

## The development of uneven-aged southern pine silviculture before the Crossett Experimental Forest (Arkansas, USA)

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Although the Crossett Experimental Forest (CEF) played a well-publicized role in the development of uneven-aged southern pine silviculture, work on a selection method in Arkansas (USA) did not originate there. In 1925, Leslie Pomeroy and Eugene Connor acquired the Ozark Badger Lumber Company and initiated an expert-driven selection management system compatible with small parcels, with few absolute rules but requiring familiarity with local conditions. Deceptively simple in its application, the uneven-aged silviculture practised by Pomeroy and Connor removed mature shortleaf (*Pinus echinata* Mill.) and loblolly (*Pinus taeda* L.) pines to improve growth of the residual trees and encourage the establishment and release of pine seedlings. For their approach to work, Pomeroy and Connor needed self-sustaining, fast-growing, accessible stands, and the privately owned, pine-dominated forests of southern Arkansas proved amenable. By the mid-1930s, Pomeroy and Connor had engaged many local farmers and small forest owners in an arrangement coined 'pine-tree banking'. In pine-tree banking, they tended thousands of hectares of other landowners' forests with their brand of uneven-aged silviculture, providing landowners with a dependable income and helping to assure a steady supply of sawtimber for Ozark Badger. The success of Ozark Badger no doubt helped inspire later work at the CEF and helped draw many visitors, including foresters, government officials, visiting academics, university students, and other landowners. While the better-documented uneven-aged southern pine silviculture on the CEF soon outshone the efforts of Pomeroy, Connor, and Ozark Badger, they were the operational pioneers of this system in Arkansas and deserve to be recognized as such.

### Introduction

The practise of uneven-aged silviculture (UEAS) largely developed in forests dominated by shade-tolerant tree species (Smith, 1986; Schütz, 1999; Puettmann *et al.*, 2009). UEAS is well-suited to species whose seedlings can persist under the relatively continuous canopy cover and competitive belowground environment of forests (Toumey and Korstian, 1947). In addition, for UEAS to be viable, those trees must positively respond to increases in resource availability following release. UEAS in forests dominated by shade-intolerant trees is considerably less common, but this system has been adapted for some light-demanding species (Smith, 1986; Smith *et al.*, 1997; O'Hara, 2014). For example, in the early- to mid-twentieth century, foresters applied UEAS systems originally developed in more shade-tolerant European forests to some of the multi-aged, shade-intolerant conifer forests in America (Kirkland, 1933; O'Hara, 2002, 2014). While these attempts were not always successful (e.g. with coast Douglas-fir (*Pseudotsuga menziesii* Franco. var. *menziesii*)), UEAS proved viable in a number of shade-intolerant forest types (Smith, 1986; O'Hara, 2002), especially when group selection and variations of

single-tree selection with lower stand-level residual stocking were developed.

Perhaps the most prominent example of successful UEAS in shade-intolerant trees can be found in the southeastern United States (US), where it has been used for many decades in some loblolly (*Pinus taeda* L.) and shortleaf (*Pinus echinata* Mill.) pine-dominated forests (e.g. Reynolds, 1959; Brender, 1973; Reynolds *et al.*, 1984; Baker *et al.*, 1996). From the beginning, UEAS in southern pines was counterintuitive because these taxa are considered to be intolerant (in the case of loblolly and shortleaf pines) to very intolerant (in the case of longleaf (*Pinus palustris* Mill.) and slash (*Pinus elliottii* Engelm.) pines) of competition (Chapman, 1944; Toumey and Korstian, 1947). The light-demanding nature of southern pines favours more open overstories—i.e. lower stocking—to ensure their seedlings germinate, establish, and grow into the canopy. Further, the tendency of unimproved southern pines to produce large branches and poor bole forms in high light environments (Garver and Miller, 1933) also favoured the use of even-aged silviculture. To one American silviculturist, the conditions required to ensure both good regeneration and growth meant that uneven-aged southern pine

stands were ‘...run[ning] with only half [their] cylinders firing—and the poorer half at that!’ (Wakeley and Barnett, 2011, p. 57).

Wakeley’s statement on the inefficiency of UEAS was made in the early 1960s as silviculturists started widely converting naturally regenerated southern pine forests into more intensively managed pine plantations. The subject of his disdain was the US Forest Service’s (USFS’s) Crossett Experimental Forest (CEF) in southeastern Arkansas (Figure 1). The 678-ha CEF opened in 1934 under Project Leader Russell R. Reynolds and has systematically studied and demonstrated UEAS in southern pines since 1937 (Reynolds, 1980; Guldin, 2011). The work of Reynolds and his colleagues have long been considered the best-documented example of UEAS in southern pines (e.g. Reynolds, 1980; O’Hara, 2002; Guldin, 2011) and still merits mention in most American silvicultural textbooks (e.g. Smith *et al.*, 1997; O’Hara, 2014). With two of the original 24 study compartments (the Good and Poor Farm Forestry Forties) now entering their 80th year under UEAS, the CEF has one of the very few examples in the world for which virtually every tree—from new seedling to mature overstory dominant—originated under this management regime (Guldin, 2011; Bragg and Guldin, 2015). During this period, annual growth on the Good and Poor Forties has averaged between 4.5 and 5.5 m<sup>3</sup>ha<sup>-1</sup> of pine sawtimber (in trees >30 cm in diameter at breast height, d.b.h.) (Guldin, 2011).

Even though the CEF has played a prominent role in the development of uneven-aged southern pine silviculture, the first implementation of UEAS in this cover type did not occur at Crossett. Rather, it was installed about a decade earlier not far to the north near the village of Wilmar (Figure 1), through the efforts of two young engineers-turned-lumbermen. These men, Leslie K. Pomeroy (Figure 2) and Eugene P. Connor (Figure 3), defied long odds and turned the small, nearly defunct Ozark Badger Lumber Company nestled in the cutover ‘pineywoods’ into a profitable, long-term example of UEAS. This narrative will review both the historical development of silviculture in southern Arkansas and the contributions of Pomeroy, Connor, and Ozark Badger to the eventual success of UEAS in southern pines.



**Figure 1** Map of Arkansas, showing key geographic locations referenced in this paper.

## Southern pine silviculture in early twentieth century Arkansas

The achievements of Pomeroy and Connor at Ozark Badger are remarkable, given the daunting circumstances they faced. By the time of they acquired the Ozark Badger mill, the prominence of the Arkansas lumber industry had faded considerably. At its peak in 1909, more than 2000 mills annually produced almost 5 million cubic metres of dimensional lumber (62 per cent of which was southern pine) and millions of cubic metres more in lath, staves, firewood, chemical wood, poles and pilings, and other forest products (Harris and Maxwell, 1912; Reynolds and Pierson, 1939). (All volumes in this paper use the following



**Figure 2** Leslie K. Pomeroy next to a loblolly pine seedling that established after the two larger pines were felled. Unknown photographer, circa early 1930s (photograph courtesy of Michael Pomeroy).



**Figure 3** Eugene P. Connor standing amongst southern pine logs stored for milling when conditions were too wet to haul logs from the woods. The Ozark Badger mill in Wilmar is pictured in the background of this image taken during the 1930s, probably by Leslie K. Pomeroy (photograph courtesy of Michael Pomeroy).

conversions adapted from [Fonseca \(2005\)](#) between the Doyle log rule and metric units of measure: for standing (live) timber of dimensions typical of that time period considered, 1 cubic metre = 255 board feet; for cut logs at a mill, 1 cubic metre = 424 board feet of sawn lumber. Note that because of cull and estimation errors, standing timber yields are less than mill-run logs.) By 1925 (the year of the Ozark Badger purchase), total Arkansas lumber production had dropped to 3.77 million cubic metres from 635 mills, a decline that would continue for another decade ([Reynolds and Pierson, 1939](#)). Forest cover statistics for the region are limited before the late 1930s, but by 1920 only about 12 per cent of the southern pine forest in Arkansas was considered old-growth ([USFS, 1920](#)), with most of this 'virgin' or previously uncut timber in the Ouachita Mountains of western Arkansas ([Greeley, 1925](#)). In an era when wood from old-growth southern pine was considered the standard ([Reynolds, 1980](#)), only widely scattered pockets of this timber remained when Pomeroy and Connor arrived—this prospect alone probably explained why most of the experts consulted told them that their efforts would fail.

Those same experts had little advice to offer Pomeroy and Connor regarding the best silvicultural options for southern pine in 1925—almost no forest management of any kind was done at this time across the region. At the turn of the twentieth century, the American timber industry had little interest in sustainable management, preferring to 'cut-out-and-get-out' ([Reynolds, 1980](#)). The quantity of virgin forest remaining, coupled with unfavourable tax policies, gave these lumbermen few incentives to practise forestry. Not surprisingly, then, silviculture evolved gradually in the southern US. Starting around 1900, the federal government dispatched trained foresters across the region to meet with interested lumber companies and develop 'working plans' for extending the life of their timberlands. These included southern pine-dominated operations in Arkansas ([Olmsted, 1902](#)), South Carolina ([Chapman, 1905](#)), and Alabama ([Reed, 1907](#)). The tentative recommendations of these early plans focused on leaving enough small pines for a second harvest years or even decades after cutting the virgin timber. This approach (derided by some as more 'conservative lumbering' than actual forestry), coupled with calls for fire protection and retention of a few seed trees per hectare, dominated the advice of the USFS during this early period ([Fernow, 1911](#)).

As World War I approached, additional suggestions for 'perpetual forestry' of southern pines appeared, including the reduction of wasteful logging, protection of forests from livestock grazing, an increase in the minimum diameter of seed trees to be left on the site, and preferential species selection (e.g. [Zon, 1905](#); [Ashe, 1910](#); [Dunston, 1910](#); [Record, 1910](#); [Foster, 1912](#); [Chapman and Bryant, 1913](#)). After years of alarming reports of an impending 'timber famine' (e.g. [US Bureau of Corporations, 1913](#); [Peters, 1916](#); [USFS, 1920](#)) and the waning of regional timber supplies, industry attitudes gradually changed. An increasing number of exceptions to industrial indifference to silviculture appeared—for example, as early as 1913 lumberman Henry Hardtner experimented with different treatments in cutover southern pines in central Louisiana ([Arthur, 1915](#); [Hardtner, 1928](#); [Barnett, 2011](#)). Faced with closure or relocation to the western US, a number of major Arkansas operations including the Crossett Lumber Company, Dierks Lumber and Coal Company, the Union Saw

Mill Company, and the Fordyce Lumber Company had started forestry programmes by 1925 ([Hamlen, 1925](#); [Hall, 1925b](#)).

Yet the focus of nascent industrial silvicultural efforts in the 1920s (usually limited to the retention of smaller-diameter pines for future cuts and the protection of seed trees and advanced reproduction; [Williams, 1923](#); [1925](#); [Hall, 1925a](#), [Wackerman, 1931](#); [Garver and Miller, 1933](#)) hardly differed from the recommendations of the US government two decades earlier. At this time there was little in terms of documented success of any silvicultural method in Arkansas—or elsewhere in the southern US, for that matter. This fact makes the eventual adoption of UEAS by Ozark Badger all the more remarkable. Although of growing popularity in parts of Europe, UEAS was virtually unknown in North America ([Hawley, 1922](#)) and was generally not considered appropriate for southern pines by most early American foresters (e.g. [Chapman, 1944](#)). Indeed, [Ashe \(1910\)](#) had advocated for the 'clean cutting' (clearcutting) of second-growth loblolly and shortleaf under most circumstances. However, as European silvicultural experiences became more widely known, perspectives began to change. For example, 20 years later [Ashe \(1929, p. 763\)](#) offered a more nuanced take on even-aged management:

Clean cutting or clean cutting with seed trees is a simple—almost mechanical—process. It is the process that requires the least judgment; it is the easiest way. It largely does away with the silvicultural problems of light and the adjustments of light to restocking by natural methods...It permits cheap logging. While it is the method of least resistance, it is also schematically the most perfect. It is a system, however, which does not lend itself to the production of large-sized timber except at enormous cost...[clean cutting] continually brings up the irritating questions of interest and carrying charges... [and] under continuous practice it is the system which on many sites may lead to rapid deterioration of the soil...

In this report, his perspective on UEAS ('selection fellings') was generally positive. While [Ashe \(1929, p. 764–766\)](#) noted that multi-aged stands fell short of the goal of maximizing stand-level annual increment,

...there remains a broad field within which selection or group selection felling or a series of partial fellings offers the most rational method of management. It is preeminently the system for farm woods and for small estates, and in many cases is adapted to larger units...[it] holds out to the timberland owner the expectancy of an early recut and the possibility of producing timber of a higher grade, timber which will command the highest stumpage price and with relatively low carrying charges on the investment. In this way it arouses the interest of the owner in his property as an investment, leaving aside the depressing subject of age of mature trees.

Ashe's assessments were based almost exclusively on the work of European practitioners and researchers, with little beyond his own personal observations in southern pines. Locally, there were few examples to consult. In west-central Arkansas, the Malvern Lumber Company had started marking pines for selective cutting in 1926 ([Heyward, 1958](#)) and around this time the Arkansas (eventually, Ouachita) National Forest developed a

selective logging strategy for their shortleaf pine-dominated landscapes, many of which were still virgin timber (Garver and Miller, 1933). Note that the terms ‘selective cutting’ and ‘selection management’ were not consistently applied during this period—for example, the title of Garver and Miller’s (1933) paper included the term ‘selective logging’ when their described practises were actually selection management; Pomeroy (1935, 1950) and Bull and Reynolds (1943) were similarly casual in how they referred to ‘selective cutting’. By convention, ‘selective cutting’ concentrates on only the trees removed (and can result in high-grading), and the ‘selection management’ system focuses on both improving stand quality through the removal of poor quality and oversized trees as well as ensuring regeneration of the desired crop species (Chapman, 1944; Puettmann *et al.*, 2009).

### Solving the challenges of Ozark Badger

While engineering undergraduates at the University of Wisconsin-Madison during World War I, Leslie Pomeroy and Eugene Connor worked together at the USFS’s Forest Products Laboratory (FPL), first part-time then as full-time employees (Connor and Pomeroy, 1971). Following the end of the war, the men continued at the FPL until their projects were closed down by late 1919. Shortly thereafter, they embarked on a self-funded world-wide tour to gain additional experiences in the timber industry, using their knowledge of kiln drying to help support their travels en route (Danielson, 2011). The next year (1920) they returned to Madison to work for lumberman Edward J. Young, who dispatched Pomeroy and Connor to work at his southern pine mills in Alabama, Mississippi, and Louisiana. Pomeroy and Connor’s experiences in the southern US intrigued them about the potential of second-growth southern pine—so much so that they purchased the Ozark Badger mill in 1925 when offered the chance by the Wisconsin-based Stoughton Wagon Company (Connor and Pomeroy, 1971).

To buy Ozark Badger, the ambitious yet poor men had to convince enough family members, friends, and others to invest in their vision (Connor and Pomeroy, 1971). Consummate salesmen, Pomeroy and Connor soon raised the money needed, but this was only the first of the challenges they faced—next, they had to supply their recently acquired mill with sufficient timber to be economically viable. Traditionally, most large-scale lumber operations in the southern US sourced wood from company-owned lands and long-term timber contracts. As an example, in 1898 the Crossett Lumber Company acquired just over 19 000 ha of prime old-growth pine in southern Arkansas and northern Louisiana for about US\$325 000 from a firm that had purchased these lands from the federal government (public domain), other speculators, and many private individuals (Darling and Bragg, 2008). After their initial acquisitions, most of the big mills like Crossett continued to buy forestland and timber contracts to ensure uninterrupted operations for decades. Using an example adapted from Wackerman (1931), a ‘typical’ large southern pine operation produced about 235 m<sup>3</sup> of sawn boards per day, or almost 70 000 m<sup>3</sup> every year (working 296 days per calendar year). Assuming an average of about 80 m<sup>3</sup> of standing pine volume per hectare of virgin timber, to meet a typical mill’s requirements ~875 ha would be felled annually. Hence, this mill

could be expected to operate for 45 years on a landbase of 40 000 ha (of course, timber lost to fire, wind, insects, disease, etc., shortened that period). Once a lumber operation secured its timber supply, the next challenge was getting the wood to their mill. The heavy, dense southern pine wood did not lend itself to floating to the mill, as had been done with eastern white pine (*Pinus strobus* L.) in the northern US. The preferred solution was to build railroad networks across their lands to haul the logs (Curry, 1953; Darling and Bragg, 2008). After the merchantable timber had been cut, the companies would remove any temporary rail lines and move them into the next stand. For this rail system to be economical, a large volume of high quality timber was required from extensive tracts of contiguous forest (Reynolds, 1980; Darling and Bragg, 2008).

When Pomeroy and Connor purchased Ozark Badger, the small mill came with virtually no forestland and few prospects for acquiring sufficient timber in the ‘traditional’ fashion. By 1925, most of the old-growth pine in this part of southern Arkansas had been cut by the much larger Gates Lumber Company, which had cleared its holdings and closed in 1924. Pomeroy and Connor purchased a limited amount of forested land upon their arrival to keep the Ozark Badger mill running. They also addressed some of their needs by purchasing unfinished boards from some of the many small ‘peckerwood’ portable mills that dotted the south Arkansas countryside during this period. This rough lumber would then be resawn and finished to meet orders placed with Ozark Badger. Portable mills had elsewhere proven economically viable in selectively logged second-growth southern pine (e.g. Garver, 1933), and Ozark Badger operated two small portable mills of their own until the Great Depression forced their closure (Connor and Pomeroy, 1971).

While these addressed the short-term need for wood, they were not satisfactory long-term solutions. To ensure the future of their company, Pomeroy and Connor had to develop a sustainable flow of timber from lands they did not control, using forestry practises that remained largely unproven, from a public that still resisted the notion that there was enough value in trees to treat them as more than a nuisance. During this same time period, even the much larger Crossett Lumber Company struggled to convince people that forestry was not a ruse to wrest their properties from them—that there was no ‘pine tree menace’, as one local politician and newspaper editor had long claimed (Bragg, 2010). The answer to their wood supply problem was both simple and fortuitous, if not revolutionary—Pomeroy and Connor relied upon scores of small private landowners in the region. These owners controlled a majority of the forest in the southern US, and had long been recognized as potential if oft-neglected, wasteful and exploited contributors to the American forest products industry (e.g. Finney, 1910; Crossett Lumber Company, 1924; Mattoon, 1930; Connor, 1934). If they could be persuaded to practise good forestry, collectively this group could reliably supply second-growth pine to Ozark Badger. Fortunately, most of these landowners were interested in income from their land, especially as the miseries of the Great Depression were magnified by large-scale droughts in the 1930s that reduced the productivity of farms in southern Arkansas. Many were desperate for income: one farmer offered to sell Pomeroy all of the timber on his land for US\$16 ha<sup>-1</sup> (Horn, 1951)—a short-term bargain for the lumberman, for

sure, but also a recipe that would have quickly consumed the available timber resource.

In these private lands, Pomeroy and Connor also recognized an opportunity that few others had realized—unlike much of the cutover US, southern Arkansas had not been entirely denuded of timber. About two-thirds of the region was still forested in the early 1930s, with an estimated 26 million cubic metres of standing pine of which less than 10 per cent was uncut old-growth (Cruikshank and Wheeler, 1937). However, the smaller logs and poorer stocking of second-growth southern pine across many ownerships made rail lumbering prohibitively expensive (Reynolds, 1980). Fortunately for Ozark Badger, technological and infrastructure improvements helped address this challenge. After World War I, larger, more powerful, and affordable trucks became widely available to small contract loggers (Pomeroy, 1950; Reynolds, 1980; Darling and Bragg, 2008). Truck-based operations made the partial cutting of stands economically viable. In addition, federal and state investments in road improvements increased as a part of Great Depression-era employment projects and rural modernization efforts (Reynolds, 1933, 1938; Heyward, 1958), providing better access to more lands. This combination allowed Ozark Badger to get limited volumes of wood from isolated tracts of private timber delivered affordably to their mill (Figure 4). However, acquiring sufficient volumes of second-growth pine timber from small private landowners (especially farmers) was meaningless if Ozark Badger could not find buyers for their finished products. At this time, conventional wisdom held that lumber sawn from faster-growing second-growth southern pines was inferior to that cut from old-growth (Reynolds, 1980). Fortunately, studies soon showed that lumber from second-growth southern pine was more than adequate for most purposes (e.g. Paul, 1932a, b; Reynolds, 1936).

Given these solutions to their wood supply and marketing challenges, Pomeroy and Connor recognized that they would need to help small private landowners sustainably manage their forests and ensure a perpetual timber supply of sufficient quality. Few farmers had any meaningful forest management experience at this time, and most that cut timber from their land when they were not farming were highly inefficient (Connor, 1934). Small landowners were more accustomed to signing long-term lump-sum contracts with the lumber companies, transferring the rights of their standing timber for a cash payout



**Figure 4** ‘Kid’ Stiles drove a log truck for the Ozark Badger Lumber Company. Photograph originally taken in June of 1934 by Leslie K. Pomeroy, courtesy of Michael Pomeroy.

at the beginning of a 15- to 20-year agreement. The company would then usually wait until the end of the lease before cutting the timber (Reynolds *et al.*, 1984). Since there were no arrangements to pay the landowner for the additional timber growth during this lease, the lumber company would benefit from the increase in volume while the landowner was responsible for paying the property taxes and protecting the stand. Rather than continuing to exploit farmers in the same fashion, Pomeroy and Connor offered an alternative they called ‘pine-tree banking’.

## Pine-tree banking

Even with their prior experience in the southern pine lumber industry, Pomeroy and Connor did not know what silvicultural system would work best on these private lands. As mentioned earlier, they consulted numerous forestry academics, government agents, local lumbermen, and the few practicing foresters in the area, but those that had not dismissed their efforts outright had not offered satisfactory alternatives (Connor and Pomeroy, 1971). Apparently none had recommended UEAS, suggesting the use of clearcutting and replanting instead (Pomeroy, 1950). Initially, Pomeroy and Connor settled on a 43-cm-d.b.h. diameter limit (even-aged) approach, which removed ~75 per cent of the sawtimber in the stands and left the rest to grow to merchantable size in time for a second cut. However, they found this even-aged system inadequate, as few stands grew sufficient sawtimber to support a second cut after 5 years (a frequent return interval was deemed necessary to produce regular cash flows to private landowners). Many of these stands also became overstocked with small diameter pines that would need thinnings to improve the performance of crop trees (Pomeroy, 1950).

What quickly emerged to replace this diameter-limit management approach was an expert-driven selection management system, with few absolute rules and requiring considerable familiarity with local conditions and species. Deceptively simple in its application, the UEAS practised by Pomeroy and Connor focused on the removal of mature pines to improve the growth of residual crop trees, release advance reproduction, and establish of new pine seedlings. In addition, they emphasized the close tending of the intermediate size classes, with targeted thinnings of smaller pines to remove diseased, poorly formed, or suppressed individuals. As needed, additional harvests in the maturing stand removed crop pines for pulpwood, telephone poles, or small sawtimber and reduced stand density to further promote growth (Pomeroy, 1950). Most trees were harvested once they exceeded 50 cm d.b.h., but even these large pines could be left if of good vigour and if they had sufficient clear bole length, straightness, and quality for pilings (pilings are long, straight, often chemically preserved large-diameter poles for specialty uses that command substantially higher prices than premium sawtimber).

For this UEAS system to work, Pomeroy and Connor needed prolific, fast-growing trees on lands readily accessible to the primitive trucks then available—and the privately owned, shortleaf and loblolly pine-dominated forests of southern Arkansas proved amenable. Research has shown that both loblolly and shortleaf pine produce good to bumper crops of seeds 3 or 4 years out of 5 in this region (Grano, 1973; Cain and Shelton, 2001), and both reach merchantable size quickly, particularly

when stocking is regulated and sites are favourable. But how best to sell their brand of UEAS to private forest owners in southern Arkansas? Unlike European foresters, who had decades or even centuries of experience working with landowners, American foresters were only just starting to offer the promise of silviculture (Graves, 1910). As one (Damtoft, 1922, p. 228) commented:

Conditions are not such today that the private timberland owner can be expected to consider more than the simplest and least expensive systems of forest management...To attempt to force on him at this time highly complicated and involved systems would result probably in completely discouraging him and in killing what little enthusiasm he might already have. He must be led to his ultimate destination step by step and not hurried to it, especially as he is not entirely sure of that destination nor entirely keen in his desire to reach it.

While today's foresters may see the UEAS practised by Ozark Badger as low impact, at the time it was considered 'intensive' forestry because of the regular interventions required (e.g. Hawley, 1922).

Success came rapidly to Pomeroy and Connor, in part because they knew how to reach farmers with their message (Connor, 1934). Under pine-tree banking, Ozark Badger contracted with a landowner to manage their properties for sustained yields of timber, with periodic selective cuts of pines ready for harvest (Figure 5). Given the capacity of loblolly and shortleaf pine to naturally regenerate, little investment in these lands was required—save a willingness to forgo certain detrimental practises. They did not overwhelm landowners with nuanced silvicultural details, but rather described cut trees as 'interest' derived from their 'deposit' (the growing stock), sold to Ozark Badger at market rates, with these 'dividends' available and paid frequently (every few years, when the timber was sold). This interpretation helped landowners view their trees as a valuable crop capable of producing a dependable income, rather than simply as a nuisance that interfered with farming.

Fortunately for Ozark Badger, numerous examples quickly became apparent. Within a couple of decades, the farmer

mentioned earlier in this paper soon received US\$21 ha<sup>-1</sup> for the portion of his timber cut, plus additional pay for cutting the trees himself—while retaining enough growing stock to harvest timber indefinitely into the future (Horn, 1951). Those landowners who found success with pine-tree banking also became some of the best and most vocal proponents of the practise (Lubell and Pollard, 1939) and their 'testimony' helped Ozark Badger enrol multitudes of farmers and other small forest owners by the mid-1930s. With the cash benefits of timber harvesting now apparent to farmers and other small landowners, other early forest conservation emphases became more tractable. For example, foresters had for years pushed landowners to cease livestock grazing and burning of their woodlots because of how damaging these practises were on seedlings and residual timber (e.g. Olmsted, 1902; Bruner, 1930; Hardtner, 1932; Westveld, 1935). Now that pine-tree banking offered financial promise, the appeal of woods-burning to kill ticks, snakes, and clear undergrowth for forage diminished appreciably, especially given the marginal value of these 'treatments'. One otherwise grazing-friendly report noted that livestock-based income provided only half the revenue of pine timber in comparable stands across southern Arkansas (Blackburn, 1947). Not surprisingly, then, by the late 1930s ~6000 farmers in southern Arkansas owning over 400 000 ha had been 'converted to pine-tree investment' by forestry advocates including Pomeroy and Connor (Lubell and Pollard, 1939, p. 622).

## The world comes to Wilmar—and Pomeroy goes out into the world

Even though most of the local pine-tree banking clients (and, hence, Ozark Badger's primary source of wood) were small landowners, a number of major lumber companies also implemented their approach to timber management (Lubell and Pollard, 1939). Such large-scale adoption of UEAS brought the work of Pomeroy and Connor national and international attention—and new-found support. After years of limited success in reaching out to large landowners (primarily lumber companies), the USFS had expanded their efforts to promote good forestry practices by hiring numerous extension experts to engage smaller firms, farmers, and other small landowners. In addition, the USFS supported state governments who established forest management and protection agencies. However, due largely to the influence of a handful of vocal opponents (Bragg, 2010), Arkansas had proven to be one of the last states in the southern US to embrace a state-level forestry programme. The successful adoption of UEAS and resultant economic development presented by Ozark Badger was an irresistible opportunity for the USFS, which (through its Southern Forest Experiment Station) had been seeking 'case studies' to further demonstrate the potential of good forestry practises (Ziegler and Bond, 1932). In late spring of 1932, Russell R. Reynolds was dispatched from his New Orleans duty station to help quantify the efforts of Ozark Badger with local volume tables, growth and yield information, and assessments of mortality (Reynolds, 1980) in the first such case study.

The operations of Ozark Badger also garnered the interest of other parties. Over the years, Pomeroy and Connor hosted many visitors, including government officials, foresters, timber industry representatives, students, and academics—an outreach role



**Figure 5** An example of 'pine-tree banking' on a small farmer's parcel in southern Arkansas, where a few large mature pines were efficiently harvested (notice the low stump). Photo courtesy of Michael Pomeroy.

they enthusiastically embraced. By one account, visitors from all of the US states and 10 foreign countries had toured Ozark Badger during the 1930s and 1940s; more would visit in the following years (Balogh, 1995; Danielson, 2011). Starting in 1930, Yale University professors Herman Haupt Chapman and Ralph Bryant became some of the earliest and most prominent Ozark Badger visitors when they brought their students for field tours, joined on occasion by students and faculty from other colleges (Connor and Pomeroy, 1971; Balogh, 1995). The detailed records kept by Ozark Badger staff made it easy to teach the value of UEAS, so not surprisingly these Yale tours were often accompanied by farmers, bankers, and politicians.

As Pomeroy's reputation as a forestry expert grew, so did his opportunities. In 1934, Pomeroy was selected by the Oberlaender Trust of the Carl Schurz Memorial Foundation to join other American lumbermen and foresters on a sponsored tour of private forest estates in Germany and Czechoslovakia. Carl Schurz (born in 1829, died in 1906) was a prominent German immigrant who served in a variety of appointed and elected US government positions (Historical Society of Pennsylvania, 2003). Schurz was also called by Shepard (1935, p. 8) the 'real father' of American forestry because while serving as the Secretary of the US Department of the Interior in the late 1870s he had proposed what would eventually become the national forest system. The Carl Schurz Memorial Foundation was established in his honour in 1930 by a number of influential German-Americans to promote cultural exchanges and foster friendship between the countries (Hogue, 1955). Founded by industrialist Gustav Oberlaender shortly thereafter, the Oberlaender Trust was one of several distinct funds administered by the Carl Schurz Memorial Foundation. Although not its sole mission, the Oberlaender Trust promoted German forestry practises through a variety of mechanisms (Shepard, 1935; Historical Society of Pennsylvania, 2003), including exchanges of lumbermen and foresters such as the August 1934 tour.

Several accounts of this tour were published in the January 1935 issue of the *Journal of Forestry*, including one penned by Pomeroy. In his report, Pomeroy focused on the lessons he learned from the estates visited as they related to the management of privately owned southern pine forests. From this tour, Pomeroy (1935, p. 18–19) gleaned the value of intensively managing land based on the use for which it was best suited, whether agricultural, pastoral, recreational, or silvicultural; that '...all material wealth...spring[s] from the soil' and thus the soil must be protected; a forestry plan was vital to ensuring sustained timber yields; and that Americans would do well to assume the German conservation ethic:

...forests must be protected and conserved for future generations. The present property owners should be made to realize through systematic education that they are, from a social standpoint, in reality not the owners but merely custodians of valuable assets to the nation as a whole as well as to the communities in which they are located. This, of course, does not mean that timber and forests should not be cut, but on the contrary, they should be cut and utilized judiciously.

Pomeroy's statement was not intended for public land managers, but private ones—a remarkable perspective for that time, in which forests were usually seen as a commodity to be

liquidated by landowners prior to agriculture or other 'higher' uses of the land.

Pomeroy seemed more favourably impressed by the lessons provided than some of his peers from the western US (e.g. Cornwall, 1935), who were still operating in vast swaths of uncut old-growth timber. Pomeroy did not identify any particular estate as being more relevant to his circumstances; judging from the three descriptions provided by Heske (1935), it would seem likely that the efforts of Count Arnim in Silesia most closely matched the operations of the Ozark Badger. Arnim's estate was overwhelmingly (97 per cent) Scots pine (*Pinus sylvestris* L.), primarily used for sawtimber, harvested with strip clearcuts and some selection management (Heske, 1935). According to Pomeroy (1935), his experience that 'shortleaf yellow pine[s]' (which included both *P. echinata* and *P. taeda*) were particularly well-suited for UEAS because of their ability to prolifically restock harvested areas with seedlings and rapidly respond to release in selectively logged stands. Pomeroy (1935, p. 18) did feel that large-scale reliance on artificial regeneration (a combination of sowing and planting) as practised on some of the estates would not be '...feasible in private American forestry for some time to come, and it is not needed in the South...' with the exception of afforestation of certain areas (e.g. former agricultural lands). Obviously, the nearly 19 million ha of plantations across the southern US today (Oswalt et al., 2014) speaks volumes about changes in silviculture in the decades since Pomeroy's assessment.

## The opening of the Crossett Experimental Forest

After working on the Ozark Badger case study, USFS scientist Russ Reynolds spent much of the remainder of 1932 and parts of early 1933 in New Orleans, Louisiana, assisting with the USFS's National Plan for American Forestry (also called the 'Copeland Report' after the sponsor of the Senate Resolution that triggered it, Senator Royal S. Copeland). This massive (nearly 1700 pages), two-volume report was part overview, part policy statement, about what the US government proposed to do about the increasingly dire state of America's forests and related socioeconomic conditions (USFS, 1933). While leading USFS officials were credited with authorship of different parts of this report, much of their material was actually based on the work of junior staffers. For example, Reynolds and his colleague A.E. Wackerman conducted much of the shortleaf and loblolly pine inventory and analysis and wrote parts of USFS Principal Economist Burt P. Kirkland's assessment of the status of private forestry (Kirkland, 1933). Undoubtedly, Reynolds applied some of the lessons (and likely data) from his Ozark Badger case study in his contribution to this report.

Perhaps not surprisingly, then, the Kirkland portion of the National Plan echoed many of the sentiments shared by Pomeroy and Connor, including the added value of farmers selling their forest products in harvested form (rather than on the stump) using their own trucks and animal teams when not actively farming. Kirkland (1933, p. 980–981) also proposed to accelerate the adoption of sustainable forestry on private lands by singling out '...a number of enterprises and a number of communities in which research workers, forest owners, and

forest industries can cooperatively demonstrate the application of existing knowledge to some of the many problems remaining...'. As noted earlier, the USFS had long sought such opportunities—so, when the Crossett Lumber Company (CLC) approached the USFS about collaborating on a number of issues they faced in their transition to 'perpetual forestry', the Southern Forest Experiment Station sent Reynolds back to southern Arkansas in April of 1933 to help them develop a selective logging plan for their remaining mature timber.

Reynolds spent weeks cruising and marking CLC lands and crafting a harvesting strategy. The CLC quickly recognized the potential of further collaboration, and offered the USFS some of their cutover land to serve as a research and demonstration forest (Reynolds, 1980). Throughout the fall of 1933, Reynolds worked closely with the CLC to identify the best-suited property, and by the end of October had chosen the 678 ha that became the CEF. The CEF officially opened for business on 1 January 1934, and Reynolds would devote the next several years developing the necessary experimental forest infrastructure (Figure 6). In addition, he continued to work with the CLC on a series of projects related to selective logging of southern pine forests. As an example, Reynolds secured funding in 1934 from the Charles Lathrop Pack Forestry Foundation to study the costs of logging second-growth shortleaf-loblolly-hardwood stands on other Crossett Lumber Company properties (Reynolds, 1980).

Although Reynolds periodically revisited the Ozark Badger case study work, and the volume tables developed on Ozark Badger lands contributed other efforts in southern Arkansas and elsewhere, his focus had necessarily shifted to the CEF. It was clear from the beginning of the CEF that Reynolds intended to feature selection management, with the majority of that property being dedicated to related studies and demonstrations in 1937 (Reynolds, 1980). This was quite a gamble by Reynolds—the work of Ozark Badger notwithstanding, there was little published evidence on the effectiveness of UEAS in southern pines. Even

though Swiss forester Dr. Henri C. Biolley's work on selection management was cited as an example of good UEAS, Kirkland (1933, p. 906) noted that the American forests most similar to those in which Biolley had found success were '...to be found in the forests of the north Pacific coast...', not in southern pinelands. While Reynolds later stated how his approach to stand regulation in loblolly and shortleaf pine was based on Biolley's work (e.g. Reynolds, 1959), his experiences with Pomeroy, Connor, and Ozark Badger must have contributed to his decision to pursue UEAS on the CEF.

## Epilogue

Pomeroy eventually stepped away from the day-to-day operations of the Ozark Badger mill to focus on developing a forestry consulting business emphasizing UEAS. In 1938, Pomeroy entered into a partnership with fellow lumberman Julian F. McGowin, whom he had advised a few years prior regarding sustained yield on the lands of the W.T. Smith Lumber Company in Chapman, Alabama (Maunder, 1976; Barnett, 2011). Their company, Pomeroy & McGowin, became one of the earliest and most successful forestry consulting firms in the southern US, and soon was advising private landowners controlling millions of hectares across the region (Barnett, 2011). Indeed, Pomeroy's contributions to consulting forestry in the South are often more recognized than his efforts to develop UEAS in southern pines (e.g. Barnett, 2011; Carter et al., 2015).

Once dismissed as a foolish gamble of inexperienced lumbermen, Ozark Badger remained operationally viable for its entire history and outlasted many other larger, better capitalized operations (Connor and Pomeroy, 1971). Ozark Badger continued its operations largely unchanged into the 1960s, when large-scale industry transformations in the southern US resulted in the closing of the mill and eventual sale of other assets (see Carter et al. (2015) for a more detailed review of this transition). Certainly, some of the success of Ozark Badger must be attributed to the unique circumstances of the company. With virtually no corporate cash reserves or family money to support this endeavour, Ozark Badger weathered the troubled economic times of the Great Depression with assistance of sympathetic bankers, local businessmen, and the willing sacrifices of the owners (Connor and Pomeroy, 1971). The fortuitous emergence of truck logging and a southern pine-based pulp and paper industry in the 1920s and 1930s benefited all operations, large and small, but particularly helped make UEAS and pine-tree banking viable options for land-poor Ozark Badger (Pomeroy, 1950; Reynolds, 1980). A relatively small mill, Ozark Badger rarely produced more than 5000 m<sup>3</sup> of lumber per year. This low demand allowed them to adopt UEAS in a way that would have been impossible for the much larger Crossett Lumber Company, which consumed from 110 000 to 175 000 m<sup>3</sup> annually between 1903 and 1961 (Arnold, 1929; Curry, 1953; Anonymous, 1962).

The UEAS of Ozark Badger was eventually eclipsed by more prominent efforts elsewhere, particularly on the CEF. Although Pomeroy and Connor assembled several 'books' of photographs and clippings of their work, and Pomeroy contributed a number of articles to professional journals and trade magazines, these were not the more formal research and technology transfer outputs needed during this period. Predictably, the meticulously



**Figure 6** Russ Reynolds standing in front of the first building constructed as a part of the newly opened Crossett Experimental Forest (CEF), circa 1934. USFS photograph from the archives of the CEF.



documented work of the CEF published between 1934 and 1969 became the standard for UEAS in southern pines. During his decades at Crossett, Russ Reynolds published a wide range of papers on the CEF and surrounding CLC lands that quantified his approach to UEAS (e.g. Reynolds *et al.*, 1944, 1984; Reynolds, 1945, 1954, 1959). As with Pomeroy, Reynolds also excelled at public outreach, thereby extending his research beyond the realm of the scientific community to foresters, landowners, students, and even the media. The publicity efforts of the Southern Forest Experiment Station also helped boost the prominence of the work on the CEF, with articles appearing in a wide range of outlets (e.g. Bond, 1938; Frost, 1946). After World War II, the CEF became a more appealing draw for tours, workshops, and other educational programmes. In 1946, Yale University established a permanent summer camp on CLC lands near the city of Crossett, making both the CEF and the now-managed company lands a more accessible resource (Clark, 1958).

This transition of prominence does not appear to have led to public friction between Pomeroy and Reynolds. Both continued to work together on a number of projects in southern Arkansas, including the participation of Pomeroy on the CEF's Forest Research Advisory Committee (Anonymous, 1956) and Reynolds' support of Pomeroy's efforts to establish a forestry school at Arkansas Agricultural and Mechanical College (today's University of Arkansas-Monticello). Pomeroy (1950, p. 37) acknowledged the 'invaluable' advice provided by the USFS's Southern Forest Experiment Station staff, including Reynolds and Wackerman, in the '...cooperation, advice and encouragement during the early uncertain days of selective cutting.' Over the decades, Pomeroy and Reynolds jointly promoted UEAS in the face of major shifts in southern pine silviculture. The growing preference of the southern timber industry and many private landowners for even-aged pine management (including both natural and planted stands) eventually led to the temporary closing of the CEF following Reynolds' 1969 retirement from the USFS. Even then, Reynolds remained an active proponent of UEAS and joined Pomeroy and his business partners McGowin, Keville Larson and others in an ad hoc group of researchers and practitioners supporting UEAS as a viable option for small landowners (e.g. Larson, 1973).

By the early 1970s, UEAS had fallen out of favour across the southern US, and one prominent silviculture professor even claimed that the American forestry profession had '...already cured itself, the hard way, of the fallacy of the universal uneven-aged forest. The selection cutting detour of the 1930s and 1940s was an honest, if misguided, effort to make the idea work.' (Smith, 1972, p. 91). Imagine the consternation of Reynolds, Pomeroy, and their colleagues that the decades of their documented success in UEAS being labelled as 'misguided'! In consultation with Pomeroy and the rest of the ad hoc group, Reynolds (1974) penned a spirited defense of selective timber management to counter this movement, but their best efforts notwithstanding, the application of UEAS in southern pines continued to decline. Today, the CEF still offers a rare opportunity for academics, foresters, and students to see this system in pine forests of the southern US. Yet without the pioneering operational efforts of Pomeroy, Connor, and Ozark Badger, the long-term success of UEAS at the CEF and engagement of many others in sustainable forestry may not have been possible.

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