



## CASE STUDY BOOKLET

# Chester Zoo: Fodder production from Short Rotation Coppice willows

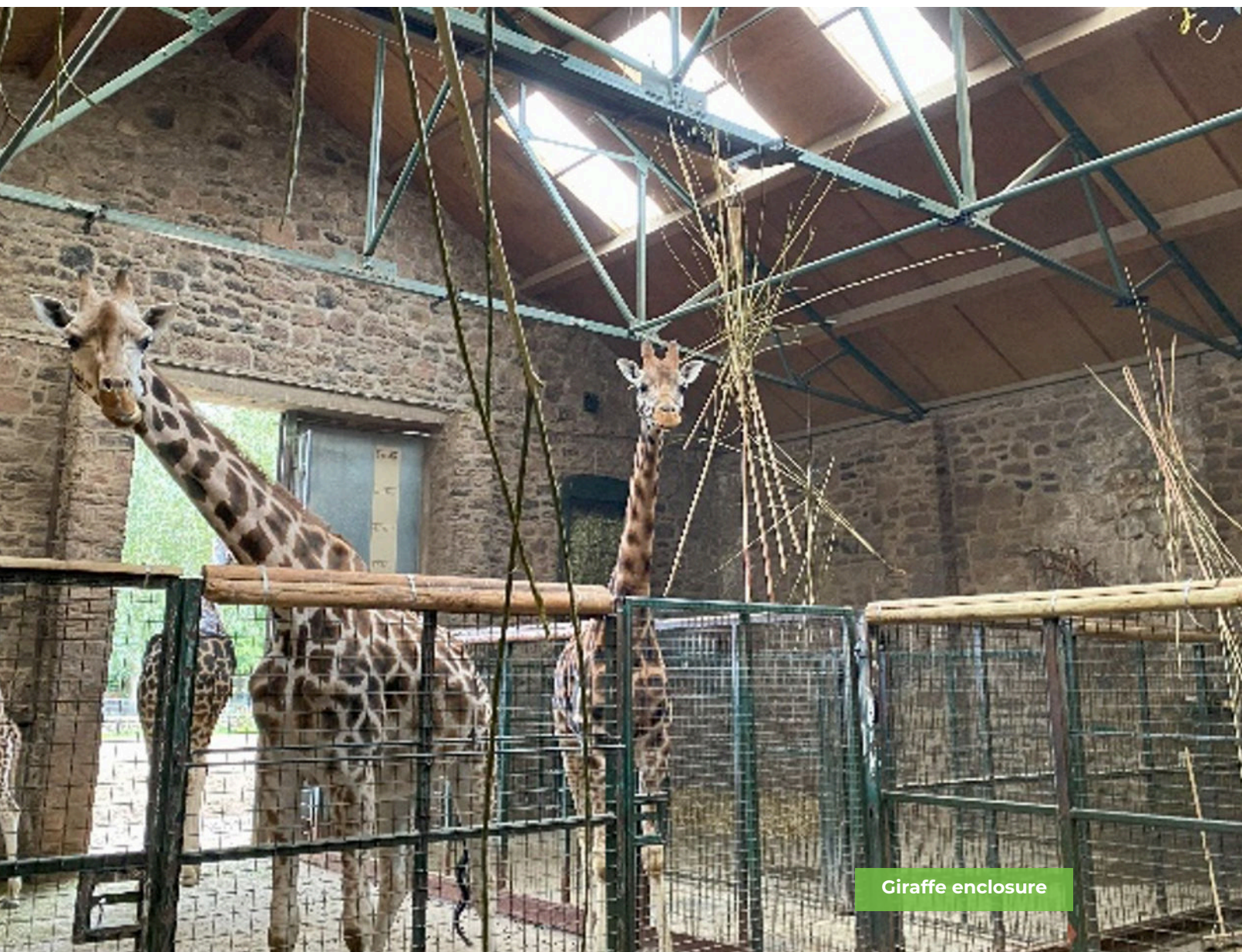


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## Summary

Chester Zoo produces around 25% of the fodder required by their animals (giraffes, Congo buffalo, elephants, okapi and zebras) from Short Rotation Coppice (SRC) willow. Since 2018, the Zoo has planted nearly 16 hectares of willow on nearby farmland that they own. The willow is harvested up to two times a year (between March and October) and fed to the animals along with locally sourced arboricultural arisings (shredded stems, branches and leaves). Willow fodder is favoured food for many of the animals, is good for them and reduces the risk of these important herbivores being fed toxic plants. The supply chain for producing, processing, delivering the browse and removing the waste material and processing it into compost is very complex and costly but enables a closed loop system. The Chester Zoo browse team are learning all the time and in the future are aiming to streamline the process and cut costs.



## Background

Chester Zoo is likely to be the biggest producer of willow fodder in the UK. The willow browse harvested from nearly 16 hectares of willow grown on their own farmland surrounding the zoo, forms a proportion of the diet of several types of large exotic mammals. The willow is managed as Short Rotation Coppice (SRC) and cut daily between March and October. Each plantation is cut in sequence with one to two cuts in a year and then left to regrow for one to two years before being cut again. The farm now supplies around 25% of the browse required by their giraffes, Congo buffalo, elephants, okapi, rhinos and zebras.

Chester Zoo employs 3 people in the browse team and other workers and volunteers help out so that there is a constant supply of willow fodder. The process involves:

- The willow being cut in the field and delivered to the zoo
- Sorting of the willow stems depending on the different animals that they will be eaten by
- Delivery to the different animal enclosures
- Waste removed from the enclosures and deposited into skips
- Willow waste, straw and animal

faeces blended and processed into compost.

Chester Zoo has a team of animal nutritionists to make sure that the animals get a balanced diet<sup>1</sup>. Herbivores tend to get fed a mix of hay, willow and other tree branches with leaves, leafy greens and some processed food pellets. The willow browse has a number of beneficial properties that make the fodder tasty and nutritious and keeps the animals healthy. Some of the useful chemicals and micro-nutrients in the willow include:

- Salicylates, especially salicins and salicortin
- Tannins
- Phenolics
- Flavonoids
- Cobalt and Magnesium

## Planting

Since 2018 the Zoo has established an area of nearly 16 hectares of willow (Figure 1) made up of 11 different varieties (Table 1).

The largest area planted was 4.33 hectares in each of 2018 and 2019. The Zoo has plenty of land and is renting a lot of it out. They can therefore pick good arable land that is weed free to plant and this allows

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<sup>1</sup><https://www.youtube.com/watch?v=aEvk9rb1NXA>



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the willow cultivation to be almost completely organic. New plantings tend to be planned for well cultivated former maize fields where there are few weeds to worry about. Once in a while a pasture field is cultivated, and the grass is killed by spraying glyphosate. Some weeds do appear between the willows such as nettles, but these are seen as beneficial as they offer variety in the browse diet of the animals.



**Figure 1:** Aerial map showing the locations for different willow plots at Chester Zoo.

	Advance	Beagle	Endeavour	Endurance	Meteor	Paramore	Resolution	Terra Nova	Roth Cheviot	Roth Mournie	Roth Hambledon	Total setts	Ha
2018	/	13,000	/	13,000	/	13,000	13,000	13,000	/	/	/	65,000	4.33
2019	10,833	10,833	/	10,833	/	10,833	10,833	10,833	/	/	/	64,998	4.33
2020	10,000	10,000	10,000	/	/	/	10,000	10,000	/	/	/	50,000	3.33
2021	4,000	/	4,000	/	4,000	/	4,000	4,000	/	/	/	20,000	1.33
2022	300	/	2,175	575	2,375	/	6,625	3,450	/	/	/	15,500	1.03
2023	/	/	/	/	/	/	5,000	/	5,000	5,000	5,000	20,000	1.33
<b>Total setts</b>	25,133	33,833	16,175	24,408	6,375	23,833	49,458	41,283	5,000	5,000	5,000	235,498	15.70
<b>Total area</b>	1.68	2.26	1.08	1.63	0.43	1.59	3.30	2.75	0.33	0.33	0.33		

**Table 1:** Areas of willow planted at Chester Zoo between 2018-2023 and the breakdown of different varieties.

Prior to planting the willow setts are put in a shallow water bath for 24 hours to rehydrate.. The cuttings are planted with a Checchi and Magli planting machine that was purchased second hand for around £5,000. The stocking rate is 20,000 per hectare with 1m spaces between plants in the row and 0.5m spaces between the rows. The planting operation

usually takes place in April and requires three persons (one driving a tractor and two planting). Planting one hectare takes 2.3 days in total (7 person days).

The small area planted, the weed free seed bed and slow methodical work rate means that there have been few failures.

As a result, the team has never needed to gap up.

The main cost of planting are the labour costs and the willow plant material (£0.15 – £0.17 per 40 cm cutting, £3,000 to £3,400 per hectare).



**Figure 2:** The willow setts being soaked in a shallow water bath.



**Figure 3:** Chester Zoo's Mark Hargreaves with the willow planting machine.



**Figure 4:** Newly planted willow plantation.



**Figure 5:** Newly planted willow plantation.



## Harvesting

Once established a plantation is left for at least 2 years before a first cut is taken. After that, the majority of the willow plots are kept at 1-2 years old regrowth. Some older plantations also provide thicker wood for other uses.

The willow is harvested between 1st March and the 31st October. An MCR crawler excavator and skid steer loader machine with an attached tree shear is used for the

job. This cuts and places stems in a trailer. One of the operatives uses the tree shear for four hours per day. In this time period it is possible to harvest around 250 multi-stemmed stools (1 stool per minute) which provide around 1,500 stems and fills a single trailer.

The willow plantations are harvested sequentially, and it is possible to get two cuts per year. The only thing that halts progress is one of the team spotting a bird's nest. In this situation the area



**Figures 6 & 7:** The willow is harvested with an excavator with a tree shear and grab attachment.



**Figures 8 & 9:** Newly harvested willow stems in a trailer.

around the nest is marked and the harvester goes around it giving it a wide berth. Since 2018, only around 5 or 6 nests have been spotted as immature, weed free willow plantations do not usually attract nesting birds.



**Figure 10:** Aerial photo showing the gradual harvesting and regrowth of the Buzzard field planted in 2019. The area on the left-hand side has been left, probably as a result of a nesting bird family.

The harvesting process is slow. If the willow was cut manually with chainsaws the team could cut more but it would take a longer time to gather the stems. In addition, the cut stools can act as a tripping hazard and cutting at ground level and excessive manual handling can cause operators to suffer from repetitive strains leading to work days being lost to staff sickness.

The main costs associated with harvesting are the rental of the excavator, the cost of labour each day and the diesel used (100 litres per week). The tree shear was a one-off capital cost of ca £7,000.



## Animal browse preferences

The willow only remains fresh for 2-3 days, so it is moved immediately to the Zoo yard where the team processes it depending on the type of animals that eat it. To mimic natural habits of feeding from high tree branches, the willow stems are tied together and suspended from poles in the giraffe house. Some are stuck in the ground for elephants or pushed through cage sides to offer angled whips for rhinos and Congo buffalos. Some willows are stripped, and the bark and leaves placed in ball cages as a form of willow silage.

This is a laborious job and often is done by volunteers or people on corporate away days.

The typical yield of willow fodder (fresh stem, first year shoots after cut back, cut in May and September) is estimated to be 0.05 kg per stem, 2 kg per stool and 30



**Figure 12:** Willow that is used to feed giraffes needs to be tied together by staff and volunteers.

tonnes per hectare. Table 2 indicates the typical amounts of browse consumed by each type of animal and the area of willow required to meet 25% of their dietary needs.



**Figure 11:** Mixed browse pile in the yard ready for sorting



Most animals get bored of eating the same food all the time so having lots of different willow varieties is important. Ideally, varieties should have big leaves that go all the way down to the base (such as Endurance, Paramore and Terra Nova).

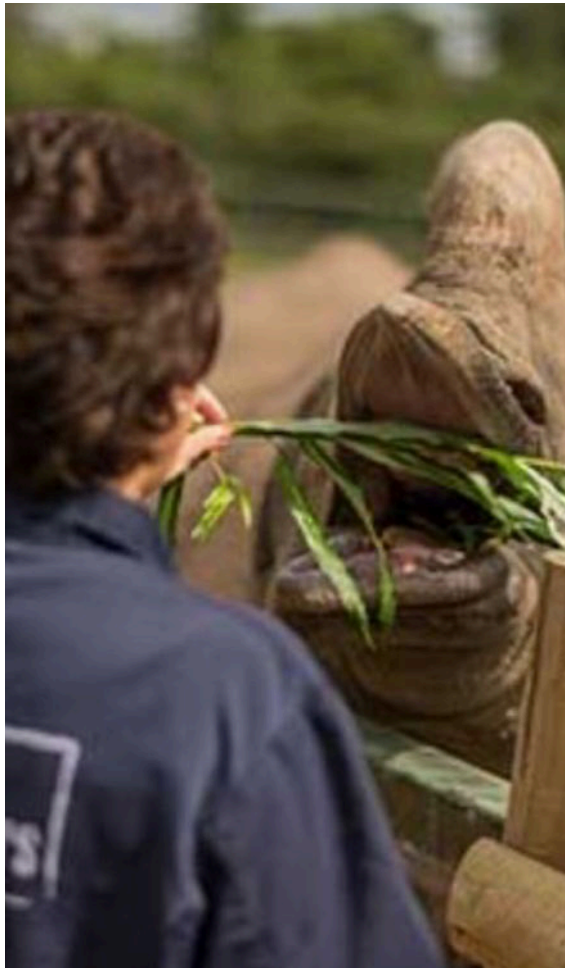
Type of animal	Giraffe	Zebra	Congo Buffalo	Okapi	Elephant	Black Rhino
Amount of fodder required per day (kg)	34	8	17	27	155	60
Amount of fodder required per year (tonnes)	12.41	2.92	6.21	9.86	56.58	21.90
Inclusion rate of willow (overall per year)	0.25	0.25	0.25	0.25	0.25	0.25
Inclusion rate of willow (per day in summer)	0.5	0.5	0.5	0.5	0.5	0.5
Amount of willow required (tonnes)	3.10	0.73	1.55	2.46	14.14	5.48
Area of willow required per animal	0.103	0.024	0.052	0.082	0.471	0.183
Number of animals fed per hectare of willow	9.7	41.1	19.3	12.2	2.1	5.5
Number of animals at Chester Zoo	9	4	7	5	12	12
Area of willow required	0.9	0.1	0.4	0.4	5.7	2.2
Does animal eat:						
Leaves	Yes	Yes	Yes	Yes	Yes	Yes
Bark	Yes	Yes	Yes	Yes	Yes	Yes
Stem wood	No	No	Yes	No	Yes	Yes

**Table 2:** Browse requirements for different herbivores kept at Chester Zoo and the estimated area of willow required to meet these needs.

Other favoured trees are beech, hornbeam, silver birch, apple and ash. From November to the end of February the zoo has to rely on donations from tree surgeons. Currently they accept 4-5 donations of browse per week from golf clubs and fishing clubs.

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**Clockwise from top left:** Black Rhino, baby elephant, Okapi, Giraffe (being hand fed and feeding from a silage ball).





Congo Buffalo

## Dealing with the waste matter

Some animals eat the leaves and bark and other eat the wood too. But there is still a great deal of waste material to clear up. The leftover stem wood could be chipped and used as a biomass fuel to heat the premises. However, currently all the leftover willow is mixed with other arboricultural arisings and muck from the Zoo and shredded before being turned into compost. This can be spread out on the land or used as a soil improver around the zoo gardens.



**Figures 13 & 14:** Giraffes eat only the leaves and strip the bark of willow. The waste is removed from the enclosures, moved back to the farmyard where it is mixed with other waste materials prior to being shredded.



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Figures 15, 16, 17 & 18: Waste material is shredded and then allowed to compost.

## Successes

The animals really enjoy willow fodder and eat it readily. It is also nutritionally valuable to the animals and is advantageous to the zoo as provides a very consistent and safe food source. This is one of the main worries for zoos as they have to find plentiful supplies of locally available browse. Some plants can be safe for some animals and poisonous to others. Furthermore, arboricultural arisings may contain material that is toxic, and this is

difficult to pick out during sorting especially when a number of people with different plant identification skills are doing the job. As a result, it is hard to avoid some unwanted vegetation getting through the sorting process. Therefore, by using their home-grown willow, Chester Zoo can be sure that their prize assets, the zoo animals are less likely to be affected by poisonous plants.



## Challenges

There are several parts of the chain that could be improved on:

- The harvesting and sorting process is slow and laborious. The efficiency could be improved but this would require investment to design, build and test bespoke machinery.
- One area that would be beneficial is the potential to harvest earlier in the spring and later in the autumn. Certain willows produce leaves outside the seasonal norm. For instance, the variety Endeavour flushes early (February) whilst Endurance doesn't lose its leaves until late in the year (early December).
- The Zoo would like to increase the amount of willow and other browse material that they produce themselves. Currently, willow provides 25% of the fodder each year. The limiting factor is the amount of labour required to process this and remove the waste. The latter is particularly important as failure to deal with the waste material can cause a backlog earlier in the supply chain.
- Using other favoured trees is interesting but problematic as they tend to take up a larger area (as they require more space between plants), grow slower and take longer to grow back once harvested.

## Economics

Chester Zoo's total feed bill is £550,000 per year. The cost of willow production has not been fully determined as there are many variables, especially as many people are involved in different parts of the process and the amount of time for individual tasks is not recorded.

However, based on discussions with staff members we have estimated the cost of production for each tonne and each kg of willow browse. This is detailed in Table 3.

## Lessons learnt

The Chester Zoo willow browse production system enables an admirable closed loop allowing all the material produced to be utilised as feed and the waste recycled into compost. It is currently a very expensive and labour-intensive process, but this has to be weighed up against their number one priority for animal welfare. It is still early days, and the browse team are interested in developing ways for the process to be streamlined in order to improve efficiency and cut costs.

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Item	Cost	Notes
Willow plant material	£2,510	15.7 hectares, £3,200 per hectare, annualised over 20 years
Willow planting	£550	7 person days per hectare, annualised over 20 years
Willow planter	£500	Capital cost, second hand, annualised over 10 years
Harvesting	£13,375	1 person for 245 days, 4 hours per day
Rental of harvester	£12,250	£50 per day for 245 days
Tree shear and grab	£ 700	Capital cost, new, annualised over 10 years
Diesel for harvesting	£5,000	100 litres per week for 35 weeks
Diesel for delivery	£5,200	Tractor and trailer 10-mile round trip for 245 days 0.66 miles per litre
Sorting and adding to animal enclosures	£39,200	4 people for 245 days, 3 hours per day
Removal of material from animal enclosures	£39,200	4 people for 245 days, 3 hours per day
Shredding machine	£3,000	Capital cost, second hand, annualised over 10 years
Composting operative	£6,500	1 person for 245 days, 2 hours per day
<b>Total</b>	<b>£127,985</b>	
Amount of willow fodder produced per year (tonnes)	122.5	250 stools per day for 245 days, 2 kg per stool
Production cost (per tonne)	£1,045	
Production cost (per kg)	£1.045	

**Table 3:** Estimated annual costs of willow production and disposal at Chester Zoo.



## Contact Details and Links to Further Information:

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Further information can be found on the Biomass Connect website [[www.biomassconnect.org](http://www.biomassconnect.org)] or by contacting the Biomass Connect Project Office and referencing Chester Zoo Case Study.

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## Links

Chester Zoo: <https://www.chesterzoo.org>

BIAZA Plant Working Group: <https://biaza.org.uk/plant-care-management>



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