

**Integrating Ducks Into Log-grown Shiitake Mushroom Production for
Slug Control and Added Yields**
2012 – 2014

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Grant Documents can be accessed at:

<http://mysare.sare.org/mySARE/ProjectReport.aspx?do=viewProj&pn=FNE12-745>

Abstract

Log-grown shiitake mushrooms are a growing interest of many Northeast Farmers. Barriers to entering the market include the labor-intensive process, frequent slug problems, and that laying yards are situated in woodland areas, often far from normal farm routines.

Integration of meat ducks into the mushroom laying yard brings more yields for the farmer on a single trip, promotes effective slug control, and better utilizes forest ecosystems in the farm landscape. Ducks are an under appreciated farm asset with potential to sustainably manage pests while providing high-quality products for market. Little research has been done to demonstrate the potential of integrated duck farming in the Northeast.

SARE grant funds supported bringing 50 ducks into a 700-log commercial operation in 2012 and 2013, where efforts were focused on breed selection for temperament, foraging ability, and weight gain. In 2013, the operation increased to 1000 logs and the project focused on optimizing the system efficiency, forest improvement and profit. Throughout both seasons the mushroom yard, duck population, and forest ecosystem were monitored for health and productivity.

Key Findings:

- 1) Ducks can likely provide a level of pest control *throughout* the farm (including forests, fields, and gardens) and if rotated, do not appear to have adverse effects on the farm landscape.
- 2) Only one of the four breeds of duck we raised (Muscovy) gains sufficient weight to make a profit. A duck would need to get to at least 8 lbs in a season to make it economical under our model. 150 - 400 ducks would need to be raised per season to be economically viable.
- 3) Integrating ducks into the mushroom yard did appear to have a positive effect on reducing slug populations and thus mushroom damage, though the mix of variables (weather, temperatures, labor, etc) made it difficult to collect good data on the dynamics at play.

PART I: INTRODUCTION

Before moving to the land where Wellspring Forest Farm is located, we got ducks because we wanted to supply or own eggs, but after raising chickens for years and not enjoying it that much, thought we would try something new. Also, many of our neighbors and friends raise chickens and we thought duck eggs could be a nice change/addition. It turned out that this happenstance decision led to a relationship we never expected.

That first season we bought a half dozen ducks (the NY State minimum of purchase) – 3 Indian Runners and 3 Khaki Campbell's, and constructed a simple house for them. We set up a pen in a wooded spot in the backyard of our rental house. Because the wooden area was close to the house and we would visit the ducks twice a day, we decided to place our 30 shiitake mushroom logs in the duck pen, soaking them weekly and harvesting enough mushrooms for personal use.

That season we made an exciting discovery; that our slug challenges with growing shiitakes were almost entirely gone! But it made perfect sense; slugs love eating perfectly ripe shiitake mushrooms, ducks love slugs – why not raise them in the same locale. Once we bought land and as we transferred the mushroom operation to our one-acre sugar maple grove (to be a small sugarbush) we became intrigued with the fact that a three-way relationship was emerging - a polyculture of a producer (sugar maple trees), consumer (ducks), and decomposer (mushrooms).

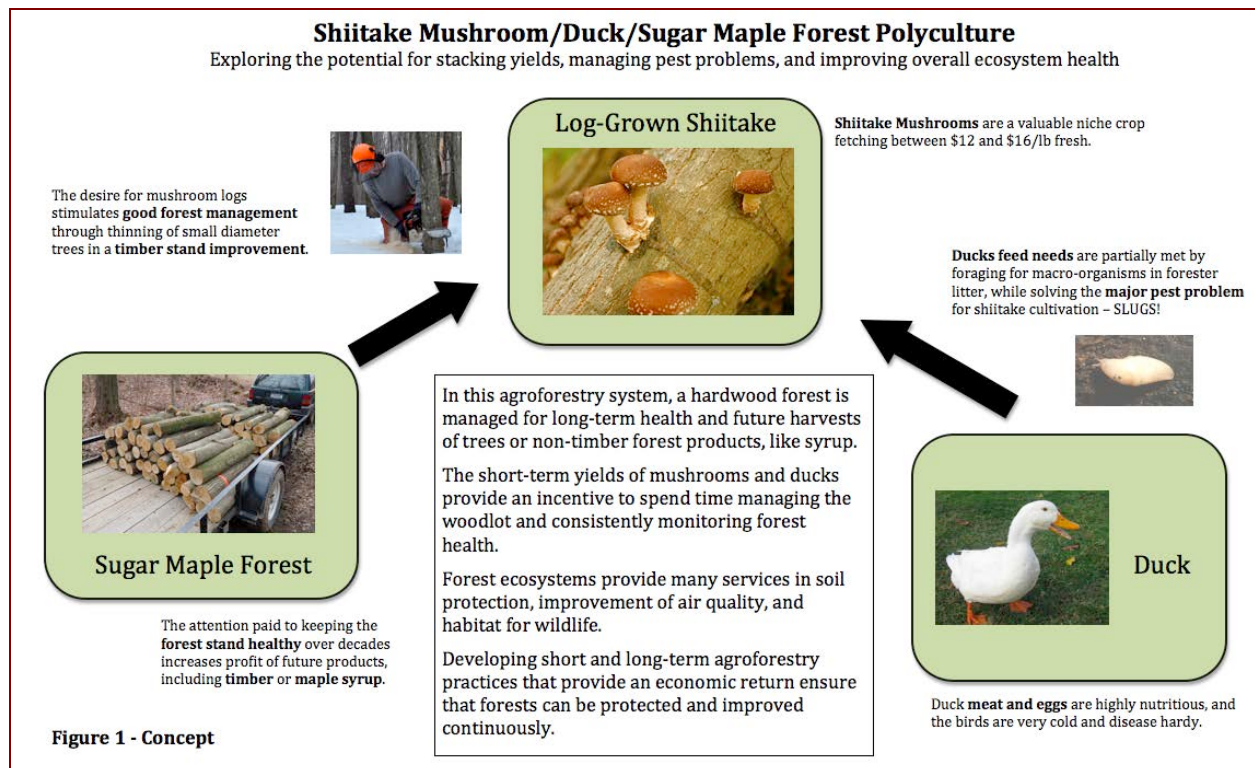


Figure 1: Concept for the forest polyculture, which emerged by “accident”

The Farmer Research grant from Northeast SARE was intended to help explore this polyculture relationship in a more thorough way. The project included raising 50 ducks of four varying breeds (Rouen, Muscovy, Cayuga, Swedish Blue) for two seasons and experimenting with rotating them around the mushroom yard to see if they would help with slug control and enhance the forest ecosystem.

The funding was critical as it enabled us to invest roughly \$5,000 into necessary fencing, materials, and ducklings even though there was a risk we would not make a profit from the enterprises. Additionally, funding enabled us to be compensated to take the time to collect and analyze observations and data, which are described in section 3, and document our experiences in a short pamphlet. Raising ducks is NOT like raising chickens, as many books and articles seem to suggest. Part one of this publication offers some basic information on ducks. Part two is more specific on raising ducks, our experience with breeds and care considerations. Part three summarizes the grant activities and research results.

This document is gathered from our experience at Wellspring Forest Farm after raising ducks for three seasons on a backyard and small commercial scale. It is not meant to be a complete reference for duck raising, but rather aims to serve as a guide for anybody interested in adding ducks to your landscape. The information we chose to include here are things that would have been helpful to us before getting started with ducks.

About Our Farm

Wellspring Forest Farm, in the Finger Lakes region of Upstate NY, about 10 miles west of Ithaca, NY (yellow pin on map) The farm is 10-acres, with about 6-acres of degraded pasture, 1-acre of maple woods, 2-acres of very wet mixed scrub forest, and some hedgerows. The farm is off-grid, with solar power performing the electricity functions and wood providing our heat. We do not currently have a well; we use rainwater collection for our home and either rainwater or pond water for our animals. We have had to ensure that all of our animal systems are adaptable to fit these resource limits.



Read more about the farm at: www.WellspringForestFarm.com

Philosophy

Wellspring Forest Farm approaches animal raising from the perspective that animals should be:

- Appropriate to land and stage of farm development
- Supportive of landscape health first and yields second
- Healthy and happy in their living environment
- Economical to maintain
- Easy to move through the use of portable housing and fencing
- Enjoyable to raise and work with

From this perspective, we've come to several conclusions with regards to ducks:

1. Ducks are an appropriate and positive addition to many contexts in the farm landscape including forest, pasture, vegetable plantings, and integrate well with other livestock.
2. Ducks offer valuable ecosystem services including manure high in phosphorous, natural pest control tendencies, and their ability to produce onsite food sources (eggs and meat).
3. Here in the Finger Lakes there is high demand for duck products, both meat and eggs. The number of animals needed to make a profit from these products makes duck unfeasible for a small-scale farm – assuming products are sold at reasonable and competitive market rates. *There is more detail on this in section three.*
4. 20 – 30 ducks is an optimal flock size. This size is feasible to house in easily portable housing, produce manageable amounts of manure, and does not overgraze an area too quickly. In addition, we have found this size flock is most enjoyable to work with.

Key Considerations for Raising Ducks

It is very surprising to us that more people don't raise ducks. We have found them to be significantly preferable to chickens for many reasons, as explained. Of course, chickens have a place in the farmscape and do offer several advantages over ducks, as well. The chart below offers some general observations of some of the differences between the two.



1. WATER - ducks need a lot!

Ducks root around in the ground looking for edibles, and since they have no useful teeth, they need to be able to submerge their heads into water and clean out their nostrils and beak. Our ducks appear happiest when they have access to, at a minimum, a 5-gallon tub/10 birds they can bathe in. Some texts explain that bathing is essential for the duck to clean their feathers so to enable their down to remain oily. In the summer, the oils keep them cool; in the winter, it keeps them warm. We usually use 5-gallon

tubs in the winter and switch to larger 10-gallon tubs in the summer, where water access from the pond is readily available.

2. FORAGING - ducks are really good at it

We have found that ducks are incredible foragers. Unlike chickens, which peck at things for hours and pre-digest food in a gullet before swallowing, ducks take their food whole. This is a VERY significant difference because it means that ducks can be used in agricultural situations as a pest control while the plants are growing (e.g. they LOVE slugs. Imagine, a garden without

slugs). Depending on the breed of duck and how often you rotate their grazing area, they



generally seem to be only tempted by tender greens and shoots of garden plants and not full size plants. This is a big difference to chickens as they are often useful to the garden at the beginning and end of the season, but never during, as they'll annihilate a garden in short order.

3. Character: BURROWING vs. TILL & SCRATCH

Probably our favorite aspect to ducks foraging technique is that they don't till and scratch like chickens do, but instead they borrow into the soil with their beaks. This means that while they can remove seeds and insects like chickens do, ducks do not turn over the soil. In our vegetable garden it appears that the burrowing promotes a healthy aeration of the soil, without destroying it's structure. This quality also means that ducks can be grazed in forested settings, since they do not destroy the leaf cover and understory. Of course, we realize there are times when we all need tilling and scratching in the landscape, but as a whole we have found that ducks fit nicer as a long-term resident on our homestead and chickens services seem more temporarily useful.

4. POOP

All animal waste that is not managed well will smell really bad. The 2 flocks of 50 ducks we had in 2012 and 2013, and our current flock of 20 ducks, poop enough to create a terrible and stinky mess if not managed properly. The same amount of chickens, cows, sheep, humans, etc. would produce the same problem. Three tips we've learned to keep smell down and better help us manage manure as a resource (our potatoes loved it!) are:

- 1) Keep bedding fresh
- 2) Leave water out of the duck house at night (except when they are young) to minimize water spillage inside
- 3) Move housing frequently

Duck poop is a highly nutritious resource (great source of phosphorus) and we use their manure filled straw for fertility on our farm. We mulch potatoes, garlic and trees directly with it after cleaning their house, and we sheet mulch as much of the vegetable garden as we can with this "waste" throughout October-April.

5. DISEASE & COLD TOLERANCE

Ducks are extremely disease and cold tolerant. We are not concerned with mites or foot rot as long as the bedding stays clean. Their down feathers provide excellent insulation and as such, their cold tolerance is very high. We observe our ducks bathing in their water tubs in all temperatures. Duck houses don't need to be insulated though should be designed to remain dry in blowing wind and snow conditions. We have read that most ducks can tolerate as low as -30 degrees Fahrenheit, though we have not found specific information on this statement with

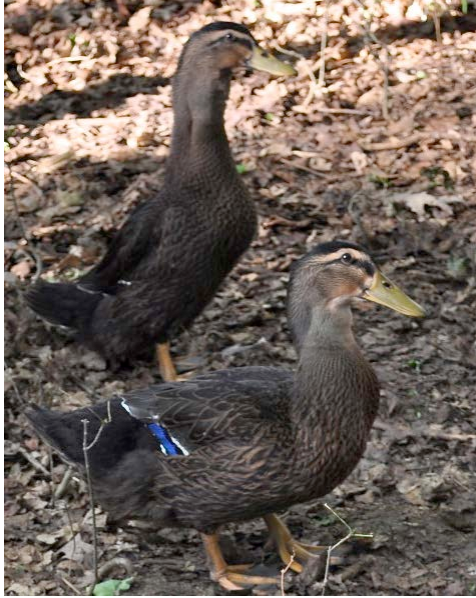
relation to breed or length of exposure. Of concern in cold weather is that their feet and legs do not freeze. This is another reason why fresh, dry bedding is important in their house.

Comparing Ducks and Chickens

The following chart offers some points of comparison between ducks and chickens:

Ducks	Chickens
Extremely cold hardy; ducks can thrive in cold conditions with minimal shelter; though some wind protection is recommended; can withstand some wet & wind	Moderate to good cold hardiness; depends on breed, age, size; need protection from wind and wet and insulation in the winter; too much exposure can be problematic
Few disease and general health problems	Can develop problems with mites, disease
Being waterfowl, they need consistent access to freshwater (>5 gals per 10 ducks per day)	Minimal water needed; dehydration can be a concern, especially in cold conditions.
Many breeds of ducks can forage for much of their diet in summer months; some resources claim that their entire diet could come from a landscape. Meat birds definitely need grain input.	Some breeds forage well, if given access to good pasture and “scratch”. Some supplemental grain likely needed, especially for meat birds.
Since they “burrow”, they can be rotated through many environments without damaging plant root systems; they can be raised in gardens if care is taken to fence off tender greens from being eaten.	Scratching tendencies mean that extra caution must be taken; best for establishment of new plantings and when following grazing animals; in the garden they are best in the beginning and/or end of a season
Vulnerable to predators. Guard goose recommended.	Some breeds excellent at evading predators; but overall vulnerable.
Less overall breeding leads to more variation among a breed; less breed choices out there.	Many breed options available; more breeding has been done also within some breeds
Housing should be shorter and wider: “nesting” tendency	Housing can be narrower and taller; “roosting” tendency
Tend to be noisy, except Muscovy	Besides roosters, are quiet
Some breeds lay eggs 300-330 days per year	Most egg-laying breeds are over 300 eggs per year.





Breeds

There are many breeds to choose from. We will discuss only the breeds we have direct experience with. In our experience, it is dangerous to make generalizations about breed performance because animals respond as much if not more to “nurture” (management) as much as “nature” (genetics). That said, some distinctions could be made when considering the appropriate breeds.

With regards to researching the significance of ducks on forest systems and mushroom production, the factors that were most important to us were:

1. Forage Tendencies

The central reason for the trial was to examine the role ducks play as biological control agents in perennial agroforestry systems and specifically, will ducks eat

enough slugs so to reduce slug damage on commercial shiitake production? A secondary consideration was that good foraging ducks would need less feed purchased from off-farm.

2. Pounds of Feed vs. Pounds of Meat

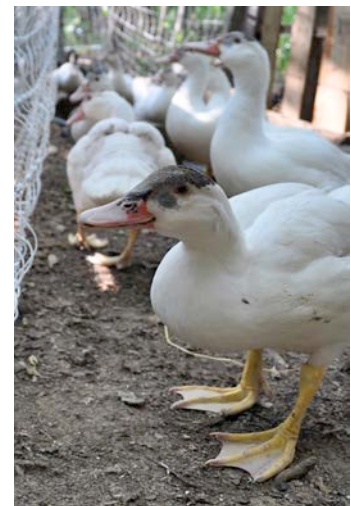
Rather than just focusing on the breeds that put on the most weight, we questioned more the efficiency of converting food to meat. Some books claim the heritage breeds can forage for almost all of their diet. These same breeds typically put on less weight however if that bird is able to get his/her food needs mostly through foraging, this benefits the ecosystem, provides an ecosystem service to our mushroom business, reduces our costs for feed and our reliance on outside imports.

3. Enjoyable to Work With

This category remains largely subjective but having raised animals we know there are variables in temperament, aesthetics, and even entertainment value. We also know we hold a slight bias toward the heritage breeds of ducks; in a time where our food system has nearly eliminated many animal species it feels important to try and play a role in maintaining agricultural biodiversity.

4. Taste & Flavor

As is common with many livestock, meat breeds often pack on more pounds, while heritage breeds have more complex and interesting flavors. To compare flavors, with the help of Cornell Cooperative Extension Meat Specialist, we concluded the first season with a duck tasting where local chefs prepared each breed in the same way and fellow duck farmers and restaurant owners ate and judged samples based on texture, appearance and flavor.



The chart below summarizes our experience by breed (*note, only four of these breeds were part of the SARE grant. The other details are from additional experience*):

Breed	Type	Behavior	Foraging	Meat Yield/Taste	Eggs	Notes
Rouen	Meat, Homestead	Docile, flocking	Excellent	Live weight 6 – 8 lbs after 5 months, meat is dark and savory	Moderate;	Plumage very similar to mallard; best as a homestead meat breed
Muscovy	Meat, Commercial	Males can be aggressive, independent	Fair	Very lean, best to harvest at 3.5 – 5 months, exceptional weight gain; males	Low	Not a true duck, quietest of all breeds, best (other than Pekin) for commercial meat
Khaki Campbell	Eggs, commercial	Docile, friendly, flocking, very cold hardy	Excellent	Too small for meat	Excellent; began laying at 5 months, almost daily	Began laying at 5 months,
Indian Runners	Eggs, homestead, maybe commercial (eggs)?	Skittish, flocking, erratic, cannot fly	Very Good	Too small for meat	Medium to good	upright, dignified look, “walking wine bottle”
Cayuga	Mixed, homestead, maybe	Docile, flocking, may have retained mothering instincts, very cold hardy	Excellent	Very good, dark, flavorful meat (small portions)	Moderate to good (won’t lay for 12 - 18 months)	history links to the local bioregion (Cayuga lake).
Swedish Blue	Mixed, homestead	Docile	Excellent	Very good, dark, flavorful meat (small portions)	Fair (no personal experience)	a beautiful mix of whites, greys, and blues.

With the exception of Muscovy, all the ducks mentioned are essentially bred originally from wild Mallard ducks. More notes on our experience with the various breeds will be found in section three of this document, which describes the research project. Of the 6 breeds we raised, we ultimately settled on a mixed flock of Khaki Campbell and Cayuga because we feel they balance our goals for pest control, foraging, egg laying, temperament, and the occasional harvest for meat for our home table.

PART II: BASIC CARE



Ducklings

Ducklings can be hatched from eggs incubated for 28 days or purchased as young as 1 day old from hatcheries. Upon hatching or arrival, it is critical to have a brooding area set up to provide **continuous** food, water, and warmth. A 125 or 250-watt heat lamp is a necessity because ducklings will have no down feathers.

We raise ducklings in metal stock tanks (which we re-use later in the season for soaking mushroom logs) in a

barn. These tanks provide shelter from wind and cold, are easy to keep warm, have a spout for draining liquid, easy to cover and clean. The tanks of course are open on top and ducklings need complete protection. We constructed simple frames made of wood and hardware cloth that lay on top of the tank. The hardware cloth facilitates ventilation so ducklings don't overheat.

We begin moving the ducklings to pasture (or the garden) within their first week if the weather is warm (>50 degrees and sunny). We cart them outside on warm and sunny days so they can begin to forage and bathe in a shallow trough.



Ducklings can be exposed to water and are eager to wade and swim at a very young age (think of the ducklings



you see on a lake). Of course, protection from predators (and pet dogs!) is critical when they are so tiny. We construct simple 4' in diameter hoops from scrap irrigation tubing 1" in diameter and welded wire fencing, with a removable lid made from the same material. We also have a lid made of scrap roofing, which covers half the hoop in case of rain and to provide shade. These structures are lightweight and easy to slide to new pasture every few hours, or whenever their circular plot is well soiled. 10-20 ducklings per ring are

ideally moved 2-3 times per day. Ducklings almost constantly eat and drink and quickly soil their entire ring of pasture with poop. **It's critical to not leave them outside unattended for more than half a day.** A sunny day can become cold or rainy in the spring, and the ducklings should be moved back to the stock tank. The ducklings should be taken back to the tanks and brooding lamp before dusk.

At about 8 – 10 weeks, or when there is evidence of down feathers, the ducks can be transferred to more permanent housing. It's rather obvious when their coat changes from puffy fur to feathers. It is important to make sure access to their new housing is a gradual ramp that has some degree of "grip" so their webbed feet can maintain traction. We have observed ducklings will generally not jump up into their housing without a ramp, especially when young. When first moving the ducks to new housing we typically close them inside for 2-3 full days so they learn this is home. Even with these few days of 'lock-down, some effort to shuffle them in at night may be necessary until they catch-on. (Once they have their down feathers, these 2-3 days are the only time we put food and water in their houses).



Water

Access to clean water is critical. Ducks prefer to be able to clean themselves by getting in the water and splashing it all over their bodies. They require water for cleaning out their beaks, which become dirty from burrowing in the soil. Some texts explain that bathing is essential for the duck to clean their feathers so to enable their down to remain oily. In the summer, the oils keep them cool; in the winter, it keeps them warm. Of course, some water is necessary for drinking, but it is minimal when compared to their need/desire for bathing.

As ducklings, a water fount should be available at all times. Once they are a week old, and only during the day when the temperatures are warm and the sun is out so we are sure they can get fully dry, we cart the ducklings to a small pen in the pasture to be in the fresh air and forage. We give them a shallow tray of water (a paint tray works well) to play and bathe in, and can easily walk in and out of. Once they are a few weeks old, disc-style sleds or lids work great as wading pools.

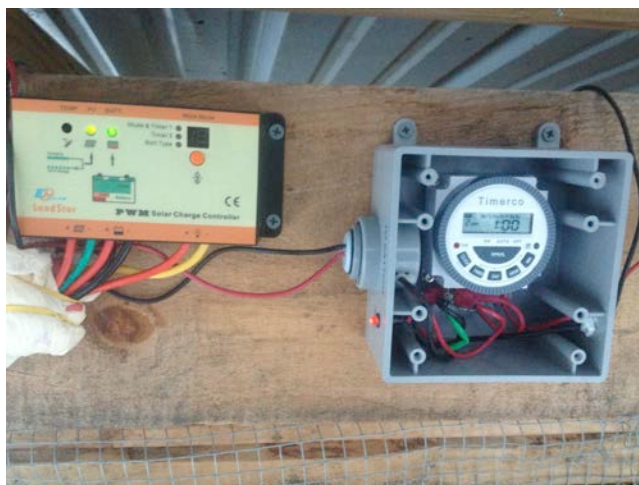
As they mature, small 5 or 10-gallon capacity tubs (found in feed stores) work well. After a season of giving our ducks a kiddie pool of water, we found this size to be ideal. They seem to enjoy the extra space and can swim a bit in the pool, but it was much more wasteful and challenging to change the water regularly, and in winter, almost impossibly heavy to lift if the water froze. Of course, if you have a pond on your land, this is ideal for ducks. We observe our ducks bathing in the tub of water even in temperatures as low as -15 degrees. The tub seems to enable them to love life, a quality that shouldn't be discounted!

Water tubs should be filled and drained daily, as the water quickly becomes dirty and soiled. Do not worry when the ducks appear to dirty water within minutes of giving it to them; changing the water every one to two days is sufficient. In the winter, the smaller tubs can be easily turned over and dropped on the ground to break any accumulated ice-free before refilling with fresh water.

Once the ducks have most of their down feathers and are in their permanent housing, we only give them food and water outside, and never inside their house (other than the first 2-3 days when they are locked inside their new home). This is fine for their health (assuming you let them out at a reasonable hour in the morning), as they do not need water at all times if they are not eating. More important for us, keeping water out of their house reduces the amount of fresh straw needed and you avoid a complete wet mess from occurring inside their house.

Fencing and housing

Ducks can be easily contained with moveable net fencing designed for poultry. Our preference has been to fence them with 80 or 164-foot sections of net fencing rather than allow them to “free range,” which limits our ability to control where they forage and fertilize. Most breeds,



when given adequate access to forage, food, and water, will not leave the fence, though some choose to jump/fly a short distance and leave the fence (most notably Muscovy). *We have not found it necessary to clip wings on any of our duck breeds.*

Care needs to be taken with portable fencing to keep the grass cut around the fence line to ensure the electricity will not short out. The fence should be placed to maintain a tight line and voltage should be checked at least once a week and/or when

fence is moved to a new place. A simple set up with an energizer, solar panel, and car battery makes for an easy setup that can be moved with the flock.



Housing should be movable if possible. Unlike chickens, who roost, ducks nest and so do not need a tall ceiling, 2 -3 feet tall is sufficient. They do need adequate square footage since

they prefer nesting. 1.5 to 3 square feet of floor space per duck is recommended by NOFA organic standards. We have found that a house built with a 4 X 8 sheet of plywood as the base is adequate space for 10 – 20 ducks, who will cluster tightly together in the winter months and spread out more in the hotter summer months. Through trial and error we have found that building duck houses directly on top of old trailers is the easiest way to ensure the houses are moveable. We move them with the hitch and the farm truck. This is doable by one person.

The best bedding for ducks is straw or hay. It can be somewhat “rotten” and damp material can be used when it’s not winter. A fresh layer of straw should be added every 2 – 3 days to cover manure to keep the smell to a minimum. The straw can be cleaned once a month in the warmer months and applied to plantings. In the winter, we let the bedding build up to a few inches. The combination of straw and poop creates heat (N+C) and helps provide additional warmth for the birds. We try to clean the house out once a twice during the winter if there’s a few days of thaw. Harvested bedding is used at the base of trees, as mulch on potatoes or garlic, or when sheet mulching. *It’s important to consider regulations for fresh manure application if selling produce to markets; a minimum of 90-120 days between application and harvest is the organic standard.*

Infrastructure: Tips and Tricks

Just to review, a few very specific things we highly recommend:

Small water tubs: Bigger tubs don’t mean less work, as one might think. Since the water gets dirty quickly, small 5-gallon tubs are easier to manage less wasteful. In the winter, a 5-gallon tub can be turned upside down and stomped on to break any accumulated ice. These rigid plastic tubs last for years and are the size we’ve found to be most amenable. This size also makes it easy to ration out water via five gallon buckets. On cold winter days, unless you have heating implements for the water, you may need to loosen up ice or bring ducks fresh water mid day.

Water catchment: Since duck houses have roofs, and ducks need lots of water, a logical effort is to catch rainwater from the roof. We have done this by fashioning a simple gutter and hose that empties into a 30-gallon tank and/or a 10-gallon trough.

Solar lights: We rigged a simple solar panel (40 watt), lawn mower battery, charge controller, and timer along with some LED lights so that during the winter we can extend the daylight hours for the ducks. It is recommended that ducks get 14 hours of daylight year round to lay eggs, though we observed Indian Runners and Khaki Campbell's to stop laying if temperatures were below 15 for a consistent 3-weeks or more.

No water in house: We've kept water out of the duck houses for three years and there appears to be no negative effect; only easier work for us.

Food

When young, ducklings should be fed granular feed, often labeled "crumbles", and always have access to food (and water), basically eating and drinking as much as they want – which they will do with pleasure. ***Make sure the feed is not medicated, as this could kill your ducks.***

Once they are larger – about the same time you move them to their permanent housing – ducks can eat pelletized grain. Pellets are a better choice because they are cheaper to buy and the ducks don't let it go to waste it as much. It appears that unlike chickens, grown ducks leave behind fine granular particles, perhaps just too hard to grab with their wide beaks.

We experimented with feed amounts for all the breeds we have raised. We always start with a standard recommended amount per bird. (.4lbs/bird/day for meat 8+ weeks to slaughter) We then have experimented to determine the optimal ration based on breed, production goal, and site conditions. When raising meat birds, we weighed them weekly; when raising layers, we document eggs/day. Simply observing the ducks feeding behavior will give you good insight into their feed needs; Do they gorge themselves on feed in seconds/minutes? Do they eat the feed slowly throughout the day? Do leave a lot of feed leftover? Overall, if the farmer wants to determine the optimal ration of feed for your flock, it is necessary to do some data collection of duck weight and/or egg yields.

In our experience, a ration of feed should be allocated at somewhere between .2 and .4 pounds per bird, per day. We rotate our birds to new pasture every week and feed each bird .2 pound/day. In the case of our meat birds, on average, each bird gained only a half-pound less of total weight than if we fed them .4 pounds of food per day. We are currently settled at .2 lbs/day and will see if we can increase onsite forage and further reduce this number.

Unless you are trying to fatten up your ducks for meat production, it is optimal to feed ducks once/day, at the end of the day, so to encourage them to forage during the daylight hours. We tried this, but because our personal morning schedules are more consistent – and routine

appears to be an important effect on animal behavior – it is more practical for us to feed them in the morning. Even with feed available, Runners, Khaki's, Cayuga's and Swedish Blue's tend to ignore the feed and choose to forage in the non-winter months.



Fodder

We have observed that ducks love greens, especially lettuce, radish, beet, collard and arugula. We have only let them forage in lettuce and arugula beds once these crops are bolting and we don't want them for ourselves. We unintentionally learned they liked beet and radish tops because they mowed them all down in our garden, however the roots of both were left in perfect shape. Throughout the summer our Khaki and Cayuga ducks took very rare bites from full-grown collard, kale, brussel sprout or chard plants.

However, as colder temperatures settled in, and their forage options being less abundant, we noticed an increased interest in these greens. We fenced them away from the plants we were still eating from, but by January were pleased to let them feast on what they liked. Some resources cite that boiled potatoes and squash can be served to ducks as supplemental feed as well, though we have witnessed Arcana ducks energetically eating raw squash at Whole Systems Design, LLC in Vermont. We have not experimented with feeding squash and potatoes to our ducks at this time.

Cover crops have proven to be excellent feed source on our farm for the ducks. The ducks foraged with excitement on radish tops, buckwheat, clover, and pea shoots and can facilitate soil building in this way, especially if care is taken to rotate ducks so that only the tops are clipped and the roots can re-grow another succession of vegetation. In the future we plan to grow much more of our ducks food. Many of their favorite foods are quite easy to grow at large quantity, they will gladly eat seconds of these crop and it serves our fertilizer needs to have them rotate through our garden as we finish harvesting for ourselves.

Predators

The best strategy for dealing with predation is to take a multi-faceted approach. At Wellspring Forest Farm, predators can include fox, raccoon, skunk, coyote, bobcat, dogs (our neighbors) and birds of prey.

Fencing

The first line of defense is a good fence! As mentioned above, good fencing habits are critical to success. We lost a few birds quickly when we were a little lazy for a few days, and let the Khaki flock free-range. We highly recommend taking the time to place fences in the ground properly and ensure electricity is working.



Geese

After a bit of online research we decide to add a guard goose to each of our duck flocks. It was suggested a single male goose, raised with a young flock, would protect them as though the entire flock were his mate. We have seen this to be very true with African male geese. While ducks are often busy foraging, geese keep watch in all directions and honk whenever someone or something approaches. This noise is a good general deterrent to predators, and the ducks lift

their heads too, as though they are paying attention.

Of course, any of the predators in our area could be fooled by the honk of the goose and still decide to attack, we do credit our geese with our minimal loss of ducks. Though male geese can be aggressive, especially in the spring when egg laying and rearing is taking place, we have had great success with African geese. These geese are threatening but don't charge people very often. And, it is worthwhile setting a rapport with your goose early, making sure they know who is in charge. Even with a trusted goose, a farmer should be ready and willing ready to grab a goose by the neck if he charges. (Grabbing by the neck won't hurt the goose)

Dogs

Our lab and husky mutts, though not "working" dogs at all, do offer some degree of protection for our ducks. They are trained to have no interest in the flock for chasing or eating, but we believe their bark, smells and urine do help deter predators. We frequently walk the outer boundaries of our land with the dogs, so that their smell is present and strong.

Rotation

We believe that animal systems should be designed with rotation in mind because it is best for the animal and the land. When animals are in one place for too long they overharvest flora and below ground forage problems, their manure and urine accumulates creating the potential of too much nitrogen on the soil and disease for the animals, and the pen and housing generally becomes smelly. Rotating animals regularly to fresh pasture ensures their diet is diverse and abundant and reduces disease potential for the soil and animals.

In our experience, from July - October, a flock of 15 – 20 ducks in an 80-foot fence should be moved once a week if on pasture, and every 3-4 days if in the forest.

In pasture settings, the forage/grass/cover crop should be examined as an indicator of when it is best to move them. In the forest, the presence of leaf litter and vegetation is a good indicator that there is not overgrazing going on. In both cases, we try to time cleaning out the straw from their house just prior to moving the ducks. This allows us to leave a layer of manure/nutrient filled straw in the paddock where they had just grazed. This technique, along with seeding the appropriate cover crop mixture depending on the time of year, ensures a very healthy paddock that regenerates soil rapidly.

Products



Meat

There is certainly a large demand for duck meat in the regional market outlets in our area. The barriers to production of meat on a commercial scale are discussed in more detail below. Duck meat is very delicious and favored for its fatty nature. As is with chicken, once the duck is cooked and enjoyed, the carcass makes a delicious stock.

One of the drawbacks to raising ducks for meat is plucking. Unlike chickens, ducks have two layers of feathers; the outer feathers and the down or “pin” feathers. The down feathers are very hard to remove fully. We have had some success in getting birds quite clean with a lower scalding temperature and plunging the ducks for a longer period of time, but it’s certainly not as easy as cleaning a chicken and you have to be cautious not to scald the bird for too long, so the flavor isn’t affected.

A final consideration with respect to raising ducks for meat is the end point of production. In New York State, if ducks are consumed by the farmer or sold directly to customers, up to 1000 birds can be slaughtered on farm and sold fresh or frozen. If the ducks are being sold to restaurants or retail markets, (not direct to consumers) birds must be taken to an approved facility for slaughtering. Facilities near us, typically Amish owned and operated,

charged \$4.50/duck in 2012 and \$4/duck in 2013. Obviously, adding this cost to each duck makes it that much more difficult to make duck meat economical at the commercial scale for restaurants and retail markets. Further, we were disappointed in the cleanliness of the duck that came back from the slaughter facility and were not able to sell them all as we had planned.

Given there is limited information about raising ducks, it is not surprising that slaughter facilities are not experienced with cleaning ducks. If you have plans to sell duck for meat, we suggest developing a direct outlet and doing the slaughtering on farm, unless you are able to find a local slaughterhouse that has experience and demonstrates proficiency processing ducks.

Ultimately, as discussed in more detail in section three, we decided that meat production for commercial markets was not the type of farming we wanted to get into with regard to ducks, but because of the scale necessary to make a profit and the large need for external grain inputs. Focusing on eggs allows us to pay more attention to the use of ducks as a pest control mechanism on the farm and also allows for more experimentation with reducing grain inputs by providing more forage on-site.



Eggs

There are a few key needs of ducks to be healthy and happy egg layers. One is adequate floor space in the co-op, so that they feel comfortable and able to nest and lay without disturbance.

Nest boxes with 8 – 12” walls are a good idea to provide this security. Ducks also need to be warm and receive adequate nutrition to lay. In the winter, we layer straw on the house floor every second or third day and leave the pack in the house as

long as possible, to provide a measure of insulation. We also ensure that there is adequate protection from wind at all times. All this said, during very cold winters ducks will likely cease laying for several months if not until springtime.

Egg laying breeds such as Khaki and Runner will often begin laying in 6 or 7 months, while the mixed breeds often take longer, sometimes 16 – 18 months before laying eggs. Hens can be viable layers for 2 or 3 years, after which production will decline. In regards to Khaki Campbell hens, we found that adding a small 1’x1’ nest box in their house offered an ideal spot to lay, made it easier for us to find the eggs and possibly increased egg production (or just encouraged them to lay in one place).

Eggs should be collected daily and cleaned as soon as possible after they are gathered. Avoid scrubbing the shell too hard as this removes a protective layer that allows the eggs to last longer and be stored out of the fridge. Pack eggs in cartons and store in a dark, cool place. They should last several weeks in these conditions. Niche markets should fetch between \$4 -6 per half dozen. Duck eggs are slightly larger with a bigger yolk when compared to chicken eggs. They

are often white or bluish in color. Their shell is much thicker than chicken eggs and often is best cracked with a knife rather than on the edge of a pan or bowl.

Summary of Basic Care

Our goal in the previous section is to highlight the lessons we learned from raising ducks, especially those items we didn't read in the books and discovered as we went along. There is much more to know about ducks, and we highly recommend the resources at the end of this publication. We found it necessary to consult all of these sources and others in order to become competent raisers of ducks.

PART III: RESEARCH SUMMARY: Can ducks in the woods provide slug control for shiitakes?



Research was conducted over two mushroom growing seasons (April through October), with the first season focusing on breed selection (2012), and the second season on system optimization (2013).

The overall goal of this farmer research project was to explore the interaction and relationship between the forest as a farm ecosystem, a log-grown shiitake operation and related pest problems (slugs), and ducks as a pest control agent/additional income stream. We wanted to

see if a win-win-win situation could emerge; that the pest pressure on the shiitakes would be reduced, the ducks would be enjoyable to work with and profitable (for meat), and that the forest would not display any adverse impacts, but rather, positive ones.

In 2012, we used fencing to set up three separate areas in the woods. Two areas enclosed different duck species for the entirety of the season, and one served as a control (no ducks). Each plot was about a quarter of an acre (see figure 3). Each area had approximately 200 - 250 logs, which was managed in 8 groups of about 20 logs per group. (Mushroom logs need 8 weeks of rest between soakings.)

Each week, we soaked a group from each of the three trial areas on the same day. After soaking and upon fruiting, we harvested the shiitakes and attempted to calculate percent slug damage from the three yards as a comparison of treatments. Because this system proved to be challenging, we switched methods in year two and ultimately were able to only make some general observations about the results with a few indicators of success.

The main research questions were as follows:

1. Are ducks effective and reliable slug control in log-grown mushroom cultivation?
2. Is the forest affected in any negative way from the presence of ducks?
3. Are ducks economically viable as an additional farm income stream?

In addition, though not formally researched and some may say challenging if not impossible to measure, the well-being and happiness of the birds was an important component of our system. Some people may disagree with raising animals for meat but we believe home meat production is a critical element to a sustainable food system in our climate and take pride in providing our animals with complete care and access to natural environments. We do not view these birds as commodities but as sentient beings that deserve respect and admiration. Duck happiness had to always been evident on our farm.

YEAR ONE – 2012



Summary of Activities

As a way to summarize the season, here is what we did, month-by-month:

JANUARY - APRIL

In the beginning months of 2012 we spent time talking to duck growers, researching material options and supplies, and ordering ducklings for a May delivery. After

conversations with farmers and Extension agents we decided to open the study to include four breeds including heritage ducks and that the season would conclude with a tasting event to see if consumers (or chefs) had a preference among breeds.

MAY

The ducklings arrived and were raised in metal stock tanks for 2 weeks, then given access to grass forage during the day for 2 more weeks. All of the ducks purchased in 2012 were male, so to offer some consistency since we were tracking their weight. Ducklings were given free choice

of grain during this time and there were two groups, which would remain throughout the season:

Group #1: 10 Rouen, 15 Muscovy, 1 Chinese Goose (protection)

Group #2: 10 Cayuga, 10 Swedish Blue, 1 African Goose (protection)

We only lost the Chinese Goose (strangled, sadly in the net fence) and one Rouen who also became entangled in some baling twine and had to be killed.

JUNE

In early June three yards were set up with logs: one for each group and one as a control. Each section had roughly 120 active logs. The duck house was also completed and put into place. The ducks moved into the site on June 10th, when we began taking data on mushroom yields, slug damage, duck weights, feed measurements, and any other notable observations. All the ducks were rationed at .4 lbs of feed per bird, per day over two feedings (recommended rate for meat ducks).

JULY, AUGUST, SEPTEMBER

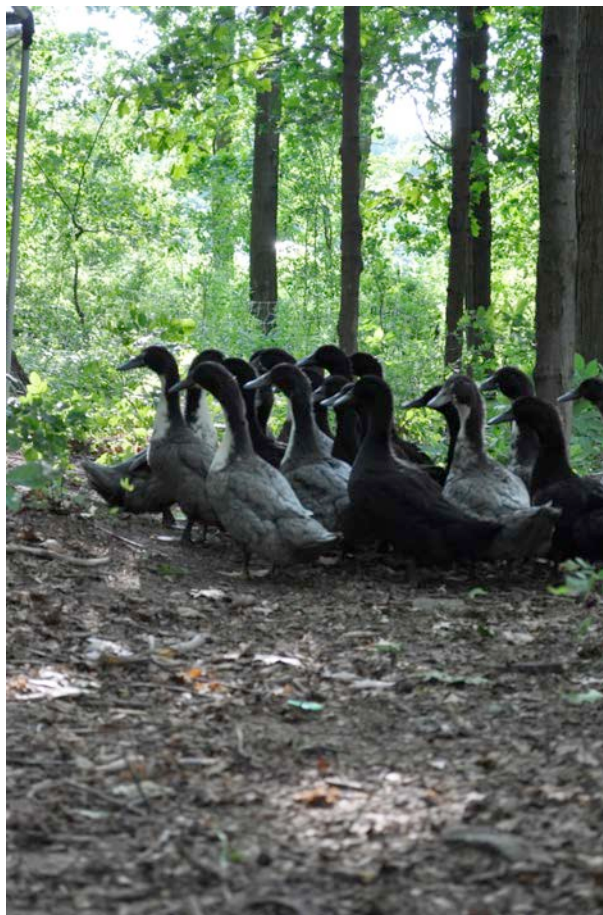
During these months work was limited mainly to feeding (.2 lbs per duck, 2x each day), watering, mushroom soaking and harvesting, and observations. Three randomly selected ducks from each breed were captured once per week and weighed. We learned many things about duck behavior and the differences in breeds, noted in the previous sections of this publication.

OCTOBER

The ducks were taken to a local slaughterhouse on October 16. We stretched the kill date this long to see if there was any benefit to weight gain – or if weights would level off. Ducks were all sold to a local restaurant, which also hosted the tasting event.

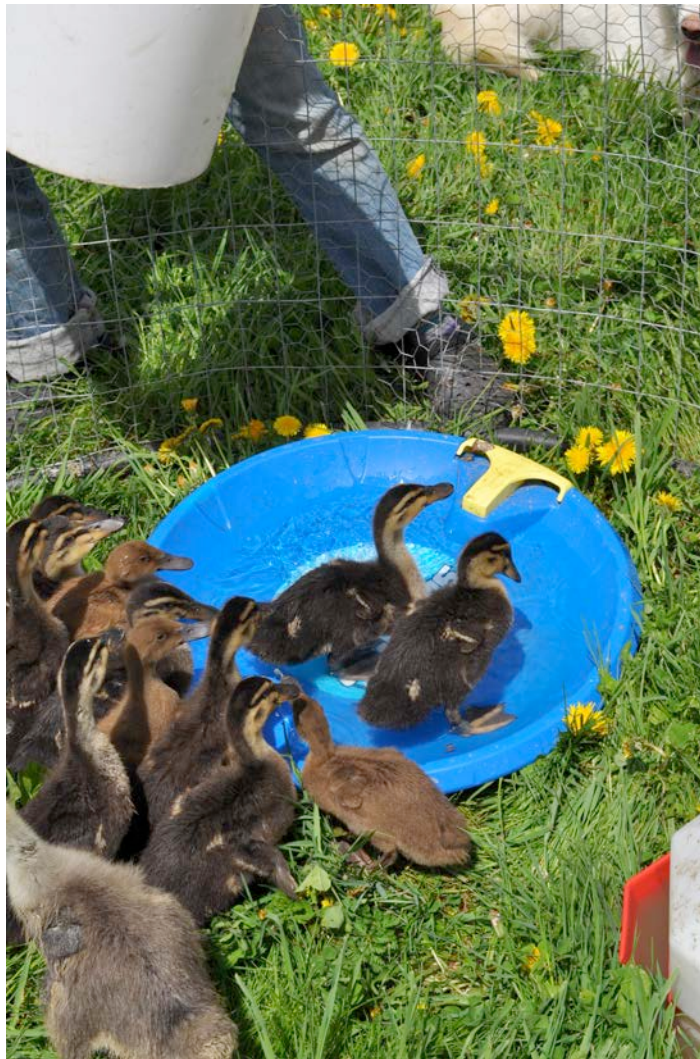
NOVEMBER

The tasting event occurred November 6th. We had 16 participants including chefs, farmers, Extension associates, and consumers. Each breed was minimally prepared and served in a blind test in two rounds; round one was breast meat (light meat), round two was leg (dark meat).



Participants tasted the varieties and made notes on a worksheet provided. The most surprising element agreed to by all was that there was such a difference in taste between breeds. The Pekin (donated from a local farm) was the consistent favorite, while the Muscovy received poor marks and the three heritage breeds (Rouen, Blue, Cayuga) had positive marks with many participants noting more interesting flavors, in comparison to the Pekin which was deemed a “safe eat” for general consumers.

YEAR TWO – 2013



For the second year, our trials were simplified and several changes occurred. First the size of the paddocks were reduced and restricted to areas right around mushroom fruiting zones rather than integrated directly in the fruiting area. The ducks were rotated from forest to field to diversify their diet as well as reduce the impacts from continuously grazing the woods.

Based on the previous year, we decided to raise two flocks of 25 ducks each; one Rouen and one Cayuga. The flocks were ordered as a “straight run”, meaning a mixture of male and female. The biggest change overall was that grain inputs were limited and offered at a lower rate while trying to maintain weight gain (.2 lbs per bird/day, which is HALF of the previous year)

We again received ducklings in the mail (April 22), raised them in the metal stock tank brooders, and then transitioned them to pasture on May 20 and forest on June 16 (this is when the rationed feed began). Duck houses were rebuilt to be smaller than in 2012 and

more easily movable. The ducks were moved once a week from field to forest or vice versa. Each of the three mushroom yards got a different treatment; one was a control (no ducks), one had ducks constantly in and around the mushrooms, and one had ducks visit only twice throughout the season.

The results were suggestive at best, at least in terms of slug control (see more below). One variable was that slugs actually didn't show up in prolific numbers unless the conditions were rainy, or at least moist. It turned out to be hard to collect reliable slug damage data, but from general observations the mushrooms harvested from the logs that were protected by the ducks were in significantly better condition than those not near the ducks.

Timeline for 2013 Season

22-Apr	Chicks arrived
20-May	Ducklings moved to pasture
16-Jun	Ducks begin rotating – first visit to woods
17-Jun	Food rations begin (.2lb/bird/day)
10-Oct	Ducks Slaughtered

A discovery made in both 2012 and 2013 is that some ducks will make an effort to eat, or at least nibble at, the mushrooms. This was observed in the Muscovy/Rouen flock of year one and in the Cayugas in year two. This means that to maintain a good crop, fruiting mushrooms need to be fenced off from the ducks. This is acceptable because the ducks can be rotated around this enclosure to reduce slug pressure, rather than eating the slugs right off the logs. Fencing off the mushroom also eliminates any concerns with sanitation of manure and associated concerns with food safety.

In 2013, about ½ of the ducks were slaughtered on October 10 and sold to a local meat butcher, who sold them to consumers almost immediately, as well as to a local restaurant. Of the other half, some were traded to a neighbor for labor and we kept 12 of the Cayuga (10 female, 2 male), merging them with our Khaki Campbell flock (not part of the study) to establish our long term laying flock.

Final Results



We achieved many good results, some based on observation and some on data. The first result is that ducks provide a significant level of pest control *throughout* the farm (including forests, fields, and gardens) and, if rotated, do not appear to have adverse effects on the landscape.

Of the ducks we raised for meat, only the Muscovy gains sufficient weight to make a profit and a duck would need to gain at least 8 lbs in a season to make it economical

under our model. Given feed costs and market prices, and depending on a farmers slaughtering capacity, a range of 150 - 400 ducks would need to be raised per season to be economically viable.

Bringing the ducks into contact with the mushrooms did appear to have a positive effect on reducing slug populations, though the mix of variables (weather, temperatures, labor, etc) made it difficult to collect good data on this relationship.

We will offer our final results including our summary observations and any relevant data by revisiting each of the three main questions this study sought to answer.

1. Are ducks effective and reliable slug control in log-grown mushroom cultivation?

Summary Observations

From this study, we were unable to collect conclusive data on if ducks offer a viable means to reduce slug infestation on shiitake mushrooms because of variables and unpredictability in weather, precipitation and temperature. However, our observations did lead us to believe that the presence of ducks in the vicinity of fruiting mushroom logs can help but not entirely eliminate slug pressure on a shiitake crop. Ducks are not the perfect solution, but rather a supplement to other strategies including the removal of organic matter from the fruiting area, placement of gravel under logs, use of beer traps, and daily monitoring.



In 2012, the drought conditions meant the mushroom yard had very low slug pressure. We saw some slugs toward the end of the summer and at the same time observed that ducks were effective at slug control IF mushroom logs are located near to duck food, water, and housing.

In this same year, we had almost 0% slug damage in the Muscovy/Rouen pen, but only after the fruiting logs were fenced off because the Muscovy would actually take large bites from the mushroom.

The fruiting area in the Cayuga/Swedish Blue pen was probably located too far away from food/water/shelter of the ducks and slug

damage was comparable to the control. It seemed that the ducks did not spend that much time near the logs and thus did not feast on the slug population.

In 2013 we had a much wetter season and with this saw the rise and fall of slug pressure. Since we rotated the ducks weekly this season, we did not have the ducks continuously grazing near the mushroom logs. As such, we created three levels of interaction: The Control (no duck visits), Light Interaction (two visits in the season) and Heavy Interaction (ducks constantly in or near mushroom yard). The Control yard most certainly had the most slug activity. The Light area had ~ 50% less observed slug activity, and The Heavy area had very little slug activity.

As we suspected, and now observed, slug populations directly relate to moisture/weather. A further fact is that slugs don't have eyes, and thus attracted to the mushrooms by smell as they open up and release spores. Removing slugs from the general area when mushrooms were pinning proved to be helpful. If precipitation patterns are timed with soaking mushroom logs, and subsequently mushroom fruiting, high slug pressure may be avoidable, but certainly it will vary from year to year depending on weather. Though we are just starting to test this out in our system, these cycles and timings may important for the shiitake grower to take note of in order to lessen overall slug damage on fruiting mushrooms.

A final key point is that the presence of ducks in the woods does two things: first, it decreases organic matter which is ideal habitat for slugs, and two, it directly reduces the ability of the population to both move in toward the mushrooms as well as build up a population. In conclusion from our observations, it did not appear to be important to have ducks in a particular place at a particular time. If they can be rotated around the area that the mushrooms are produced, there will likely be some benefit for the farmer.



Data/Documentation

We had a difficult time collecting good data to support our observations for a number of reasons. In 2012 we tried to calculate the percent of damaged mushroom caps vs. perfect caps in the three laying yards, but found that this assessment is subjective and that, since there are other causes of damage (weather, rodents, farmer, transport), it was hard to ensure that damage was from slugs and not other factors.

In 2013 we attempted to switch our collection methods and tried collecting and weighing the slugs that were found in the general vicinity of the log fruiting rack. This proved to be

challenging, as it took an incredible amount of time and just because a slug is in the mushroom laying yard does not mean that slug will damage a mushroom cap. Further, on several occasions, even a day after a sweep of the area, the slugs were present on the mushrooms and would take constant monitoring of the yard to be effective. Balancing the need for monitoring with the realities of farming (not to mention that picking up slugs one by one and weighing them is rather disgusting), we did not continue trying this method for too long.

All this being said, there were two definitive indicators that offer evidence to support that foraging ducks near a mushroom laying and fruiting yard is worthwhile to control slug pressure:

1. Average slugs/log

On two occasions in 2013 we were able to sample ten logs from each laying yard and count and average the slugs/per log for each area. This was done during a wet period when overall slug activity was high and when timing allowed for this to work. While this isn't enough data for anything conclusive, it does offer some suggestive evidence of some benefit.

Date	Yard 1 (control)	Yard 2 (light)	Yard 3 (heavy)
6/27	12.3	9.8	3.1
7/13	10.1	8.4	2.7

Average slugs per log for two random dates in 2013

2. No mating pairs

One positive outcome of the study was that no mating slugs (see image below) were found in the mushroom area with ducks heavily grazing around versus many dozens found during wetter parts of the growing season in the control area and a few in the light area. This was a constant observation made on a weekly basis throughout the season. While this doesn't directly relate to damage, the ability of a population to reproduce is arguably one indicator of overall population success.



2. Is the forest affected in any negative way from the presence of ducks?

Summary Observations

The presence of ducks in the forest has one critical impact observed; leaf litter from the previous fall decomposes much more quickly when animals are in the forest. In some areas of the woods, particularly where water pooled and flowed during heavy rain events, grazing appeared to

create bare ground and mild compaction, which led to some minor erosion. This impact was much more dramatic in year one when the stocking rates were high (50 ducks continuously in a 1/3 acre paddock) versus year two, where smaller flocks of 25 were rotated in smaller, 1/4 acre paddocks.

One good strategy to balance the trampling of organic matter was to time the cleaning out of the duck houses so that the straw and manure accumulated was removed just before the ducks were moved to a new location. It is recommended that additional organic matter is available to be added to a forest grazing system. In the future we plan to monitor nutrient content and percent organic matter in our soils to get a better grasp on potential benefits or harm from grazing animals.



In 2012, we let the ducks forage in one area continuously. As a result, there was noticeably less forest litter and in some case bare ground due to the movement of the duck flocks. (see picture, above). In the Muscovy/Rouen pen this was especially the case. In this regard, continuous duck presence had a negative effect on forest health. As a result, and to keep more inline with our farm goals, in 2013 ducks were rotated weekly between different plots in the pasture and the forest.

We observed ducks to forage understory vegetation at will. This could be both a positive and negative thing depending on understory vegetation. Another positive impact was the large amount of manure left in the forest. We realize in hindsight that it would have been great to sample the soil and the beginning and end of the season to get a comparison. We will begin this practice in 2014 to help better understand the impact. Also in 2013, rotating the ducks once per week and using a smaller paddock size improved the impact of the ducks on the forest. In some

cases, however, the ground and leaf litter was significantly reduced with even just a short stint of the ducks.

Data/Documentation

No data collection was attempted for this question. Perhaps soil testing or some sample plots could have been monitored.

3. Are ducks economically viable as an additional income stream?

Summary Observations

The simple answer to this question from our experience is “yes”, if a farmer is willing to greatly scale up flock size. To be an economically viable duck meat farmer production would need to be a primary goal, not a byproduct of a desire to control slugs and enhance an ecosystem. In the context of a small woods (about 1 acre) and a 1,000 log shiitake operation, a flock of 20 to 25 ducks is plenty to maintain some degree of protection from slugs, including some time rotating in gardens and fields, too. This size is NOT viable for meat production.

The good news for those interested in raising hundreds of ducks for meat (see below) is that the market demand is very high (at least in our region). It should be noted that we sold to restaurants and a retailer who cater to customers in a market of customers willing to pay more decent prices (\$5 – 6/lb) for sustainably raised and local meats.

In 2012, the chef at the restaurant we sold our birds to was happy with the product and sold out of them within two days on the menu. There is clearly a demand in this market. This restaurant, as well as several others, told us they wanted more duck and have a hard time finding it. With regards to specific breeds, this particular place (a small restaurant in rural New York, with 50 seats, serving as much local food as possible for \$15-30/plate) felt the Muscovy were a bit too big and preferred the birds that were 5 – 6 pounds (finish weight), which is about a pound larger than we could get the heritage breeds to, but under the finish weight of the Muscovy.

Further, when considering economics it is challenging to quantify the value of fertilizer the ducks provide to the system, along with the benefits of slug control. We are finding that the ducks are proving valuable not only in the woods, but in our gardens and around planted tree crops as well. In 2013, our garden saw little to no slug and bug damage to plants, and the ducks also performed well when given access to cover crops we had sown as part of a soil building protocol. It is also our observation that the Khaki Campbell and Cayuga's, are better foragers and less interested in grain than the breeds more ideal for meat production.

Data/Documentation

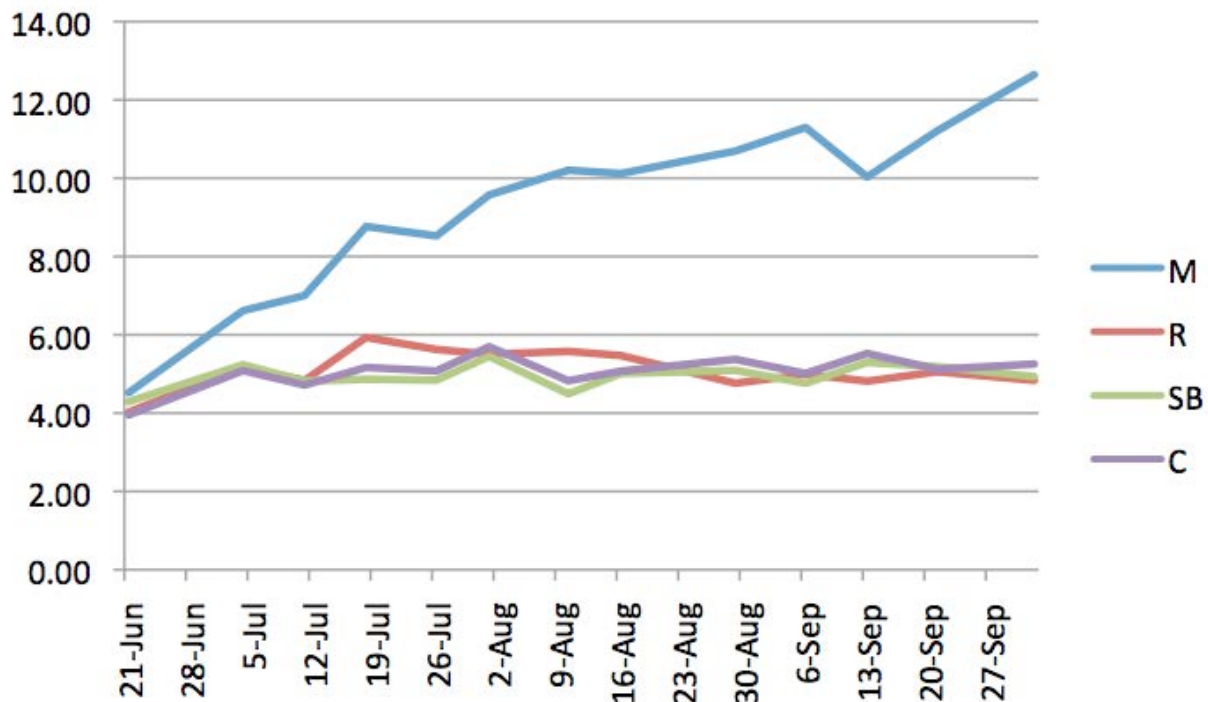
Weight Trends

We can examine trends in weight gain from the ducks. In 2012 we randomly weighed three ducks once/week from late June through early October. The entire dataset and averages per week are presented below.

Notable is that there is a decent amount of variation among the duck weights from week to week. The Muscovy is the only breed that had solid growth over the course of the season. Most of the other breeds could arguably be slaughtered much earlier in the season since they appeared to reach average max weight in August.

Important to note in this trial is one aspect of a poor experimental design, where the Rouen/Muscovy were lumped as were the Swedish Blue/Cayuga. While the latter group appeared to share their food and finish throughout the day, the Muscovy dominated the Rouen flock and ate far more than their fair share. Either way, it is clear that if weight gain is a clear goal for commercial meat production, then Muscovy is the choice from these breeds.

DATE	MUSCOVY			Avg	ROUEN			Avg	SWEDISH BLUE			Avg	CAYUGA			Avg
21-Jun	4.44	4.60	4.53	4.52	3.76	4.10	4.22	4.03	4.31	4.26	4.31	4.29	4.20	3.91	3.75	3.95
4-Jul	6.65	6.78	6.42	6.62	5.69	4.82	5.02	5.18	4.98	5.29	5.44	5.24	5.19	5.32	4.75	5.09
11-Jul	7.41	6.50	7.10	7.00	4.80	4.70	5.00	4.83	4.30	5.35	4.80	4.82	4.66	4.68	4.81	4.72
18-Jul	8.90	8.40	9.00	8.77	5.60	6.50	5.70	5.93	4.60	4.80	5.20	4.87	5.40	5.50	4.60	5.17
26-Jul	8.19	8.79	8.60	8.53	5.75	5.45	5.68	5.63	4.71	4.91	4.91	4.84	5.05	4.72	5.46	5.08
1-Aug	9.18	9.18	10.36	9.57	5.62	5.24	5.65	5.50	5.77	5.51	5.07	5.45	5.82	5.71	5.56	5.70
10-Aug	9.93	10.04	10.64	10.20	5.54	5.33	5.86	5.58	4.61	4.24	4.63	4.49	4.67	5.12	4.69	4.83
16-Aug	8.86	11.10	10.40	10.12	5.49	4.90	6.02	5.47	5.10	4.84	5.09	5.01	5.43	4.91	4.88	5.07
29-Aug	10.33	11.47	10.28	10.69	4.68	4.83	4.78	4.76	5.42	5.11	4.75	5.09	5.56	5.08	5.48	5.37
6-Sep	12.08	9.79	12.02	11.30	5.08	5.21	4.69	4.99	4.77	4.44	5.08	4.76	4.16	5.38	5.50	5.01
13-Sep	9.50	11.20	9.40	10.03	4.73	5.28	4.44	4.82	5.10	5.14	5.65	5.30	5.81	5.51	5.25	5.52
21-Sep	10.37	11.99	11.28	11.21	4.35	5.68	5.14	5.06	5.52	5.00	5.03	5.18	5.45	4.97	4.94	5.12
2-Oct	12.83	12.21	12.90	12.65	4.81	4.68	5.02	4.84	5.00	4.86	4.94	4.93	6.01	5.02	4.73	5.25



Feed costs

A second metric with consideration for meat production is feed cost, since it impacts potential profit. Our strategy was to feed the ducks “free choice” for the first eight weeks of their life and then transition to a ration, based on the recommendations of books. In 2012 we provided a maximum amount of .2 lbs/bird twice each day (.4/lb/bird total) and did not rotate their pens, whereas in 2013 we cut that amount by 50%, feeding only once a day at a rate of .2lbs/bird though rotated them weekly.

Based on the number of ducks, we calculated the cost of feed per day for the first eight weeks and then did another calculation for the remaining time until slaughter. Since the rationed feed was cut in half the second year, the cost per bird is roughly half from one year to the next.

Costs of feed

Year	Number of ducks	Days Free Choice (\$3.05/day)	Total Cost	Days with Rations (\$6.24/day for 2012, \$3.12 in 2013)	Total Cost of Rations	TOTAL COST	Cost per bird
2012	50	53	\$161.65	129	\$804.96	\$966.61	\$19.33
2013	50	56	\$170.80	117	\$364.04	\$534.84	\$10.70

The interesting analysis comes when we looked at the potential profits based on the weight gain and price per pound we got. For this we removed the Muscovy ducks from the dataset because we did not have them in the second year, and all the other ducks were in a similar weight class. This worked well because it made the number of ducks in the sample size equal, since we did not harvest all 50 the second year.

Potential Profit for Medium Weight Breeds

Sample Size	Cost per bird	Avg Weight Per bird	Price per lb	Avg Gross Per bird	Profit/Loss
30	\$19.33	3.49	\$5.50	\$19.19	- .14
30	\$10.50	3.31	\$5.50	\$16.55	\$7.70

Potential Profit for Muscovy

Sample Size	Cost per bird	Avg Weight Per bird	Price per lb	Avg Gross Per bird	Profit/Loss
30	\$19.33	8.14	\$5.50	\$19.19	\$25.44

We were pleased to see that cutting the feed in half and rotating the ducks weekly led to only a very small decline in average weight per bird. (keep in mind we didn’t raise Muscovy

when we did this - this may not be the case for the larger meat breeds) We can say for certain that for Cayuga and Rouen, more feed did not contribute to more weight gain, and in fact resulted in some net profit, at least when only feed is taken into consideration.

The \$7.70 in profit is just taking into account feed costs. When we consider other costs, the potential looks less optimistic. For one, in both seasons we took the ducks to a certified facility, as we lacked the space and infrastructure to slaughter on farm properly. Furthermore, to sell to the outlets we chose (in 2012 a restaurant and in 2013 a butcher shop), New York State law requires that we process at such a facility. It cost \$4/duck to slaughter and package, which means that we have a further loss in potential profit per bird in 2012 and reduce our potential profit to \$3.70/bird.

Furthermore, we also have to subtract the cost of a duckling from this number, which was \$5 per bird. In the end, considering the costs of feed, slaughtering, and ducklings, a total potential profit in 2012 was \$1.30/bird for the medium weight breeds and \$21.44 for the Muscovy.



One point of good news for those interested in ducks for meat is that the heritage birds appear to gain their maximum weight early in the season and then level off. This means that smaller breeds could be raised on shorter rotations, which may improve their profitability since feed costs, time and labor would all be less. We found that a 3 – 4 pound duck (finished weight) was acceptable to some customers and though not very large, very delicious and can provide a sizeable meal to two people. The breasts and legs from one bird are a good serving size for two people, with the carcass making a fine stock. If a farmer can find markets willing to purchase smaller heritage birds, she/he may be able to find a profitable niche.

Other costs: Infrastructure

Of course, feed and slaughter costs were not the only costs. Over the two years we spent a considerable amount of money on the facilities to house, feed, and provide water to our duck. Certainly many of these expenses are capital requirements that are beneficial for the long-term and not recurring annually. In this case \$2,950.29 (see next page) of materials and supplies can be spread out over say, ten years, or \$295.29 per year. To cover feed costs (above) and break even on infrastructure costs, a farmer would need to raise about 15 Muscovy ducks per year for ten years. If we raised around 150, then we could pay this infrastructure off in a season, and begin making profits in the second year. This is a viable and realistic option for meat production; however, these numbers do not take into consideration time/labor.

Movable Electric Fence	\$866.00
Fence Charger	\$227.50
Fonts, tubs, feeders	\$71.45
Duck House Materials	\$688.08
Water Pump	\$399.00
Water System	\$698.26
TOTAL	\$2,950.29

Labor

The above figures do not include accounting for our time. We consistently spent an average of 30 minutes a day on chores, which equals 64 hours in 2012 and 58.5 in 2013. Add another 40 total hours on building, repairs, etc. This is a total of 100 hours of labor. At \$12/hour, this is another \$1200 to the total cost. This means that raising Muscovy ducks for meat, a farmer would need to add another 60 ducks per season to break even.

Financial Summary

The total costs to raise ducks for meat appear to be approximately:

\$20 per bird for feed (for meat breeds that gain sufficient weight)

\$5 per bird for duckling

\$4 per bird for slaughter

\$3000 in start-up costs (\$300/year)

\$1200/year in labor

If an 8-pound bird can be sold for \$40 (\$5/lb), then 150 birds would allow for a break-even including labor over ten years, while raising 420 birds would pay off the costs in a single season. The calculations we have provided are based off 50 birds, and relatively minimal numbers with regard to labor, material, etc.

Unfortunately, this is a reality with many small farm operations. We are aware of this challenge and it remains one of the reasons we stack the duck chores with mushroom cultivation – where we get two yields for my time.

Reducing Costs

There are many ways that costs could have been reduced, which might make this scenario more reasonable for a farmer considering the potential for meat production. They include:

- 1) **Purchasing feed in bulk.** This would require an upgrade of storage facilities but could probably pay off in a ten-year timeframe. Since we were trialing the concept we didn't invest in such a unit.
- 2) **Being more careful on infrastructure purchases.** Some of the items in the chart above

turned out to be less ideal in the system and could have been reduced or avoided. This included some of the fonts, feeders, and troughs. We recommend the necessary infrastructure in the previous sections.

- 3) **Raising meat breeds with good weight gain.** Remember that the first potential profit calculations above were done with the medium weight birds and that the Muscovy fared much better. The medium weight breeds are simply not appropriate for meat production in the current market, though they might be able to be successful in a local niche market where customers are willing to work with smaller birds.
- 4) **Raise your own ducklings.** More analysis would need to be done on the costs of infrastructure, but since purchasing ducklings from a hatchery runs roughly \$5 per duckling this could be a big money saver.

PART III: CONCLUSION

Out of all the lessons we learned through this project, the most valuable result was considering how this system affected our farm goals and values.

One of the primary goals on our farm is to continuously try to reduce outside inputs, especially grain feed, as it is energy intensive and cost increases. One of the initial appeals of ducks was the idea that they could forage much of their food needs on the farm. What we did not consider was that raising poultry for meat inherently means relying on some grain, as there is pressure from consumers to get the birds as big as possible in as short a time as possible.

We question if raising poultry for meat markets is inherently unsustainable, especially when compared to ruminants, who can largely be fed from maintained pasture and on-farm feed (hay). Our focus is moving forward is to examine the potential to produce eggs and see if we can maximize onsite food production. Our focus for meat production, at least commercially, is shifting to sheep, which we think we can raise with less outside inputs as compared to any poultry.

Our idea to integrate ducks into other farm systems appears to be a good road to head down, but we recognize that ducks are but a mere part of the whole system. It was perhaps too optimistic hope that adding ducks to a dynamic forest ecosystem would rid us of our slug problems. This project reminded us that we cannot expect that one species or strategy will solve a single problem entirely. This is not how nature operates. Instead, ducks have proven to be *part* of the solution, one that we will continue to explore over the many seasons ahead.

We also learned that research is challenging to do when one is also farming a crop or system. The time and discipline required to capture all the data we may have wanted to just wasn't always available. This is often why farmers are making decisions on the fly, and more often based on observation or instinct rather than numbers and statistics. Yet, we have recognized through this project the incredible importance in data collection. It's most important benefit is that it aids in our decision-making.

Without measuring feed and calculating costs, how would we ever know if we were even close to making a profit, much less breaking even? While there are endless possibilities as to the

types of data one could collect, we are keeping a keen eye to those which would be worth it; especially feed costs and the effect of rotation and a larger diversity of forages on animal health and weight gain.

The opportunity provided by the funding to step into a new venture without the pressure of economics was critical in our ability to collect information, reflect on our experience, and learn a great amount about the potential of integrated systems. We are pleased that ducks will continue to rotate through our forest and fields, offering a worthwhile service, providing us with product, and enjoying a healthy existence all at the same time.

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Our Sincere Thanks to:

NE-SARE for funding and support

Roger Ort and Ken Mudge for providing technical expertise

Joshua Pezet for his help wrangling and weighing ducks all season (2012)

Jennifer Gabriel for her wonderful photos.