NON-TIMBER FOREST PRODUCTS: RAMPS IN THE WAYNESVILLE, NC WATERSHED

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Abstract--The potential of forest farming was noted as far back as 1929, but the recognition of its importance dates back only 20 to 30 years. The U.S. market for harvested foods and medicinal plants from forests now exceeds $4 billion annually. Ramps (*Allium tricoccum* Aiton), or wild leeks, grow in patches in the rich moist forests of the eastern United States. They are harvested during the spring, and their use is becoming more popular. This increased harvesting pressure is forcing national forests and local municipalities to consider the long-term sustainability of plant populations. In 2010, a study was initiated in the Waynesville, NC watershed to examine the reproductive biology of ramps and to assess the field survival of their seeds. Flower stalk survival and seed production of individual ramp plants were tracked, length of time ramp seeds remain viable in the seed bank was determined, and the basic germination requirements of seeds were studied. We found that seeds will not germinate without some form of stratification and that no seeds remained ungerminated in the sample buried for 20 months in the field.

INTRODUCTION

We have little information about the flowering cycle and seed development for some understory plant species. Also lacking are data on how long seeds of certain understory species survive naturally in the field or how long they can be stored at low temperature in the laboratory. This information is not only critical for assessing potential of a species to thrive in the field but also can be used to evaluate its storage potential in artificial germplasm reserves. Ramps (*Allium tricoccum* Aiton; fig. 1) grow in patches in the rich deciduous forests of eastern North America from Canada south to Tennessee and North Carolina (Davis and Greenfield 2002). A member of the Liliaceae family, the plants have broad, smooth leaves that appear in March or April and send up a shoot of white flowers in summer. Ramp plants also reproduce vegetatively from underground rhizomes or when a bulb is large enough to split. The plants were the first 'greens' of spring for early settlers in the eastern United States and are now harvested during annual spring festivals which are growing in popularity, as evidenced at http://www.richwooders.com/ramp/ramps.htm [Date accessed: April 17, 2013]. Typically, both the leaves and bulbs are harvested as well as any attached underground rhizomes (Rock and others 2004).

Ramp flower stalks appear after leaves have senesced. Each stalk has a head of small

Figure 1--Ramp leaves emerging (early March).

(approximately 6-mm long) flowers, each of which contains one ovary. The ovary matures into a three-celled seed capsule; each cell can produce one seed, thus there is a maximum production of three seeds per flower. The seeds, which mature in late August or early fall, are shiny black spheres approximately 3 to 3.5 mm in diameter (fig. 2). Because harvesting occurs before flower stalks are readily apparent and

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long before seeds mature, genetic diversity in wild populations may be devastated if harvesters fail to nurture individual patches by allowing some mature plants capable of flowering to remain *in situ* and by leaving rhizomes undamaged [Davis and Greenfield 2002; Edgar and others (no date); Rock and others 2004].

Figure 2--Ramp mature seed head (September).

OBJECTIVES

Our study objectives were to: (1) determine flower stalk survival and seed production of individual ramp plants; (2) observe ramp seed longevity and viability in the seed bank; and (3) examine the basic germination requirements (stratification procedures, light requirements) of ramp seeds.

MATERIALS AND METHODS

The Study Site

The field study was installed and seed heads harvested on the 8,400-acre Waynesville Watershed, located in Haywood County, southwest of Waynesville, NC [35 29' 19" N, 82 59' 20" W (fig. 3)]. The 50-acre man-made reservoir and surrounding watershed are classified by the state of North Carolina as WS-1, the state's most stringent classification, under which development is forbidden. The watershed is one of the largest tracts of undeveloped, non-federal forest land remaining in western North Carolina. Detailed information on soils and forest cover can be found at http://www.townofwaynesville.org/content/view/374/347/ [Date accessed: July 14, 2010].

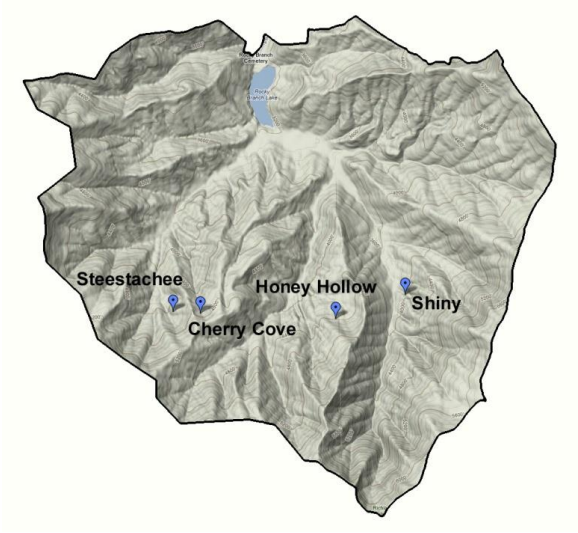

Figure 3--Map of the Waynesville Watershed and study site locations.

Flower Stalk Survival and Seed Production

Fifty individual ramp plants with flower stalks forming were flagged in May 2010 on each of four sites in the watershed: Honey Hollow (HH), Shiny Gulch (SH), Cherry Cove (CC), and Steestachee (ST). Two months after flagging, an average of 37.5 percent of the flower stalks had aborted or died. Flags were moved to plants with fully formed flower stalks to maintain data collection on 50 plants per site. The number of flowers per stalk, the number of seeds developing per stalk, the number of dominant seeds forming, and the number of mature seeds produced by each stalk were counted and recorded. A dominant seed is defined as one which, at the time of observation, is visually larger than other seeds formed on the same flower (fig. 4).

Seed Bank Study

Ramp seeds for the seed bank study and laboratory study were collected from plants transplanted from western North Carolina (Waynesville Watershed; Franklin, NC; and Robbinsville, NC) to raised beds in Blacksburg, VA (37° 16' 29.63" N, 80° 25' 15.40" W, elevation 2,024 feet). Seeds were harvested in 2009 and cold-stored prior to field study establishment.

Figure 4--Example of dominant seed (arrow).

Screen mesh bags measuring 7.6- by 10.2-cm (3- by 4-inches) and sewn with plastic thread were made to enclose the seeds for the seed bank study. Each bag contained 100 seeds. Four bags were harvested at each sampling time throughout the year. Bags were buried 1.27-cm (0.5-inch) deep and covered with mineral soil in September 2010. A wire mesh 'sandwich' enclosed each set of 4 bags (fig. 5). Sites were marked with numbered flags to facilitate recovery, with 4 bags anchored to each flag. The flag to harvest on each collection date was randomly determined at the start of the experiment. Seeds that were harvested but had not germinated in the field bags were used to determine the laboratory germination requirements of ramp seeds.

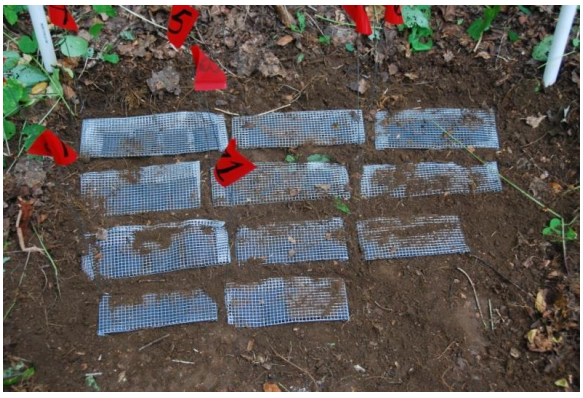

Figure 5--Bags enclosed in a wire mesh 'sandwich' and buried in contact with mineral soil. Bags are attached to flags to facilitate retrieval.

Laboratory Study

Treatments--In initial germinations tests, we found that placing boxes of ramp seeds straight into a Precision® low-temperature illuminated incubation chamber set at a uniform temperature of 30 ˚C without prior cold stratification resulted in no germination. In addition, cold stratifying seeds for 12 weeks prior to placing them in the germination chamber at a uniform 30 ˚C resulted in no germination. Cold stratification was accomplished by rolling the seeds in a moist paper towel, sealing the towel in a plastic bag, and storing in the cold room at 5 ˚C. We abandoned the uniform temperature approach and reset the Precision cabinet to register 25 ˚C for 16 hours with no light and 30 ˚C for 8 hours with light.

Four replications of 100 seeds each were placed in clear plastic boxes layered with moist sand. In addition to the lid, the top of the box was sealed with a layer of clear plastic wrap. The boxes were put in the low-temperature illuminated incubation chamber using the fluctuating temperature regime (fig. 6). Seeds remained in the germinator for 12 weeks. They were then cold stratified for 12 weeks by placing the boxes in the cold room at 5 ˚C. After stratification, the boxes were put back in the germinator for an additional 12 weeks.

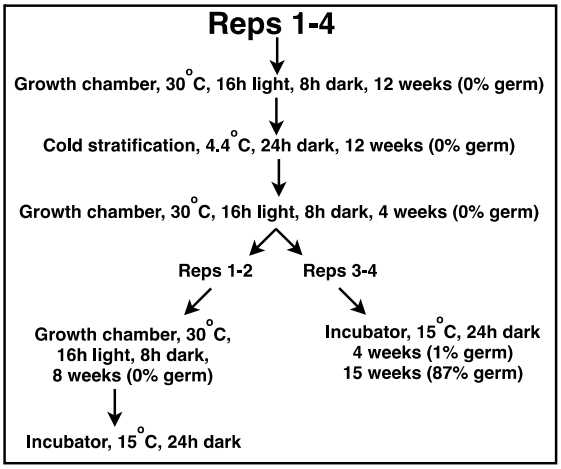

Figure 6--Ramp seed laboratory germination flow diagram.

Although it was not part of our original study plan, we acquired a non-illuminated, refrigerated Revco® incubator well after the study was well

Table 1--Ramp flower and seed production information for four sites within the Waynesville Watershed, NC

Site Code	Average flower stalk length	Average flowers per stalk	Total seed sites (T)[a]	Total dominant seeds (D)[b]	Total seeds collected (C)	C/T	C/D
	mm			*number*		*percent*	
ST	317.4	11.2	1,594	355	337	21.1	94.9
CC	290.7	10.6	1,584	574	343	21.7	59.8
SH	256.9	12.5	1,762	691	453	39.2	65.6
HH	279.5	17.9	2,680	1,036	857	32.0	82.7

[a] There are typically three seeds (a cluster) formed in each flower. Some of these seed sites, however, were necrotic or unformed and were not included in the total.

[b] Dominant seeds were those in each seed cluster that were developing normally and that could reasonably be expected to form mature, viable seeds. They were visibly larger than other seeds formed from the same flower (fig. 4). These seeds were counted in August and collected in October.

underway and utilized it to expand our experiment (fig. 6). Replications 1 and 2 remained in the illuminated incubation chamber for an additional 8 weeks. Replications 3 and 4 were placed in the non-illuminated incubator, set at 15 ˚C, for 12 weeks.

RESULTS AND DISCUSSION

Flower Stalk Survival and Seed Production

Seeds were only collected once during the fall, and some may have shed before collection. Because of this, it is said with qualifications that an average of 10 seeds were produced per flower stalk (table 1). Like all members of the Liliaceae, each ramp flower can produce three seeds. Of the total potential seed sites on each stalk, 74 percent did not form or were aborted, resulting in an average seed yield of 26 percent. We also counted the number of dominant seeds (fig. 4) that were being formed in each ramp flower in August 2010 and found that an average of 75 percent of these seeds survived to maturity when collected in October 2010, again with the qualifier that only one collection was made during the fall. Insect predation was apparent on 14.3 percent of collected seeds (fig. 7). Eighty percent of these damaged seeds were found at the HH site.

Seed Bank Study

Ramp seeds did not germinate in the field until the collection in August 2011, 11 months after the bags were buried. Then, only roots had emerged. We did not observe shoot emergence in the field until May 2012, 20 months after study initiation (fig. 8). We found no viable, ungerminated seeds in that collection or in the July 2012 collection. From these data, we hypothesize that ramp seeds will not remain in the seed bank longer than 2 years. If mature plants are removed from a site and rhizomes harvested or damaged, it is doubtful that populations will recover.

Figure 7--Seed pods damaged by insect activity prior to harvest.

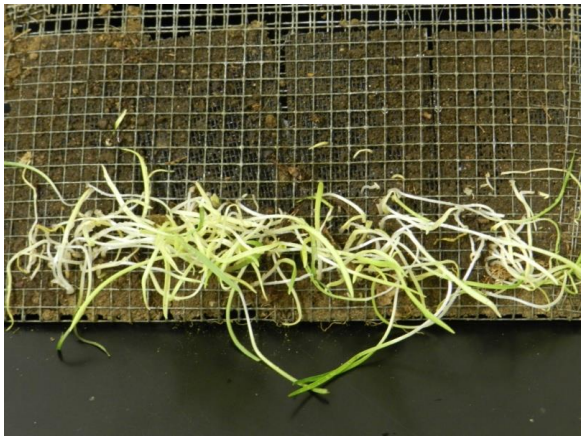

Figure 8--Ramp seeds with both root and shoot emergence in bags collected from the field (May 2012).

Laboratory Study
Laboratory seed germination proved difficult. Alternating light and dark regimes at uniform temperature in the chamber proved ineffective, as did a cold stratification treatment, in accelerating germination.

It wasn't until we acquired an incubator and put seeds into it for 24 hours without light and at a cooler temperature (15 ˚C) that roots emerged. Determining if it was the absence of light or the cooler temperature that affected root emergence will be the subject of another study, when more seeds can be acquired from the study sites. Shoot emergence in the laboratory tests was not achieved.

ACKNOWLEDGMENTS
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