Self Sufficient Mountain Communities

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Table of Contents

Abstract

The goal of this research is to define self sufficiency for mountain communities, understand the resources that make up a mountain community, and describe how current and future mountain communities can take steps toward self sufficiency. What the report explores and finds is that most mountain communities have all the resources available to become autonomous, sustainable areas able to support human, wildlife, and environmental health. This conclusion came from an extensive literature review on the resources of mountain communities, followed by analysis of the resources held in the mountain community of Summerhaven, Arizona. A list of prescriptive steps based on Summerhaven's current needs is discussed, giving the community a ranked order of how they can utilize their resources to full potential and become autonomous to any outside resources. While further research into other communities is needed to more effectively understand the different scope of resource issues mountain communities are facing, this report has a general view of what effects all mountain communities. No two mountain communities will be the same in their resource needs, but the analysis on Summerhaven can be repeated in all existing communities. Self sufficiency in mountain communities is entirely possible and should be explored in order to make the mountain a healthy, sustainable, and beautiful landscape to be enjoyed by people for the rest of the time that they will be occupying Earth.

Introduction

The mountains have long served as a source of testing the human spirit. Those who have climbed mountains have understood the challenges and the joys of overcoming them. Similarly, building a community on mountains' slopes and valleys provide many difficulties to overcome, but the triumph can lead to a sensational living experience. Reasons to build on the mountain include clean air and water, unique recreational opportunities, and the chance to live among the high-altitude beauty. With climate change threatening coastal and already hot cities, future generations will be looking to the mountains for their cooler climates and protection from rising water levels. The mountains have the resources to give life to plants, animals, and humans; to allow each of those groups to interact, benefit each other, and thrive.

In order to make mountains socially livable, economically viable, and environmentally beneficial, there are many strategies that may transform the mountain into a model for sustainability. Ancient history up to recent academic research has provided numerous individual aspects of mountain communities that have very long-lasting aspects applicable to making mountain communities self sufficient. For example, a view today of Machu Picchu, Peru shows that though civilized society left hundreds of years ago, the stone infrastructure for Incans life and the study of their agricultural terraces exists without much alteration. In addition to historical examples, recent technological advances will provide mountain communities with sustainable practices that could have not existed without human innovation and understanding, and years of iteration. To develop prescriptions for existing mountain communities to become more self-sufficient, or to design a completely autonomous new mountain community, a synthesis of ancient knowledge and innovative thought is necessary.

On the community level, self-sufficiency means being able to provide all the resources necessary to let the people, structures, and landscapes exist without required help from outside communities' resources. This involves, but is not limited to, collection, sanitation, and distribution of clean water to homes and agricultural sites, using energy that is locally available to power buildings, and to create a social atmosphere where community participation is encouraged and necessary. Planned steps ensure everyone's wellbeing, and help create environmental and economic stability. It would be beneficial for the planners, governing officials, and citizens to make sure each individual procedure is simply done, or at least to make them easily understood. Community-wide comprehension of the systems existing will aid in self-sufficiency by relying on the most important resource the mountain community has, the people in it.

The mountains may be a difficult medium to build and live on, but that doesn't mean development shouldn't be considered. This project proposes that looking toward the mountain will be beneficial to the present and future of mankind and mother nature alike. The mountain communities have all the resources they need to be self-sufficient; with progressive thoughts and actions, thorough planning, and individual and community wide goals of sustainability, this self-sufficiency can be achieved.

Methodology

This is the description of the workflow necessary to gain a complete understanding of mountain resources and how to make mountain communities self-sufficient. The purpose of each product is to build upon the previous one, using information, research, analysis, and design to approach the problems of building at high elevations holistically and thoroughly. The goal is by the end of the project the researcher will have all the information needed to design a mountain community from scratch, with the previous work products justifying the end design. Form following function, following understanding.

The first product is a literary review on the specific resources involved in making mountain communities self-sufficient. For each resource, academic journals, articles, and books were utilized to further the understanding of the issues and innovative ideas in resource management. Through the work of academic experts, a broad synthesis of all the aspects involved in self-sufficiency can be performed. The goal of the literary review is to gain a general understanding that will serve for the analysis of other mountain communities and development of steps to help approach self-sufficiency.

The second product is an analysis of an existing mountain community located in the Santa Catalina Mountains northeast of Tucson, AZ. Summerhaven has approximately 40 permanent residents and 100 seasonal residents with recreation and economic opportunities associated with the mountainous area. The analysis will include data, observations, and inferences on the community's existing resources. An analysis of Summerhaven will serve as means to judge the strengths and weaknesses of the community, and steps for how the community can move forward toward self-sufficiency.

The final product is a best practice guide for how Summerhaven can reach autonomy from resources outside the community. Strengths of the existing community will be discussed as areas that should not be changed or already operating with self-sufficiency. Weaknesses will also be discussed with the purpose of picking out areas that need to be addressed for change. To conclude, a list of six steps will be laid out for how Summerhaven can reach resource independence.

Literary Review: How to Make Mountain Communities Self Sufficient

Water

In order to understand where water in mountain communities currently comes from, issues surrounding water, how to use it efficiently, and how to protect it while utilizing its full potential for giving life to the community, more information needs to be discovered on the successes and failures of current water systems. Water is one of the most important resources to the community because of its ability to make living on the mountain possible.

Sources being used include *Water Resources for Sustainable Development* from the Hydrological Sciences Journal, and *Community Irrigation Supplies and Regional Water Transfers in the Colca Valley, Peru* from the Mountain Research and Development Journal. The latter contains information surrounding the general use of water as a resource and how it can be sustainably designed into a community, and the former supplying a specific case study of water rights issues, water delivery technology, and the effects water has on local agriculture.

As the Continental Divide of North America directs water from high elevation mountain glaciers to the eastern Gulf of Mexico and the western Colorado River, so do the Andes Mountains providing water to much of the lowland regions of Peru. Since the dawn of ancient Peruvian civilization, communities have relied on the Colca Valley water resources as a means of producing the basic sustenance required for living. Recently, as Thomas Malthus has predicted, there is a lack of resources to meet the needs of an ever-growing population. Population growth leads to conflict for who should get the water and how it should be divided up. For this study, “water distribution and negotiation practices were studied at and across household, community, and extra-community levels, including agency workers and neighboring communities, and were cross-verified accordingly" (Vera Delgado, Vincent, 2013). The Colca Valley provides a unique mountain environment to study due to the aridity, the terraced nature of the agriculture, the mixed variety and seasons for food growth, the animal husbandry needs, and the precision required to have enough food to survive. The traditional crops grown between September and April consist of maize, beans, barley, and quinoa, with niche tourism markets popping up leading to the growth of onions, garlic, lettuce, and artichokes. "The 16 communities of the Colca Valley lie at altitudes of 2800-4000 m along both banks of the Colca River, with crops cultivated on steep terraces irrigated by complex systems of canals and reservoirs tapping upland water sources that consist of snow, wetlands, and springs" (Vera Delgado, Vincent, 2013). The need to keep everyone in the valley fed means that the water belongs to all who rely on it. Community organization, education on how to preserve and only use what is necessary, and possible government water allocation are all needed in order to ensure this valued resource is available to all who need it. The lessons from this publication are wide-reaching, from communities being adaptable to change some of their old practices to benefit other communities to not developing more communities where water will not support the people in the future.

In Kundzewicz's *Water Resources for Sustainable Development*, there is a specific section on how to address water issues in a fragile mountain area. To begin, the ability to monitor water levels, flows, and systems has been diminished by the large area of high elevation land, the lack of utilities at high elevations, and the lack of human settlement in high elevation areas. That being said, "the orographically enhanced precipitation and high runoff coefficient (due to steep slopes and low natural storage in mountainous catchments), mountains are source of a significant portion of freshwater resources of the World" (Kundewicz, 1997). With so much life relying on the mountain freshwater, it is important to understand who and what are being influenced by the mountain runoff, what issues may be present, and how flows can be utilized more efficiently. Kundewicz (1997) refers to mountains as "the water towers of the Earth," because of their importance to the lowland areas. With mountain development, it is vital that pre-existing lowland societies' water is unaffected by the water use in the highland. This is possible through recharging a high percentage of what is used back into the flows that are along the mountain development. According to Kundewicz (1997), "there are several important water-related issues related to sustainable development of mountainous areas, such as: watershed management to control deforestation, erosion and soil impoverishment, and reducing hazards of water-related disasters." The key points to be taken from Kundewicz's study on mountainous water use include the need to be able to monitor and manage the resource better and for development to address water-related issues while leaving the lowlands with the water they need too. A sustainably developed mountain area will be able to slow the water down for monitoring and community use, and then recharge just as much water back into the flow regime as what they diverted.

The sources provide a solid base to help make suggestions on what current communities can do to become more water self-sufficient, and how future communities can become completely water autonomous.

Renewable Energy

Mountain communities have the resources to produce all energy needed through renewable energy resources. Use of renewable energy is mandatory in order to make the mountain community truly self-sufficient. This section hopes to provide understanding on how to take the community off the grid successfully and without looking back.

The main source for the literary review on this section is *Benefits from a renewable energy village electrification system* from the Renewable Energy journal. The source discusses how 1.5-2 billion people in the world rely on burning of wood or oils (biomass) as their only form of light, heat, and cooking, and how mountain communities can be the hardest to deliver true electricity to. The burning of biomass for light is not only detrimental to the respiratory health of those living in the homes but is also a drastic source of deforestation.

The solution presented in this article is in renewable energy at a small scale to meet the basic needs of the villagers of Humla in Nepal's remote mountains. This is the most extreme condition in which to provide electricity, "16 days walk from the next grid connection, in the most difficult terrain, with high, snow covered peaks, thick forests, wild rivers and a harsh climate, with freezing winters, stormy springs and the annual monsoon rain" (Kimber, Zahnd, 2009). The authors go on to explain how a RAPS (Remote Area Power Supply) system can provide enough energy for the users at an affordable cost. RAPS requires forward thinking and planning to provide just enough power for the families to have light, the ability to cook, and possibly charge batteries on mobile devices.

To model energy demand, Kimber and Zahnd (2009) looked at the electrical needs of the villagers and the amount of time they needed it per day. They tracked population growth in the past two decades, the number of days renewable resources were available, what local materials could be used, and financial commitment was needed from villagers with the possibility of national subsidies. They go on to list the benefits that were seen after applying RAPS to Humla including health benefits from no longer inhaling smoke from fire-light, extended education time, increases in social interaction time, income generation from being able to work during the night, and a drastic lessening of the environmental impact of deforestation.

The other source in the field of energy is about a community, Kenora, Canada, testing three different renewable energy technologies (RET's) to see which one makes most sense to make the community off-the-grid. *The feasibility of renewable energies at an off-grid community in Canada* goes into detail about renewable biomass, solar photovoltaic, and wind turbines to provide the community with the 100 kilowatt demand load. The results showed that biomass would have the quickest return on investment at 4.1 years, with 6.1 years for wind, and 13.5 years for the high initial cost of solar (Thompson, Duggirala, 2009). Both wind and solar power, because they are intermittent sources of energy, require large batteries in order to have stand-by power, while biomass is more of a burn-as-needed energy source. Each of the sources was calculated on parameters of initial cost, operations and management costs (per year), local climatic data, and high heating values in the cold Canadian climate. Thompson and Duggirala decided that the single best way to get Kenora off-the-grid would be to invest and utilize biomass energy.

There is an opportunity with off-the-grid renewable energy technologies to be synthesized and used at different scales for different purposes. In each different setting, there is often one option which is an overwhelmingly better choice than the other RET's. In the example of Humla, Nepal it made sense to use a small scale solar for the RAPS, and at the larger scale Kenora, Canada, biomass would be the most reliable and cost-efficient option. The best scenario for a self-sufficient mountain community would be to diversify the RET's, capable of utilizing small-scale renewables at an individual household level, with the capability of larger scale renewables at the community level.

Food

Food production inside mountain communities will be vital to feed and support its population. The idea of self-sufficiency with food is that no one should to go hungry with all the food produced in the community, and that no food will need to be brought in from outside the community.

To grow food year round in the mountains, a combination of outdoor growing techniques and greenhouse environmental control is necessary. The first source to be looked at in this section is *Impacts on Mixed Mountain Agriculture in the Rupal Valley, Nanga Parbat, Northern Pakistan* by Marcus Nusser and Jurgen Clemens (1996). This discusses the techniques, seasons, animal husbandry, and environmental impact of mixed agriculture in Pakistan. The authors aim to assess the ecological impact of grazing and crop production in the Rupal Valley, and analyze four regions of the mountainous area to analyze: The Lower, Middle, and Upper Rupal Valleys and the Chungphare Glacier Region. Agriculture is mainly contained in the lower and middle valley's southern slopes, while grazing is seasonal, during warm weather in the upper and glacier regions is highly utilized, and in colder the lower and middle valleys are used more.

Along with the findings that agricultural practices did not lead to any land degradation, Nusser and Clemens (1996) found that "the investigations into edible pasture phytomass (in the sense of standing crop, measured by harvesting at the end of the vegetative period) compared with the actual intensity of use (stocking density, fodder needs of grazing animals) show that the yield exceeds the basic fodder requirement." The study concludes that most current land conditions exceed the amount of food required for grazing.

The authors also discuss the economical impact from the food being produced in the Rupal Valley, both plant and animal. They explained how animal husbandry is the central focus of the areas economy, but room for improvement is still needed. The authors pointed to wool and milk production alongside looking to sell meat to neighboring towns to make the time and resources required to raise the animals more worthwhile.

The second source is *A family-sized greenhouse for a remote mountain region of Nepal.* This comes from the Australian Solar Council and demonstrates the design and capability of making small, inexpensive, highly productive greenhouses for individual families in Humla, Nepal. In the report, authors Sawyer and Fuller did three case studies on pre-existing mountain greenhouse designs. The designs, while all separate due to climatic and site conditions, provide great general insight on what makes mountain greenhouses possible- south facing glazing, thermal mass walls, nighttime heat production, and natural ventilation. For their greenhouse design, Sawyer and Fuller utilized the naturally rocky terrain in Humla to build the greenhouse walls, used double-layered polyethylene film with air gap for an insulated glazing, and locally sourced timber for the framework. After a year of post-occupancy study, they found that the greenhouse nearly doubled the growing season of many nutritional crops while continually offering some plants year round. This is a great success for a region with malnutrition prevalent due to the limited growing season.

Through grazing, outdoor crop production in warm seasons, and indoor mountain greenhouse production in all seasons, there should be enough sustenance in the mountain community to survive. Along with year-round food production, the community can gain economic capital through selling what they produce.

Social

Socially, the mountain community will strive for empowerment of the citizen, equity for all, and productive organization. The perfect article about this is from the Journal of Health, Population and Nutrition, by the title of *A Framework Linking Community Empowerment and Health Equity: It Is a Matter of CHOICE*. This source will help in developing some community ideals. Social issues are more theoretical and less straightforward and scientific than physical infrastructure, but is just as important in making the community successful and long-lasting. According to Rifkink (2003), CHOICE stands for Capacity-building, Human rights, Organizational sustainability, Institutional accountability, Contribution, and Enabling environment.

> "Capacity-building has been defined as the process by which people gain knowledge, skills, and confidence to improve their own lives… Supporting and ensuring human rights is one critical way in which the process of empowerment directly influences equity in resource distribution and decision-making… if organizations do not address issues of equity and empowerment, health gains are difficult to pursue… While accountability is a core concern of all members of governing institutions, its impact is most pronounced among the poor in all

countries… The contribution defines the interest and gives space in the decision-making process… The existence of an enabling environment is the glue that sticks all these factors together" (Rifkin, 2003).

With CHOICE as the framework of the mountain community, people will be free to reach their individual potential, while being able to rely on others for help, and wanting to benefit the community as a whole.

Residential and Commercial Building

The buildings in the community should be built with the aim to optimize energy performance. This involves passive heating/cooling and proper solar orientation for lighting. Norbert Lechner's *Heating, cooling, and lighting as form-givers in architecture go* through the basis of understanding. The main lesson from this publication is the characteristics of a zero-energy house, which include superinsulated walls, roof, and floor, airtight construction with a heat recovery unit for ventilation, high performance and properly oriented windows that are fully shaded in the summer, passive solar heating, active solar domestic hot water, high-efficiency appliances/electric lighting/heating and cooling system, and photovoltaics on the roof for the small remaining energy needed (Lechner, 2014).

Lechner goes on to explain how the architecture should reflect the regional vernacular not only to match the cultural setting of the building, but also to be designed for the climate of the region. He then talks about the three tiers of a well-designed system: tier 1 including basic building design with heat retention, rejection, and avoidance through the building's envelope, windows, and appliances; tier 2 including passive systems with natural energy through passive heating, natural ventilation, and daylighting strategies; and tier 3 including mechanical equipment for heating, cooling, and lighting through high-efficiency heat pumps, lighting fixtures, and air conditioning. Lechner finishes the chapter by going into the importance of dynamic, rather than static buildings. The building should be able to adapt to the changing conditions of the day, season, and overall time period.

As far as passive energy building for a mountain climate, *Sun, Wind, and Light: Architectural Design Strategies* gives suggestions for what the design should follow for maximum efficiency. To begin with, high-elevation, cold climate needs to be taken into consideration with regards to the building envelope. The authors advise that the perceived climatic condition will be heating dominated and that a building designed with low internal gains, skin load dominance, and high insulation will perform the best in colder climates (Dekay, Brown, 2014). Furthermore, the authors provide a hierarchy of strategies in order to make buildings net-zero, ranging from the most basic design considerations and easy to perform actions to new technology to make buildings autonomous from the energy grid.

The first level contains archetypes such as siting, orientation, and building shape and size. Moving onto level two, efficient technology, including the building envelope, its air tightness, and the heat gains and losses associated with the envelope. The third level includes passive green design utilizing solar day lighting and heating, and natural ventilation for cooling. Next is the high performance of the utilities needed, such as efficient lighting fixtures, HVAC systems, and automated controls. At the apex of the hierarchy is the level of green power, calling for renewable energy to account for the small amount of energy needed to power the highly efficient building made from following the steps in the hierarchy (Dekay, Brown, 2014). By following the steps in the hierarchy and building for the cold climate associated with mountain areas, the builder can achieve a net-positive (producing more than using) energy building.

Political Structure

The making of self-sufficient communities won't be possible without some political structure behind it. This project will not go into great detail about the exact political format, but rather focus on the notion that community involvement in the major decision making of the community is key.

From *Sustainable Urban Development Reader,* the section entitled "A Progressive Politics of Meaning" provides an informational groundwork for the successes and challenges in inviting major political involvement of citizens. "One strategy has been to reform planning processes by making them more open and participatory, in contrast to past decades when politicians or local government staff often made decisions with little public involvement" (Lerner, 1993). While citizen participation may seem like a fundamental part of making the most amounts of people happy, often public planning policies are made without the public to cut down on gridlock of opposing views and convenience of doing the job without any public help. Lerner goes on to define progressive politics by the effort to accomplish five goals: one "to create a society that encourages and supports love and intimacy, friendship and community, ethical sensitivity and spiritual awareness among people," two being to change the bottom line of a project to not just consider the money but social factors as well, the third being to create conditions that recognize the uniqueness and importance of every human being, the fourth "to create a society that gives us adequate time and encouragement to develop inner lives," and the fifth being "to create a society that encourages us to relate to the world and to one another in awe and joy." The five defining points of political progressiveness will not be accomplished by one man being elected, but rather involve the community harboring the values of life, liberty, and the pursuit of happiness.

While progressiveness will not eliminate the need for elected officials, the idea is that the officials won't be a necessary and integral part of each citizen's day-to-day life. Human connection will be the most vital part of the political structure of the mountain community, without it many will lose purpose and focus, but with connection to others the community can thrive and ensure happy living for each individual.

Environmental Stability

Environmental stability is a major issue when building or modifying the mountain landscape. Key considerations for this involve human impact on wildlife, the land, and protection of mountainous areas. One of the ways to ensure protection of wildlife and land is developing human values for the other living and non-living things around them. *Protected Area Planning Principles and Practices* discusses the importance of managing protected areas for a sustainable future. The lessons from this will be important when implementing a culture in the community of natural resource protection and careful observation in the mountain community. Here, self-sufficiency requires a protection of nature. The authors note that recognition of what needs to be protected isn't enough to actually protect it, "designating and identifying boundaries does not guarantee protection of the values for which the areas were established" (Borrie, et al., 1998). In the case of an area clearly needing protection to preserve its intrinsic value, not only do boundaries need to be established, but also a management strategy and careful observation of how management is proceeding is also necessary.

The authors go on to give principles for protection of areas with high visitor usage. Explicitly stated management goals; diversity of resource, social, and managerial conditions; management directed at influencing human-directed change. The need for understanding impacts on resource and social conditions are inevitable consequences of human use, impacts can be spatially or temporally discontinuous, and many factors go into the impact/use relationship; many management problems are not density dependent and that limiting use may not be the most appropriate management strategy; monitoring is essential to professional management; the decision-making process should separate technical decisions from value judgments; and consensus among affected groups about proposed actions is needed for successful implementation of protected area management strategies; all are the principles suggested for managing human/protected area effectively (Borrie, et al., 1998).

Furthermore, carrying capacity and limits for acceptable change (LAC) need to be established by managers and understood by the people using protected environments so natural resources are not exploited. In order to establish carrying capacity and LAC, the authors provide nine-steps a manager should go through: first, identify areas' special values and issues for concern, then describe the recreation opportunities, then select indicators for the resource and social conditions, followed by taking inventory of the resource and social conditions, with specifying the conditions in each of the opportunity classes, while identifying alternative opportunity classes allocations and management actions for each alternative, then selecting a preferred alternative, and finally implementing actions and monitoring conditions (Borrie, et al., 1998). To ensure sustainable environmental conditions, in depth and specialized management needs to be in place with a culture of thoughtful citizens to be mindful of potential environmental issues. While creating a protected environment that inhibits human use may be difficult, it is of high importance in order to develop a mountain community with a healthy and long-lasting landscape.

Recreation

The mountain community should provide all of its inhabitants with ample opportunity to recreate in the surrounding areas. In this sense, the recreation opportunities could also be a source of tourism. With higher use, however, management is required. *The Recreation Opportunity Spectrum: A Framework for Planning, Management, and Research* discusses how the community can plan for people's recreation experience and make sure it is not leading to land degradation. The recreation opportunity spectrum (ROS) can be defined by saying, "the end product of recreation management is a diverse range of opportunities from which people can derive various experiences" (Clarke, Stankey, 1979).

The driving force behind many people's reason to recreate is to gain a new and interesting experience, or to relive a previous experience they've already had. Mountain ranges get used for recreation because of the varying opportunities for experiences they provide. Mountain experiences include hiking, biking, camping, fishing, swimming, boating, driving, and reaching peaks all with the purpose of reaching new heights, creating a connection with nature, and becoming healthy in the process.

The recreation opportunity spectrum incorporates all of the human nature interaction within six categories ranging from primitive lands to urban spaces. Primitive lands is the first category which has specific characteristics associated with recreation in them, including zero tolerance for mechanical equipment and strict rules to ensure the land is as close to natural as possible. Primitive lands provide a person entering with the least likelihood to run into other people or other human influence. The next category is semi-primitive, non-motorized land usually located on the periphery of primitive lands but without the strict guidelines of to keep the land primitive. Furthermore, the semi-primitive, motorized land category allows for vehicles to travel in them and is less protective still. Roaded natural is the next category involving actual pavement through a natural environment. Rural and urban are categories five and six which contain much human influence with the highest probability to see other humans and human influence. The authors go in depth to describe appropriate management strategies for each categories and conclude that the ROS has specific application for four major concerns: "(1) allocating and planning recreational resources, (2) inventory'ing recreational resources, (3) estimating the consequences of management decisions on recreational opportunities, and (4) matching experiences recreationists desire with available opportunities" (Clark, Stankey 1979).

Economic Productivity

The *Sustainable Urban Development Reader* section on "Community Capital: Using All Our Resources" focuses on small business development. In order for the mountain community to be self-sufficient, and economy needs to be in place that is not only relevant to the citizens inside, but consumers and other business from outside the community. This section focuses on small-scale development based on meeting the needs of the local people and are rooted in community and designed to meet internal community objectives. “These have emerged in response to the negative effects of globalization and as policy approach to sustainable development at the community level. Community economic development (CED) and sustainable livelihoods are two examples of these alternative strategies” (Roseland, Soots, 2007). The focus here is placed on community self-reliance, the thought that each unique community has the power to be economically sound through relying on the local strengths and resources available rather than worrying about the community’s deficiencies.

Community economic development integrates ecological and social aspects of the community as well as direct and meaningful community participation. Distinguishing features of community participation is characterized in this definition of CED: “communities can initiate and generate their own solutions to their common economic problems and thereby build long-term community capacity and foster the integration of economic, social, and environmental objectives” (Roseland, Soots, 2007). The authors go on to give examples of sustainable CED initiatives with the most relevant strategies including closed-loop economic networks in St. Paul, Minnesota, increases in affordable housing varieties in Portland, Oregon, and encouragement from the Gothenburg, Sweden government to develop environmentally friendly products. For the self-sufficient mountain community, the goal is to have every citizen serving a purpose for the community and its economy. Through focusing on community capital, it’s possible to make everyone employable and proud of the role they are playing in the community’s economy.

Transportation

Depending on the size and scope of the mountain community, transportation to and around it will look differently. Still, *The Sustainable Urban Development Reader* has methods on transit-oriented design, bike-friendly urban spaces, and walkability of neighborhoods. The subjects will be important in reducing energy consumed by the community, reducing carbon emissions from cars, and making the citizens healthier, happier, and more involved in the community. “Transit-Oriented Development (TOD) is a mixed-use community within an average of 2,000 ft. walking distance of a transit stop and core commercial area. TOD’s mix residential, retail, office, open space, and public uses in a walkable environment” (Calthorpe, 1993).

In order for people to stay healthy and engaged to the community, walkabililty is a key component to the community's structure. The ideal mountain community would have all of the components Calthorpe mentioned together in a way that fits into the natural surroundings while linking people with employment, retail, recreation, and other people. Designing the community around transit will ensure that this can happen, while leaving room for growth and different forms of transportation to exist alongside. Ideally, the mountain community has limited but allowable car use, large network of bike lanes, and easy circulation even during snowy winter months. In the mountain community, during the season of bicycle use, it will be encouraged over driving through increases in cost of auto use, expanding bike facilities and the number of roads bikeable, linking cycling to wellness, and having special promotions for bikers (Pucher et al. 1999).

Observations, Data, Analysis: Understanding of Mount Lemmon's Summerhaven

30 miles from Tucson in the Santa Catalina Mountains is the small community of Summerhaven, at roughly 8,000 ft. The community is grounds for the analysis of its current existence compared to what is found in the literary review to be a self-sufficient community. In order to appropriately evaluate Summerhaven, thorough understanding of the community is necessary. Information on Summerhaven was achieved instrumentally through site visits.

Water

The Mt. Lemmon Water Cooperative Company is the only source of fresh water for the current residents of Summerhaven. The water is collected from springs located in nearby Sabino Canyon and Carter Canyon. The quality of the spring water is considered pristine because of it flowing from fresh mountain run-off. Testing is done on a three year pattern to ensure there are no major problems with the source water, however the water from the springs is considered to be consistently the same quality as a bottle of spring water from the grocery store. From winter and monsoon season, runoff to the springs can range from 20-40 gallons per minute (GPM), during the summer dry season flows go down to only 4-5 GPM. Collection is done predominately during the wet seasons at two main sites, Sabino and Carter Canyons, combining to hold 200 million gallons in tanks.

From the collection tanks, a one-time pump sends the water to a 500,000-gallon storage tank on Miner's Ridge, which then feeds residences through gravity. The delivered water is metered constantly and the residents are billed monthly for their use. Currently 27 structures (with the potential of 50) send their wastewater to the Pima County system to be handled the same as Tucson resident's wastewater. The remaining buildings are on a septic system local to their residence. In times of drought, when less than expected rain and snow is delivered, there is a five level system in place to preserve what water is available, including demanding residences to reduce water consumption in half and in the most extreme case trucking gallons up from Tucson. One time in the co-op's 34-year history have they had to ask residences to reduce water consumption, so having enough water has never been a major issue for Summerhaven.

Before the 2003 Aspen Fire, the co-op had modeled the demand for all 800 building parcels that could be available, concluding that 3 million gallons would be needed to provide all 800 buildings during the peak 3-month demand period. The entire water system is highly efficient, technologically advanced, and managed to ensure Summerhaven gets its water in the most sustainable ways as possible. Water officials from Guatemala and other mountainous foreign countries have come to examine the system in place to take notes on how a similar system could exist in their mountain region. (Special thanks to Operations Manager Michael Stanley for the in depth information on the Mt. Lemmon Water Cooperative Company).

Vegetation

Summerhaven's vegetation is an interesting mix between the high-elevation plants accustomed to the climate and the desert plants located at the lower elevations below. This section consists of a list of the families, Latin nomenclature, and common names of the most well-known and important (listing every plant species found there would take over ten pages and isn't important in the scheme of this essay) flora that can be seen in Summerhaven and the surrounding areas.

Ferns and fern allies:

Dryopteraceae - *Dryopteris filix-mas* - Male Fern

Woodsiaceae- *Cystopteris reevesiana* - Southwestern Brittle Fern

Gymnosperms:

Pinaceae - *Abies bifolia* - Cork-bark Fir

Abies concolor - White Fir

Pinus arizonica - Arizona Pine

Pinus ponderosa - Ponderosa Pine

Pinus strobiformis - White Pine

Pseudotsuga menziesii var. glauca - Douglas Fir

Flowering plants/dicots:

Adoxaceae - *Sambucus racemosa var. microbotrys* - Red-Berried Elder

Apiaceae - *Pseudocymopterus montanus* - Mountain Parsley

Asteraceae - *Cirsium arizonicum* - Arizona Thistle

Tagetes lemmoni - Mountain Marigold

Cannabaceae - *Humulus lupulus var. neomexicanus* - Hops

Caprifoliaceae - *Lonicera arizonica* - Arizona Honeysuckle

Fagaceae- *Quercus arizonica* - Arizona Oak

Quercus chrysolepis - Canyon Oak

Quercus gambelii - Gambel Oak

Quercus rugosa (reticulata) - Netleaf Oak

Geraniaceae- *Geranium caespitosum var.eremophilum* - Purple Wild Geranium

Geranium richardsonii - Geranium

Lamiaceae- *Salvia arizonica* - Arizona Sage

Satureja vulgaris - Wild Basil

Onagraceae - *Epilobium canum ssp. latifolium* - Hummingbird Trumpet

Rhamnaceae- *Ceanothus integerrimus* - Deer brush

Rosaceae - *Agrimonia striata* - Agrimony

Fragaria vesca subsp. bracteata - Wild Strawberry

Purshia stansburiana - Cliff Rose

Sorbus dumosa - Arizona Mountain Ash

Salicaceae - *Populus tremuloides* - Quaking Aspen

Salix lasiolepis - Arroyo Willow

Sapindaceae - *Acer glabrum* - Rocky Mountain Maple

Acer negundo - Box Elder

Flowering plants, monocots:

Asparagaceae- *Agave parryi* - Parry Agave

Poaceae - *Festuca arizonica* - Arizona Fescue

Muhlenbergia longiligula - Long-tongue Muhly

Triticum aestivum - Cultivated Wheat

Hordeum vulgare - Cultivated Barley

The health of the landscape and vegetation around Summerhaven is poor. The Aspen Fire of 2003 has left much of the mountain with remnants of burnt trees on the most visible mountainside west of the center of town. The Aspen Fire, alongside 2002's Bullock Fire to the east of Summerhaven, destroyed 44% of the forested areas in the Santa Catalina mountains, a number that would leave the forests recovering to this day (Meyers, et al. 2010). After the fires, the ground was left with soil fertile for new vegetation, but lacking development of such since the fire. Certain areas are more prominently green than others, however the general health isn't best characterized by the ground color.

The climate and environment of Summerhaven is capable of supporting a beautiful and lush evergreen forest, which is visible in much of the surrounding area. The danger for another fire in the future is relatively high, with much of the ground covered in dead pine needles and other dried plant material would make great fuel for another ground fire. Spacing of trees around development leave enough of a buffer zone to create security from future fires from likely affecting existing structures, however with the right conditions Summerhaven could become an easy target for future fire devastation.

Climate and Precipitation

At an elevation of 8,200 feet, Summerhaven experiences a high elevation climate of cool summers and cold winters. The name of Summerhaven came from it being a site of refuge from the sweltering desert heat of surrounding areas such as Tucson, AZ. The Santa Catalina mountains are considered a Sky Island due to isolation from the desert (usually 20 degrees Fahrenheit cooler than Tucson) with climate and vegetation characteristics completely separate from what would be found at a lower elevation in the same general area.

According to Summerhaven locals who live there year round, the area gets roughly 30" of rain annually that mostly comes in during the monsoon season from July to September and snowfall ranging from 65-100" in the winter season. Summerhaven sees approximately 60 days of precipitation per year, with just under 300 days of sunshine in the same period. Average high temperatures reach approximately 80 degrees Fahrenheit in June and July with average lows in the low-20's for January and February. As far as mountain communities go, Summerhaven has a relatively temperate climate and predictable timetable of temperatures and precipitation.

Roads and Infrastructure

Summerhaven is most commonly accessed by the General Hitchcock Highway (also known as the Catalina Highway or Mt. Lemmon Highway). This highway connects Tucson to Summerhaven and other of Mt. Lemmon's destination. The only other way in to Summerhaven is through the Control Road which is unpaved and connected to Pinal County for fire protection purposes. Inside Summerhaven, other major roads include Phoenix Avenue and Carter Canyon Road to the west of the highway, and Tucson Avenue and Loma Linda Extension Road to the east. Other small paved and unpaved roads exist in order to reach certain development and recreation areas.

Utilities are all buried underground with the exception of a few telephone and power lines visible in town along the highway. Tucson Electric Power (TEP) serves most people for their electricity needs and the Mount Lemmon Co-Op Water Company to deliver freshwater to their homes.

Population and Demographics

From the 2010 Consensus, Summerhaven registered 40 people as permanent residents, 30 of which were white, 6 Native American, and 4 Asian. With roughly 4.6 square miles of Summerhaven, there is a population density of 8.7 people per square mile. There are approximately 100 residents who live in cabins during the summer who leave in the winter to avoid the season.

Energy

Each building will perform differently as far as energy use is concerned for Summerhaven. From December through February, each day requires on average 20-25 degrees Fahrenheit of heating to get the home from outside temperature to a pleasant indoor temp of 76 degrees. From June to August cooling may be necessary on especially warm days, but for the most part outdoor temperatures mirror ideal indoor temperatures. The remaining half of the year, March-May and September-November, low temperatures are rarely below freezing but constant heating will likely be necessary, just at a smaller scale than in the winter months.

Energy demand is dependent on size, orientation, materials used, the appliances used and their efficiency, and many other small factors that vary from structure to structure. Most of the residential and service buildings of Summerhaven are a cabin style, with cut wooden beams as the outer envelope and a masonry or cement base providing for high insulation values from the wood with potential for cold temperatures to creep in through the masonry and cement floor. The building footprints of most residences are relatively square and freestanding meaning there is a higher percentage of surface area exposed to the outdoor elements and a higher opportunity to cold weather to creep in through cracks or windows. Most of the structures have small window openings that can be beneficial to keeping the building better insulated, but can hurt in getting sunshine in to naturally heat the structures. Residential cabins on Summerhaven can use anywhere from 2-5 kilo Watt hours per day (kWh/day) dependent on efficiency, size, and occupant lifestyle. With around 100 cabins in use during the summer season, the community could potentially see anywhere from 200-500 kWh/day for residential use alone.

Currently, Summerhaven's residents are reliant on Tucson Electric Power for their electrical needs. For heating needs, many use fireplaces, gas heaters, or a combination of the two. There are not currently any major renewable energy sites generating power for Summerhaven's buildings.

Economic

The Mt. Lemmon Cookie Cabin can be seen with a line out the door at any time people are traveling up to Summerhaven. The Mt. Lemmon General Store is also a source of tourism stimulation with the selling of fresh fudge and souvenirs unique to the area. Other local businesses and services include Summit Realty, Living Rainbow Mountain Craft Gallery, Sawmill Run Restaurant, the Mt. Lemmon Community Center, Mt. Lemmon Fire Department, Mt. Lemmon Post Office, Mt. Lemmon Realty, Mt. Lemmon Water Cooperative Company, Pima County Wastewater, Karen's Sky Mountain Realty, and the Zimmerman School. Other services that were lost in the Aspen Fire of 2003 included a coffee house, bed and breakfast, and a lodge. The summer and fall seasons are vital for the local businesses as many people arrive in Summerhaven to get away from the desert heat and see the fall colors. Summerhaven has a 5.5% unemployment rate (mainly due to retirees), with half a percent of annual job growth, and high expectancy for positive future economic growth. Income per capita is roughly $28,000, with a 6.1% sales tax, and 3.4% income tax.

Food

As far as the resource of food goes in Summerhaven, options are limited to a few restaurants in the small community. The Mt. Lemmon Cookie Cabin and Sawmill Run Café are the only two options for getting a meal, with the Mt. Lemmon General Store having basic rations and fresh fudge. The nearest grocery store is at the base of Mt. Lemmon in Tucson, at least a half an hour drive. There is no commercial food growing inside Summerhaven, be it outdoors or in greenhouses. The only way for the residents to eat is at one of the two restaurants, the general store, or driving down to Tucson.

Environmental Protection

Fire is the major concern with environmental protection in and around Summerhaven. Any heavily forested area will be highly vulnerable to wildfire, with Mt. Lemmon being no exception. Luckily, the warmest months in Summerhaven are also the most wet, with monsoons providing heavy rainfall in July and August. Coronado National Forest is located on Mt. Lemmon, with many of the forest managers being affiliated with the US Forest Service. The management plan for Coronado National Forest is under revision currently, but is expected to include in depth strategies in the areas of fire, forest, range, and travel management. Fire management is based off the 2001 Federal Fire Policy, which includes fire mitigation, controlled burns, and in depth education to Summerhaven's community about how to create a fire buffer zone around their home, how to avoid starting a forest fire, and what to do in case of one. There is a high emphasis on human safety with concerns of fire.

Forest management encompasses landscape and watershed assessment, road analysis, and serve as a step in between fire management policy and large-scale public planning policy. Though not located near Summerhaven, grazing is done with 35,000 cattle through 200 separate ranges, so the forest service provides a management plan for that as well. Travel management encompasses the facilitation of movement of people in and out of the forest through roads, unpaved vehicle travel, trails, and open spaces. The University of Arizona has facilities inside Summerhaven that deal with water resources and wastewater treatment. Pima County also has a sewage facility in Summerhaven that directs 27 homes' wastewater to the Pima sewers. There are parcel lots to ensure that land isn't overexposed to buildings, but there is currently a proposal to consolidate some of the lands in order to develop a children's summer camp right outside the Summerhaven boundaries.

Political Involvement

Summerhaven is an unincorporated community within Pima County, Arizona. Political affiliation is relatively split down the middle between Republicans and Democrats, depending on the size of the election, what the position is for, and the trending politics it is a toss-up for which party will take the votes of Summerhaven. There are no elected officials residing inside Summerhaven, rather just citizens living together, with occasional help from Pima County, the US Forest Service, and City of Tucson when necessary.

Recreation

Coronado National Forest has the full range of the recreation opportunity spectrum (ROS) from primitive wilderness land to urban settings. Summerhaven is the most urban setting which exists, with remote cabins classifying as rural, roaded natural consisting of the Catalina

Highway and other drives up and around Mt. Lemmon, semi-primitive motorized containing the Control Road for fire protection and other unpaved drives, semi-primitive non-motorized as the trails located closely by Summerhaven such as Marshall Gulch, and primitive lands including the Pusch Ridge Wilderness to the southwest of Summerhaven. Recreational activities available in the forest include bicycling, camping and cabins, fishing, hiking, climbing, horse riding, nature viewing, picnicking, scenic driving, water activities, and winter sports. Ski Valley is the southernmost operational ski resort in North America, and is located two miles to the northwest of Summerhaven. Furthermore, within a few miles of the communities' grounds are popular trails such as the Aspen-Marshall Gulch Loop, Sunset Trail, and the Mt. Lemmon Lookout Trail, each within walking distance from the community.

Results and Discussion: Best Practice Guide for Summerhaven, AZ

Strengths

The water delivery system from Mt. Lemmon Water Cooperative Company is the community's biggest strength. The advanced state of technology used, the efficiency of the system in extraction and delivery of water, and abundance of pure water for the existing community all make the water co-op the greatest strength of the existing Summerhaven community. The current state of vegetation has positive aspects in that the soil has potential to hold healthy vegetation and that there is a unique variety of flora that is existing already on the mountain. The climate is predictable and relatively warm for a mountainous community, providing an enjoyable environment and ample precipitation for the water needs of the people in Summerhaven. The roads and underground infrastructure ensure that the residents have access to the water, energy, and structures needed for their survival on the mountain. Demographically, Summerhaven is a small and tightknit community with plenty of room for growth if needed. The small community uses limited energy and most of the cabins are designed with the intent to keep energy use low. Economically, Summerhaven has a small number of productive small businesses and the potential for more small businesses to enter and succeed. Residents have access to food through two restaurants and the general store located inside the community. The environment is managed thoroughly by different bodies including US Forest Service and public education on environmental protection exists and distributed throughout Summerhaven. Politically, Summerhaven is not a hot bed for political unrest with people participating to the degree that they want to without any contention. Recreation opportunity is also one of the biggest strengths of the Summerhaven community with each category of the ROS existing in a walkable area, each with a wide variety of outdoor experiences.

Weaknesses

The only weakness available in the Mt. Lemmon Water Cooperative Company is what is done with the water after the residents use it. Historically, there have been problems with polluting Sabino Canyon at the lower elevations and residents rely on septic tanks or Pima County wastewater infrastructure for discharge. The state of the vegetation around Summerhaven has a problem in the susceptibility of fire. In addition, vegetation is overly dried and lacks aesthetic coherency, especially on the western slopes around Summerhaven, which still shows ill effects from the Aspen Fire of 2003. The cold climate in the winter keeps many of the seasonal residents away, which can lead to an economic sinkhole in that season. The climate also makes the infrastructure susceptible to frost damage. Road access is also limited by the winter season. Demographically, Summerhaven is not very diverse, with most of the permanent and part-time residents and visitors being white and with enough disposable income to make the high rent for the mountain cabins. The cabins and structures on the mountain have the ability to become more heavily insulated and utilize passive solar daylighting to a greater degree. Summerhaven does not use any renewable energy for the structures energy demand, with the exception of tree biomass that may be burned to heat the structures, which can be argued is not a healthy, sustainable, or safe practice altogether. Economically, Summerhaven is not reaching it's full potential for the amount of visitors that arrive. The community keeps some people with a lower income away because of the travel and time cost associated with visiting Summerhaven, with it becoming even more challenging if a low-waged person wants to live permanently in Summerhaven. Furthermore, business potential isn't optimized in that their visitors are limited to the two very busy restaurants during single-day trips with no option to sleep over until the next day without camping in the forest. Visitors and residents are also confined in terms of food resources, having limited restaurant options and few fresh grocery opportunities inside the town. Environmental education and more thorough land management are always able to grow with new technology and specialization of those responsible for keeping the environmental resources secure. There is potential for Summerhaven to establish more governing bodies within the community, however a need that could be met first would be strengthening the bonds of the community members through increased interaction and collaboration for success. Recreation opportunities are widely available around Summerhaven, however trailhead labeling and trail maintenance could be improved to make the user experience better.

List of Steps Toward Summerhaven Self-Sufficiency

Ranked below are steps laid out based on immediate need, severity of the issue, and economic viability on a sliding scale. Completing the steps should lead Summerhaven to becoming a mountain community that is able to run and operate on its own, sustainable, and self-sufficient in all resources.

1. Landscape alteration and improvement:

Currently, the state of vegetation and overall landscape health need to be improved so that future development will not be in danger of fire destruction. To improve the landscape burnt, dead, or dried plant material should be removed and stored in a fire-safe area to be used by the community later as a source of biomass heating. Clearing unhealthy vegetation will open up the soils nutrients to be used on new and healthy vegetation that will be more aesthetically pleasing and resistant to fire, and will also show areas that will work for development of new structures that will be useful to the community.

2. Sustainable infrastructure development for future development:

In having the capability to increase Summerhaven's carrying capacity, alterations to the current infrastructure need to occur so future development can take place efficiently and effectively. The biggest change Summerhaven needs to adopt is developing a sustainable waste infrastructure. In order to utilize the water resources fully, a basic wastewater treatment and grey water reuse system should be in place so the water can be utilized again inside the community. Even if the community does not wish to reuse wastewater, being able to make it pure again will make recharging it down stream from the community environmentally beneficial. The other sustainable infrastructure that should be in place consists of tanks that will utilize human and animal waste as a source of methane that can then be burned for heat and energy. Using biogas produced inside the community will make a new energy resource available inexpensively. Recycling waste through infrastructure changes will make Summerhaven a more self-sufficient community.

3. Agricultural and food development:

With a higher population and demand for the energy from food, development of the edible resource within Summerhaven will make year-round local food consumption possible for the community. The current state of having to drive down to Tucson for the nearest grocery store is very wasteful of gas and the citizen's time. A new system of food production and sales will eliminate the need to travel far to get healthy, fresh food. Year round food production will require mixed agriculture, grazing, and greenhouse technology. Limited grazing will be necessary to keep the protein demand of the community, other sources of protein should be focused on sustainably raising chickens for their dual potential of eggs and meat. Waste from raising the animals that will eventually be eaten can be repurposed as nutrients for crop production or biogas slurry. During the warm seasons, agricultural fields should be planted to grow outdoor crops that will thrive in the mountain environment, including barley and other grains. Cold-weather outdoor plants can also be utilized for food production. Environmentally controlled greenhouse technologies will be responsible for producing crops in the winter season. Crops should also have inherent economic value in that greenhouses cost more money to grow in order to control the environment. High value crops include tomatoes, cucumbers, and colored peppers. With an intensification of vegetation being grown in Summerhaven, water resources also need to be taken into account. While modeling for the water use of plants will be necessary to see what will need to be taken out of the water co-op, the mountain should be able to provide more than enough water to support both human and crop production needs.

4. Increase supply of affordable, energy-efficient housing and business structures:
Summerhaven has the resources to hold 800 parcels of land to be built upon. Currently, only 40 permanent residences exist, with around 100 seasonal cabins being used too. There is opportunity to develop the nearly 600 remaining parcels with mixed-income housing capable of housing up to a few thousand residents. While supply of housing units should meet demand and unnecessary residencies should not be built, there is a market for people to who want to live on the mountain both permanently and in the different seasons. Temporary housing such as hotels and lodges should be built to help bolster economic growth while giving visitors the opportunity to make their stay in Summerhaven a little bit longer. Mixed-income and mixed-use development should be implemented in short steps that mirror the current needs of the growing

community and the economic viability of the development project. Diversity in available housing will translate into diversity of the population demographic sector, which Summerhaven is currently lacking. Each parcel developed should strive for energy-use optimization through high-density building, highly insulated mountain structures, and passive solar daylighting and natural ventilation. Energy efficient technology should also be implemented, such as solar hot water heaters, efficient light bulbs and appliances, and HVAC systems that use as little energy as possible. With the development of more structures, infrastructure modernization and improvement will be needed to ensure safe travel to all the structures. This infrastructure should enable automobile use, but should encourage alternative means of transportation, including bike and walking pathways through areas that people will want to travel through. Discouraging car use will improve energy usage while making the people and environment healthier in the process.

5. Renewable energy infrastructure:

After developing new places for people to live and work, renewable energy technology should be implemented to provide electricity for the new and previously existing structures. Ideally, the infrastructure will be developed incrementally, taking chunks of the entire energy supply needed out through adding diverse renewable energy technologies as the community can afford them, eventually encompassing the entire energy demand and becoming a net-positive energy producing community who can then sell the extra power produced back to the Tucson Electric Power grid which they are already connected to. For example, the community may decide that solar arrays should be added to the southern facing hills to utilize the nearly 300 days of sunshine every year. From there, the community could work toward adding small wind turbines in some of the more windy areas of Summerhaven, then add a biogas generator to finally meet the nightly energy demand that solar and wind may not cover completely. Rooftop solar should also be considered and encouraged for certain structures that can hold and afford it. Renewable energy diversification and proliferation will be necessary for Summerhaven to reach true resource autonomy.

6. Social structure:

With all of the basic needs of survival (water, food, energy, and protection from the weather) met, Summerhaven can begin to focus on creating a cultural atmosphere that will be conductive to environmental protection, economic proliferation, and overall well-being. While anthropocentric ideals are harder to articulate plans for, certain community beliefs and ethics should be developed to make every community member feel a sense of purpose in contributing to the benefit of Summerhaven. Each individual should feel free to pursue his or her own path to a happy life, while having a responsibility that improves the quality of other community member's lives. Following the CHOICE structure will enable the community to reach full potential in productivity and happiness.

7. Recreation improvement:

With the community reaching self-sufficiency in all resources, optimization of the recreation opportunity spectrum can be the final step in making Summerhaven a community self-sufficient. Making the surrounding forest areas desirable for recreation in all seasons and activities will ensure visitor activity in Summerhaven. The more people coming up the mountain to reach beautiful trails, peace and quiet, and cool weather, the more people will be stopping in Summerhaven before or after their recreation trips. This influx of people provides quality economic possibilities from restaurants to recreation equipment rental and sales, and lodging for those who want to extend the trip to more than one day. Recreation opportunity improvements can involve making trailheads easier to access with clearer entrance ports, having businesses come in to lead guided tours and enable visitor participation in recreation, and developing new ways to access and enjoy the mountain.

Conclusion

Mountain communities have all the resources needed to be self-sufficient. Autonomy comes from forward thinking and community buy-in to a highly efficient lifestyle. The mountains may be a difficult medium to build and live on, but that doesn't meant it shouldn't be considered. Many mountain communities have the resource potential that Summerhaven has, and while they all will be different, with specific analysis of the given area, development toward self-sufficiency can be achieved. Cost will be a limiting factor for most of the communities looking to become more self-sufficient, but patient development starting with the easiest and most controllable resources can be made through small steps reaching toward sustainability. For a community with a budget, some of the low-cost self sufficiency strategies can be employed, such as improving landscape health, making food a more important and easier to get resource, and creating a social environment conducive to a highly productive community. In communities that have some of the basics of self sufficiency in place and the available money, higher cost strategies such as varied renewable energy development, infrastructure improvement, and energy-efficient building investment should be considered.

Limitations

Each mountain community is different. One solution for the community of Summerhaven may not work whatsoever in another mountain community. With each solution outlined, basic ideals were laid out with limited engineering and cost analysis, leaving the possibility of the solution to not be viable either economically or technology wise. The mountain is a much more complex system than just looking at ten different resource categories. While the study of making mountain communities self-sufficient is based around the ten categories, the mountain has many more variables that can affect the resource availability.

Recommendations

Future data, observation, and analysis need to occur across the board for mountain resources. The further the understanding of mountain resources, the more effectively can those resources be managed for the benefit of the natural environment and the communities surrounding. If more people will go to the mountains, more will be understood about them and the information gained can be shared. Further research on the mountains, in diverse mountain locations, and further specialized professionals doing the research will only make the it easier to make mountain communities self-sufficient in the future.

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