

Reviving the Past to Feed the Present: Re-Introducing Sustainable Meat Sources in the Virginia Highlands and Other Temperate Mountain Regions Globally

Elizabeth C. Hirschman*, Mackenzie Holden, Morgan Miller, Taryn Moreno, Ian Mullins,
Michael Rogers, Houston Sarvis

Department of Business and Economics, University of Virginia-Wise, Wise, VA, USA

Email: *Eh9b@virginia.edu, elizabeth524@aol.com

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Abstract

This research puts forward an agroforestry plan to re-introduce white-tailed deer, elk and mountain bison game animals, along with silviculture-raised cattle, sheep, pigs and chickens, as sustainable meat sources for Climate Change Haven Communities in the Virginia Highlands. The model should be applicable throughout Appalachia and other temperate mountainous regions in North America, Europe and Asia.

Keywords

Sustainable Meat Sources, Climate Change Haven Communities, Virginia Highlands, Bison, Elk, White-Tailed Deer, Agroforestry, Silviculture

1. Introduction

Most Americans are devoted meat consumers, eating an average of 270 pounds of meat per year. Unfortunately, the majority of this meat is produced by factory farming methods which have been identified as large-scale contributors to climate change, as well as using animal-raising techniques which are inhumane [1]-[4].

The present study proposes the introduction of meat production methods consistent with agroforestry-silvopasture practices which will provide meat sources to persons living in mountainous, temperate areas of the planet that are both sustainable and cruelty-free. The research uses as a case example the area in the Ap-

*Corresponding author.

palachian Mountains called the Virginia Highlands. **Figure 1** below depicts the Virginia Highlands Region which is the brown, striated area. Efforts are now underway to transfer approximately 2,000,000 Americans living in climate-endangered areas of the country to Climate Change Haven Communities in the 39 counties of the Virginia Highlands [5]. However, prior to their arrival an agricultural plan must be developed that will enable these American migrants to continue to consume meat in an eco-sustainable way.

Virginia

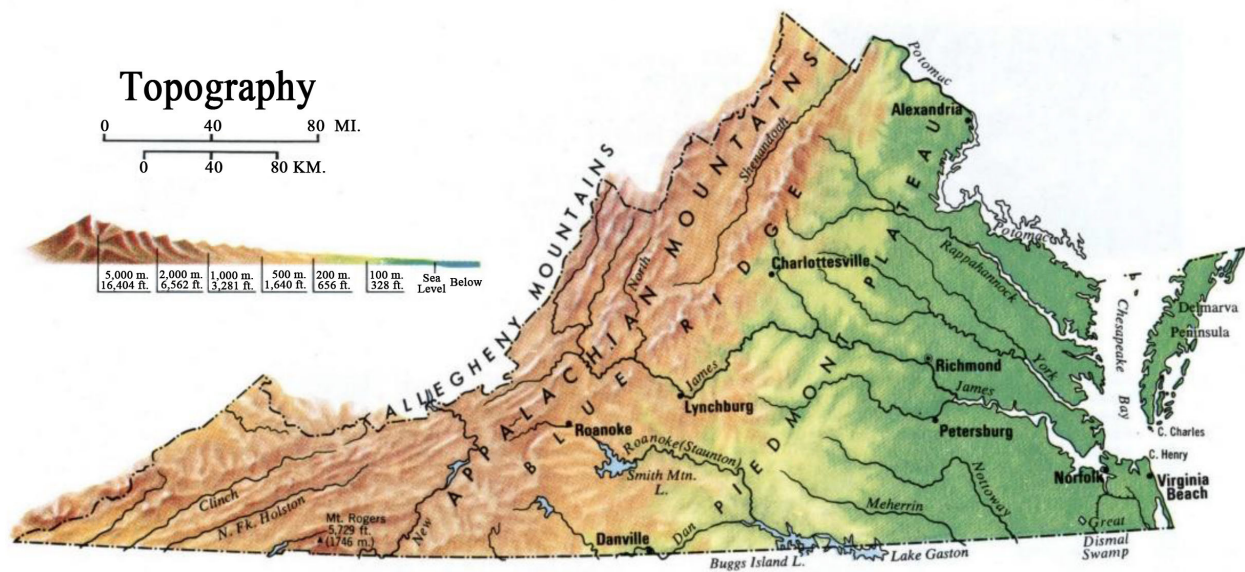


Figure 1. The Virginia Highlands Region in the US state of Virginia.

In the early days of European colonization in Virginia, settlers had access to three important animal species that provided much of their meat. These were the elk, mountain buffalo and white-tailed deer. However, as the inflow of colonists grew larger from the 1600s to 1800s, the numbers of these animals dwindled. By 1790 the elk had been eliminated; the mountain buffalo were gone by 1854, and the white-tailed deer population had been dramatically reduced [6].

During the following time period, American agriculture evolved to embrace the use of factory farming techniques which supplied large quantities of beef, pork and chicken to consumers, but at a great cost not only to animal welfare, but also the climate [7]. In particular, the grain-fed beef produced this way is highly fatty, laced with hormones and antibiotics, and may be tainted with *Escherichia coli* bacteria as shown in **Figure 2** below.

White-tailed deer, elk and mountain bison are all nutritionally superior to corn-fed cattle which are currently the primary red meat source now consumed by most Americans. Further, these three species are able to subsist easily in a “wild” state by grazing on forested mountain land, valley grasses and shrubs [8]-[11].

Beef's Nutritional Ledger		
	Grain-Fed Beef	Grass-Fed Beef
Added Hormones	Usually	No
Fed Antibiotics	Usually	No
Fed Grain	Yes	No
Omega-3 Fatty Acids	0.10	1.22
Omega-6 Fatty Acids	3.10	1.08
CLA	0.21	1.46
Beta Carotene	41.00	87.00
Vitamin E	1.30	5.30
Vitamin A	10.00	52.00
Total Fat	High & Saturated	Perfect Balance
Flavor	Bland/Pasty	Original & Bold
All Other Factor	Fair	Perfect
E. Coli Risk	Present	Not Likely

Figure 2. Corn and grain fed beef nutritional content.

This is termed silvopasture; “silvopasture is an interactive system that integrates forage, livestock, and trees into one system where the components are intentionally selected to enhance each other” [12]. By combining the re-introduction of these three wild species with the adoption of silvopasture systems for regional stocks of beef, pigs, sheep and chickens, an environmentally-sound and nutritious source of meat can be provided to the climate migrants now entering the Virginia Highlands Region. The pictures in **Figure 3** and **Figure 4** below show Mountain Bison and Elk. The chart in **Figure 5** below gives the nutritional values of elk and bison as compared to grass-fed beef. Deer meat is very comparable to that of elk, as they are in the same species group.



Figure 3. Mountain bison.



Figure 4. Elk.

GROUND BURGER 4 OZ. SERVING	ELK	grass-fed organic BEEF	BISON
CALORIES	190	240	200
CALORIES FROM FAT	90	150	100
TOTAL FAT	10g (15%)	17g (26%)	11g (17%)
SAT. FAT	4g (19%)	7g (33%)	4.5g (24%)
CHOLESTEROL	75mg (25%)	75mg (25%)	80mg (26%)
SODIUM	90mg (4%)	75mg (3%)	65mg (3%)
PROTEIN	24g	21g	22g
VITAMIN A	0%	0%	0g
VITAMIN C	0%	0%	0g
CALCIUM	0%	0%	0g
IRON	15%	15%	15%

Figure 5. Nutritional comparison of elk, bison and grass-fed beef.

Thus, the most eco-sustainable breeds for providing red meat dietary supplies for the Virginia Highlands Region are elk, mountain bison, and white-tailed deer together with grass-fed/silvopasture cattle. In the Virginia Highlands Region these will be provided by enlarging existing stocks of Hereford, Black Angus and Charolais cattle breeds. Images of these three breeds are shown below in **Figures 6-8** below. These breeds are suitable for silvopasture grazing using the wooden fencing shown in **Figure 7** [13]. Details for constructing eco-sustainable fencing systems for elk, white-tailed deer and mountain bison are obtainable from the US Department of Agriculture [14].



Figure 6. Hereford cow in silvopasture setting.



Figure 7. Angus cow. Note the wooden fence enclosure.



Figure 8. Charolais cow and calf in silvopasture setting.

2. Raising Deer, Elk and Mountain Bison in a Fenced Ranch Setting

The discussion below takes a closer, more detailed look at introducing deer, elk and mountain bison in silvoculture ranches to the Virginia Highlands. Understanding the behavior of each species is key to using them as an effective food source for Climate Change Haven Communities. A detailed discussion of the silvoculture grazing requirements for these species is available from the US Department of Agriculture [14].

2.1. White-Tail Deer Ranching

White-tail deer ranching is already well-established in the Northwestern and Mid-western parts of the United States [15] [16]. The North American Deer Farmers Association publishes a list of breeding stock animals for sale, along with detailed guidance for raising deer and selling deer meat [16]. The benefits of raising deer for the rancher are that the animals mature quickly and begin reproducing in two years. Their reproductive life can last 20 years, and a lucrative market for deer by-products such as antlers and hides is already present in the US. Thus, their increased presence in the Virginia Highlands should be beneficial both for incoming American migrants and for the farmers who engage in deer ranching.

Deer are natural foragers and do very well in silvoculture environments; they consume a variety of grasses, bushes, and weeds. Because of their intensive grazing habits, it is important to rotate the deer herd across three or more pastures per year; this gives the grazed area a chance to recover its vegetation. During colder weather, the deer need to be provided with hay and/or grain to maintain their weight. They should also be provided with a sturdy, three-sided shelter for cold or rainy weather. A photograph of a deer shelter is shown below in **Figure 9**.



Figure 9. Deer shelter.

Deer do best in herds of 30 or more animals; this helps them create a sense of community. Females and their young usually group themselves together, while the males form their own separate group. Fencing for deer herds must be a minimum of eight feet high and made of heavy grade wire. Wooden corner posts should be used to support the fencing and need to be at least 5 inches in diameter and set into the ground at least 3 feet deep. It is also useful to place canvas along the fence line to prevent the deer from searching for potential predators. This also helps prevent predators from seeing the deer [15].

Deer prefer to live and graze on high, mountainous terrain, making them an ideal food species for the Climate Change Haven Communities in Appalachia [15]. **Figure 10** below shows deer in a fenced silviculture setting.



Figure 10. Deer in a silviculture ranch setting.

2.2. Elk Ranching

Elk (Wapiti) are the largest members of the deer family in North America. Once an abundant game species throughout Appalachia, they were hunted to extinction by the 1800s [11]. However, over the past 50 years there has been a resurgence of commercial elk ranching, especially in the western US. Elk prefer temperate weather and have proven to be quite content in a silviculture ranch environment. Thus, it should not be difficult to establish domesticated elk herds suitable as food sources for the Climate Change Haven Communities in the Virginia Highlands Region.

Elk become sexually mature at 15 - 27 months of age. Adult males weigh between 420 - 600 kg, while females range from 220 - 320 kg. Breeding stock is available from the ranches associated with the North American Elk Breeders Association, which covers both the United States and Canada [11]. The grazing requirements of elk are much more eco-sustainable than those of cattle. The acreage required for one grazing cow will support three female elk [11].

In addition, elk are accustomed to agroforestry settings in which meadows are interspersed with forests and do not require additional medical or nutritional supplements, because this is their natural habitat [11]. Adult elk herds need to have an exterior fence of at least 8 feet; welded wire with deep wooden posts is the recommended fencing system. Fortunately, once they are accustomed to their fenced range and supplied with fresh water and weather shelters, elk are usually content and do not often attempt to escape their pastures [11]. **Figure 11** below shows an adult male elk in an appropriately-fenced silviculture pasture.



Figure 11. Adult male elk in an appropriately fenced silviculture pasture.

2.3. Bison Farming

It is truly one of the great ironies of American history that at the outset of the 1800s, there were an estimated 60,000,000 bison in the country. But by the mid to late 1800s the number of bison had plummeted to only 20,000 remaining animals due to over-

hunting and the expansion of American cattle ranches across the Midwest and Northwest regions of the country [17]. Fortunately, by the early 1900s US conservation groups began efforts to restore this species which had become celebrated in American folklore as symbols of the “taming of the west” [18]. The bison, much like the American Indians shown in **Figure 12** below are symbolic also of the tragic consequences of “modern civilization” and “industrialization” [19].



Figure 12. Indigenous Americans hunted buffalo/bison using only bows, arrows and spears.

Bison are well-suited for a silvoculture setting. They eat a variety of wild grasses, weeds and forbs. They are resistant to heat and drought and their shaggy winter coats protect them from extremely cold temperatures. Once provided with a suitable area in which to graze, they seldom try to escape [16].

Bison are “roamers” and require a large grazing area. This area should be enclosed using wire fencing at least 6 feet high. The females can produce calves at the age of two years and continue reproducing into their twenties. It is recommended that herd size be 30 bison or above in order to give the animals a sense of safety [16]. **Figure 13** below shows a bison herd in a silvopasture setting.



Figure 13. Bison grazing in a silvoculture setting.

2.4. Eliminating Predators from Climate Change Haven Community Food Sources

Because human populations residing in Climate Change Haven Communities throughout the Virginia Highlands will be depending primarily on locally-grown sources of meat, it is necessary to prevent wild predators from entering the silviculture-agroforestry game and cattle ranches. Wolves, cougars and coyotes can be kept out of the grazing areas surrounding each Climate Change Haven Community using methods recommended by the US Department of Agriculture [20].

2.5. Monitoring for Chronic Wasting Disease

Chronic Wasting Disease (CWD) is a transmissible form of spongiform encephalopathy (TSE) causing neurologic disease in mule deer, white-tailed deer, elk, and moose. It is caused by an infectious prion. CWD is fatal in all cases.

Clinical signs of CWD include decreased control of body movements and wide-based stances, head tremors, or carrying the head and ears lowered. Affected animals may walk in repetitive courses, sleep for excessively long periods of time, or be found near water sources or in riparian areas. Transmission occurs directly through contact with an infected animal or indirectly through contact with a contaminated environment. There are no treatments available [21]-[24]. Therefore, it is important that fences be well-maintained to prevent wild deer, elk and bison from entering the grazing areas of Climate Change Haven Community deer, elk and bison herds.

3. Additional Climate Change Haven Community Meat Sources

The greatly enlarged population of the Virginia Highlands will require additional domestic supplies of meat, as wild game and domestic cattle alone will be insufficient. Thus, additional stocks of sheep, pigs and chickens need to be added to existing farms in the Region. The most appropriate breeds of sheep, pigs and chickens for silvopasture farming in the Virginia Highlands Region are discussed below.

3.1. Sheep

There are seven sheep breeds which are currently accustomed to temperate climates and can be successfully raised as meat-providing animals in a silviculture environment. Each of these is discussed below. Existing stocks of some of these breeds are already present in the Virginia Highlands. These can be enlarged by increasing the amount of silviculture acreage. Local farmers will be asked to consider adding the additional sheep breeds discussed below as a way of diversifying their flocks. As the climate changes over the next decade, some breeds may prove to be more adaptive than others [25].

3.1.1. Dorper Sheep

Dorper sheep are a South African breed. They are thick and muscular with a black or white head and a white body. The mature rams grow to around 230 lbs, and

ewes average 180 - 210 lbs in live weight. They are harvestable in 8 - 9 months.

Figure 14 below shows Dorper sheep in a silvopasture setting [25].



Figure 14. Dorper sheep in silvopasture setting.

3.1.2. Katahdin Sheep

The Katahdin sheep is a medium sized American breed which has a hair coat. Katahdins don't need shearing, making them a low-maintenance breed. Adult rams grow to around 180 - 250 lbs and ewes range from 120 - 160 lbs. Their meat is naturally lean, fine-grained and has a mild flavor. They can be harvested in 6 - 9 months and provide 35 - 50 lbs of meat on average. Katahdins are disease resistant and cold-hardy, making them a good choice for Climate Change Haven Communities with colder winters [25]. **Figure 15** below shows a Katahdin sheep in a silvopasture setting.



Figure 15. Katahdin sheep in silvopasture setting.

3.1.3. Suffolk Sheep

Suffolk sheep, shown in **Figure 16** below, have white wool coats. Adult rams weigh from 250 to 350 lbs, while ewes range from 180 to 250 lbs. Suffolk lambs are fast-growing and produce high-quality meat at around 7 - 8 months of age. At the present time, American rural homesteaders and small farm owners often prefer raising Suffolks [25]. Thus, they should be a very good choice for Climate Change Haven Communities on a global basis.



Figure 16. Suffolk Sheep in silvopasture setting.

3.1.4. Texel Sheep

Texels have a short, white face with black noses; their heads and legs are hairless. Mature rams weigh 200 - 250 lbs, while ewes range from 140 to 175 lbs. Lambs are 55 lbs at weaning (12 weeks) and ready for processing 24 weeks, weighing around 95 lbs [25]. They are known for lean, tender meat. **Figure 17** below shows a Texel sheep in a silvopasture setting.



Figure 17. Texel sheep in silvopasture setting.

3.1.5. Hampshire Sheep

Hampshire sheep originated in Southern England. They are a large, stocky breed with white wool and dark faces, ears, and legs. Mature rams will weigh around 175 lbs. The lambs mature early and produce quality meat at a weight of 45 - 55 lbs [25]. These sheep are easy to breed and produce healthy lambs, making them ideal for Climate Change Haven Community agriculture. **Figure 18** below shows Hampshire sheep in a silvopasture setting.



Figure 18. Hampshire sheep in a silvopasture setting.

3.2. Pigs

In this section the best breeds of pigs for silvoculture are discussed. Each of these breeds should be suitable as a meat source in global Climate Change Haven Com-

munity settings within temperate climate zones [26].

3.3. Tamworth

Tamworth pigs are recognizable by the red or golden red color of their skin. They are excellent foragers and protective mothers, making them strong choices for silvopasture agriculture. Tamworth meat is considered to be among the tastiest pork [26]. **Figure 19** below shows a Tamworth pig in a silviculture setting.



Figure 19. Tamworth pig foraging in a forest.

3.4. Berkshire

Berkshire hogs, shown in **Figure 20** below, are a heritage breed originating in England. Their meat is darker than most pork often served in high-end restaurants [26] (23). This characteristic makes them a strong candidate for farmers in Climate Change Haven Communities who desire to sell their meat at a good profit.



Figure 20. Berkshire sow with piglets in silviculture setting.

3.5. Mangalitsa

Mangalitsas are unusual looking pigs (see **Figure 21** below). They originated in Hungary, almost became extinct, but were revived by Spanish farmers. The meat they produce is of very high quality. This breed is cold hardy and also excellent at foraging, making them a strong choice for global Climate Change Haven Com-

munities in temperate regions [26].



Figure 21. Mangalita pigs in a silviculture setting.

3.6. Red Wattle

Red Wattle pigs, shown in **Figure 22** below, are a large breed originally developed in Texas. The breed had been put on the Livestock Conservancy listing, although current climate change trends show it returning to popularity. Homesteaders prefer the Red Wattle hog for its docile temperament, lean meat, and good mothering traits [24]. It would be a strong choice for global pork production in temperate zone Climate Change Haven Communities.

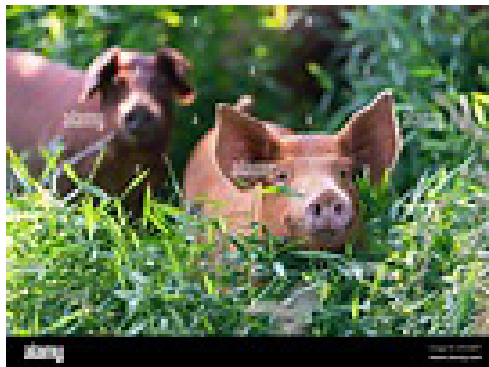


Figure 22. Red Wattle pigs in a silviculture setting.

3.7. Hampshires

Hampshires pigs are a common breed on American farms due to their climate hardiness and lean meat. They do well in silviculture settings and are often used as a cross-breed to increase size in other pig breeds [26]. **Figure 23** below shows a Hampshire pig.



Figure 23. Hampshire pig in fenced meadow.

Bottom of Form

Because most hogs are natural foragers, transitioning them from a fenced barnyard shown in **Figure 23**, to a silvopasture setting is an easy transition. All pig herds should be rotated across multiple fields over the course of a year to enable the foraged fields to recover their biological diversity [26]. They are capable of providing a reliable, nutritious and low-maintenance meat source for global Climate Change Haven Communities.

3.8. Chickens

The best chicken breeds for silvoculture in Climate Change Haven Communities are described below. The material for this section is adapted from the Livestock Conservancy [27].

3.9. Sussex

The Sussex chicken shown above in **Figure 24** is both docile and friendly. This breed is an excellent choice for Climate Change Haven Communities, because it produces both eggs and meat, while eating a low-cost, foraged diet [27].



Figure 24. Free range Sussex chicken.

3.10. Welsummer

Welsummer chickens shown below in **Figure 25**, are good foragers and prefer being in a silvoculture setting. They can provide both eggs and meat [27]. Thus,

they are an excellent choice for the global temperate zone Climate Change Havens.



Figure 25. Welssummer chickens in silviculture.

3.11. Buckeye

The Buckeye chicken breed shown below in **Figure 26** is another excellent choice for Climate Change Haven Communities globally. They are heat and cold tolerant, produce large numbers of eggs and have high protein meat. They prefer silviculture environments [27].



Figure 26. Buckeye chicken in silvopasture setting.

3.12. Leghorn



Figure 27. Leghorn chicken.

The Leghorn chicken shown above in **Figure 27** is useful as an egg-layer. They are climate adaptable and excellent foragers in silviculture settings [27].

Other recommended chicken breeds for use in global Climate Change Haven Communities in temperate climates include the Plymouth Rock, Rhode Island Red, Wyandotte and Ancona [28] [29].

4. Extending Silviculture Food Sources to Europe and Asia

The foregoing discussion focused primarily upon developing silviculture food animal resources in North America. The same model will be applicable in mountainous, temperate zone regions of Europe and Asia, as well. Suggestions for appropriate animal species in these two locations are discussed below.

4.1. Europe

Figure 28 below depicts the primary animals now used for meat production in Europe. As can be seen, these are predominately the same species used in North America, with a small population of goats present in the southern Baltic Region. Thus, the previous discussion of silviculture requirements for these animals should be applicable with a predominant emphasis placed on the temperate mountainous areas of the European Region. Importantly, several of the southernmost areas of Europe are now becoming too hot and dry to support the animals being raised there. [30] [31]. Efforts will need to be made as soon as possible to move these endangered animals to temperate mountainous areas of the EU which can provide more sustainable climates. Once moved, the animals will need to be placed in forested, silviculture pastures.

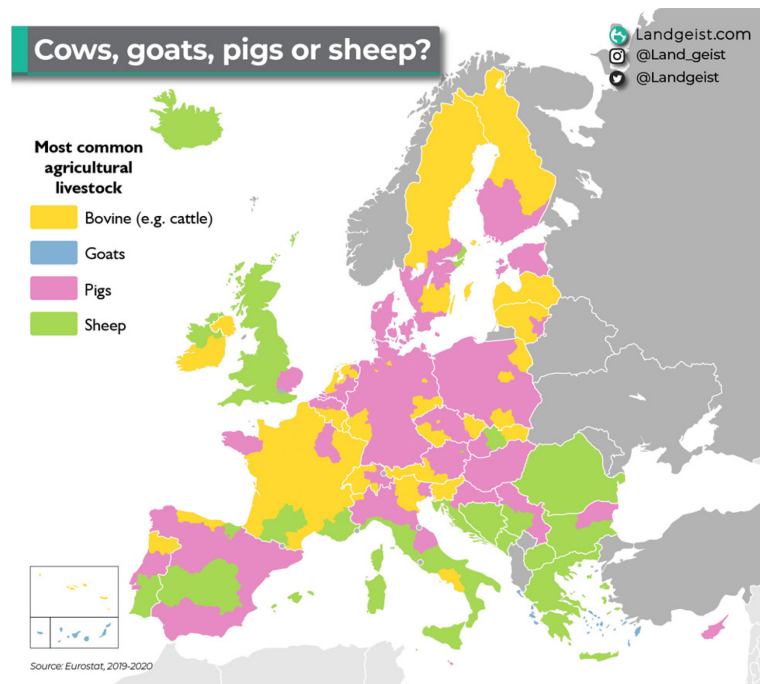


Figure 28. Current domesticated food animal species in Europe.

The European Union is currently re-formulating its requirements on internal livestock transfers [32] [33]. This effort should include permitting the transfer of domestic livestock from climate-endangered areas of southern Europe, e.g., Spain, Italy, to agriculturalists in the temperate regions of the European Union, e.g., Austria, Germany, with some form of credits provided to the southern EU countries transferring animals. These “transfer credits” would allow the southern EU “donor” countries to purchase meat at reduced prices over the next 3 to 5 years, which would allow their populations more time to prepare for their own transfer to less climate-endangered areas of the EU. Otherwise, the temperate regions of the EU may be overwhelmed economically by the large-scale arrival of both people and farm animals from the south.

There are also several European wild animal species comparable to the North American elk, bison and deer discussed earlier. These are presented below and can serve as silvoculture meat sources in a ranch setting.



Figure 29. European buffalo/bison.

4.2. European Bison/Buffalo

The European bison/buffalo shown above in **Figure 29** is native to most of the EU countries. After facing near extinction (like its North American cousin), it has been brought back by conservationists. This European species is an ideal candidate for agro-forestry/silvoculture ranching, because it is very cold hardy and prefers forest grazing environments. There are now adequate stocks available to permit rapid enlargement of their numbers [34].

4.3. European Elk

The European elk habitat ranges across the northern and eastern parts of Europe, including Norway, Sweden, Finland, and Russia. These elk are native to boreal forests, tundra, and colder mountainous regions. They require abundant vegetation and access to fresh water, which are readily available in Northern and Central Europe. Thus, elk should be strong candidates as alternative meat sources for European Union populations [35]. Existing elk herds can be quickly enlarged in numbers using silvoculture methods. However, adequate fencing will be required to contain the herds, as they are athletic jumpers [36]. Elk meat is highly nutritious and an excellent source of protein [37]. **Figure 30** below shows a European elk in

a silviculture pasture.



Figure 30. European elk in a silviculture setting. Note the high fence behind the elk.

4.4. European Deer Species

There are three species of European deer that are appropriate for silviculture settings as food animals. They are discussed below, along with accompanying images [38].

Red Deer are the largest European deer species, with mature stags weighing over 200 kg and reaching 130 cm at the shoulder. Their coat is reddish-brown in summer and greyish-brown in winter to provide camouflage from predators. These deer prefer grassy meadows for grazing. Red deer are already prevalent across the entire European Region; thus, they would be an excellent candidate for large-scale, fenced silviculture ranching. Since southern Europe now faces increasing heat waves and drought, their current red deer herds should be shifted farther north as soon as possible and placed on silviculture ranches. An image of red deer in a silviculture setting is provided in **Figure 31** below.



Figure 31. European red deer in a silviculture setting.

Roe Deer are a smaller species, weighing between 15 - 30 kg and standing 60 - 75 cm at the shoulder. Their summer coat is a bright reddish-brown, fading to grey-brown in winter. As with the red deer above, this coat color change provides camouflage against predators. The males grow short, upright antlers with three points. Roe deer prefer mixed woodlands, forests, and agricultural areas with good cover, and are found throughout most of Europe. As with the red deer, they are very strong candidates as sustainable food sources (**Figure 32**).



Figure 32. Roe deer in a silviculture pasture.

Fallow Deer have a coat that is light brown with white spots in summer. They weigh around 40 - 100 kg and stand 80 - 100 cm tall as adults. Fallow deer are found in deciduous and mixed woodlands; they are often found in public parks and on estates due to historical introductions. Fallow deer populations are currently present across central and southern Europe. As with the two other deer species discussed, this species would be a very viable food source in a silviculture ranch setting. A fallow deer buck is shown below in **Figure 33**.



Figure 33. Fallow deer in a silviculture setting.

4.5. Meat Consumption by Species in Asia

Meat consumption by animal species varies widely across Asia. For present purposes, China is used as the model, since it has the largest population in the region and the most current statistics. As the chart in **Figure 34** below indicates, per capita meat consumption in China has increased at a rapid rate over the last 20 years [39].

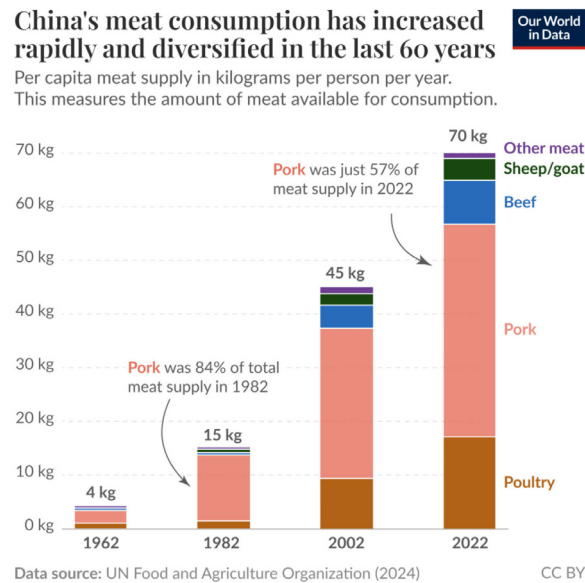


Figure 34. China's meat consumption per capita from 1962 to 2022.

There are also some trends visible in meat preferences over this time period. Pork remains the predominate Chinese meat source; however, beef has increased in preference and sheep/goat meat consumption has also increased. Notably, the consumption of meat has grown as the country has become more prosperous and consumers are able to afford more meat in their diet. This is shown in **Figure 35** below.

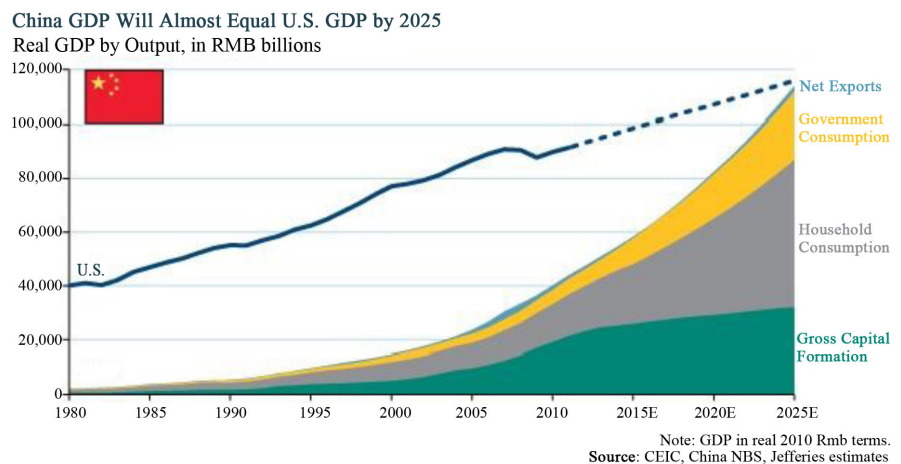


Figure 35. Growth rate of Chinese economy.

Importantly for present purposes, China began a reforestation program in 1978 which is intended to transform 88 million acres of desert into a forest [40]-[42]. This program will enable the country to make widespread use of agroforestry/silviculture for its existing food animal sources e.g., pork, beef.

It also means that China will be able to add wild species of food animals to its meat sources by creating ranches which fence herds within silviculture pastures. The meat from these wild species is substantially healthier for human diets than the traditional meat sources. Each species is discussed below.

4.6. Deer

There are several deer species native to China; they include the Red deer, Pere David's deer, Sika deer, Water deer, Roe deer and Musk deer. An image of a Red deer herd is shown below in **Figure 36**.



Figure 36. Chinese Red deer in a silviculture setting.

Some of the Chinese deer species are very small in size, while others are quite rare. These species would not be suitable as food sources. However, Chinese Red deer, discussed earlier with regard to Europe, and shown above in **Figure 36**, would be appropriate for ranching using the same fencing types required in North America and Europe.

4.7. Elk

Elk similar to those in North America and Europe were re-introduced to China in 1986 [41]. They have now increased in numbers to 8,502 in 2025, including 3,673 living in the wild. Thus, it would be desirable for China to systematically increase their elk population over the next decade in order to provide the country with another viable food source. As discussed earlier in the present study, elk is nutritionally superior to beef and would be a desirable addition to the Chinese population's diet. Below in **Figure 37** is a photograph of a Chinese elk in a silviculture setting.



Figure 37. Chinese elk in a silvoculture pasture.

4.8. Asian Guar

There are no animals analogous to the European and North American bison discussed earlier as silvoculture food sources. However, there is an Asian animal in the bovine family termed the guar, which is pictured below in **Figure 38**. Guar are the largest bovine animals on Earth; they once roamed across much of south Asia including portions of China, such as Xizang. The domesticated types of guar are called Gayals and, importantly for the present purposes, they are comfortable dwelling in forested hills, grassy clearings and mountains up to 5905 feet high [42].



Figure 38. Domesticated guar in a silvoculture setting.

5. Discussion

Industrial agriculture, which presently produces the majority of the food supply in the United States and globally, was first introduced during the advent of the

Industrial Revolution in the late 1800s [43]. The use of petroleum-powered machines to plow fields and harvest crops now is the most widely used means of agricultural production across the globe.

Accompanying the mechanization of agriculture has been the widespread application of chemically-produced pesticides, herbicides, insecticides and fertilizers, all of which are now in use across the world. This practice has provided food to billions of humans [44], but at an extraordinary cost in damage to the environment and ultimately to human life, as well. Additionally, the mechanization of agriculture has displaced generations of family farmers both in the United States and globally.

As a result, we are now confronted by a likely permanent shift in the global climate which, www.who.int/news-room/questions-and-answers/item/). The tropical, semi-arid and arid regions of the planet are becoming unable to produce adequate food for their human populations, due to the increase in temperatures and the lack of water for irrigating crops and animals [45].

While there will be some agricultural gain from warmer growing seasons in the far Northern portions of the earth, the meat animals in these Northern Regions will be under increased stress during the winter months due to the increasing frequency of Northern Polar Vortex intrusions. These animals will require shelters in order to survive severe winters, or ranchers will face very heavy livestock losses [46] [47]

The areas of the Northern Hemisphere that now appear to be the most viable as food production sites are those located in temperate and/or subtropical regions, preferably with mountainous terrain. The mountains will help ameliorate the destructive effects of anticipated heavier rain and snow precipitation, as well as severe wind storms. A map of these areas is shown below in **Figure 39**.



Figure 39. Map of temperate mountainous areas.

The present research suggests that the best response to this scenario is a global transition from industrial agriculture methods to those of agroforestry and silviculture. The breeds of meat animals discussed in this study, as well as the use of agroforestry/silviculture, should be generally transferable to other mountainous

temperate zones globally [46]-[48].

A second global action suggested by the present study is the purposeful reforestation of as much temperate zone land as possible on a global basis. This can be accomplished by immediately beginning reforestation of those areas earlier cleared for industrial agriculture [49] [50]. China has been a world-leader in undertaking reforestation. “These projects have played a key role in reducing dust storms, improving air quality and enhancing regional biodiversity. At present, China has completed the ecological restoration of more than 5 million hectares of land in 2024” [51]. These efforts have led to habitat expansion for several important food species and are successfully reducing the risk of climate change damage to current crops [52].

The map below in **Figure 40** shows the global areas in which reforestation is still possible in terms of current climate conditions. These areas are western Canada, the eastern United States, Colombia, Brazil, and areas of Central Europe [53]. If reforestation efforts are begun now, humans forced to migrate due to climate change will have viable options for continuing their lives in safe and climate-secure places.

In a very genuine sense, all humans (and plants and animals) on the planet are now “in this together”. There is no “new world” we can venture to where things will be better, safer, or happier than the one we are presently occupying. Fortunately, there are solutions, but they must be implemented now, not “sometime tomorrow”.

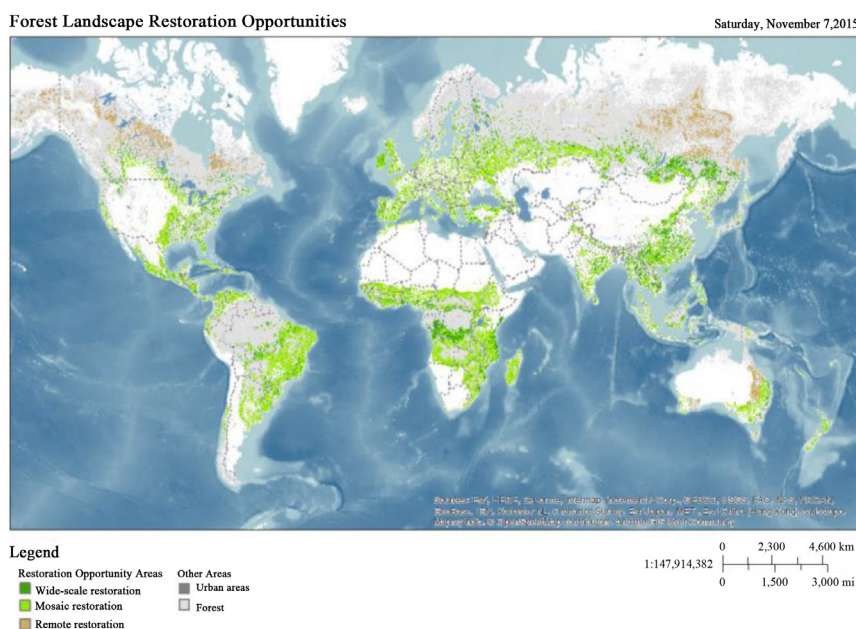


Figure 40. Areas of Earth available for reforestation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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