (DeDatta and Vergara, 1975; International Rice Research Institute, 1979; Vergara and Chang, 1976; Yoshida, 1981). Flowering does not occur until September, and heading and ripening proceed through October and early November, when daily mean temperatures drop below 20° C (68° F). For native varieties the length of the growing season is between 120 and 160 days (Tiyawallee, 1983). The phenological effects of the cool season temperatures are a reduced yield capacity through retardation of flowering, self-pollination, and the flow of carbohydrates from culms and leaf sheaths to spikelets (Yoshida, 1981). By harvest time plants have large numbers of seedsthat are sterile (up to eighty percent for imported varieties at 1400 meters), and they have low numbers of filled seeds per panicle and low seed weight (Thai-Australian Highland Agricultural Project, 1981; Tiyawallee, 1983; Tiyawallee, 1986).

## Data Base and Methodology

The climatic data base for this study includes monthly, seasonal and annual temperature and precipitation averages. It is assumed that the data sources contain reliable statistics, since the use of recording equipment and calculation of temperature and precipitation averages require minimum training. There are about two dozen weather stations operating within the opium zone, but only those stations with data for five years or more are used in the analysis. The data were compiled from various sources by the author during field work in 1981-1989. The longest period of data among the stations is fifteen years, the average is nine years.

The opium zone stations were compared with stations located worldwide that have data for a minimum of ten years. Information about the latter stations was drawn from *World Climate Data* (Wernstedt, 1981), *The World Weather Records* (U.S. Department of Commerce, 1965-68), *World Survey of Climatology* (Landsberg, 1969), and *Tables of Temperature, Relative Humidity and Precipitation for the World* (Great Britain Meteorological Office, 1958).

The specification of locations with thermal properties similar to those of Thailand's opium zone involves three operations. First, the Köppen climate classification (Trewartha, 1954) is used as the standard for selecting general areas with similar climates where experimental rice varieties may be located. Next, the opium zone's highest and lowest average annual precipitation recordings are used as parameters to sort out stations that are either too dry or too moist. Then, since crop yields in the opium zone are keyed to cool season temperatures, H.P. Bailey's warmth index (Bailey, 1960) is used to identify specific locations which have thermal characteristics that are similar to the Thailand opium zone.

Due to its specificity, the Bailey warmth index is used to characterize the geographic limits of upland rice strains that would be adaptable to the temperature regime of the opium zone. Bailey assumed that the earth's annual march of temperature can be approximated as a sine curve and that plant life responds predictably to correspondent changes in the amplitude of temperature. Thus, Bailey derived a planetary scale of temperatures (warmth indexes) representing temperatures at the beginning and end of the thermal summer period in which plants prosper. He also calculated the number of days that temperatures exceed each warmth index.

Bailey used a nomogram and trigonometry to model this global range of warmth indexes and their durations. A simple nomogram plot of a weather station's average annual temperature and average annual range in temperature provides an index and its duration for any given location (Figure 1)(Bailey, n.d.). The nomogram consists of two sets of coordinates; the first is the average annual temperature and the average annual range of temperature and the second, superimposed at a 45° angle, is the index limits for summer warmth. The latter set of coordinates is an index of 64.4° F (18° C), which is the lowest index expressing a 365-day summer, and 50° F (10° C), which represents the highest index with zero days of summer warmth. The warmth indexes are displayed as radii diverging from the left margin of the graph. The angles formed between an index's radius and the limits of summer warmth is a function of the poleward advance and retreat of the vertical sun.

The warmth index has distinct advantages for this study compared to temperature summations, which are commonly used by plant ecologists to relate temperature and crop productivity (Mather, 1974; Yoshida, 1981). Temperature sum-

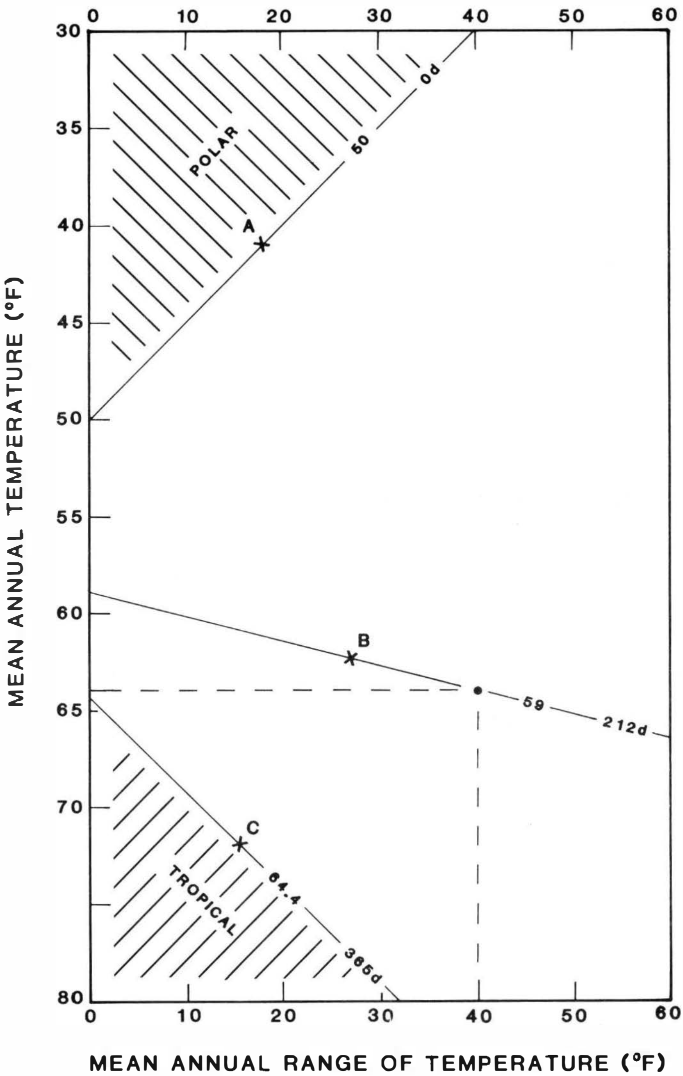


Figure 1. Bailey nomogram with warmth index limits of the thermal summer (letters A and C) and a warmth index radius (B). A determination of a warmth index and the duration of the thermal summer requires a plot of a location's temperature data. In this example, a location with an average annual temperature range of 40° F (4.4° C) and average annual temperature of 64° F (17.8° C) has a 59° F (15° C) warmth index and 212 days with mean temperatures above the index.

mation is a summation of daily mean temperatures over a certain period of growth and development. However, daily temperatures are not easily obtainable for locations worldwide. In addition, the nonlinear relationship between temperature and growth duration of the rice plant limits use of the summation term (Yoshida, 1981). Thus, the Bailey warmth index, which is based on mean monthly temperatures and nonlinear trigonometric functions, is a practical and perhaps a more accurate alternative for the study of rice and temperature relationships.

## Analysis

According to the Köppen climate classification *Cwa* and *Cwb* climates are found in northern Thailand's opium zone. Data from more than 3300 weather stations located worldwide were analyzed using the Köppen classification and 184 of these were identified as having either Cwa or Cwb climates. In order to select those stations in the Cw climate group which are more climatically similar to the opium zone, only stations with comparable rainfall levels (1200 to 2200 mm) were chosen for plotting on the Bailey nomogram. As a result, seventy qualifying stations are plotted and analyzed (Figure 2).

The opium zone's nomogram plot consists of twelve weather stations (Figure 3). The stations are ranked according to elevation with the lowest number representing the station with the highest elevation. Warmth indexes for the zone range from 59.9° F (15.5° C) to 64.7° F (18.2° C), and thermal summer durations are from 226 to 365 days. There is a negligible overestimate of thermal summers for most of the stations in the opium zone. This discrepancy can be discerned on the nomogram by observing the plots of lowest elevation stations (numbers eleven and twelve). According

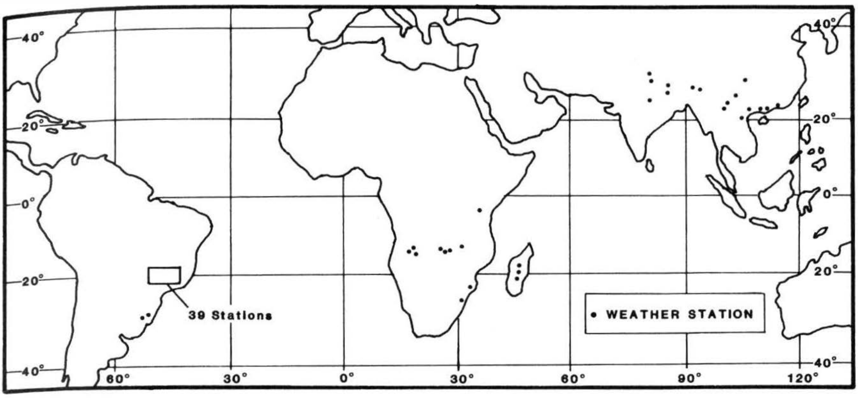


Figure 2. Location of selected Cw weather stations

to the nomogram, these stations should have 365 days with only occasional cool spells restricting plant growth, but each station has a January mean temperature slightly less than the prescribed limit of 64.4° F (18° C); 63.3° F (17.4° C) and 63.5° F (17.5° C), respectively. Such a difference is the result of minor deviations from the planetary norm and is associated with the opium zone's high elevations and the inflow of winter monsoon air.

The warmth index plots in Figure 4 are grouped to show qualifying weather stations for five broad geographic regions, each region is designated by a first-order letter. Subregions are indicated by second-order numbers. The area of index plots for Thailand's opium zone is designated by the letter A and shaded for reference. Other Cw climate areas and their first-order letter designations include: highland Brazil, B; southern Africa and Madagascar, C; South Asia, D; and northeastern Myanmar and Far East, E.

The nomogram reveals strong thermal congruence between the opium zone and many of the station locations in highland Brazil (B) and interior southern Africa (C1). Most weather stations of the other areas fall within the opium

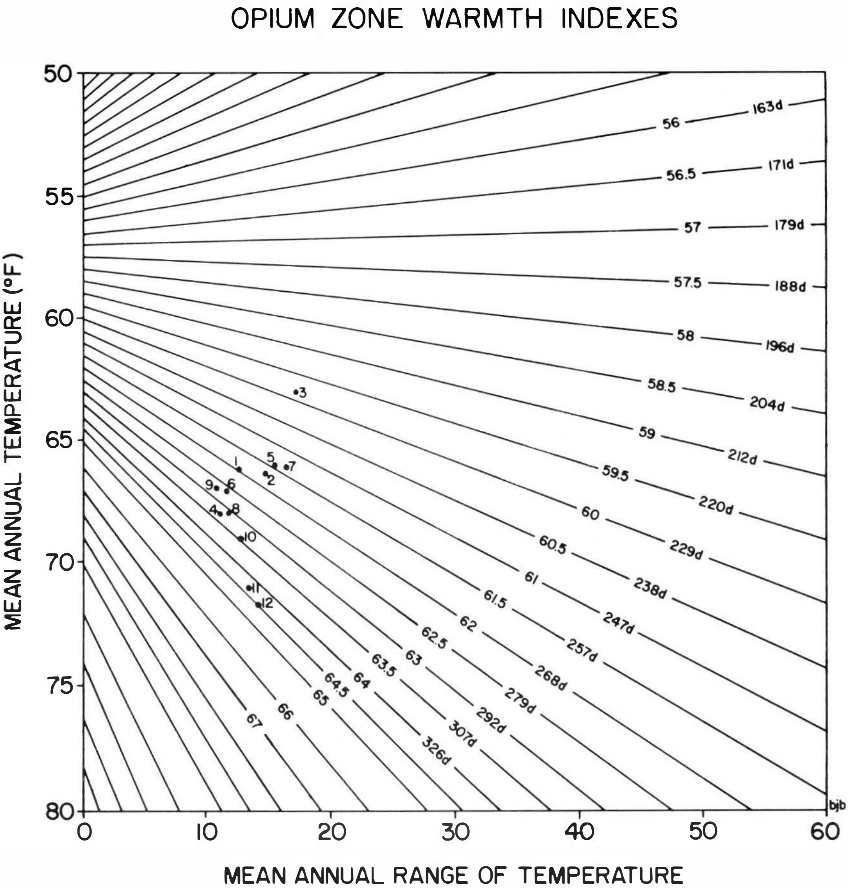


Figure 3. Warmth index plots of twelve weather stations in the Thailand opium zone

zone's index range, but outside of the zone's nomogram plot. In many cases winter temperatures account for these thermal departures (Figure 5). Such stations should be considered as secondary prospects for cold-tolerant rice cultivars and experimental genetic material. The temperature characteristic and rice production of the analog regions identified on the nomogram are discussed below.

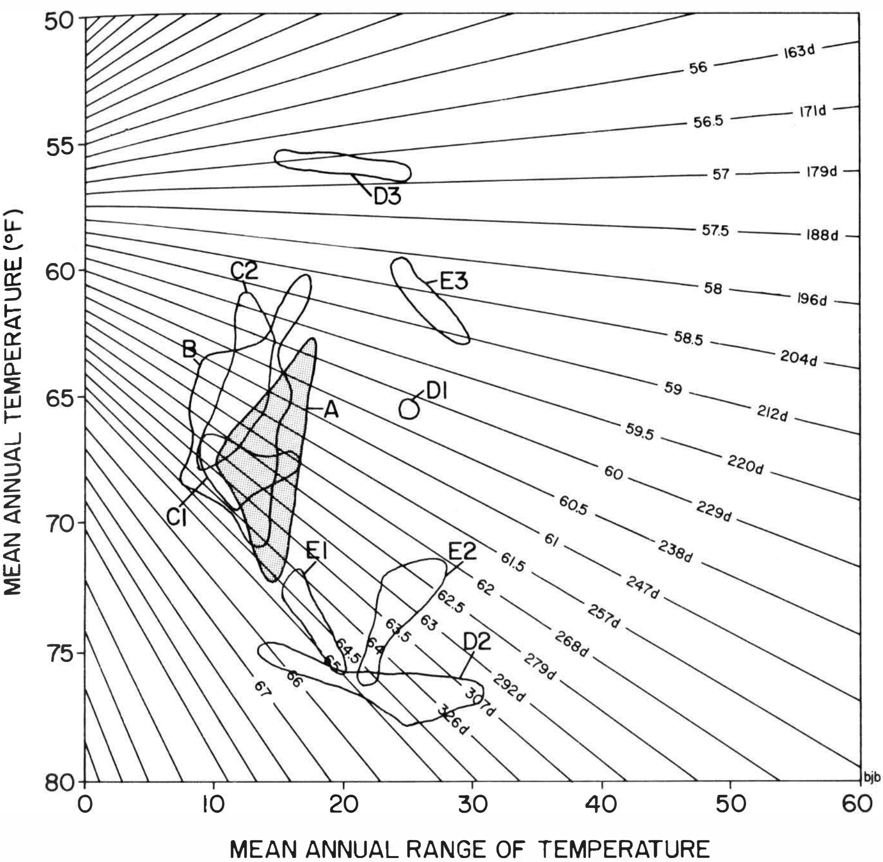


Figure 4. The nomogram plots of the Thailand opium zone (shaded plot) and comparable Cw regions. The letter designations are explained in the text.

## Discussion

1. Brazil (B) — The temperatures of highland Brazil (B) have the greatest degree of similarity with Thailand's opium zone, as indicated by the overlap of the two areas' index plots (Figure 4). The wide range in elevations and comparable temperature ranges of both regions account for much of this thermal congruence. More temperature data are avail-

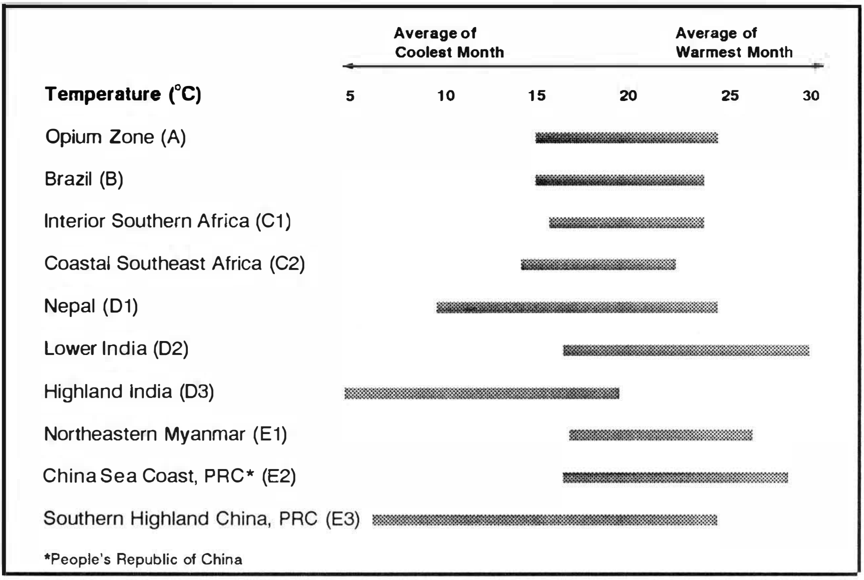


Figure 5. Winter versus summer thermal departures from the opium zone

able for this region than the combined total of all other regions (Wernstedt, 1981). The Brazilian stations are concentrated in the state of Minas Gerais (Table 1), which included 371,386 hectares of upland rice in 1979 (Sant'Ana, 1984; Gupta and O'Toole, 1986). Only two stations are located outside of Minas Gerais, in the state of Rio Grande do Sul, but they are in areas of wetland rice cultivation.

The Minas Gerais station data typify the *cerrado savanna* region of the Brazilian highlands which also includes portions of Goiás, São Paulo, Maranhão and Mato Grosso states. This region is the only significant Cw upland rice area in Latin America and the world's largest continuous upland rice-growing area. It accounts for about three-fourths of Brazil's rice production with approximately 4.0 million hectares planted annually. Rice culture is semi-mechanized and is often the first crop on newly cleared savanna lands.

## Table 1. Brazil: Selected *Cw* Weather Stations

| Station | Lat. (S) | Long. (W) | Figure 4 Area Plot |
|---|---|---|---|
| 1. Alegrete | 29.46 | 55.47 | B |
| 2. Barbacena | 21.15 | 43.47 | B |
| 3. Barreiro do Araxa | 19.32 | 47.00 | B |
| 4. Bonsucesso | 21.02 | 44.46 | B |
| 5. Cachoeiera do Itapemerim | 20.51 | 43.30 | B |
| 6. Cambuquira* | 21.51 | 45.18 | B |
| 7. Caxambu | 21.59 | 44.57 | B |
| 8. Caxias | 29.10 | 51.12 | B |
| 9. Conceicao do Serro* | 19.02 | 43.00 | B |
| 10. Diamantina | 18.14 | 43.34 | B |
| 11. Franca | 20.32 | 47.25 | B |
| 12. Gameleira* | 19.56 | 43.56 | B |
| 13. Guaratinga* | 18.36 | 46.38 | B |
| 14. Itabira do Mato Dentro* | 19.37 | 43.13 | B |
| 15. Itajuba | 22.25 | 43.27 | B |
| 16. Juiz de Fora* | 21.46 | 43.20 | B |
| 17. Lavras* | 21.14 | 45.00 | B |
| 18. Mar de Hespanha* | 21.52 | 43.01 | B |
| 19. Mendes* | 22.32 | 43.43 | B |
| 20. Monte Alegre* | 18.52 | 48.51 | B |
| 21. Monte Serrat | 22.27 | 44.37 | B |
| 22. Muzambinho | 21.22 | 46.31 | B |
| 23. Nova Friburgo | 22.17 | 42.32 | B |
| 24. Oliveira | 20.42 | 44.50 | B |
| 25. Ouro Fino | 22.16 | 46.22 | B |
| 26. Ouro Preto | 20.23 | 43.29 | B |
| 27. Passoquatro | 22.23 | 44.58 | B |
| 28. Pinheiros* | 22.31 | 44.00 | B |
| 29. Piracicaba* | 22.43 | 47.38 | B |
| 30. Pitangui* | 19.40 | 44.53 | B |
| 31. Pocos de Caldas | 21.47 | 46.33 | B |
| 32. Rezende* | 22.29 | 44.28 | B |
| 33. Santos Dumont | 21.28 | 43.33 | B |
| 34. Sao Joao Del Rei* | 21.08 | 44.16 | B |
| 35. Sao Joao Evangelista* | 18.25 | 42.47 | B |
| 36. Sao Lourenco* | 22.06 | 45.01 | B |
| 37. Tres Coracoes | 21.02 | 45.16 | B |
| 38. Uba* | 21.07 | 42.57 | B |
| 39. Valenca* | 22.13 | 43.44 | B |
| 40. Vargem Alegre* | 22.29 | 43.54 | B |
| 41. Vicosa* | 20.46 | 42.54 | B |

*Stations with a warmth index that overlaps into the opium zone's area of index plots.

Regional yields average between 1.2 to 1.5 tons per hectare (DeDatta, 1975).

Brazilian upland rice research has increased substantially since the early 1970s, but virtually no published work could be found on the development of cold-tolerant varieties (EMBRAPA, 1984; CIAT, 1984; Dall'Acqua, 1986; Steinmetz, 1986). It is unlikely that Brazilian varieties are uniquely adapted to low temperatures, but there are two plausible explanations for this surprising lack of research. Firstly, interest in moisture supply has superseded concern for temperature, because the region receives marginal levels of rainfall (1200 mm) and is subject to frequent prolonged droughts (International Rice Research Institute, 1979; Martinez, 1984; Dall'Acqua, 1986; Steinmetz, 1986). Secondly, low temperature has little impact on overall rice production because most cultivations are at lower elevations. Notwithstanding the lack of interest in temperature constraints, Brazil's highland genetic pool has considerable research potential because many primitive varieties (landraces) are used by subsistence farmers in less favorable elevations (Laing, et al., 1984).

2. <u>Southern Africa and Madagascar (C)</u> — There are two Cw climate subregions in southern Africa that are comparable to the Cw climates of the opium zone (Figure 4). The first location stretches across southern Africa's interior (C1), beginning in central Angola and ending in northeastern Tanzania. The eight qualifying Cw weather stations have warmth indexes that correspond with indexes of the lower opium zone. The second area is the southeast subregion (C2), represented by five highland stations scattered in Swaziland, Mozambique and Madagascar. The stations at Espungabera, Mozambique and Fianarantsoa, Madagascar (Table 2) account for some overlap on the nomogram with the opium zone. The predominately offset position of these stations on the nomogram relative to the opium zone reflects

## Table 2. Southern Africa and Madagascar: Selected *Cw* Weather Stations

| Station | Lat. (S) | Long. (E) | Figure 4 Area Plot |
|---|---|---|---|
| 1. Ceilunga, Angola | 12.22 | 16.54 | C1 |
| 2. Coemba, Angola* | 12.06 | 17.42 | C1 |
| 3. Kasama, Zambia* | 10.12 | 31.11 | C1 |
| 4. Mwinilunga, Zambia* | 11.45 | 24.26 | C1 |
| 5. Ndola, Zambia* | 12.59 | 28.37 | C1 |
| 6. Nova Lisboa, Angola | 12.48 | 15.45 | C1 |
| 7. Solwezi, Zambia* | 12.11 | 26.41 | C1 |
| 8. Lyamunga, Tanzania | 3.14 | 37.15 | C1 |
| 9. Mbabane, Swaziland | 26.19 | 31.08 | C2 |
| 10. Espungabera, Mozambique | 28.28 | 32.46 | C2 |
| 11. Antsirabe, Madagascar | 19.52 | 47.00 | C2 |
| 12. Fianarantsoa, Madagascar | 21.27 | 47.05 | C2 |
| 13. Tananarive, Madagascar | 18.55 | 47.33 | C2 |

*Stations with a warmth index that overlaps into the opium zone's area of index plots.

milder temperatures of a maritime location, but the stations' high elevations account for winter temperatures that are slightly cooler than the opium zone (Figure 5). Therefore, despite the southeast subregion's general thermal departure, some cultivars grown here might be adaptive to the winter continental influence experienced in northern Thailand.

An endemic African species, *Oryza glaberrima*, is still grown as a food staple in a few areas of southern Africa, but higher-yielding cultivars of introduced Asian *O. sativa* are more common in the region today (DeDatta, 1975). A diversity in natural habitats and a long history of selection pressures have led to considerable variety of Asian rice (Alluri, 1985; Zafera Antoine, 1985). The average yield is about 1.0 tons per hectare. The southern interior area produces just over 200 tons of dryland rice and the southeast area produces 2,206 tons. Nearly all of the latter tonnage comes from farms in Madagascar (2,000 tons), the only country in the southern Africa and Madagascar region that depends on rice as a dominant food staple (Garrity, 1985).

Most of the upland rice research in the southern Africa and Madagascar region is limited to varietal screening with little or no emphasis on cold-tolerance; probably because upland rice is generally cultivated at elevations lower than 1,000 meters. However, the problem of cold-induced yield reduction is beginning to attract attention as a result of regional population growth and an increase in demand for rice in Africa's urban areas. Such factors are making rice production more practical economically in areas above this elevation (Ching'ang'a, 1985; IITA, 1984; Shahi, 1985).

3. South Asia (D) — The only Cw station in Nepal (D1) is at Kathmandu (Table 3). This location's warmth index is representative of the higher elevations in the opium zone, and winter temperatures account for much of this location's thermal departure from the opium zone (Figure 5). Therefore, as in southern Africa and Madagascar, a case can

**Table 3. South Asia: Selected *Cw* Weather Stations**

| Station | Lat. (S) | Long. (E) | Figure 4 Area Plot |
|---|---|---|---|
| 1. Kathmandu, Nepal | 27.42 | 85.12 | D1 |
| 2. Jabalpur, India | 23.10 | 79.59 | D2 |
| 3. Tezpur, India | 26.37 | 92.47 | D2 |
| 4. Darbhanga, India | 26.10 | 85.54 | D2 |
| 5. Guvahati, India | 26.11 | 91.45 | D2 |
| 6. Mukteswar, India | 29.28 | 79.39 | D3 |
| 7. Simla, India | 31.06 | 77.10 | D3 |

No station has a warmth index that overlaps into the opium zone's area of index plots.

be made for investigating the possible transfer of cold-tolerant rice cultivars. Despite a more extreme temperature range caused by cold winters, rice yields fare better than those in the opium zone (Huke, 1982). In the Kathmandu Valley (600 to 2,000 m) they average 2.6 tons per hectare. However, this high average is primarily the result of the intense use of labor and cultivation on rainfed terraces (Mallick, 1982).

Rice screened in Nepal for cold-tolerance trials have concerned only varieties grown on wetland terraces (Shahi and Hue, 1979). Nonetheless, eastern Nepal, where Kathmandu is located, possesses a rich spectrum in varietal diversity among upland varieties that can tolerate cool night temperatures. Over much of the region settlements are scattered in small isolated valleys, where wetland rice is grown in the valley bottoms and nonirrigated rice is grown on terraces in rotation with other crops (Uhlig, 1978).

In Lower India (D2), which encompasses the Brahmaputra lowland and an area south of the Ganges River, only Jabalpur has a warmth index that falls within the opium zone range, but very little rice is produced here (Huke, 1982). In addition, its winter temperatures are extremely mild compared to the opium zone (December averages 16.4° C). Thus, it would be unlikely to find cultivars with cool season adaptations. The remaining stations in Lower India fall outside of the zone's index range due to their warmer summer temperatures (Figure 5).

Highland India (D3) stations, located west of Nepal in the higher portions of the Himalayan foothills, are totally outside of the range of opium zone warmth indexes. Injury due to low temperature is a major constraint to rice production. Short growing seasons require seedling bed transplantation and almost all cultivation is on wetland terraces (Hamdani, 1979; Huke, 1982). Because of extreme thermal departure from Thailand's opium zone, this region probably does not have transferable rice cultivars.

4. Northeastern Myanmar and Far East (E) — There are two stations in northeastern Myanmar: Bhamo and Lashio (Table 4). Bhamo, which is located in the Irrawaddi River Valley, has much higher summer temperatures than the opium zone (Figure 5). This location accounts for the offset position of the region's plot on the nomogram (Figure 4). It is a center of irrigated rice production and little or no upland rice is cultivated here (Hamdani, 1979; Huke, 1982). On the other hand, Lashio's nomogram plot is nearer the opium zone due to its relatively cooler summer temperatures. About one-third of the rice produced in hills surrounding Lashio is cultivated using dryland methods (Hamdani, 1979; Huke, 1982). The total area is not extensive (12,000 hectares) because production is by means of shifting cultivation. Yields average between 0.75 and 1.1 tons per hectare (DeDatta, 1975).

**Table 4. Northeast Myanmar and Far East: Selected *Cw* Weather Stations**

| Station | Lat. (S) | Long. (E) | Figure 4 Area Plot |
|---|---|---|---|
| 1. Lashio, Myanmar | 22.58 | 97.51 | E1 |
| 2. Bhamo, Myanmar | 24.16 | 97.17 | E1 |
| 3. Hanoi, Vietnam | 21.02 | 105.52 | E2 |
| 4. Hong Kong | 22.18 | 114.10 | E2 |
| 5. Hsi-Ying, PRC | 21.03 | 110.28 | E2 |
| 6. Lungchow, PRC | 22.22 | 106.45 | E2 |
| 7. Pakhoi, PRC | 21.28 | 109.05 | E2 |
| 8. Tengchong, PRC | 25.00 | 98.40 | E3 |
| 9. Ya-an, PRC | 30.00 | 103.03 | E3 |

No station has a warmth index that overlaps into the opium zone's area of index plots.

There are perhaps hundreds of landraces and wild relatives of cultivated plants still to be collected in the hills of northern Myanmar and adjoining areas in Laos; yet, there is no evidence in the literature of upland rice research by Burmese agronomists (Plucknett, et al., 1982; Arraudeau and Harahap, 1986). Notwithstanding this deficiency, at least one variety from Myanmar has been tested in the opium zone, and it has yielded better than other imported cultivars (Thai-Australia Highland Agriculture Project, 1981).

The China Sea coast area (E2) includes weather stations in Hanoi, Hong Kong and the southern coast of the People's Republic of China (Table 4). Prospects for finding suitable rice varieties are doubtful, because the subregion's thermal departure is due primarily to high summer temperatures (Figure 5). Moreover, only irrigated rice is grown at the locations of the weather stations (Huke, 1982).

Ya-an and Tengchong are southern highland stations in the People's Republic of China (E3, Table 4). They are located in the interior southwest of the country. Useful rice varieties are unlikely to be found here as a consequence of low warmth indexes compared to the opium zone. Continental winters account for the thermal departure (Figure 5). Prospects are reduced further because little or no rice is produced in the vicinity of Ya-an and only small amounts of upland rice (3000 hectares) are cultivated near Tengchong (Huke, 1982).

## Conclusions

This article demonstrates that in certain instances successful drug crop replacement studies require detailed information about several geographic regions. In considering upland rice as an opium replacement crop in Thailand, it is apparent that the Cw region in highland Brazil and the two

Cw subregions of southern Africa have considerable potential for locating useful rice varieties. There also seems to be sufficient similarity of temperatures to warrant further investigations at specific locations in Nepal and northeastern Myanmar. More information is needed about rice strains in each of these areas, particularly information regarding cold-tolerance. Moreover, the suitability of local wetland cultivars should also be investigated, since continuation of population pressures in the opium zone can be expected to force expansion of field terraces and cultivation using gravity irrigation technology.

These are not conclusive findings because only a few years of temperature data are available for many of the weather stations. The range of warmth indexes for the opium zone might be different if thirty or forty years of data were available. Similarly, if data for more weather stations were available for the other Cw climate regions, their index plots might overlap more with the opium zone. Despite these shortcomings, this climate-based approach is of practical value because it provides a beginning point for more in-depth location-specific analyses.

The regional rice yields that are discussed are useful as general references, but more information is needed to sort out how each region's physical, economic, and cultural environment effects yields. Information about factors of production is particularly important, since new rice varieties will be grown by subsistence farmers to increase their food supplies. Therefore, more data are needed about other climatic elements, about soil characteristics, varietal yields, taste and nutrition, plant physiognomy and phenology, and biological stresses. Additionally, to help maximize yields, agricultural extension workers will need more information about cultivation and management practices in the analog regions. All of these factors are overlapping concerns of plant scientists and geographers, and any further research at the many locations identified in this study would benefit from a liaison between these groups.

Fragments of a possible liaison already exist. The United Nations Fund for Drug Abuse Control operates small crop replacement programs in Thailand, Myanmar, Laos, Colombia, Bolivia, Peru, Mexico, Brazil and Pakistan. Moreover, it has field advisors working on various other projects in nearly every country of Latin America, Asia, Africa and the Middle East. Other possible links in the network are international nurseries. By working in cooperation with academic plant scientists, these nurseries have helped launch the development of hundreds of successful crops in various countries (Plucknett, et al. 1982; Smith, 1987), but only occasional collaboration has taken place with the various narcotic crop replacement programs. Geographers could also serve as links in a liaison against illicit drug production. Indeed, their role in this network has tremendous potential through the auspices of specialty groups of professional geography organizations, which could bring together geographers and non-academic scientists who are interested in combating illicit drug production.

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# PERSPECTIVES ON THE NURTURE OF GEOGRAPHERS WITH SPECIAL REFERENCE TO CSU, CHICO

*James F. Petersen*

"In the long run the best evaluation of a college education is likely to result from studies of alumni. What are they like...years after graduation? How have they been influenced by college experiences?" (Freedman 1964)

## Introduction

It should be an unusual surprise to encounter a geographer-colleague who also graduated from my undergraduate *alma mater*, California State University, Chico (CSUC). Nevertheless, this situation has occurred to me on several occasions, which made me wonder if it is coincidental, or if the program at Chico has produced an inordinate number of undergraduates who later would complete a Ph.D. in geography. Further, if this is true, why is it so?

A wide number of factors can influence a student's decision to seek a doctorate. Astin (1963; 1977) examined the motivation of talented undergraduate students toward earning a Ph.D., and found that individual experiences in a college environment are more important than a student's

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educational or family background. Heist et al. (1961) found that schools with a high productivity of future scholars generally benefited from quality students and a "fortunate combination of faculty and student expectations, interests and values."

This may have been the case at California State University, Chico, which has an apparently high number of undergraduates (about 30, according to departmental information) who later went on to complete a Ph.D. in geography. CSU, Chico has been a regional college/university during the time that the Geography Department has been in existence (since 1966), with a small master's program since 1970. On a nationwide scale, the geography program at CSU, Chico may not be widely known. The department could be referred to as one of the often under-rated, "overlooked" departments of geography (de Souza et al. 1981). Yet, as de Souza, Vogeler, and Foust suggested, there are many ways to evaluate the contributions of a department to its students, the university, the discipline, and scholarship in general. The productivity of baccalaureate graduates who continue their education to receive a Ph.D. is one indicator that has been used to estimate undergraduate program quality (Hanson 1984; Hall 1984).

Data from the *Membership Directory* of the Association of American Geographers (Association of American Geographers 1990) reveal a total of 2150 Ph.D. geographers with undergraduate degrees from 430 different institutions in the United States. These data represent a mean of five geography Ph.Ds. per school with a range from 1 to 68. Based on baccalaureate origins of the AAG membership nationwide for Ph.D. geographers, CSU, Chico ranks 25th overall (tied with the University of Utah and Columbia University), and seventh among non-doctoral granting institutions. In

California, CSUC ranks third after UC Berkeley (68) and UCLA (64), the two highest rankings in the nation.

Considering its size and university mission, CSU, Chico has produced a respectable one-quarter to one-half the output of future geographers compared to these much larger, "flagship" schools. An exact estimate is difficult, because a majority, but not all, academic geographers belong to the AAG. Sixteen Chico graduates are members of this organization, roughly half of the total alumni with Ph.Ds. Table 1 shows the rankings of U.S. schools in terms of baccalaureate origins of Ph.D. geographers. Table 1 lists the top 25 schools overall including those that grant a geography doctorate. Table 2 lists the top 25 institutions that do not grant a geography Ph.D.

Most of these schools have undergraduate and/or master's level programs, but some have no geography degree program at present. Boldface type in Table 1 indicates that there is no doctoral granting geography department at that institution. While it is clear that the large, doctoral institutions dominate in numbers per institution, the role of non-doctoral institutions should not be underestimated. The baccalaureate origins of geographers in the United States are widely dispersed, and several non-doctoral universities have an excellent record of developing future geographers, particularly Wayne State, Dartmouth, Valpariso, Illinois State, and Brigham Young. These raw rankings do not consider school or departmental size.

An examination of the data in Tables 2 and 3 generates several germane questions. If certain schools have generated a particularly high rate of undergraduates who go on to earn a doctorate in geography, what are some of the reasons for this high productivity? Further, what are the attitudes of professional geographers relative to their undergraduate ex-

Table 1.

U.S. Undergraduate Origins, AAG Membership, 1990: Top 25 ranks for all institutions including those with Ph.D.-granting geography departments.

| Rank | School | Graduates |
|---|---|---|
| 1 | UC BERKELEY | 68 |
| 2 | UCLA | 64 |
| 3 | WISCONSIN | 51 |
| 4 | MICHIGAN | 40 |
| 5 | WASHINGTON | 39 |
| 6 | MINNESOTA | 37 |
| 7 | CLARK | 36 |
| **8** | **WAYNE STATE** | **29** |
| 9 | CHICAGO | 27 |
| **9** | **DARTMOUTH** | **27** |
| 11 | SUNY BUFFALO | 24 |
| **12** | **HARVARD** | **22** |
| 12 | PENN. STATE | 22 |
| 14 | INDIANA | 21 |
| 14 | MICHIGAN STATE | 21 |
| 14 | OHIO STATE | 21 |
| 17 | COLORADO | 20 |
| **17** | **VALPARAISO** | **20** |
| 19 | ILLINOIS | 19 |
| 19 | SYRACUSE | 19 |
| **21** | **BRIGHAM YOUNG** | **17** |
| **21** | **ILLINOIS STATE** | **17** |
| 21 | KENT STATE | 17 |
| 21 | TEXAS | 17 |
| **25** | **CSU, CHICO** | **16** |
| 25 | COLUMBIA | 16 |
| 25 | UTAH | 16 |

Institutions without a Ph.D. granting geography department are in bold face.

Table 2.

U.S. Undergraduate Origins, AAG Membership, 1990: Top 25 ranks for institutions not offering a Ph.D. in geography.

| Rank | School | Graduates |
|---|---|---|
| 1 | WAYNE STATE | 29 |
| 2 | DARTMOUTH | 27 |
| 3 | HARVARD | 22 |
| 4 | VALPARAISO | 20 |
| 5 | ILLINOIS STATE | 17 |
| 5 | BRIGHAM YOUNG | 17 |
| **7** | **CSU, CHICO** | **16** |
| 8 | MISSOURI | 15 |
| 8 | IOWA STATE | 15 |
| 10 | SAN DIEGO STATE | 14 |
| 11 | WEST CHESTER | 13 |
| 11 | CSU, NORTHRIDGE | 13 |
| 11 | ANTIOCH COLLEGE | 13 |
| 14 | SLIPPERY ROCK | 12 |
| 14 | MIDDLEBURY COLL. | 12 |
| 14 | MIAMI UNIV. | 12 |
| 14 | FLORIDA STATE | 12 |
| 18 | SAN JOSE STATE | 11 |
| 18 | INDIANA U. PA. | 11 |
| 20 | WEST. ILLINOIS ST. | 10 |
| 20 | U.S. MIL. ACAD. | 10 |
| 20 | MARSHALL | 10 |
| 20 | GEO. WASHINGTON | 10 |
| 20 | E. ILLINOIS ST. | 10 |
| 20 | CARROLL COLLEGE | 10 |
| 20 | BUCKNELL | 10 |

Note: some institutions listed do not offer a baccalaureate degree in geography.

periences? Do they feel that their experience was influential in their career choice, and is there some agreement about the factors that were influential to them? This study seeks to explain the high productivity of future geographers by the CSUC department as one example of a non-doctoral institution. The CSU, Chico case study should offer some insights into the process of encouraging talented undergraduates to seek further education in the discipline. A question to consider is whether or not Chico graduates have significantly different attitudes about their undergraduate experience, in comparison to the attitudes of a general sample of geography Ph.Ds. Another important concern is developing an understanding of the impact that undergraduate training may have had on a person's decision to continue with graduate school and to seek a career as a geographer.

## Research Design

Attitudes of Ph.D. geographers towards their undergraduate experiences were tested by a mail survey. A questionnaire was mailed to 20 Chico graduates (all Ph.D. geographers who could be located, including five non-AAG members), and a second group of 75 geographers from the AAG *Directory*. The AAG group was limited to persons holding an earned doctorate (presumably in geography) who received their undergraduate degree from a university in the United States, but otherwise participants were randomly selected. Persons with foreign undergraduate degrees were not included in this study, as their training may not be directly comparable to programs in U.S. schools. Of 95 inquiries, 65 were returned, a fairly good response rate (sixty-eight percent) for an unsolicited questionnaire. Sixty-four percent of the AAG group and eighty-five percent of the Chico group returned the questionnaire. The Chico group did not include the author. An introductory letter accompanying the questionnaire explained that gathering information about the potential impacts of one's undergraduate program was the purpose of the study. The goal of considering one particular school was not mentioned in the correspondence.

The questionnaire was comprehensive, yet brief enough to encourage a satisfactory return rate. In developing the format, questions concerning a wide variety of potential influences were included, and organized into three parts. Section one contained eighteen questions concentrating on participants' <u>attitudes</u> about potentially important influences in their decision to continue with graduate school, and to become a professional geographer. In this part, the scale of responses ranged from very important influence (3), important influence (2), little influence (1), no influence (0), negative influence (-1), or not applicable. Section two concerned actual <u>experiences</u> in the respondents' undergraduate program, their professional careers today, and relationships between these two factors. Section two had an even division of positive and negative responses: strongly agree (2), agree (1), neutral (0), disagree (-1), and strongly disagree (-2). Because of the unequal scaling (which seemed appropriate to the questions), and a different intent, mean responses from the two sections are not directly comparable.

Section three provided background information. Questions here dealt with whether the respondents are dominantly research- or teaching-oriented today, the nature of their current department, and their professional lives. Another page was provided for supplemental comments.

A potential for bias exists in a questionnaire written by a member of a target group in the survey, and efforts were undertaken to mitigate this problem. In other words, a positive response by the Chico group might to some extent be an artifact of bias introduced because a CSUC alumnus designed the study. This possibility was minimized through review of the questionnaire by several colleagues, and subsequent revision. As a post-test check, factors listed by respondents on the open-ended part of the questionnaire were examined. However, on the open-ended portion of the questionnaire, very few unaddressed points were mentioned, and none of these points related directly to the respondents' undergraduate experiences. For example, one factor mentioned was the influence of travel on developing an interest in geography.

## Questionnaire Analysis

The twenty-eight questions dealing with undergraduate experiences and career influences were tested for significant differences between the mean responses from each group. The Mann-Whitney U-test, a distribution-free test of association, was applied because it is appropriate to Likert Scale (ordinal) measurement, and the response data had a non-normal, skewed distribution.

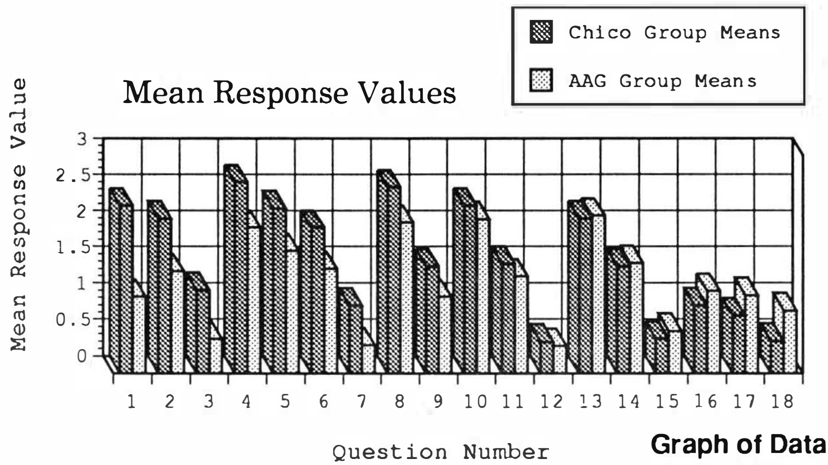
Individual questions for each section of the questionnaire are shown in Tables 3 and 4, ranked in order of difference between the mean response for each group. These tables each have a corresponding graph to illustrate response levels. A negative number indicates a generally negative response to the question. The results show that there are significant differences in response to several questions between the Chico and the AAG groups, but the overall responses were not greatly different. A Spearman's Rank comparison of mean responses for the eighteen questions in section one yielded a strong positive correlation between the two groups (Rho = 0.76). The correlation suggests that in

Table 3. Section one questions ranked by differences between the group response means: Boldface type represents statistically significant difference (.05 level).

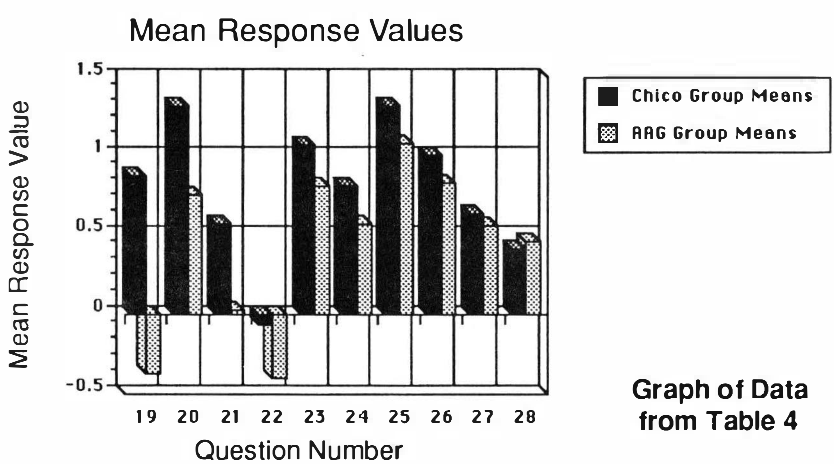
| QUESTION | Chico | | | AAG | | |
|---|---|---|---|---|---|---|
| RATED HIGHER BY THE CHICO GROUP (N≤ 17): | Mean | Rank | N | Mean | Rank | N |
| **1. Recommendation of this career by a geography faculty member.** | **2.31** | **3** | **17** | **1.05** | **12** | **46** |
| **2. Teaching style of a particular geography professor (or several).** | **2.13** | **6** | **17** | **1.40** | **8** | **45** |
| **3. Attending a conference of professional geographers.** | **1.14** | **12** | **15** | **0.47** | **16** | **38** |
| **4. Influence by a mentor-professor in geography.** | **2.63** | **1** | **17** | **2.00** | **4** | **44** |
| 5. The eclectic approach of geography, and its holistic nature. | 2.27 | 5 | 16 | 1.68 | 5 | 44 |
| 6. Geographic knowledge as an enrichment of one's everyday life. | 2.00 | 8 | 16 | 1.43 | 7 | 45 |
| **7. Involvement in geography student groups (geog. club, GTU).** | **0.93** | **13** | **15** | **0.38** | **17** | **37** |
| 8. Enthusiasm for the discipline of geography, shown by a professor. | 2.56 | 2 | 17 | 2.07 | 3 | 46 |
| 9. The opportunity for field work. | 1.47 | 10 | 16 | 1.05 | 12 | 43 |
| 10. My undergraduate course work in geography (content knowledge). | 2.31 | 3 | 17 | 2.12 | 2 | 44 |
| 11. Opportunities for research into geographical problems. | 1.50 | 9 | 17 | 1.33 | 9 | 42 |
| 12. Inspiration by visiting geographic scholars/speakers. | 0.43 | 18 | 15 | 0.37 | 18 | 37 |
| RATED HIGHER BY THE AAG SAMPLE GROUP (N ≤ 48): | | | | | | |
| 13. The discipline of geography itself, its content and approaches. | 2.13 | 6 | 17 | 2.17 | 1 | 44 |
| 14. The potential applications of geography to real-world problems. | 1.47 | 10 | 16 | 1.51 | 6 | 44 |
| 15. Discovery of the area near your undergraduate institution. | 0.47 | 16 | 16 | 0.58 | 15 | 43 |
| 16. Opportunity for specialization in a sub-discipline of geography. | 0.93 | 13 | 15 | 1.13 | 10 | 42 |
| 17. Camaraderie with geography student peers. | 0.79 | 15 | 15 | 1.07 | 11 | 44 |
| 18. Interest in the research program of a geography faculty member. | 0.44 | 17 | 17 | 0.86 | 14 | 39 |
| OVERALL MEANS (ON A SCALE OF 3 MAXIMUM) | 1.55 | | | 1.26 | | |

Table 4. Section two questions ranked by differences between the group response means: Boldface type represents statistically significant difference (.05 level).

| QUESTION | Chico | | AAG | |
|---|---|---|---|---|
| RATED HIGHER BY THE CHICO GROUP (N≤ 17): | Mean | N | Mean | N |
| **19. As an undergraduate, I was encouraged by a faculty member to attend a meeting of academic/professional geographers.** | **0.87** | **16** | **-0.37** | **40** |
| 20. As an undergraduate, one or more of my professors recognized and nurtured my potential as a future professional geographer. | 1.31 | 17 | 0.75 | 43 |
| 21. As a professor, my approach to *undergraduate* teaching is somewhat similar to that of my *undergraduate* professors. | 0.56 | 17 | 0.02 | 48 |
| 22. In my geography undergraduate program, I gained a good idea of what my own career as a geographer would be like today. | -0.07 | 16 | -0.40 | 43 |
| 23. As an undergraduate, I received a fair amount of attention (academic interaction or counseling) from geography faculty. | 1.06 | 17 | 0.80 | 43 |
| 24. My geography undergraduate program prepared me well for the graduate school experience (compared to my grad. school peers). | 0.80 | 16 | 0.56 | 44 |
| 25. Dealing with undergraduates today, I consider that some of them may have the potential for continuing on to doctoral-level education. | 1.31 | 17 | 1.07 | 48 |
| 26. The process that led me to become a geographer was coincidental, due to circumstances rather than by design. | 1.00 | 17 | 0.82 | 48 |
| 27. My undergraduate education has influenced my professional endeavors (*e. g.,* research interests) today. | 0.63 | 16 | 0.55 | 40 |
| RATED HIGHER BY THE AAG SAMPLE GROUP (N≤ 48): | | | | |
| 28. My approach tc *undergraduate* teaching is somewhat similar to that of my *graduate-level* professors in their undergraduate courses. | 0.40 | 16 | 0.45 | 47 |
| OVERALL MEANS (ON A SCALE OF 2 MAXIMUM) | 0.79 | | 0.43 | |




**Graph of Data from Table 3**




**Graph of Data from Table 4**

terms of relative importance of these influences, Chico graduates are much like the AAG sample. The factors that exerted a strong influence on the Chico graduates were also important among the AAG group, but the Chico respondents tended to be more positive in their responses.

In general, the CSUC alumni were very positive concerning the impact of their undergraduate experience (overall

**Table 5. Important Influences for Becoming a Ph.D. Geographer: Groups by Rank**

| *Chico Group* | *AAG Group* |
|---|---|
| 1. **Influence by a mentor** | 1. The discipline of geography by itself, its content |
| 2. **A Professor's enthusiasm for geography** | 2. **Influence by a mentor** |
| 3. The eclectic/holistic approach of geography | 3. **Undergraduate course work** |
| 4. Opportunity for field work | 4. **A Professor's enthusiasm for geography** |
| 5. Undergraduate course work (tie) | 5. Applications to real-world problems |
| 5. Recommended career by a professor (tie) | 6. Research opportunities in geography |
| 5. Geography enriches everyday life (tie) | |

**[bold = shared between both groups]**

means for Chico = 1.55 and AAG = 1.26). In section one, which primarily concerned attitudes and influences, the Chico group had a higher response level on twelve of the 18 questions. Five differences were significant at the .05 level. Of the ten questions in section two, concerning actual events and experiences, the Chico group ranked nine out of ten with a higher response level (one question was significantly different). In this section, the sole question that was ranked higher by the AAG group dealt with whether the individual's teaching was influenced strongly by graduate experiences (rather than undergraduate experiences).

## Strong influences

The statistically significant factors can be grouped to develop several generalizations concerning influence. The strength of mentoring and teaching styles by faculty is especially evident in the Chico group. Although faculty mentoring, undergraduate course work, and enthusiasm for the discipline were also ranked highly by the AAG group, several other points suggest particularly strong influences by faculty at CSUC. These include actively recommending a career as a university professor to talented students and encouraging undergraduates to attend a meeting of professional/academic geographers. Members of the AAG group were strongly influenced by the characteristics of geography as a discipline and the potential for geographic applications.

After completing section one of the questionnaire, participants were also asked to underline the two factors that they felt were most influential. In determining the most important influences, the respondents' choices from the list of 18 may be more valid than the highest mean ranks. This is because in the case of influences, extremes may be more significant than means. A comparison of key factors in Table 5 reveals several differences between the Chico group and the AAG group. Three factors, however, were important to both groups: influence by a mentor, enthusiasm shown by a professor, and undergraduate course work. The Chico group gave great merit to the eclectic/holistic approach to geography, opportunities for field work, career recommendations by a professor, and geographic knowledge as an enrichment of everyday life. The AAG group reinforced their emphasis on the discipline of geography, applications to real-world problems, and research opportunities.

About twenty-five percent of all respondents did not have an undergraduate degree in geography, a factor that is not listed in the AAG Directory. These people were asked to complete the questionnaire and also to list the two most important reasons for their switch to geography in graduate school. Practically all responses fit the eighteen influences in section one. Most of these people switched to geography because of positive contact with undergraduate geography teaching and faculty. A notable exception was the feeling that geography graduate work would provide an appropriate extension of a respondent's undergraduate major.

## Weak Influences

The low rating of "interest in faculty research programs" reflects a generally modest emphasis on introducing research in many undergraduate programs. This response also reinforces the idea that strong teaching makes a crucial contribution to the discipline by attracting talented students to continued study. Two other factors that were not ranked high by the participants were, influences by a visiting speaker, and participation in student geography groups. These factors, however, may be important despite the low scores, because they are strongly dependent on the opportunity for, and participation in, activities which may not have been available at all institutions.

A personal surprise was the low rank of "discovery of the area local to your undergraduate institution." Learning the joy of landscape interpretation by discovery in the field was a key element that convinced me of geography's value as a discipline of study, yet this factor was ranked low by the respondents of both groups.

Most respondents from both groups felt that their undergraduate training did not necessarily give them a good idea of what their job would be like today. Few of these present-day professors thought that their undergraduate classes have exerted an influence on their current approaches to teaching. Further, many felt that their undergraduate program did not necessarily prepare them well for graduate school, either. Perhaps the most critical point in this regard is that their undergraduate experience encouraged them in some way to continue their education. These responses underscore the divergent roles of undergraduate and graduate education, as well as the importance of quality training as defined in terms appropriate for each level of education. As one Chico graduate stated:

> "Geography was my interest hub.... I am most happy with my undergraduate education.... Graduate school, however, made me a mature scholar and a professional."

## The Nurture of Geographers

Recently, the leadership of the Association of American Geographers has called for an effort to increase the number of geographers in the United States (Abler 1989; Cohen 1990). Based on differences and similarities between the two groups examined in this study, a few observations can be made concerning the process of nurturing future Ph.D. geographers. It is not likely that any of these factors will interfere with the process of educating all undergraduates, whether or not they continue on to graduate studies. First, strong teaching is important at the undergraduate level to generate interest in the discipline because few students begin with a major in geography. Karen and Mather (1986, 96). have criticized geography professors for their "widespread professional snobbishness" toward those colleagues who emphasize good teaching. This study has shown that a professor's enthusiasm for the discipline is a particularly effective inducement for students to seek further education. Enthusiasm is often most effective when it is supplemented with realistic information about what advantages and applications geographic knowledge offers a person in life, scholarship, or perhaps the job market. Second, faculty can take an active role by recognizing talented students and encouraging them to continue their geographic studies in graduate school. This is particularly important to the discipline, because many geographers attribute their career choice to "accident" or serendipity, rather than to design or plan (question 28, section 2). Martin Kenzer, a Chico alumnus (BA 1974) has noted, in *On Becoming a Professional Geographer*:

> "One of my initial thoughts about graduate school, curiously enough, was no thought at all. ...An instructor asked me where I intended to pursue my graduate degree.... The question elicited a total blank on my part" (Kenzer 1989, 2).

In addition, organized events that build interest in the discipline may be more important than this survey has indicated. The role of geography student groups on campus helps to build a sense of identification with the discipline. Of primary importance in this study was the relatively high rate of Chico undergraduates' attendance at geography meetings, an activity which can provide a glimpse at aspects of the discipline that students will not see on campus.

The results of this survey reveal much about the undergraduate experiences of Ph.D. geographers. The apparently successful Chico program outlines one model for encouraging talented undergraduates to consider a career as a professional geographer. CSU, Chico is only one of the non-doctoral departments that has produced a high number of future geography Ph.Ds., and every department may offer unique elements in its approach. The basic model for developing future geographers, however, involves mentoring, enthusiasm for the discipline, strong teaching, and taking an interest in students with potential.

## Conclusion

Fifty-nine percent of American geography Ph.Ds. received their baccalaureate degree from a school that does not grant the doctorate in geography (based on 1990 AAG Directory data). Only a small percentage of undergraduate will continue through a doctoral program, and doctoral-granting departments alone do not meet the demand for qualified graduate students. Thus, Ph.D.-granting departments depend on a supply of graduate students from a wide range of colleges and universities. Although John Fraser Hart (1968) regarded this as a lamentable "parasitic" situation for prestigious geography departments, the process is actually symbiotic. Teachers of geography at all levels should be committed to the duty of inspiring students and encouraging particularly talented individuals to continue their studies in the discipline. Doctoral departments have a responsibility to develop future professors who will actively contribute to this cycle. Ron Abler (1987, 552) has recently observed that, "...teaching plays (a critical role) in the ongoing education of the professorate."

Among disciplines taught in the university, geography is a relatively small one (Abler 1987; Hill and LaPrairie 1989). Geography has even been referred to "endangered," based on past reductions of its range in the academic world. These demographic conditions underscore the importance of "eternal vigilance" (Natoli 1986) in maintaining the health and vigor of geography. All species, endangered or not, base their survival on nurturing new generations. For academic departments in the universities, a part of the process is producing new Ph.Ds. to continue to advance the discipline, a responsibility that is frequently considered to be the eminent domain of Ph.D.-granting departments. In reference to an individual's doctoral education, it is often heard that, "So-and-so trained under Professor Blank at State University." Generally, this statement is issued as if it completely explained the character, development, intellect, and skills of the person in question. Yet, "So-and-so" began an education not as a fledgling Ph.D., but rather as an undergraduate. Although doctoral-level graduate training is preeminent in the development of professional and academic geographers, it is not likely that it erases every vestige of knowledge and intellectual growth that was gained while earning a baccalaureate or master's degree. Further, it is clear that the role model for many professors was a faculty member at a pre-doctoral level of education, and that first impressions of the discipline often remain strong. Without stimulus at the *undergraduate* level to generate interest in the discipline and build a desire to continue with graduate studies, talented individuals may be lost to the geographic gene pool. The importance of undergraduate training cannot be denied or overlooked, whether it concludes a person's formal education, or marks a first step toward becoming a geographic educator/scholar, culminated by completion of the earned doctorate.

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# TRYPANOSOMIASIS IN AFRICA: ITS EFFECT ON DEVELOPMENT

*Laura Moorhead*

Trypanosomiasis is a disease endemic to sub-Saharan Africa. Its vector, the tsetse fly, thrives in the savanna woodlands and tropical rain forests of the continent. Trypanosomiasis in animals and sleeping sickness, as it is called in humans, illustrates the dynamics between disease control, environmental change, and economic development. Currently, 50 million Africans are at risk each year from sleeping sickness, and 40 million cattle for trypanosomiasis (Gerster 1986). Trypanosomiasis in cattle not only lessens the ability of African states to meet the protein needs of their populations through livestock production, but also restricts a potential source of draft animals for agricultural work.

Development of an African livestock industry able to meet the needs of a growing population has been precluded by widespread infestation of trypansome-carrying tsetse flies in savanna and forest areas of the continent. Programs intended to control tsetse flies have utilized bush-clearing, insecticide spraying, human settlement, and resettlement to open new areas for livestock and agricultural development. Opponents of tsetse control programs argue that opening new areas to cattle will promote overgrazing of marginal

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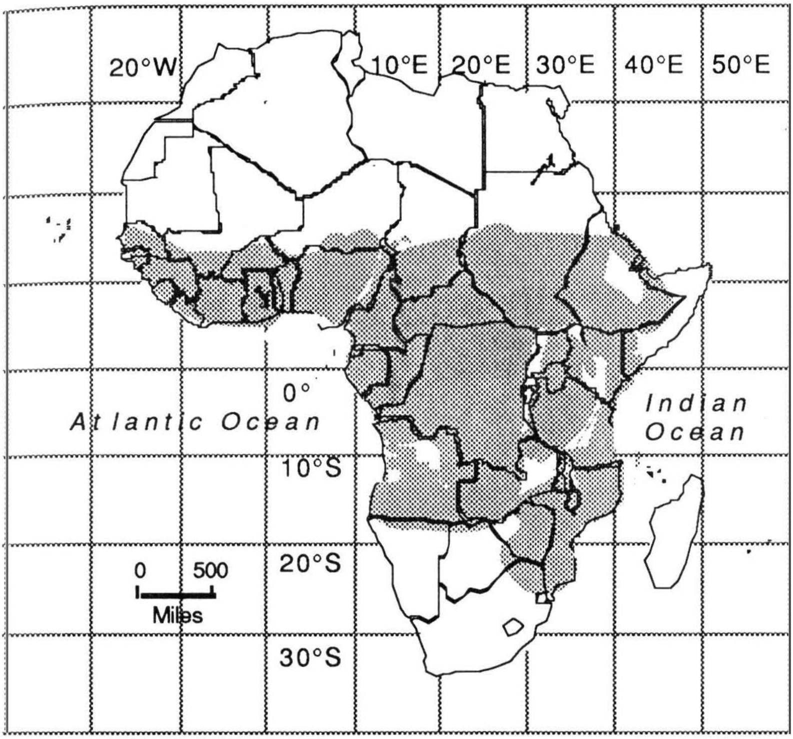
lands and threaten the habitat of Africa's diminishing wild game.

This essay examines how altering patterns of land use through tsetse control can either exacerbate an already bad land-use situation, or provide new opportunities for greater self-sufficiency through intelligent land management. The essay reviews current literature with a critical eye toward these objectives.

## Tsetse and the Trypanosomes

The tsetse fly is found only in Africa—between latitudes 15° North and 29° South (Hendry 1979). Its boundaries are primarily climatic, vegetative, and altitudinal; and they delimit an area roughly the size of the United States, between the Sahara and Kalahari deserts (Figure 1). Within more than 11 million square kilometers of the continent, high temperatures and low annual rainfall mark the northern limits of the tsetse fly, while cold temperatures mark the southern limits. In between, areas above 1300–1800 meters (approximately 4200–6000 feet), depending on temperature, are generally free of tsetse. Tsetse cannot survive in open, treeless grassland or in grassland with only scattered trees; and the fly is rarely found in areas with less than 500 millimeters (approximately 20 inches) of annual rainfall. The optimum temperature for tsetse populations is around 25° C (77° F) in relatively moist and shady environments. Tsetse larvae will not develop into adult flies if the temperature is less than 10° C (50° F ) or higher than 40° C (104° F) (Udo 1982; Jordan 1986, Lee and Maurice 1983; Rogers and Randolph 1985).

The tsetse fly is the main vector of the trypanosome pathogen (Hendry 1979). Aside from a few isolated cases of transmission of trypanosomiasis by bites from horse flies and stable flies, the only way to contract trypanosomiasis or sleeping sickness is from a bite by a tsetse fly infected with the trypanosome virus (Lee and Maurice 1983). Only in the saliva of the tsetse fly are trypanosomes able to complete




Source: J. Ford, "The Geographical Distribution of Glossina", 1970

Figure 1. Distribution of the Tsetse Fly in Africa.

their life cycles (Jordan 1986). It is difficult to imagine a more unlikely vector for successful disease transmission than the tsetse fly, with its relatively low population densities, short life-span, and dependence on only one food source.

Tsetse* belongs to the genus *Glossina*. Within this genus are three groups and twenty-two species, some of which are divided into sub-species (Putt et al. 1980). The three groups are characterized by the terrains which they inhabit: *G. fusca*

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*The word "tsetse" (pronounced 'tet´se' in English) is from the Sechuana language spoken by some groups in Botswana. It refers to a 'fly destructive to cattle' and may be onomatopoeic, suggesting a buzzing sound.

is found primarily in the tropical forests of West Africa and the Congo Basin; *G. palpalis* is found in the tropical rain forests and river basins of North–Central and Western Africa; and *G. morsitans* is found in the savanna woodlands of South–Central and Eastern Africa (Lee and Maurice 1983) (Figure 2). *G. morsitans* is the species of *Glossina* which has the greatest impact on both humans and animals. *G. morsitans* is the principal vector of the *Trypanosoma brucei rhodiense*, which causes the acute form of sleeping sickness in people and is also the major vector of nagana,† that is of animal trypanosomiasis (Jordan 1986).

The average life-span of the tsetse fly is usually ninety days, with female flies living somewhat longer than males (Lee and Maurice 1983; Jordan 1986; Langley and Weidhaas 1986). The tsetse is very temperature dependent, both in the rate of its daily metabolic activity and in the overall climatic and meteorological conditions in which it can survive (Rogers and Randolph 1985). Vertebrate blood is the tsetse's only food source (Lee and Maurice 1983; Jordan 1986). When tsetse larvae emerge as adult flies, they are free of trypanosomes. Only if they take a blood meal from an infected host will they become vectors of the disease.

Trypanosomes exist in many species of wild game without becoming pathogenic to their hosts (Jordan 1986). Trypanosomes are parasitic protozoa of the genus *Trypanosoma*. The primary hosts and relative importance of each species is outlined in Table I. It is the subgenus *Trypanozoon* that has the greatest impact on both humans and animals. The natural hosts of the trypanosomes are the wild game of Africa, such as the kudu, waterbuck, eland, and giraffe—all of which are insusceptible to the trypanosome infection (Jordan 1986).

*T. brucei* trypanosomes do not infect human beings but are the primary cause of trypanosomiasis in domestic ani-

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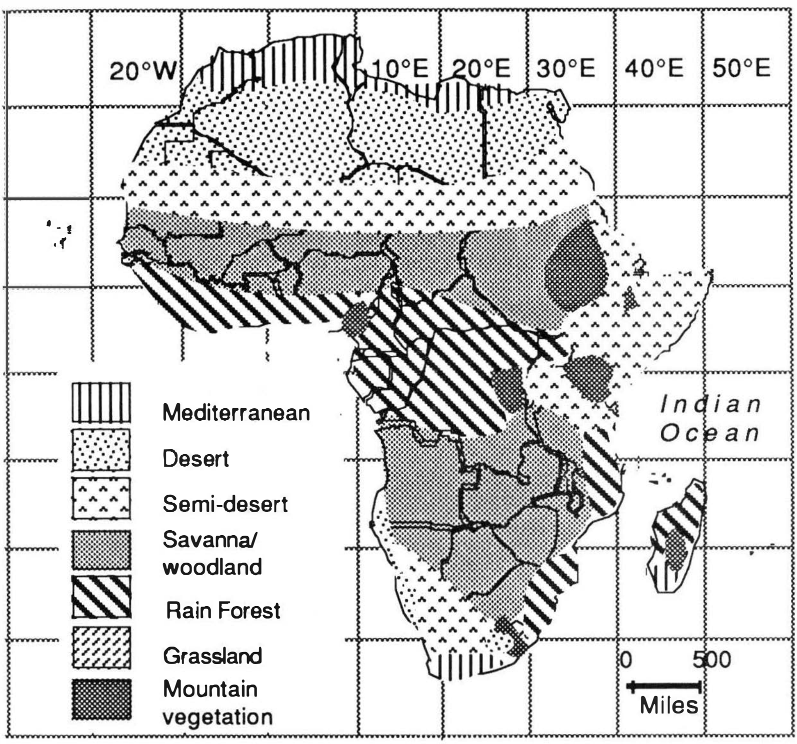
†Nagana is a Zulu word which signifies 'a state of depressed spirits.'

mals. Both *T. brucei rhodiense* and *T. brucei gambiense* infect humans. *T. brucei rhodiense* is associated with the acute form of sleeping sickness that occurs primarily in East Africa. *T. brucei gambiense* occurs primarily in West Africa and is a chronic, and usually more deadly, form of sleeping sickness (Lee and Maurice 1983).

## Human Trypanosomes

The human form of trypanosomiasis is a disease of the central nervous system; it initially manifests itself in swelling of the lymph glands, high fever, and general lethargy (Jordan 1986; Gerster 1986). Left untreated, the victim's condition may deteriorate for weeks, in the case of in-




Source: I. LL. Griffiths, An Atlas of African Affairs, 1985

Figure 2. African Vegetation Zones.

Table 1. THE TSETSE-TRANSMITTED TRYPANOSOMES OF AFRICAN MAMMALS

| Group/ Subgenus | Hosts | Distribution | Importance |
|---|---|---|---|
| *T. vivax* | Wild and domestic mammals (not pigs) | As for *Glossina* | Major disease of cattle and other ungulates. |
| *T. uniforme* | Wild and domestic mammals (not pigs) | East and Central Africa. Restricted. | Localized. Mild disease. |
| *T. congolense* | Wild and domestic mammals | As for *Glossina* | Major disease of cattle and other ungulates. |
| *T. simiae* | Wild and domestic pigs | As for *Glossina* | Acute disease of domestic pigs. |
| *T. brucei brucei* | Wild and domestic mammals | As for *Glossina* | Acute disease of dogs and horses. Chronic in cattle and pigs. |
| *T. brucei rhodiense* | Humans, wild and domestic animals | East and South–Central Africa | Acute form of sleeping sickness in humans. |
| *T. brucei gambiense* | Humans, wild and domestic mammals | West and North–Central Africa | Chronic form of sleeping sickness in humans. |
| *T. suis* | Wild and domestic pigs | Tanzania, Burundi, (elsewhere?) | Very localized. Pathogenic to young domestic pigs. |

(Adapted from A. M. Jordan, *Trypanosomiasis Control and African Rural Development*, p. 4.)

fection caused by *T. brucei rhodiense,* or even years when the infection is caused by *T. brucei gambiense.* In either case, the victim becomes more and more emaciated, falls asleep often during the day, and eventually dies. The disease progresses from the bloodstream to the cerebrospinal fluid and then to the brain itself (Jordan 1986). If treated early, before the disease enters the central nervous system, trypanosomiasis can be cured. In some ways, the acute form of the disease caused

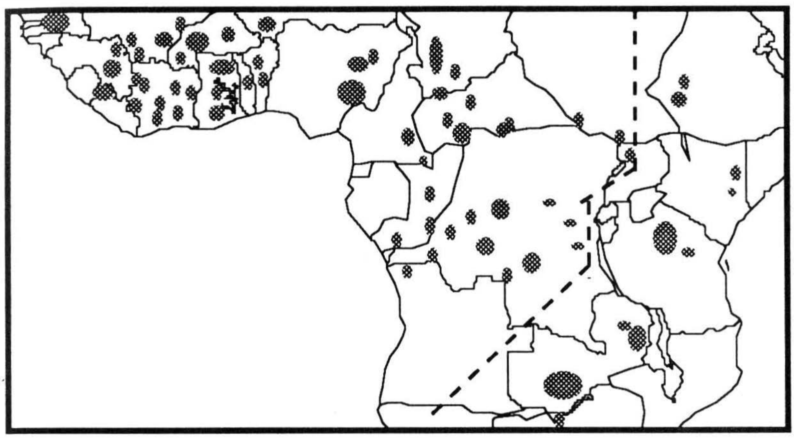


Figure 3. Approximate distribution of known foci of sleeping sickness in Africa. The dashed line divides *T. brucei gambiense* western and central foci from *T. brucei rhodiense* eastern foci. (From DeRaadt and Seed, 1977, as shown in Jordan, 1986).

by *T. brucei rhodiense* is the lesser of the two evils, since the victims are more likely to seek medical attention earlier on than are those who contract the seemingly milder form caused by *T. brucei gambiense* (Figure 3).

Between 1896 and 1906, half a million people died in the Congo Basin and another 200,000 died in Uganda during sleeping sickness epidemics (Jordan 1986). Nash (1969), Duggan 1970), and Ford (1971) have commented on the role of European colonization in disrupting the ecological balance of traditional African settlement patterns. Resettlement schemes under colonization resulted in the establishment of many rural hamlets in tsetse-infested areas (Jordan 1986).

Sleeping sickness was a greater problem earlier in the century than it is today. This is because early preventive measures were concentrated almost exclusively on the disease in humans (Jordan 1986). Nevertheless, the occurrence of sleeping sickness today is not insignificant. Up until at least 1979, 10,000 new cases were reported each year (Lee and Maurice 1983). In addition to the existence of endemic foci of sleeping sickness, other factors have contributed to continuing outbreaks of the disease. The drought in the Sahel in the early 1970's forced a concentration of population around a diminishing number of water boreholes—for both people and animals—that became sleeping sickness transmission sites in Benin (WHO/FAO 1979). Lack of access to rural areas has hampered efforts to control outbreaks in Cameroon and Gabon, while the difficulty of maintaining medical surveillance and follow-up treatments on nomadic populations, as well as drought and civil war, have all hampered control efforts in Ethiopia (WHO/FAO 1979).

W. E. Ormerod (1976) and F. V. Roboff (1977) imply that recent emphasis on trypanosomiasis control in animals instead of humans has actually helped to increase the probability of outbreaks of sleeping sickness. As larger herds of cattle compete with humans for shrinking water supplies, areas around boreholes and irrigation canals can become breeding grounds for tsetse, mosquitoes, and diseased snails (Jordan 1986). The abrupt departure of the Belgians at the end of the colonial era left medical administration and surveillance in disarray in Zaïre, thereby contributing to an increase in sleeping sickness infection rates (Roboff 1977).

Civil unrest, too, has disrupted sleeping sickness surveillance and control programs in Angola, Uganda, and Zimbabwe (WHO/FAO 1979). Failure to maintain programs in areas that previously had been cleared of tsetse resulted in new outbreaks in Tanzania in the early 1970's (WHO/FAO 1979).

The West African variety of the disease has endemic foci in Cameroon, Ivory Coast, the Central African Republic, Zaïre, Senegal, the Sudan, and the northern part of Angola. Its vectors are the riverine *Glossina*: *G. tachinoides*, *G. palpalis*, and *G. fuscipes*. Foci areas often are remote locations with dense vegetation, which makes on-going control programs difficult. The Sahelian drought contributed to an increase in tsetse populations in areas south of the desert that were previously free of the fly (Lee and Maurice 1983).

The East African form of sleeping sickness is carried primarily by the savanna/woodland *Glossina*: *G. morsitans*, *G. pallidipes*, and *G. swynnertoni* (Lee and Maurice 1983). Unlike *T. brucei gambiense*, which can be effectively transmitted to tsetse from humans, tsetse acquire *T. brucei rhodiense* mainly from infected dogs, horse, sheep, and infected wild animals. Endemic foci of the disease exist in Botswana, Ethiopia, Uganda, Mozambique, Tanzania, Rwanda, Zambia, and Kenya. Men have a higher incidence of infection with *T. brucei rhodiense*, probably because its natural reservoirs are the wild game with which hunters, woodsmen, and fishermen come in contact more frequently than women and children (Lee and Maurice 1983).

Lee and Maurice cite infection levels in Uganda as high as those of the epidemic there earlier in this century. In part this is due to an expansion of savanna/woodland vegetation which has helped to increase human/tsetse fly contacts. Also a factor is deep distrust of civilian authority on the part of a population subjected to prolonged civil unrest.

## Animal Trypanosomiasis

Animals are at a considerably higher risk of contracting trypanosomiasis than humans, since only about 0.1 percent of the trypanosomes carried by tsetse are infective to humans, while almost all are infective to animals (Jordan 1986). The primary reservoirs of infection for domestic animals are wild game. Various species of *Trypanosoma* infect cattle, horses, dogs, sheep, pigs, and camels. As with sleeping sickness in humans, trypanosomiasis in animals can be either acute or chronic. The degree of susceptibility to trypanosomiasis in domestic animals depends on their overall level of nutrition, the extent to which they are used as draft animals, and the density of the surrounding tsetse fly population. The highest infection rates usually occur at the end of the dry season and during the early rains (Jordan 1986).

The disease in cattle can persist for months with the animal becoming increasingly emaciated and comatose. Alternatively, cattle can succumb to the infection almost immediately, with no clinical signs at all (Jordan 1986). Trypanocidal drugs exist that are quite effective in controlling trypanosomiasis in cattle, at least when used in prescribed doses under veterinary supervision. Unfortunately, most African states do not have either the necessary veterinary services or the administrative expertise for sustained drug therapy programs. Beyond that, drugs are often diluted to make them last longer, a practice which can lead to development of trypanosomiasis strains resistant to drugs (Ormerod 1976; Lee and Maurice 1983). In addition, the use of trypanocidal drugs can diminish development of cattle's natural immunity to low levels of trypanosomiasis infection (Ford 1971).

Trypanosomiasis in domestic animals has a long history in Africa. Some argue that its existence affected cattle-trading routes of ancient times, accounted for the failure of Islam to expand into sub-Saharan Africa, and—in contrast to Europe and Asia—long ago precluded the use of animal power for development purposes in Africa (Nash 1969; McKelvey 1973).

The impact of animal trypanosomiasis on land use in Africa today is the same as it has been historically. Ten million draft animals in contemporary tropical Africa contribute less than 10 percent of the labor used in agriculture, while over 80 percent is still provided by hand (Jahnke

1982). This confines African agriculture, for the most part, to small subsistence plots of land, making the economies of scale which might be provided by large plots out of the question. The persistence of tsetse-infested areas also precludes the keeping of domestic livestock in large areas of the continent that would otherwise be suitable for grazing and for the development of mixed agriculture (Jordan 1986).

## Control Methods

The traditional method of preventing trypanosomiasis and sleeping sickness was to avoid tsetse-infested areas altogether. As population pressures grew and rural settlement pushed into fly-belt areas, other methods were devised. Since it was known that tsetse preferred savanna/woodland and riverine vegetation, the primary method of control was to cut back the vegetation. Similarly, after it was learned that wild game were natural hosts for trypanosomiasis, wholesale slaughter of wild animals was carried out (Lee and Maurice 1983). Gerster (1986) cites the use of pigs to distract tsetse flies from people in a West African village. In the Ugandan sleeping sickness epidemic of the early 1900's, whole populations were evacuated from the Lake Victoria area and resettled in non-tsetse areas (Ormarod 1976).

All of the traditional methods have serious drawbacks. Vegetation clearing, to be effective, must be carried out over a large area—at least three kilometers—to match the fly's range (Lee and Maurice 1983). It requires constant maintenance to prevent regrowth of vegetation and, because it is so labor-intensive, it can be extremely expensive. Killing wild game on a large scale is no longer ecologically desirable. African states have thus turned to chemical, biological, and mechanical means for tsetse control.

In the measures taken against trypanosomiasis, the emphasis is on control, rather than eradication. For several reasons, the target is the primary disease vector, the tsetse fly, rather than the pathogen trypanosome itself. Because foci of the disease are scattered in remote and often inaccessible areas, and also because of its endemicity, it is unrealistic to have total eradication as a goal in most areas (Jordan 1986). Additionally, the ability of the *Trypanosoma* to undergo antigenic variation makes it difficult to develop prophylactic and trypanocidal drugs which are effective against all species of the parasite (Lee and Maurice 1983; Jordan 1986). Eradication of trypanosomiasis is a realistic goal only in areas of isolated tsetse populations, such as those in northern Nigeria (Putt et al. 1980), or at the very edge of tsetse fly-belts, where natural barriers to re-infestation, such an open, treeless grassland exist (Lee and Maurice 1983; Jordan 1986).

Eradication campaigns, although very expensive in the short run, at least have the advantage of being short-term programs with a definite end in sight. Control programs, on the other hand, are long-term commitments which by their very nature require substantial financial and organizational resources to be successful. It is for this reason that control of trypanosomiasis is primarily a question of land use (Jordan 1986).

## Insecticide Spraying

By far the most frequently-used method of tsetse control and eradication is insecticide spraying. Insecticides are sprayed by hand on the ground, by fixed-wing aircraft, or by helicopter. Insecticides vary in their residual capacity and can be either persistent or non-persistent in their long-term effect. The effectiveness of insecticides varies with dosage per unit of land area, type of vegetation, and prevailing meteorological conditions.

The oldest and most widespread method of insecticide spraying has been ground-spraying of residual insecticides with knapsack sprayers. This technique allows insecticide to be applied selectively against "tree trunks, lower branches and other tsetse resting sites (Allsopp 1984)." These campaigns are carried out during the dry season, using persistent insecticides with high residual capacities against the daytime resting sites of the fly (Lee and Maurice 1983). The most commonly used insecticides against the tsetse are DDT, dieldrin, and endosulfan (Allsopp 1984), all of which are lethal to the tsetse far beyond the minimal pupal period. To be effective, ground-spraying campaigns must be well organized and require a great deal of labor. These campaigns also require follow-up sprayings to kill any flies missed during the initial spray (Lee and Maurice 1983).

Helicopter spraying has the dual advantage of using less labor and being logistically less demanding than ground spraying. It is, however, three to ten times more costly than ground spraying, due to the amount of insecticide used on the one hand, and hourly rates for helicopter rental on the other (Lee and Maurice 1983).

Spraying from fixed-wing aircraft is comparable in cost to ground spraying; and by using up to four airplanes in sequential operation, as much as to 6,000 kilometers can be covered in a three-month period (Allsopp 1984). Zimbabwe has used a technique of ground spraying the periphery of an area which has been selected for aerial spraying before the aerial spraying itself is done (Allsopp 1984). This has proven very effective in halting tsetse re-invasion of areas previously sprayed from the air.

Success of insecticide spraying, either on the ground or from the air, is dependent on many factors. Insecticide type, dosage per unit of land area, terrain, meteorological conditions, and even the size of aerosol droplets all have an affect on the ability of an insecticide to kill tsetse. During the rainy season, no spraying can be effective, since the insecticide will not cling to vegetation. For all of these reasons, spraying campaigns must be tailored to the conditions of a specific country and land area. Much of this work is still in the trial-and-error stage.

Another chemical means of tsetse control involves use of insecticide-impregnated traps strategically placed in infested areas. Traps have long been used as a means of sampling the size of tsetse populations. In recent years, more attention has been paid to trapping because of its potential for cost effectiveness and ease of use on a local level (Lee and Maurice 1983). Traps do not require highly-trained personnel for their use and have a lesser impact on the ecology of the trap area in comparison to insecticides.

## Environmental Impact of Control Methods

In most industrialized countries, DDT has been banned because it is a deadly toxin that remains in the food chain (Gerster 1986). Dieldrin and endosulfan can be equally toxic when used in concentrated doses. These insecticides can kill not only *Glossina*, but also other arthropods and invertebrates, as well as fish, birds, and mammals (Dance and Haynes 1980). In a study of effects from aerial spraying of endosulfan in the Okavango Swamps of Botswana, Russell-Smith and Ruckert (1981) found that when endosulfan was used as an ultra low volume (ULV) aerosol from fixed-wing aircraft in low application rates no damage was done to the invertebrate population. Insecticide-impregnated traps can also pose a hazard if they are placed indiscriminately in the environment (Langley and Weidhaas 1986).

Further research is needed to develop insecticides that are both lethal to the tsetse and safe for the environment. currently, the most promising technique for minimizing toxic side effects from insecticides is the ULV application method, which uses as little insecticide as possible in sequential, non-residual applications.

## Controversies Surrounding Tsetse Control

As earlier noted, opponents of tsetse control programs argue that they will promote overgrazing of marginal lands and threaten wild life habitats. One of the consequences of the Sahelian drought of the 1970's was to force herders to move their cattle further south onto more marginal lands where they concentrated their herds around water boreholes. W. E. Ormerod of the London School of Hygiene and Tropical Medicine argues that resultant local overgrazing in the wake of such moves is contributing to a denudation of Sahelian vegetation that could affect the region's climate (Ormerod 1976). Ormerod cites studies which indicate that decreasing vegetative cover increases the albedo—or reflectance of the area—which results in less moisture returning to the surrounding atmosphere, which in turn results in less rainfall in the area. He thinks that control or elimination of the tsetse will worsen this feedback process.

Ormerod also argues that promotion of tsetse control campaigns on the ground that they help control sleeping sickness in humans is false. Because of the economic importance of the meat industry to West African states, Ormerod contends that sleeping sickness control has been of secondary importance to trypanosomiasis control. Even if it were of equal importance, he does not think it is necessary to have widespread bush clearance or aerial spraying to protect human populations; for the normal clearing of vegetation associated with traditional farming methods offers sufficient protection (Ormerod 1976).

Ormerod raises several important points. Both overgrazing and denudation of ecologically fragile lands, for example, are readily demonstrable. Ormerod is supported in his observations by Jahnke:

> Most of the pastoral areas of Eastern Africa show the signs of overgrazing and degradation. The pastoral organization of production cannot cope with ever increasing populations of man and stock and tends to destroy the very basis of production. This process is the quicker and the more dangerous the lower the natural potential of the area. Pastoralism can therefore not only be characterized by a figure of average production and benefits, but must, in its traditional form, be seen as a system of land use with an inherent mechanism for self-destruction (Jahnke 1974).

Jahnke also argues that ecological damage to former tsetse areas from cattle grazing can be minimized by changing the land tenure basis of pastoralism. In discussing the economic benefits of tsetse control in Uganda, for example, Jahnke suggests changing the land tenure system to insure either that land is held privately by an individual or group, or that both land and cattle are owned collectively:

> In either case the management must have the power to adjust stocking rates to the long-term capacity of the land, and in either case this must be in the material interest of the individual or collective owners of cattle .
>
> The process of converting pastoralism into a stable and productive form of land use through land tenure reform is a painful one. To facilitate this process should in my opinion be the major role of tsetse control. Tsetse-infested areas are as a rule empty areas to which no traditional claims are held. The establishment of a suitable land tenure system and the determination of the suitable man-land ratios are technically and politically desirable. The provision of additional land is an attraction to the pastoralist from a neighboring area and can therefore be more easily combined with stipulations concerning the acceptance of the tenure system and the adherence to certain basic husbandry standards. At the same time population pressure in the neighboring areas is relieved to facilitate land adjudication there. The resulting systems of cattle production may not be much more productive than traditional pastoralism, but the basis has been established for the future (Jahnke 1974).

It can be argued that—with or without the presence of tsetse—human population pressures are competing with traditional agriculture and cattle herding for available land in many parts of Africa. It can also be argued that—with or without the overgrazing of cattle—desiccation and drought may well be part of the normal climatic pattern of the West African Sahel. Similarly—with or without tsetse control campaigns—there is competition for land use between traditional farmers, large-scale ranchers, and the large game reserves on which wild life harbors trypanosomes as natural hosts. All of these considerations complicate the process of conscientious land use management.

### Tsetse Eradication in Northern Nigeria

Throughout the 1960's and 1970's, the Nigerian government carried out extensive eradication campaigns in northern areas of the country which approached the limits of the tsetse fly's continental range. These areas remained fly-free as of 1980; and tsetse eradication had stimulated local economies and livestock production, as well as prompted an alteration of agricultural practices. In the past, a potential existed for crop farmers and traditional Fulani herdsmen to be pitted against each other over the use of available fly-free land. Tsetse eradication, however, opened up new areas to the farmer for cultivation and to the herdsmen for cattle grazing. Two examples of this successful campaign are the Fika Emirate and the Gongola North area.

The Fika Emirate, in the Borno state of northeastern Nigeria, comprises the districts of Fika, Nangere, and Potiskum, a small district around the town of Potiskum (Figure 4). The emirate was an area where valuable pasture resources were underutilized because of widespread tsetse infestation (Putt et al. 1980). Lowland Sudan vegetation and savanna/woodland vegetation in the emirate's uplands contrast with swampy areas, along the banks of the Komadugu–Gana and Gongola rivers, which are lined with tall shade trees—an ideal environment for riverine tsetse (Putt et al. 1980).

Historically, Fika Emirate had suffered severely during the years of the great sleeping sickness epidemics (Putt et al. 1980). The last big outbreak occurred during 1955–1956 in the Nangere District along the Komadugu–Gana river. The overwhelming majority of sleeping sickness cases were among men between the ages of fifteen and forty-nine. This was attributed to fishing trips taken during the dry season, which was a heavy period for tsetse (Putt et al. 1980).

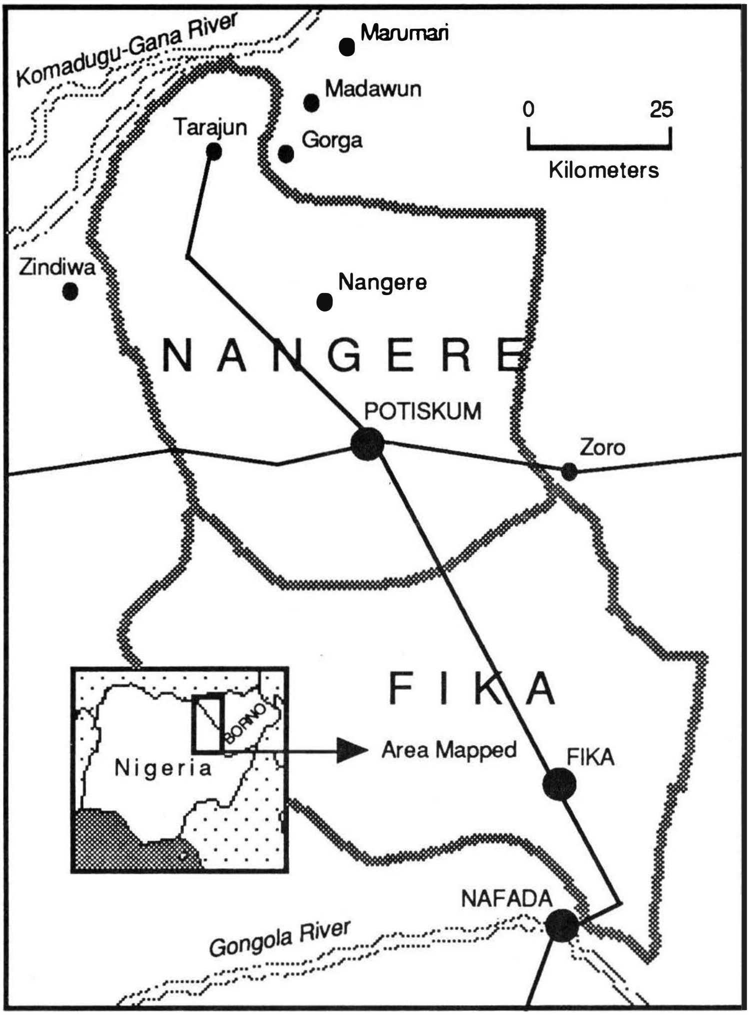



Figure 4. Fika Emirate in Borno State, Nigeria (From Putt, *et al.*, 1980)

Although *G. palpalis* was found in the region, the heaviest infiltration of tsetse involved *G. morsitans* and *G. tachinoides*, from areas along the Gongola river. Insecticide spraying campaigns commenced in the northern part of Fika during 1957–1960, and in the southern part during the years 1963–1964 and 1967–1968. A two-mile-long barrier clearing was made to prevent re-infestation in the south (Putt et al. 1980):

> Eradication has made available valuable dry season grazing and water resources to the livestock industry, which previously could only be utilized at a severe risk of contracting trypanosomiasis. Tsetse eradication has increased the year-round carrying capacity of the region, and more animals are now kept in the area.

After eradication, there was a problem with overgrazing in the northern part of the district, primarily as a result of increased pressure for dry-season grazing land during the Sahelian drought. There was no evidence of overgrazing in the southern portion of the emirate (Putt et al. 1980). Tsetse clearance opened up rich agricultural land to vegetable growing along the banks of the Gongola river. Probably the greatest single benefit of tsetse eradication for the area was the resultant ability to use cattle to do farm work and thereby greatly increase "the amount of land that can be cleared and farmed by a single farmer (Putt et al. 1980)." As of 1980, Fika Emirate—which prior to tsetse eradication was unable to support a settled cattle population—had the highest number of cattle per capita of any district in Nigeria.

The Gongola North area of Gongola State is located north of the Benue river, near the Cameroon border, and encompasses approximately 8,000 square kilometers (Putt et al. 1980) (Figure 5). Before 1970 it was a haven for tsetse flies. Although there were few occurrences of sleeping sickness, the *G. morsitans* population in the area prevented the use of its prime agricultural land and caused "the virtual disappearance of livestock from the area," with heavy cattle mortality in stretches along the Song and Tiel rivers (Putt et al. 1980). A 1970–1972 campaign of vegetation clearance and insecticide spraying—carried out in cooperation with the government of Cameroon, which undertook similar measures on its side of the border—cleared tsetse and trypanosomiasis from the area (Putt et al. 1980).

Following eradication, Fulani herdsmen not only began to graze their cattle throughout the year, but also to supply dairy products, meat, and manure to local residents.[85]

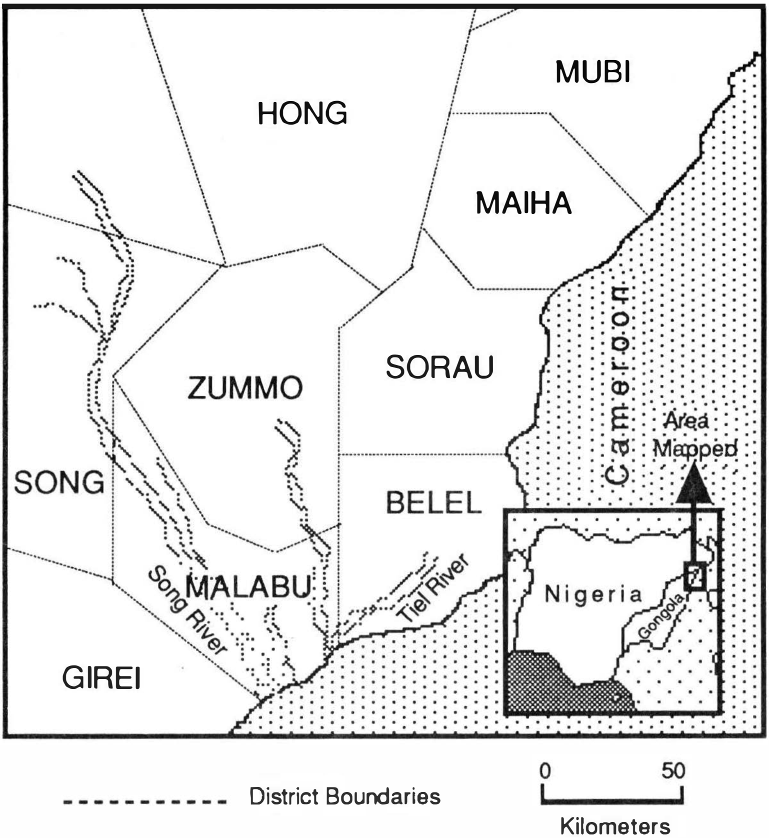



Figure 5. Gongola North Area (From Putt *et al.*, 1980).

Predictably, settlement in the area increased and, as a consequence, both agricultural development and livestock production rose dramatically (Putt et al. 1980). In the Belel District of Gongola alone—with some of the best agricultural land in the State—the population rose from 720 in 1971 to more than 5,000 in 1980. Earlier population under-reporting (as a means of avoiding taxation) was eliminated as a cause. This increase was due solely to the eradication of tsetse (Putt et al. 1980). Similarly, it was reported that before 1972 there were no cattle or horses in Belel because they had all died after the 1954 outbreak. Since eradication cattle have again been kept (Putt et al. 1980).

## Conclusions

This essay is not a complete representation of Africa's trypanosomiasis problem. Even so, a general conclusion can be drawn—specifically, that trypanosomiasis control in Africa must be part of a balanced system of land use.

Though many factors contribute to land degradation, poor land management practices of the past offer insufficient grounds to close the door on new opportunities for development. The key consideration should be whether potentially good land for development goes unused because of tsetse infestation. Marginal lands with poor soils should be left alone. Riverine areas which have good agricultural potential as well as good potential for grazing and watering should be primary candidates for development.

Opening lands previously closed—because of tsetse infestation—to development can be part of an overall program of land management which simultaneously promotes conservation of easily degradable areas as well as preservation of vegetation and wild life. The key to such land use involves both planning and utilization of resources which, to the extent possible, are in harmony with traditional agricultural practices. As pointed out by a World Bank study of trypanosomiasis control, land use, environmental impact, and livestock management studies are needed *before* carrying out tsetse control programs (Lee and Maurice 1983).

Because tsetse fly habitats do not conform to international boundaries, programs to combat tsetse should be international in scope, as was the previously noted joint campaign between Nigeria and Cameroon in Gongola State. International cooperation, in the form of subregional intergovernmental organizations, might help African states to pool limited resources and trained personnel (Lee and Maurice 1983). Indeed, successful cooperation and planning to control the tsetse fly could provide a model for tackling any number of Africa's most pressing developmental problems.

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# CLOUD SEEDING IN CALIFORNIA: AN EVALUATION OF THE RAINSHADOW EFFECT OF WEATHER MODIFICATION PROJECTS

*Teresa L. Bulman and Marlyn L. Shelton*

Rainmaking has existed for tens of thousands of years as a part of ritual, religion, and tribal politics (Lewis-Williams 1977). In historical times, a variety of methods have been used in an attempt to increase rainfall, but modern rainmaking began in 1946 when a chance laboratory observation suggested that the introduction of dry ice into a supercooled cloud would stimulate the natural precipitation process. Later that year, two General Electric scientists successfully seeded cumulus clouds in New Mexico with dry ice (Fleagle 1968), and silver iodide crystals were discovered to be efficient ice-forming nuclei for promoting precipitation processes. Although many cloud seeding experiments have claimed success in enhancing precipitation in target areas, the effects of cloud seeding on precipitation patterns downwind of target areas have been debated since the beginning of modern weather modification activities. Brier and Kline (1966) reported positive precipitation anomalies up to 240 kilometers downwind of target areas, and Gabriel and Mather (1986) concluded that summer precipitation was relatively high downwind from seeding areas. In contrast, rainshadow enhancement was detected downwind from a

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northern Sierra Nevada cloud seeding location (U.S. Bureau of Reclamation [USBR] 1974) and downwind of cloud seeding projects in Mexico and Arizona (Weather Modification Advisory Board [WMAB] 1978). Both positive and negative precipitation effects downwind of a seeding operation were reported by others (National Research Council 1973).

Among concerned citizens and public officials, a widespread perception persists that a downwind rainshadow is created by cloud seeding. The Ecological Society of America, in its study of potential downwind effects of weather modification, advocated that all cloud seeding cease until extra-area impacts on long-term weather patterns could be fully appreciated (National Science Foundation [NSF] 1966). Approximately 25 percent of all public comments on a proposed snow augmentation program in the northern Sierra Nevada concerned the possibility that downwind areas would be robbed of precipitation they would otherwise receive (USBR 1974). Residents of Colorado's San Luis Valley were so convinced that cloud seeding activity had created a rainshadow and resultant drought in their area that they destroyed the weather modifier's equipment in protest (Lambright 1984). In 1989, officials in Utah's Uinta Basin expressed concern that upwind cloud seeding had reduced annual rainfall in their watershed. Given the inadequacy of the current level of understanding of cloud seeding processes and results, such concerns may have merit.

Much of the early scientific information on cloud seeding and downwind influences was based on single experiments, programs extending over a season, or project durations of a few years. Today, some cloud seeding projects have been operating for thirty years or more; and these long-term programs provide an improved data base for assessing the spatial influences of cloud seeding activities. The purpose of this paper is to test the hypothesis that cloud seeding in one locale results in the creation of a rainshadow effect, that is precipitation deprivation downwind from the target area of the cloud seeding activity. Two long-term cloud seeding projects in California are analyzed.

## The Rainshadow Effect of Cloud Seeding

The term "rainshadow" refers to the area on the leeward side of a topographic barrier where precipitation is less than on the windward side. Although a rainshadow effect is often a naturally occurring phenomenon, such as the rainshadow of the Sierra Nevada in California and Nevada, in theory human weather-modification efforts to increase precipitation in one locale could create a rainshadow downwind of that locale even in the absence of an orographic barrier. Such efforts could also intensify a naturally-occurring rainshadow effect. This theory rests on the assumption that, all other factors remaining static, artificial removal of atmospheric moisture from a cloud or cloud system results in less atmospheric moisture available for precipitation as the cloud or cloud system moves downwind.

Unfortunately, all other factors do not remain static; and the processes of precipitation and storm segregation make it difficult for the researcher to isolate any one factor for analysis (Flueck 1984). Moreover, it is generally recognized that atmospheric moisture is rarely a limiting factor in precipitation processes. It is estimated that 10 percent or less of the moisture in most storms is extracted in the precipitation process; so even with seeding there should be substantial moisture available for downwind areas (USBR 1974). Nonetheless, the theoretical consequences of a cloud-seeding induced rainshadow on ecology and agriculture are significant enough to merit investigation (NSF 1966).

If cloud seeding does deprive downwind areas of precipitation, the precipitation changes caused by an extensive-area, long-term, well-controlled cloud seeding program could alter the local environment in a number of important ways. Environmental changes linked to cloud seeding could include altering the historic climatic variability of the downwind area; altering trends in soil formation, erosion, and retention; shifting rates of growth and production of plant communities (with possible extinction or migration of plant species); and changing the hydrologic elements of the climate system, including changing patterns in runoff, stream discharge, sediment flow, water temperature, and turbidity. In addition, Simpson and Dennis (1974) have concluded that the extended-area effects of cloud seeding go beyond changes in precipitation patterns to include changes in radiation and energy budgets, momentum transports, boundary layer processes, severe weather manifestations, and wind circulation patterns. Such precipitation changes and their consequences are of particular concern in arid environments because such environments are comparatively more sensitive to precipitation variability (Cooper and Jolly 1969). Hence, a decrease in downwind precipitation in an arid area, such as the leeward side of the Sierra Nevada, would have a severe impact on agriculture, water supply, flora, and fauna in dry years.

## The California Study Areas

Cloud seeding has occurred in parts of California annually since 1947, primarily for increasing the water supply, but also for hydroelectric generation, recreation (snow skiing), research, and suppression of fire, lightning, hail, and fog (Figure 1)(Roos 1988a). The two oldest, continuing precipitation augmentation programs in California are the Lake Almanor Project, designated here as the northern study area, and the Upper San Joaquin River Project, used here as the southern study area (Figure 2).

*The Lake Almanor Project.* The Lake Almanor Project is operated by the Pacific Gas & Electric Company in the northern Sierra Nevada, targeting the Lake Almanor watershed. The purpose of the project is to increase high elevation snow pack and subsequent dry-season runoff for storage in hydroelectric installations (Marler 1988). A structured program of

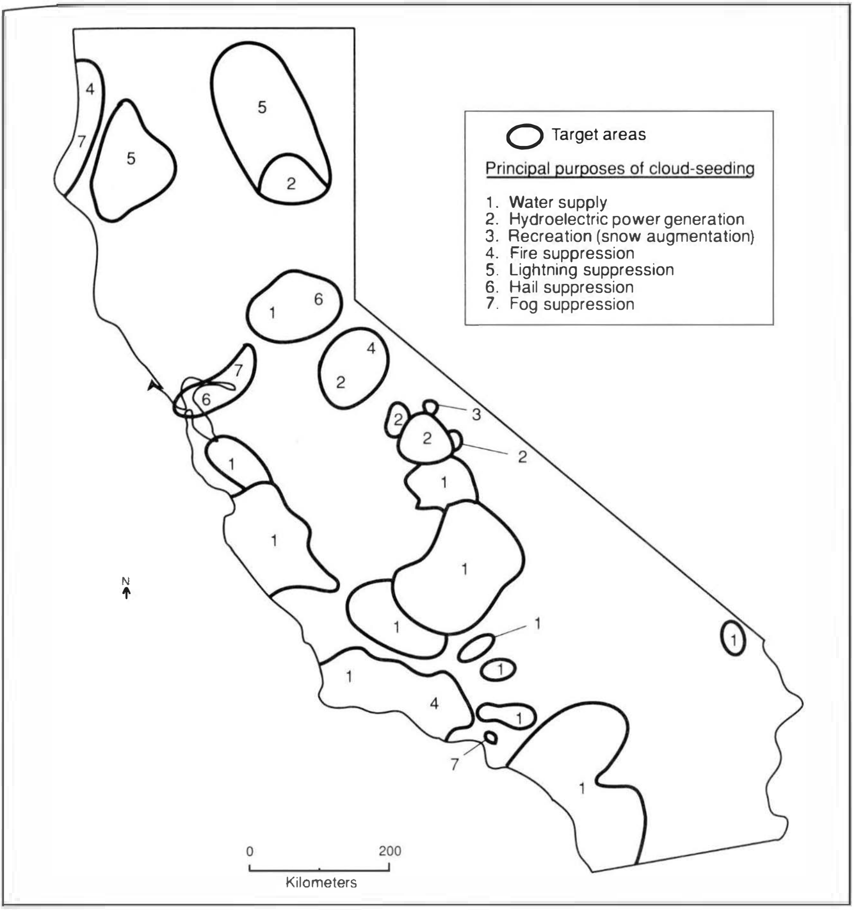


Figure 1. Target areas of weather modification projects in California, 1947-1988.

cloud seeding was established in 1954, but seeding had been conducted in the area as early as 1951 (Bartlett et al. 1975), and randomized cloud seeding programs have been conducted periodically at Lake Almanor. The seeding is effected by the use of six to eight automatic, radio-operated ground generators using silver iodide-in-acetone burners (Marler 1988).

The Lake Almanor watershed occupies 1,295 square kilometers and ranges in elevation from 1,370 meters to 3,190 meters at Mt. Lassen. The target area for the project is a 777 square kilometer area located below 1,980 meters. There is a high frequency of storms in the area from November to May. Snowfall accounts for one-half of the annual precipitation, and the winds are predominantly westerly and southwesterly (National Research Council [NRC] 1973).

*The Upper San Joaquin River Project.* The Upper San Joaquin River Project, operated by Southern California Edison Company, is also intended to enhance water storage for hydroelectric purposes. The project began in 1951 and is the longest continuously operated cloud seeding project in the world (Elliott 1975).

The target area is the watershed of the upper San Joaquin River and its tributary streams in Fresno County in the southern Sierra Nevada. The project operates twelve to fifteen radio-controlled ground-based generators which emit silver iodide; beginning in 1971-1972, aircraft have been using pyrotechnics to disperse silver iodide crystals into clouds at selected elevations (Elliott 1975).

## Methodology

Precipitation data were collected at three stations in the northern study area and three stations in the southern study area (Table 1). Although a dense observational network of stations in each study area would have been preferable, there are few weather stations in the target areas or downwind areas with long precipitation records. Because the analytical method employed in this paper is to compare precipitation patterns before and after cloud seeding activities began, a pre-cloud-seeding calibration period for each station was required. This eliminated the use of most stations because records are short or sporadic. As a result, only the stations with the longest precipitation records were used to represent precipitation in each of the target areas and the downwind areas. No feasible proxy data are available to substitute for weather station data. Furthermore, the resolution of proxy data, such as tree rings, is not sufficient to re-

**Table 1. LOCATION AND PRECIPITATION INFORMATION**

| STATION NAME | Elevation (Meters) | Location (Vis-à-vis seeding) | Range in Mean Monthly Precipitation for 1931-1951 (in centimeters) | | |
|---|---|---|---|---|---|
| | | | February | April | December |
| **Northern Sites** | | | | | |
| Chester | 1379 | Target | 00.9–30.0 | 00.4–19.0 | 00.1–41.0 |
| Greenville | 1085 | Downwind | 01.0–40.0 | 00.7–21.7 | 00.5–56.8 |
| Doyle | 1292 | Downwind | 00.0–08.4 | 00.0–09.6 | 00.0–11.0 |
| **Northern Sites** | | | | | |
| Auberry | 652 | Target | 00.0–32.0 | 00.2–27.0 | 00.3-43.0 |
| Bishop Airport | 1252 | Downwind | 00.0–03.3 | 00.0–41.0 | 00.0–04.7 |
| Deep Springs College | 1593 | Downwind | 00.0–08.4 | 00.0–09.6 | 00.0–11.9 |

veal precipitation changes on a seasonal or monthly basis as is required here.

In each study area one station is located in the target area of the cloud seeding activity and two stations are located in a downwind transect from the target station. Most researchers agree that determining what is "downwind" of a target area is one of the most difficult aspects of weather modification experiments (Lackner 1971), particularly since cloud seeding can itself affect wind circulation patterns (Simpson and Dennis 1974). Using an "area of effect" model developed to predict the area influenced by seeding of winter storms over an orographic barrier, Elliott and Brown (1972) concluded that precipitation patterns in winter systems observed in the western United States, whether or not seeded, moved west to east. The "downwind area" of cloud seeding activities as measured by fallout of seeding particles and other criteria was generally found to be due east of the primary area of effect.

Based on the prevailing winter winds in the study areas and on the research results concerning what constitutes "downwind" as reported by others (Elliott and Brown 1972; American Meteorological Society [AMS] 1975; Young and Gall 1975), it is assumed for purposes of this study that "downwind" is essentially due east of each of the target areas. This assumption is confirmed by the consistent reporting of westerly winds at various elevations in the few weather modification reports which identify wind patterns in the northern and southern target areas (Department of Water Resources 1957-1988).

Each downwind station is within 150 kilometers of the respective target areas. Most studies have concluded that downwind effects, if any, extend to a maximum of 240 to 320 kilometers downwind of the target area (Lackner 1971; NRC1973). Neither study area is downwind of any known cloud seeding project except the Lake Almanor Project and the Upper San Joaquin River Project, respectively.

Precipitation data are used rather than runoff data or some other parameter of the hydrologic cycle because the basic means of evaluating the effectiveness of cloud seeding is the measurement of the amount of precipitation before and after cloud seeding. In addition, precipitation data do not involve the lag effect inherent in runoff data (Flueck 1984).

Monthly precipitation data were compiled for the years 1931 to 1980, for the months of February, April, and December. In addition, the number of days in each of these months in which cloud seeding occurred was tallied (Table 2). The months of February, April, and December were selected because most cloud seeding in California occurs from December to April (Roos 1988a). Summer cumulus clouds are low in moisture, have poor vertical development and high bases, and thus are not good candidates for seeding (St.-Armand and Ennis 1978). In selecting the months of greatest cloud seeding activity, the data will be more likely to show a discernible effect from cloud seeding.

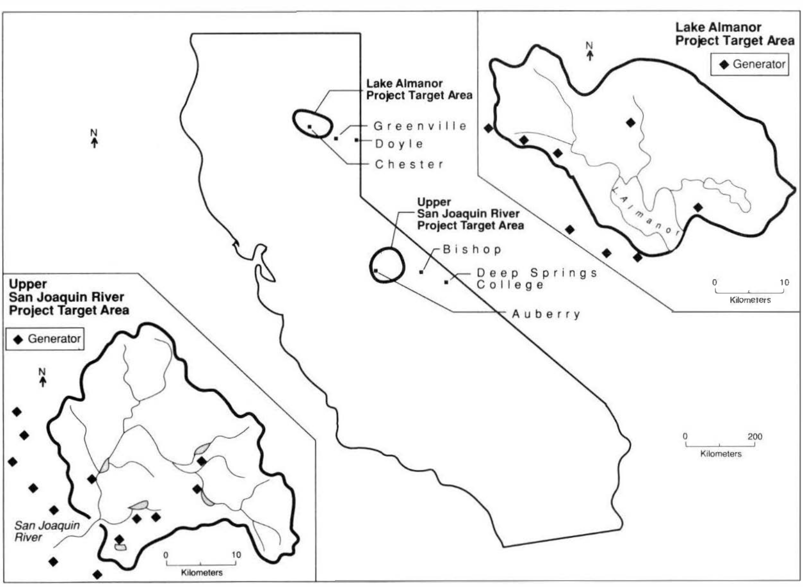


Figure 2. Study areas and weather station locations.

Table 2. NUMBER OF CLOUD SEEDING DAYS IN EACH AREA

| | Lake Almanor | | | Upper San Joaquin | | |
|---|---|---|---|---|---|---|
| **Year** | **Feb.** | **Apr.** | **Dec.** | **Feb.** | **Apr.** | **Dec.** |
| **1952** | 8 | 0 | 4 | 0 | 0 | 0 |
| **1953** | 2 | 10 | 0 | 0 | 0 | 0 |
| **1954** | 6 | 9 | 12 | 0 | 8 | 15 |
| **1955** | 9 | 17 | 11 | 10 | 23 | 12 |
| **1956** | 7 | 11 | 2 | 0 | 7 | 6 |
| **1957** | 22 | 12 | 8 | 12 | 9 | 13 |
| **1958** | 8 | 0 | 1 | 14 | 0 | 8 |
| **1959** | 5 | 2 | 9 | 13 | 4 | 2 |
| **1960** | 8 | 8 | 2 | 6 | 9 | 4 |
| **1961** | 3 | 4 | 0 | 9 | 4 | 3 |
| **1962** | • | • | 2 | 10 | • | 0 |
| **1963** | 6 | 21 | 2 | 5 | 19 | 6 |
| **1964** | • | 1 | 11 | 8 | 5 | 13 |
| **1965** | 4 | 11 | 8 | 2 | 8 | 11 |
| **1966** | 7 | 5 | 7 | 14 | 4 | 10 |
| **1967** | 4 | 17 | 7 | 7 | 20 | 9 |
| **1968** | 8 | 4 | 13 | 5 | 4 | 20 |
| **1969** | 2 | 1 | 4 | 5 | • | 10 |
| **1970** | 9 | 4 | 10 | 1 | 8 | • |
| **1971** | 2 | 3 | 12 | • | • | 14 |
| **1972** | 2 | 9 | 6 | 13 | 10 | 10 |
| **1973** | 15 | 5 | 8 | 9 | 1 | 6 |
| **1974** | 10 | 1 | 2 | 5 | 18 | 9 |
| **1975** | 2 | 11 | 6 | 8 | 4 | 13 |
| **1976** | 7 | 7 | 4 | 1 | 9 | 4 |
| **1978** | 12 | 8 | 2 | 14 | 13 | 1 |
| **1979** | 8 | 7 | 0 | 11 | 1 | • |
| **Mean** | 7 | 7.14 | 6 | 7.44 | 8.54 | 8.39 |

• = no data available

The northern study area consists of three stations in the northern Sierra Nevada (Figure 2). Chester is in the target area and in the central portion of the Lake Almanor watershed. This is the preferred location for determining the mean annual precipitation in the central watershed (NRC 1973). Greenville is 30 kilometers downwind of the target area and in a valley between mountain ridges that trend east to west. Doyle is 100 kilometers downwind of the target area in a valley 200 meters higher than Greenville. A series of northwest to southeast trending mountain ridges separate Doyle from the target area.

The southern study area stations are widely dispersed (Figure 2). Auberry, at an elevation of 652 meters, is in the cloud seeding target area on the west side of the Sierra Nevada and on the extreme western edge of the southern study area. A more centrally-located station is not available for this project area. Bishop is 95 kilometers downwind and 600 meters higher than Auberry and is on the lee side of the Sierra Nevada. Deep Springs College occupies a site 130 kilometers downwind from the target area and 300 meters higher than Bishop, and is partially blocked from the target area by the southern tip of the White Mountains.

The northern study area has one downwind station, Doyle, in the rainshadow of the Sierra Nevada. Greenville has no significant topographic barriers separating it from the northern study target area. In contrast, both downwind stations in the southern study area are in the rainshadow of the Sierra Nevada and have arid conditions which, theoretically, would be aggravated by a cloud-seeding enhanced rainshadow.

## Data Analysis

*Natural Variability of Precipitation.* Precipitation data for the months of February, April, and December for each of the stations are divided into two segments. The years 1931-1951 represent the control period or period before cloud seeding. The twenty-nine years from 1952-1980 represent the period of continuous cloud seeding.

The range in mean monthly precipitation for the years prior to cloud seeding (Table 1) indicates the natural cycle of precipitation variability at each of the stations. Monthly precipitation varies considerably with a range of 0.0 to 3.3 centimeters at Bishop in February, to a range of 0.5 to 56.8 centimeters at Greenville in December. These data show that the range can be large at an arid site (for example, Bishop's April range of 0.0–41.0 centimeters). Because of this variability in the natural precipitation input, it is difficult to demonstrate that cloud seeding has a downwind effect unless a significant or consistent precipitation difference is detected in the could-seeding period. Any detectable differences may simply reflect either a sampling fluctuation or the natural variability of precipitation at the station.

A comparison of the precipitation data over the twenty-one-year period before cloud seeding began and the twenty-nine-year period of continuous cloud seeding in the target areas yields inconsistent results. The mean monthly precipi-

**Table 3. MEAN MONTHLY PRECIPITATION (In Centimeters)**

| STATION NAME | Feb. 1931-1951 | Feb. 1952-1980 | Apr. 1931-1951 | Apr. 1952-1980 | Dec. 1931-1951 | Dec. 1952-1980 |
|---|---|---|---|---|---|---|
| Auberry | 12.27 | 10.35 | 5.56 | 6.60 | 13.59 | 10.44 |
| Bishop | 9.40 | 0.88 | 2.77 | 1.98 | 8.86 | 0.78 |
| Chester | 13.18 | 13.61 | 5.77 | 5.16 | 14.76 | 14.07 |
| Deep Springs | 0.41 | 2.25 | 1.96 | 1.55 | 1.32 | 1.92 |
| Doyle | 3.81 | 2.25 | 1.35 | 1.41 | 3.96 | 5.27 |
| Greenville | 13.77 | 15.88 | 6.81 | 6.91 | 16.64 | 18.20 |

tation for each station before and after cloud seeding is given in Table 3. After commencement of cloud seeding activities, both positive and negative precipitation effects are seen at both target and downwind stations. The exceptions are the two downwind stations of Greenville, which has a consistent positive effect, and Bishop, which has a consistent negative effect. This comparison does not indicate a clear pattern of rainshadow effects.

*Comparison of Mean Monthly Precipitation*. T-tests are applied to the mean monthly precipitation data to test the null hypothesis that the mean monthly precipitation at each station in each February, April, and December before cloud seeding was the same as after cloud seeding. For this test, and all tests described below, a 0.10 level of significance was chosen in order to maximize the probability that any positive seeding effect would be revealed in the analysis. Analysis of the t-tests provides mixed results (Table 4). In two-thirds of the cases, there is a high probability—ranging from 25 percent to 92 percent—that the means are from the same population. Thus, there is no basis to reject the null hypothesis because there is no significant change in the sample means.

However, in the remaining one-third of the cases there is evidence that the change in the mean precipitation is significant at the 0.10 level. One of these cases is December precipitation at Auberry. A significant positive change is expected from the 1931-1951 control period to the 1952-1980 period of continuous cloud seeding because the Auberry station is located in the cloud seeding target area. However, the change identified is a decrease in precipitation. In the other five cases (Bishop's February and December precipitation; Deep Springs College's February precipitation; and Doyle's February and December precipitation) the significant changes are at stations, and during months of normally low precipitation, where small changes in monthly precipitation values have a large effect on the monthly mean. For exam-

Table 4. TEST VALUES FOR STATISTICAL TESTS OF PRECIPITATION AND CLOUD SEEDING

| STATION | MONTH | t-Test Values | Probability (2-tail) | Kendall's Correlation Coefficient | Correlation Coefficient "r" |
|---|---|---|---|---|---|
| CHESTER | February | 0.248 | 0.81 | 0.150 | 0.223 |
| | April | -0.800 | 0.43 | **0.296** | **0.564** |
| | December | -0.352 | 0.73 | 0.022 | 0.013 |
| GREENVILLE | February | 1.064 | 0.30 | 0.193 | 0.199 |
| | April | 0.105 | 0.92 | **0.300** | **0.459** |
| | December | 0.585 | 0.56 | 0.014 | 0.065 |
| DOYLE | February | **-3.125** | 0.01 | 0.138 | 0.248 |
| | April | 0.438 | 0.66 | 0.177 | 0.041 |
| | December | **-3.651** | 0.01 | 0.200 | 0.239 |
| AUBERRY | February | -1.178 | 0.25 | 0.175 | 0.213 |
| | April | 0.965 | 0.34 | 0.145 | **0.401** |
| | December | **-1.798** | 0.08 | -0.051 | 0.172 |
| BISHOP | February | **-43.428** | 0.01 | 0.138 | 0.203 |
| | April | -0.558 | 0.58 | 0.138 | 0.051 |
| | December | **-38.307** | 0.01 | 0.191 | 0.309 |
| DEEP SPRINGS | February | **3.718** | 0.01 | 0.138 | 0.199 |
| | Aprii | -0.933 | 0.36 | 0.177 | 0.121 |
| | December | 1.092 | 0.28 | 0.200 | 0.282 |

Values in bold type are significant at the 0.10 level.

ple, such variability could be caused by isolated storms with heavy rainfall unrelated to cloud seeding activity. Three of these five cases are decreases, rather than expected increases in precipitation.

*Correlation between Cloud Seeding and Precipitation.* Kendall's rank correlation coefficient is used to test the degree of association between the two paired variables of the number of cloud seeding days and monthly precipitation to determine the correlation between cloud seeding and precipitation at each of the stations. If there is a rainshadow effect from cloud seeding, the results would tend toward a coefficient of –1 for downwind stations, indicating a perfect inverse correlation between cloud seeding activity and downwind precipitation. A coefficient of +1 at the target stations would indicate a perfect direct correlation between cloud seeding and enhanced precipitation at the target station.

In all but two cases the correlation coefficient is low (+0.014 to +0.2) and not significant at the .10 level (Table 4). The two cases that produced a significant coefficient occurred in April. Chester has a correlation of +0.296, which is expected at a target station and indicates the possibility of enhanced precipitation due to cloud seeding. Greenville has a correlation of +0.3, indicating a significant but unexpected correlation with an increase in precipitation at a downwind station. It is important to keep in mind, however, that even a high correlation coefficient does not prove a causal relationship, since a third factor could be responsible for a significant change in mean monthly precipitation.

*Regression Analysis.* A least squares regression analysis is performed to determine how well cloud seeding activity predicts precipitation in the target area and downwind. Moderate relationships are found between Chester's April precipitation and cloud seeding days (correlation coefficient of 0.564) and Auberry's April precipitation and cloud seeding days (correlation coefficient of 0.401), which are not unexpected for target stations. A correlation coefficient of 0.459 is found between Greenville's April precipitation and cloud seeding days, which is significant at the 0.10 level. No other significant correlation is found and very low correlation values—ranging from 0.013 to 0.459 (Table 4)—indicate an approximation which is so general as to be useless in making predictions of precipitation based on cloud seeding.

*Correlation between Target Precipitation and Downwind Precipitation*. The hypothesis that increased precipitation in the target area results in decreased precipitation downwind is tested by computing a series of Wilcoxon signed-rank tests for each study area to determine if increased precipitation at the target station is related to decreased precipitation downwind during the same period. By looking for significant differences between the paired values of precipitation at target and downwind stations, the test identifies the probability that the distribution of the target station precipitation data is related to the distribution of the downwind precipitation data. If the hypothesis is true, the Wilcoxon test would yield low "Z" values, indicating a relationship between the two distributions of precipitation data. In fact, in all cases the "Z" scores were so high (the lowest was 3.16), and the associated probabilities so small (in all cases less than 0.003), that the hypothesis could be rejected at the highest level of significance (Table 5).

Table 5. WILCOXON "Z" VALUES

| | STATIONS | | | |
|---|---|---|---|---|
| MONTH | Chester & Greenville | Chester & Doyle | Auberry & Bishop | Auberry & Deep Springs |
| February | 3.16 | 4.78 | 4.70 | 4.66 |
| April | 4.09 | 3.41 | 4.09 | 4.09 |
| December | 3.91 | 4.63 | 4.78 | 4.57 |

None of the values are significant at the 0.10 level.

## Limitations on the Methodology

There are various general and specific limitations on the data and methodology used in this study. The general limitations relate to the difficulty of modeling or analyzing the results of any cloud seeding activity. Cloud seeding takes place in a short-term, small-scale atmospheric event, such as a thunderstorm or cloud, and is thus hard to monitor in any fashion. Efforts have been made to analyze the effects of cloud seeding on particular segregated storms or clouds based on non-randomized storm events in which specific seeded storms were compared with non-seeded storms (Brown and Elliott 1968). The generalized conclusions drawn from these studies have been criticized for lack of data and appropriate controls (NRC 1973; Martner 1984).

Results of cloud seeding in areas with strong topographic gradients, such as Doyle and Bishop, are more difficult to interpret because of the myriad of variables affecting the precipitation pattern (Houghton 1969). McDonald (1968) described the complexity and difficulty of analyzing precipitation patterns as follows: "[O]ur atmosphere is a physical system characterized by many degrees of freedom and exhibiting enormous variability. And it defies attempts at execution of 'controlled experiments.' " Adding the analysis of the additional factor of deliberate human intervention in the atmospheric processes almost negates the use of random, independent samples. Cloud seeding operations tend to be opportunistic by nature: their location, operation times, and techniques are related to the particular precipitation pattern developing, which is the variable under investigation, making appropriate study and sampling difficult.

The special limitations in this study relate to data collection. The seeding unit "seeding days per month" was used rather than other units such as "seeded storms," "generating hours," and "volume of seeding agent used." None of these latter units is used consistently or continuously by weather modifiers. "Generating hours" refers to the total hours of seeding-generator operation and aircraft-seeding equivalent, and has recently become the most universally used index to describe amounts of cloud seeding activity (Marler 1988). However, although "seeding days per month" is not as accurate a representation of the actual amount of cloud seeding effected in a month as "generating hours" or the other units, it is the only unit reported in each of the California cloud seeding reports (Department of Water Resources 1957-1988).

The sparse rain gauge network restricted the number and choice of stations available for study. The location of climatic stations has a distinct lowland bias (Flaschka, Stockton, and Boggess 1987) which is reflected in the paucity of Sierra Nevada precipitation stations with a long historical record. The use of only a few stations as a measure of precipitation causes a problem because even adjacent gauges will differ due to slight differences in exposure, construction, operation, and interpretation (Wegman and DePriest 1980). A vast network from which an average could be obtained is preferable. Furthermore, great topographic irregularity in the study areas means precipitation patterns will show pronounced local variations which can be effectively averaged only by a several-fold increase in the gauge network (Houghton 1969; Cooper, Cox, and Johnson 1974).

As a result of these limitations, this study used the approach taken by most researchers faced with a severe lack of data for a definitive statistical analysis of cloud seeding effects: dealing with differences in precipitation patterns based on normal precipitation data collected at a limited number of stations (Caouette 1980).

## Discussion of Results

It is difficult to arrive at unequivocal answers by purely statistical methods. Any conclusions about the effectiveness of cloud seeding based on this study would at best have to be made with extreme caution. Any conclusion reached would likely be supported by some segment of the weather modification community as there is no consensus on downwind precipitation impacts due to cloud seeding. Various studies around the globe have reported increases and decreases in precipitation downwind of target areas and upwind areas as well (Adderly and Twomey 1958; Henderson 1966; AMS 1972; Gagin and Neumann 1974). In this study, few significant differences were found in precipitation patterns after commencement of cloud seeding activities. With respect to those few significant differences which were found, it cannot be stated without qualification that cloud seeding operations produced the differences.

Analysis of the data herein does not support the hypothesis that cloud seeding in one locale produces a rainshadow effect downwind, as there is no conclusive evidence that cloud seeding treatments resulted in detectable differences in downwind precipitation patterns. This is in accord with the only other study of the downwind effects at either the northern or southern study areas (Marler 1981), which concluded that the calculated, quantitative changes in precipitation at both target and downwind stations associated with specific cloud seeding events were small and not statistically significant. Without long-term, well-controlled, randomized weather modification experiments, it is not possible to separate clearly the influences responsible for either variations in long-term precipitation patterns or relations between precipitation in target areas and downwind areas.

## Conclusions

A great deal of uncertainty exists as to the areal effects of weather modification projects. The inability to demonstrate these effects, as well as target area effects, constitutes a principal inhibition in the formulation of state and national weather modification policies and represents a major hurdle in the practical economic matter of evaluating liability for changes in precipitation patterns. A better understanding of the downwind impacts of cloud seeding is necessary if prudent policies to regulate weather modification projects are to be developed. Otherwise, there is a possibility that projects designed to enhance various aspects of water supply, demand, storage, and distribution, agricultural practices, multi-purpose planning, and water systems and capital costs in one area will result in a detrimental impact on those same concerns in another area. Moreover, adequate knowledge and prudent regulation could help prevent unintended climate modification, such as rainshadow effects, from occurring as a result of intended weather modification. Those involved in the nascent weather resource management efforts should collaborate with those whose research focuses on long-term, large-scale climate change. This may be particularly important since weather modifiers have made recent advances in technology which may greatly enhance their ability to extract moisture from the sky (Marler 1988; Boos 1988b).

Brown (1984) has stated that weather modification was born in an industrial laboratory and raised in the tough neighborhood of entrepreneurs and free enterprise. Research followed application and effectiveness was assessed by interested parties, not by objective scientists. After four decades of cloud seeding the promise is great, but the concrete results are few and modest with neither the nature, magnitude, nor areal extent of cloud seeding having been established (Simpson and Dennis 1974). As late as 1984, a review of over thirty cloud seeding experiments in four continents showed that none had produced credible statistical evidence of a precipitation increase in the target area (Flueck 1984). Proven results are limited to single cloud experiments (Martner 1984; Simpson and Dennis 1974).

What is needed are modeling advances, detailed measurements of precipitation, wind speed and direction, and other relevant data, and judicious application of statistics. Current cloud seeding models are not capable of predicting effects of a seeding operation, or of designing cloud seeding projects to produce maximum benefits with minimum unintended consequences. The downwind anomalies found to date, such as in this study, call for further research into the causes of these anomalies.

The ideal analytical structure for the study of downwind effects of cloud seeding would include data focussing on a limited area with a high number of stations and instruments, backed by a model that links the various elements in the target area to downwind spatial precipitation processes. This will not be easy as numerous and complex factors influence the precipitation pattern downwind from a weather modification project, including natural climatic variability, variation in precipitation mechanisms, and variations in cloud seeding practices. Such further research and experimentation will surely prove helpful, but for now it remains unresolved whether cloud seeding leaves a detectable precipitation footprint downwind.

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# 1991 Annual Meeting

## Porterville College, May 3-4

Porterville College provided the setting for the Society's 1991 Annual Meeting. Opening day activities included a field trip led by Darwin Atkins of UC Riverside to examine frost damage to tree crops resulting from the winter's cold weather, a barbecue dinner (served in the College Quad), and a marvelous slide presentation by Dr. Lary Dilsaver on the history of Sequoia National Park.

On Saturday evening action moved to La Fuente Mexican Restaurant in downtown Porterville for the Annual Awards Banquet. Guest speaker for the banquet was Mr. Jack Pandol, President of Pandol Brothers Farms of Delano, who spoke on "Problems and Promises of California Agriculture."

Awards were announced by retiring CGS President Richard Hough (San Francisco State University). Awards of Merit for Distinguished Teaching in Geography went to **Sherry Grazda** (Fieldbrook Elementary School); **Edy Nielson** (McKinleyville Elementary School); **Mary Miller** (Palms Junior High School); **Emmett Hayes** (La Puente High School); **Pamela Gilgert** (Butte Community College); **Joan Clemons** (Los Angeles Valley College); and **Richard Raskoff** (Los Angeles Valley College). **William Preston** (Cal Poly, SLO) was awarded the Distinguished Service Award, and **Dave Lantis** (CSU, Chico) was presented with the Outstanding Educator Award.

The top prize for student papers in the graduate division, $100, was awarded to **Caroline Berghout** (CSU, Chico), who presented the results of her morphometric investigations of relict cirques in the northern Sierras. Second prize in the graduate division, $75, went to **Michael Kiley** (CSU, Fresno), who reported on cloud-seeding technology and its success in the central Sierras. Third prize in the graduate division, $50, went to **Gregory Reed** (CSU, Chico), who presented an historical-geographic analysis of the home range of the Modoc Indians.

In the undergraduate division first prize, $100, was awarded to **Marcia Holstrom** (San Jose State University). Ms. Holdstrom's paper was a search for the "capital" of Silicon Valley. Second prize, $75, was awarded to **Ryan Stuhr** (CSU, Fresno). Mr. Stuhr presented a detailed analysis of climate and vegetation patterns in the American West. Third prize, $50, was claimed by **Laura Griggs** (CSU, Sacramento). Ms. Griggs presented a policy paper on salinized soils and waste-water disposal in the western San Joaquin Valley.

**Note:** Through a series of unforeseen circumstances, the winners of the student awards at the 1990 meetings at the University of Southern California were omitted from the 1990 *California Geographer*. First prize of $100 in the graduate division was awarded to **Katherine Nashleanas** (CSU, Hayward) for her presentation on "Treasure Island: Symbolic Landscape, Artifact of Technology." Ms. Nashleanas is now in the doctoral program at the University of Nebraska—Lincoln. The first prize of $100 in the undergraduate division was awarded to **Bryan Garcia** (CSU, Hayward) for his presentation "Northern California Sport and Commercial Fishing Industry: Economic and Environmental Problems."

## PRESENTATIONS

FABIAN ACOSTA and JOHN HIGGINS, California State University, Hayward, **A Geographer's View of the Hayward Fault.**

MICHAEL T. BAUBLITZ, Lawrence Berkeley Laboratory, Berkeley, **An Historical Bio-Geography and Environmental Analysis of the Phyloxera Disease in Northern California Viticultural Areas: The Future Impact of a Biotype on the Landscape Ecology as a Model of Land Use Planning in California Agriculture.**

CAROLYN BAUER-CLANCY, California State University, Hayward, **Mountain House: Cow Pasture to Instant City.**

JOSEPH P. BEATON, California State Polytechnic University, Pomona, **Instructional Travel Videos.**

CAROLINE BERGHOUT, California State University, Chico, **A Morphometric Comparison of Cirques Along the Feather-Yuba Divide, Northern Sierra Nevada, California.**

JOAN CLEMONS, Los Angeles Valley College, **Mental Maps, Cultural Perception and Writing: Getting Students into the Field!**

RICHARD EIGENHEER, Sacramento City Schools and University of Nevada, Reno, **Rock of Ages: Ethical Tourism at Yulara, Australia.**

RICHARD ELLEFSEN, San Jose State University, **Using Traditional Physiographic Provinces to Teach U.S. Geographical/Historical Relationships.**

GINA GILLICH, California State University, Hayward, **Hayward's Wetland Restoration Project.**

MARK A. GOODMAN, California State University, Fresno, **Spanish Language Billboards in Fresno.**

LAURA L. GRIGGS, California State University, Sacramento, **Accumulation of Toxins in San Joaquin Valley Soils.**

LEE HADLEY, California State University, Hayward, **Bay Area Airports: A Geographer's View.**

ROBERT J. HALL, California State University, Fresno, **Nabataean Hydrology: The Potentials of Applying an Ancient Middle East Agricultural System to the Arid Regions of California.**

LYNDA HAMPTON and VICKI JOHNSON, California State University, Hayward, **More Than Fog and Artichokes: A Day-Trip Thru Coastal San Mateo and Santa Cruz Counties.**

DAVID M. HELGREN, San Jose State University, **Physical Geography in the 1990 California Science Framework (K-12): New Themes and Old Opportunities.**

JAY HICKS, Sonoma State University, **The U.S. Propaganda Campaign for the 'Hearts and Minds' of the South Vietnamese.**

MARCIA M. HOLSTROM, San Jose State University, **Capital of Silicon Valley: A Legitimate Claim for the City of San Jose?**

CHRISTINA KENNEDY, California State University, Hayward, **The Road to San Antonio Valley: Mt. Hamilton and Beyond.**

MICHAEL D. KILEY, California State University, Fresno, **California Cloud Seeding: Winter 1990-91.**

GUY KING, California State University, Chico, **Geomorphology of Vernal Pool Basins on the Vina Plains, Northern Great Valley of California.**

JAMES MAYFIELD, California State University, Hayward, **A Geographer's View of Strawberry and Environs.**

THEODORE R. MCDOWELL, California State University, San Bernardino, **Attitudes and Behavior Regarding Seismic Hazards in San Bernardino and the Inland Empire of Southern California.**

THEODORE R. MCDOWELL, California State University, San Bernardino, **Impacts of Trekking in the Annapurna and Khumba (Everest) Regions of Nepal.**

SUSAN MCLAREN, California State University, Hayward, **The Diversity of Uses Within the San Francisco Bay Wildlife Refuge.**

GEORGE NASSE, California State University, Fresno, **Albania's Italian Connection.**

CLEMENT PADICK, California State University, Los Angeles, **Update on Aerial Imagery of California.**

THOMAS PAGENHART, California State University, Hayward, **A Delta Field Trip.**

NICHOLAS POLIZZI and GARY PETERS, California State University, Long Beach, **Recent Trends in the Brewing Industry: A Geographical Perspective.**

GREGORY A. REED, Modoc High School and California State University, Chico, **An Historical Geography Analysis of the Modoc Indian Territory.**

DAVES ROSSELL, University of California, Berkeley, **Well Off Down Home: Backwoods Vernacular Design in Tradition and Commercialization.**

DEBORAH SAND, California State University, Hayward, **Coastal Erosion: A Natural Hazard in California.**

RODNEY STEINER, California State University, Long Beach, **Recycled Railroad Stations in North-Central California.**

HERSCHEL STERN, Mira Costa College, Oceanside, **Getting the "Big Picture" in International Physical Geography.**

RYAN D. STUHR, California State University, Fresno, **Climatic Control of Vegetation Distribution: Testing and Refining Mather and Yoshioka's Model.**

JERRY TOWLE, California State University, Fresno, **Fish Introduction in California.**